2022

Conserving Prairies on North Texas Ranches:

Community and tech-driven approaches to applying phenological data for more resilient prairie management on working lands

Megan O'Connell, PhD
Quivira Coalition & the Botanical Research Institute of Texas
Kelly Carroll, MS
Texas Tech University
Daniella Biffi, PhD
Andrews Institute, Texas Christian University
Ashley Titus
Andrews Institute, Texas Christian University
Jeff Geider
Institute of Ranch Management, Texas Christian University
Jon Taggart
Burgundy Pasture Beef
Ben Taggart
Burgundy Pasture Beef
Dan Caudle
TSSRM Youth Range Workshop
Meredith Ellis, MLA
G Bar C Ranch
Philip Boyd
Dixon Water Foundation
Casey Wade
Dixon Water Foundation

DIXON WATER FOUNDATION
LEO UNIT

2022

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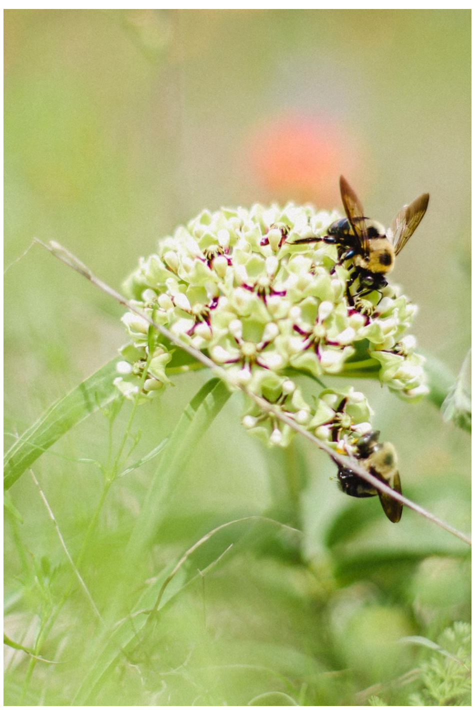
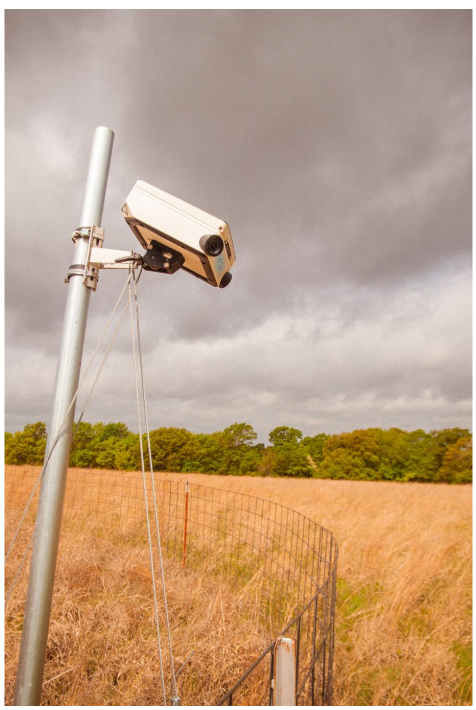
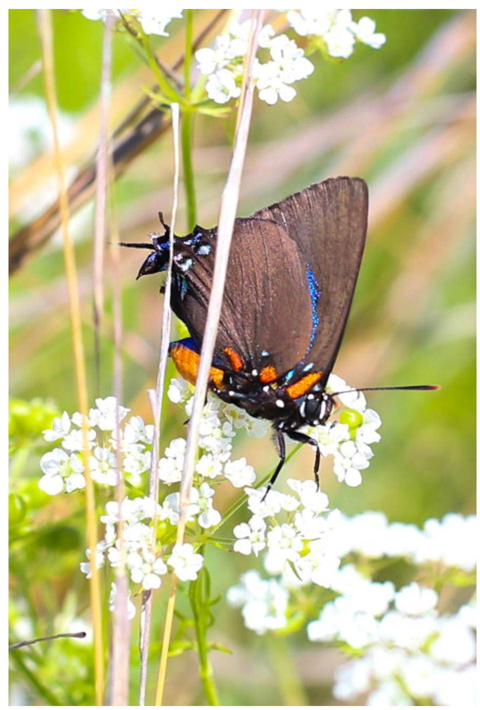






Background

More than 1/4

More than 1/4 of land in the United States is impacted by ranching activities and in Texas, >70% of land is considered ranch land. Thus, in Texas it imperative for conservationists and ranchers to work collaboratively to turn working lands into agroecological restoration spaces where biodiversity and business can coexist (USDA 2019). Very little intact native prairie habitat (<1% Blackland Prairie) remains in North Texas and working rangelands in this region are incredibly important potential conservation spaces for the Fort Worth and Blackland Prairie ecosystems (NPAT 2022). Intact Fort Worth Prairie, historically home to hundreds of species, is now one of the rarest ecosystems in the US, with a G1/G2 ranking, meaning it is critically imperiled with only 6-20 known occurrences today (GPRC 2023). While small scale prairie restoration projects and campaigns have successfully restored several prairie preserves in the region, questions remain whether these approaches can be pursued at scale and how historic ecological dynamics, i.e. grazing by large ungulates and wildfire, will be simulated and maintained in these habitats long-term.

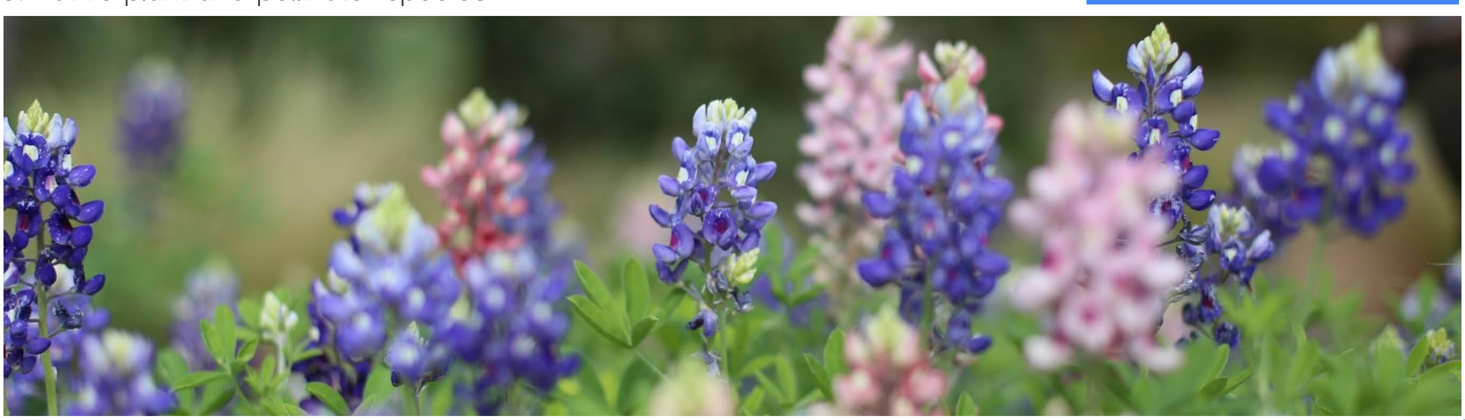
Restoration on working lands, and more specifically the conversion of ranchlands to agroecological systems, when managed through sustainable grazing and restoration practices, can have substantial, large scale conservation impacts. Working pastures can also be home to hundreds of native plant species that are critical habitat for pollinators and wildlife, can create corridors for migratory species, and sustain innumerable critical ecosystem services (Dass et al. 2018). Prescribed grazing methods prevent overgrazing of plant communities that grow in pastures through rest-rotation cycles, allowing prairie plant communities to recover and sustain climax species assemblages. While not new, prescribed, rotational grazing practices are not widely utilized due to their perceived complexity and a lack of data to showcase their conservation and economic benefits. By recovering working lands' native plant assemblages and ecological function, not only do these lands become beneficial habitat, they transmit economic sustainability to ranching operations,

Background

making them more resilient to climate and market fluctuations, protecting businesses and guaranteeing land management into the future.

For the purposes of conservation, these prescribed grazing practices need to be informed by the ecology of the species that ranchers are attempting to restore and conserve. Ranchers will need annual data conveying the composition and diversity of plant communities in their pastures, as well as regular temporal observations of what plant species are present when and more specifically the phenology of these species, i.e. when they are flowering and going to seed to ensure their return each year. Such observations are time consuming and an impractical undertaking to ask of a busy ranch manager's schedule, therefore, to make these conservation goals more accessible to more ranchers, measuring and predicting phenology to inform prescribed grazing practices will need to be data-informed, adaptive, and streamlined. Conservationists and agricultural producers will need to collaborate to develop practical means of restoring, managing, and monitoring working lands to assess progress into the future to ensure that we maintain a more sustainable balance between the tenants of the triple bottom line: People, Planet, Prosperity (UN 2015). To help ranchers obtain this information without adding extensive labor to their busy schedules, we aim to conduct a pilot study on several North Texas ranches in the spring-summer of 2022 to test novel remote imaging technology and community science protocols to measure the phenology of prairie species so ranchers can better time their prescribed grazing practices for the conservation of native plant and pollinator species.

PHENOLOGY:
the study of cyclic and seasonal natural phenomena, especially in relation to climate, plant and animal life



Objectives

Regenerative ranching practitioners are balancing many factors daily as a part of their livestock and landscape management goals: weather and seasonality, business and economics, animal health and diet, plant and forage resources, among others. Traditionally it has been believed that these goals are in opposition to the goals of conservationists, who ideally are working to restore as many ecosystems to their ecological climax communities and conserve as much biological diversity as possible. For this project we aimed to follow the tenets of the Radical Center, which posits that ranchers and environmentalists can and should be working toward the common goal of appropriate use and management of the land to balance ecology and economics (Quivira Coalition 2020). Through a collaborative and community-engaged approach to collecting ecological monitoring data, we aim to pilot methods and protocols for engaging ranchers and communities in collecting phenological data in prairie plant communities that are actively being grazed on working ranches. **We aim to refine ecological monitoring on regenerative ranches and foster the adoption of regenerative practices through the following 6 objectives:**

OBJECTIVE 1:
Establish a system of phenological observation cameras in pastures at several North Texas ranches practicing prescribed grazing to collect phenology data of Fort Worth Prairie species.

OBJECTIVE 2:
Collect accompanying pollinator community data during the phenological observation period to model targeted species-specific conservation practices on working lands.

OBJECTIVE 3:
Practice simple ecological monitoring protocols to aid regenerative ranchers in assessing their progress and combine contemporary and historic data to inform conservation tools.

OBJECTIVE 4:
Develop a community science campaign to engage the public in phenological data tracking to amplify the data collection capacities of conservationists and ranchers.

OBJECTIVE 5:
Practice collaborative conservation approaches to develop resources and management recommendations. Disseminate these practices to new audiences and expand our network.

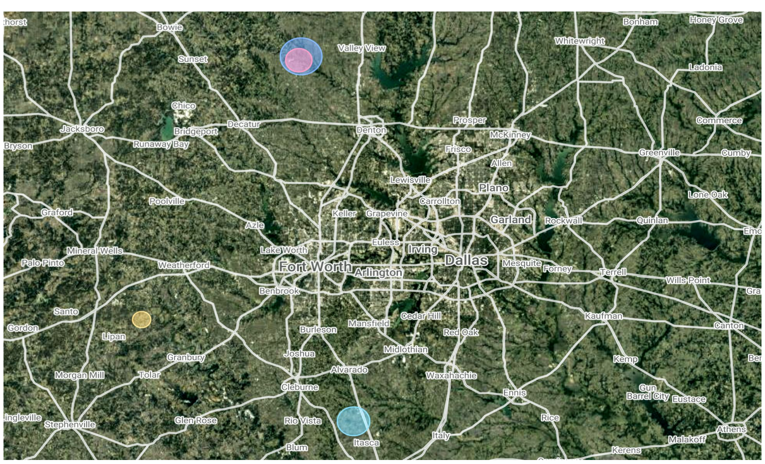
OBJECTIVE 6:
Present and share data and resources used to compile and developed from this project in publicly accessible, open source, and engaging formats for a variety of audiences and shareholders.

Study System

OBJECTIVE 1:
Establish a system of phenological observation cameras in pastures at several North Texas ranches practicing prescribed grazing to collect phenology data of Fort Worth Prairie species.

To pursue the 6 aforementioned objectives, we established a study system composed of a network of **4 ranches** in and around the Dallas-Fort Worth metroplex, specifically ranches that are located within the Fort Worth Prairie ecoregion (see map below or on google). With the generous collaboration of our participating ranches (*the Dixon Water Foundation and G Bar C ranch to the North near Era and Rosston, TX, Burgundy Pasture Beef at C7 ranch to the South near Grandview, TX, and Cougar Hollow ranch to the Southeast near Lipan, TX*) we installed **10 weatherproof, solar-powered, Tikee 3 long-term timelapse cameras** in **10 pastures** (4 @DWF, 2 @GBC, 2 @C7, 2 @CH) where regenerative, rest-rotation grazing is practiced. At three of these ranches that did not previously have weather stations (GBC, C7, CH), Columbia Capricorn FLX weather stations provided by Texas Christian University's Ranch Management Program (Columbia Weather Stations).

The Fort Worth Prairie is a vegetative sub-region nested between the East and West Cross Timbers that extends into Cooke, Montague, Denton, Wise, Tarrant, Parker, Johnson, and Hood counties. It is composed largely of treeless vegetative assemblages with gently sloping topography and "cuesta" escarpments derived from the thin soil that covers hard layers of limestone. North American tallgrass prairies once covered this region, but today these habitats have mostly been degraded, with only remnants remaining (TPWD 2005). Home to hundreds of native species, the Fort Worth Prairie and surrounding tallgrass prairies also act as important parts of the North American Central Flyway for migratory birds and insects such as Monarch Butterflies and several species of warblers (Audubon & Journey North 2023).



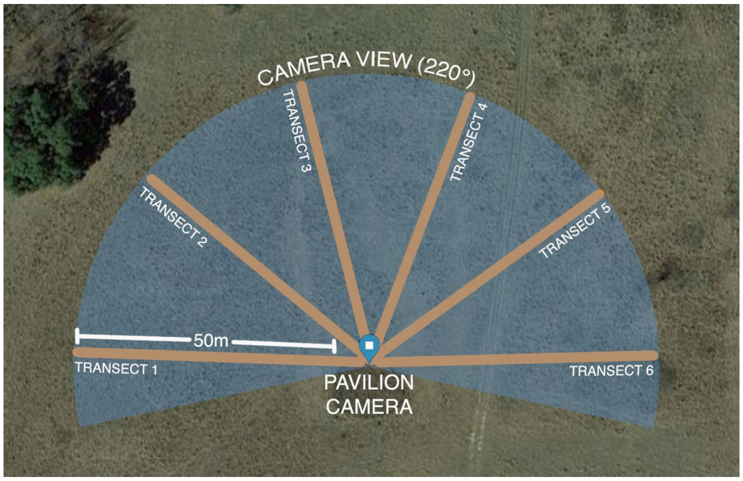
LAND ACKNOWLEDGEMENT:
The Fort Worth Prairie is the ancestral homelands of the Wichita, Kickapoo, and Comanche peoples for whom American bison were an important cultural staple. Selective grazing by bison and wildfires historically maintained prairie ecosystem health in the central United States. Settlers over-hunted bison, inhibiting the ability of these tribes to sustain themselves on the land and permanently altering the ecology of these ecosystems (Native Land Digital 2023).

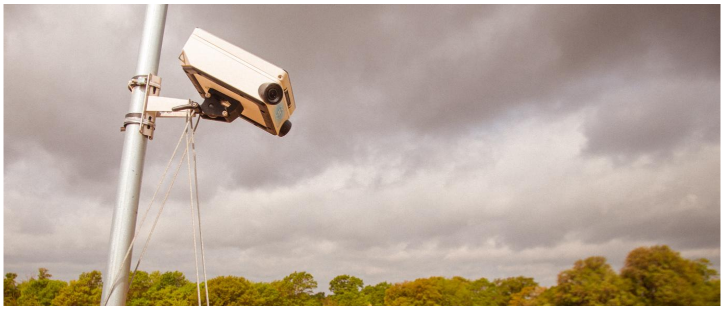
All data from this project is publicly available through our online data dashboard.

Field Methods

- The field study portion of this project took place between March and September 2022 during the spring and summer flowering seasons in North Texas.
- Solar-powered, long-term Tikee 3 timelapse cameras (see page 18 for more information) were placed facing North or South in pastures selected by participating ranchers due to their interest in seeing temporal change in the plant communities in these pastures.
- Cameras were staked into the soil behind cattle guards at approximately 6 feet off the ground to prevent cattle interference with the cameras.
- The Tikee 3 cameras were programmed to take and upload 1-3 daily 220° stitched images to cloud data storage on the myTikee interface via cellular networks (cameras are equipped with SIM cards) where they were downloaded and shared via google drive with team members and participating ranchers: **Phenology Field Photo Share**
- Protocol were developed to collect floral species count data from these images over the fall of 2022 (see Data Analysis Methods on Page 8).

OBJECTIVE 3:
Practice simple ecological monitoring protocols to aid regenerative ranchers in assessing their progress and combine contemporary and historic data to inform conservation tools.

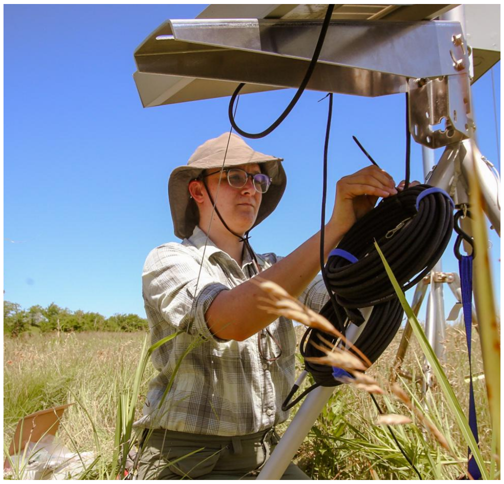




OBJECTIVE 2:
Collect accompanying pollinator community data during the phenological observation period to model targeted species-specific conservation practices on working lands.

- Accompanying pollinator community data was collected once per month from May to September at 2 cameras per ranch along six 50 m transects radiating from each phenological camera as a focal point (see figure below).
- Pollinators were collected opportunistically along transects and using sweep netting methods identified as the most effective method for collecting the highest diversity of native pollinators (Prendergast et al. 2020).
- For the sake of this study, "pollinators" were considered any floral visitor observed along the designated transects - species of insects seen on a flower, landing on a flower, or departing from a flower.
- Upon capture, pollinators were stored in labeled 1.5 mL tubes and placed in a -20° freezer upon return from the field each day.
- In August 2022, pollinators were vortexed in 70% ethanol to remove all pollen from their bodies, then were pinned for identification and pollen slides were made using fuschian jelly stain (as per Kearns & Inouye 1993).
- In the fall of 2022, pollinators were identified to family, genus or species by M. O'Connell.
- Pollen preferences of our pollinators will be analyzed from the pollen slides at a later date.

Data Analysis Methods

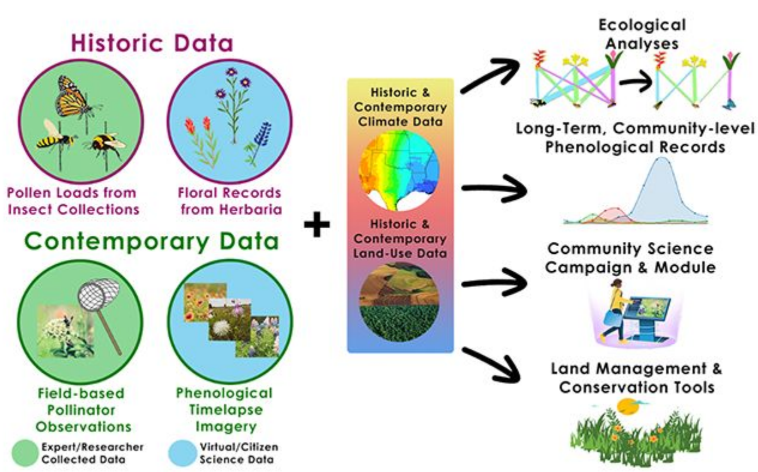


OBJECTIVE 3:
Practice simple ecological monitoring protocols to aid regenerative ranchers in assessing their progress and combine contemporary and historic data to inform conservation tools.

OBJECTIVE 4:
Develop a community science campaign to engage the public in phenological data tracking to amplify the data collection capacities of conservationists and ranchers.

The data collection goals of this project are multifold: we aim to use our digital data collection methods as an opportunity to engage more people, beyond the scientific and agricultural communities, in understanding these issues and participating in the creation of conservation solutions (Gonsalves 2005). By crowdsourcing data processing, we can provide information to ranchers faster, while engaging the public in important conversations about climate change, agriculture, and conservation. To do this, we are engaging in a multiphase data analysis program that engages education researchers to develop a community science protocol that will produce quality ecological data. The data needs for this project are also multifold in that we aim to combine historic records with contemporary observations to better inform conservation tools that we can apply in rotational ranching operations (see research scheme below). As we have worked on year 1 of this project, we have maintained an adaptive approach that has helped us determine the following necessary phases for the creation of a community science program that creates real results:

1. **Expert analysis of phenological camera image:** *initially we intended to have community scientists analyze images from our cameras but realized that data collection from the images was more complex than expected, so we developed a protocol for analyzing these images and research team members refined the protocol to determine if it can be translated into a community science protocol (see page 9).*
2. **Expert analysis of pollinator communities:** *After identification, our team quantified pollinator community diversity (H), species abundance and richness, and each pasture's potential max diversity ratio (HMax). In future years of this project, we aim to combine this information with historic records from the region to assess long-term shifts in pollinator presence on the landscape.*
3. **Community scientist analysis of historical records:** *We worked with educational researchers from TCU to pilot a community science program that engaged non-science major undergraduates in helping collect phenological information from historic botanical records from the BRIT herbarium. Additionally, TCU researcher's developed an educational research scheme to understand how participatory research influences student perspectives on conservation and regenerative agriculture (see page 16).*
4. **Expert data synthesis:** *Using this year 1 data and future iterations of this project, we will synthesize historic and contemporary phenological observations with meteorological data from our weather stations, and pollinator observations to produce the suite of outcomes listed in our research scheme: ecological analyses, long-term, community level phenological records, community science campaigns and modules, as well as publicly accessible land management and conservation tools.*



Data Analysis Methods

ImageJ Download and install.

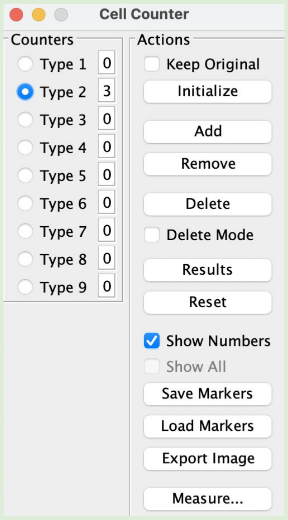
- Download **ImageJ**: https://imagej.nih.gov/ij/download.html
- Download **cell_counter.jar** plugin: https://imagej.nih.gov/ij/plugins/cell-counter.html
- Add **cell_counter.jar** plugin to **ImageJ** folder.
- Restart **ImageJ**.

Before starting the analysis.

- We subsampled 12 squares per image in which we quantified floral species richness
- To select random squares, go to: https://randomnumbergenerator.org/
- Do not repeat; Numbers: **12**; From: **1** To: **36**

Analyze images.

- Open ImageJ
- File > Open > *select picture*
- Analyze > Tools > Grid
  Area per point: ***80,000*** *pixels/squares > [OK]*
- Plugins > Cell Counter > **Cell Counter** window opens:
  Click [Initialize]
  Click [Add] until you have ***30+*** *types.*
  Start scrolling for the selected squares
- Count each flower type in each grid square.
- If you aren't sure of a species you're seeing - refer to our floral guide: https://docs.google.com/presentation/d/1qCHqPeUBsbpECc2XqlIa6EDSL3p4_HPZ/edit#slide=id.p1
- Count the number of individuals of each species in all 12 squares without resetting the cell counter



Saving results:

- Click [Results] > *Copy/paste to excel*

Saving Markers:

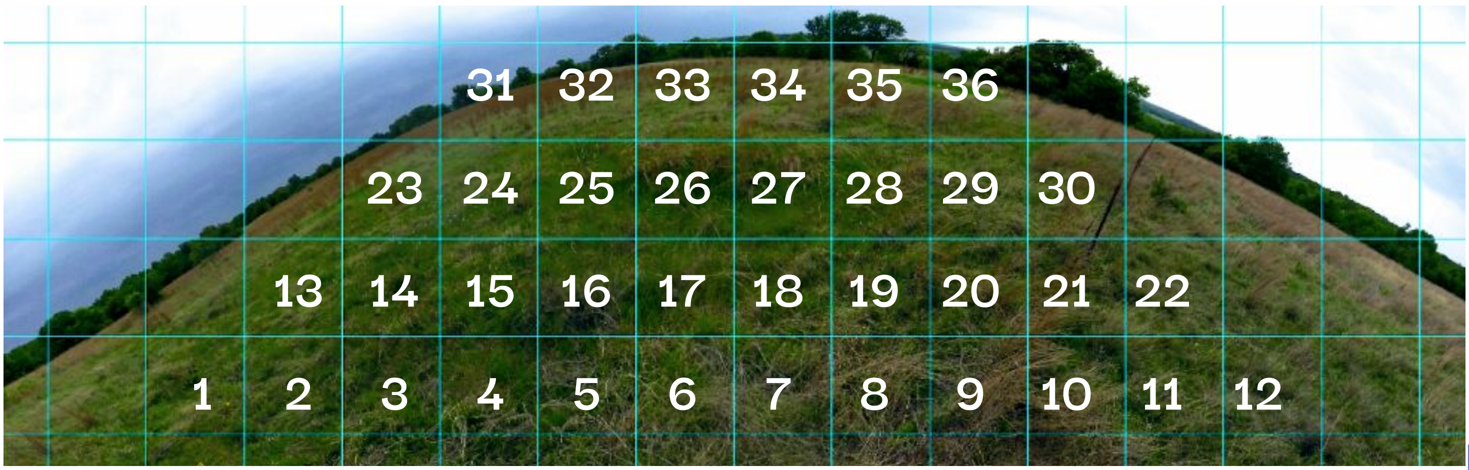
- On Cell Counter click [Save Markers]
  Output name will be like:
  CellCounter_2022-05-05-14-30-00-001
- Delete Cell Counter
  The file name should be:
  2022-05-05-14-30-00-001.xml

Saving images:

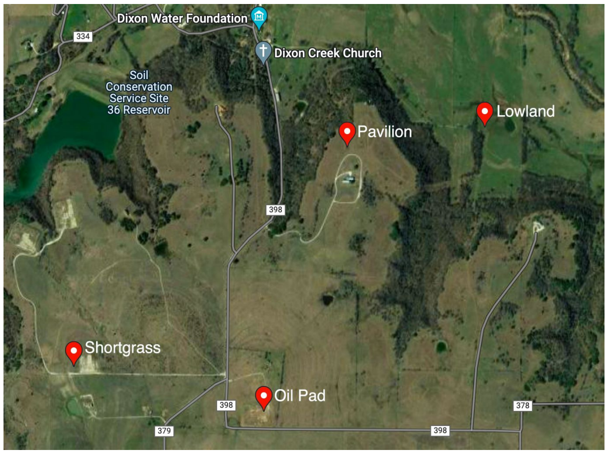
- File > Save As > .Jpeg
  Output name will be like:
  Counter Window - 2022-05-05-14-30-00-001
- Delete Counter Window
  The file name should be:
  2022-05-05-14-30-00-001.Jpeg
- Both .xml and .Jpeg files need to have the same name

If you want to edit an image [open an image again]:

- File > Open > 2022-05-05-14-30-00-001.Jpeg
  Image opens with the grid.
- Plugins > Cell Counter > *Cell Counter window opens*
  🚨 *Do not click [Initialize]*
- Click [Load Markers] > 2022-05-05-14-30-00-001.xml
- [Add] the rest of the Types until 30+
- Reanalyze

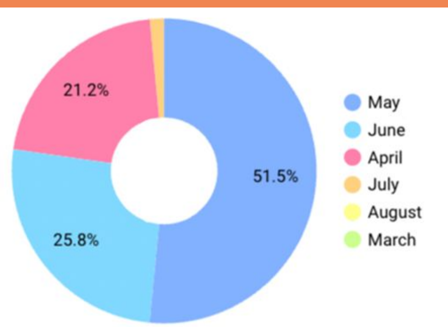


Phenology Results

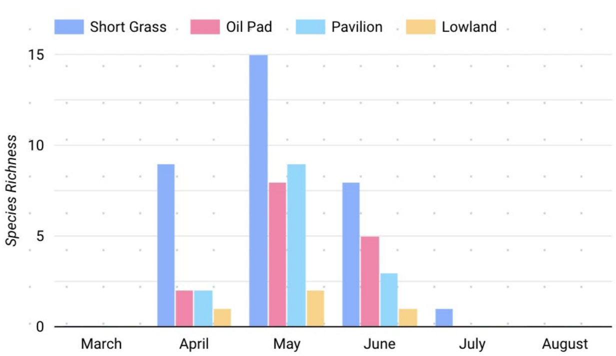


26
forb species observed
1,581
individual flowers detected

Floral abundance by Month

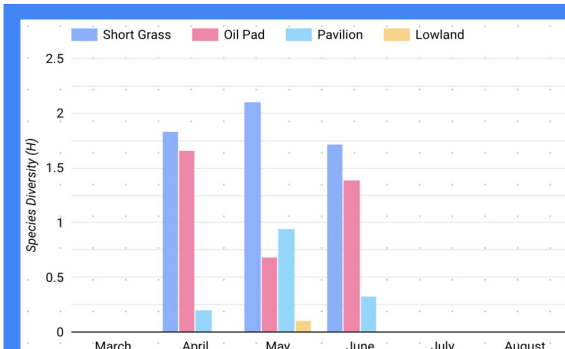


Floral Species Richness

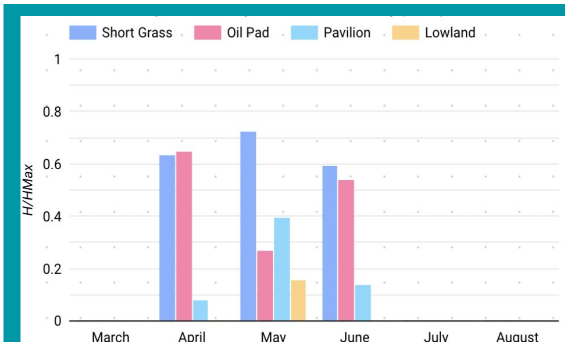


Phenological data was collected and analyzed at the per pasture level. At the Dixon Water Foundation Leo Unit, phenological data were collected in 4 pastures: the Shortgrass, Pavilion, Oil Pad, and Lowland pastures (google map). As per the ImageJ floral counting protocol (page 9), the following phenological time series (ages 10-11) show the temporal presence and abundance (number of individual flowers observed) of each floral species in each pasture from ~March to ~September of 2022. From these time series we were able to calculate floral abundance, species richness, diversity (Shannon-Weiner Index(H)), and the potential max diversity ratio (species diversity/potential max diversity (Hmax)).

At the Dixon Water Foundation Leo Unit, we experienced a late spring start to blooming and did not detect floral species with our cameras until April. Overall, the Shortgrass pasture outperformed the other three pastures in regard to floral species richness and diversity in all studied months, likely due to the shallow, rocky soil conditions in the site (Loughmiller et al. 2018). Across all pastures, May by far was the most prolific month for floral abundance (>50% of all floral observations were made in May), species richness and diversity, but this may have been due in part to the late start to the season, delaying first blooms for several species. Although the Shortgrass pasture harbored a greater species diversity in most months, in regard to species diversity compared to the maximum diversity each pasture could potentially host, other pastures such as Oil Pad, in April and June were hosting similar Hmax ratios to the Shortgrass pasture, with both pastures in 2022 harboring around 60% of their potential maximum diversity, potentially showing substantive restoration progress.



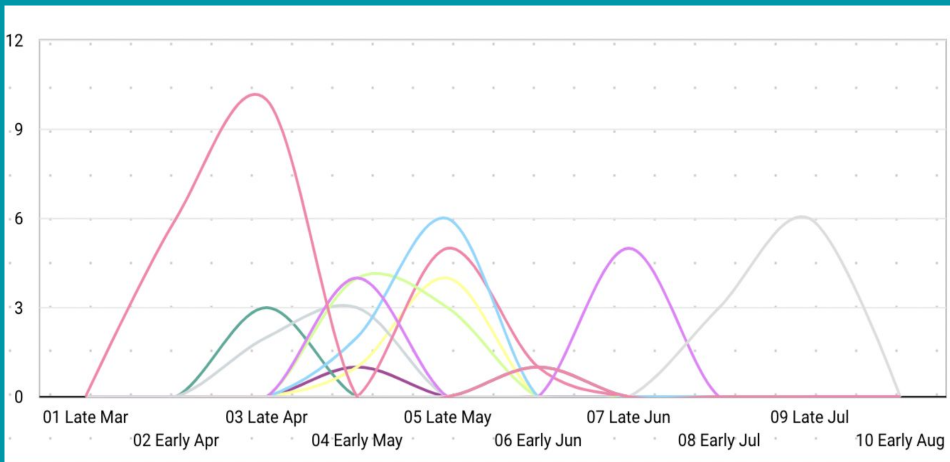
Floral Species Diversity (H)



Potential Max Species Diversity Ratio (Hmax)

Phenology Results

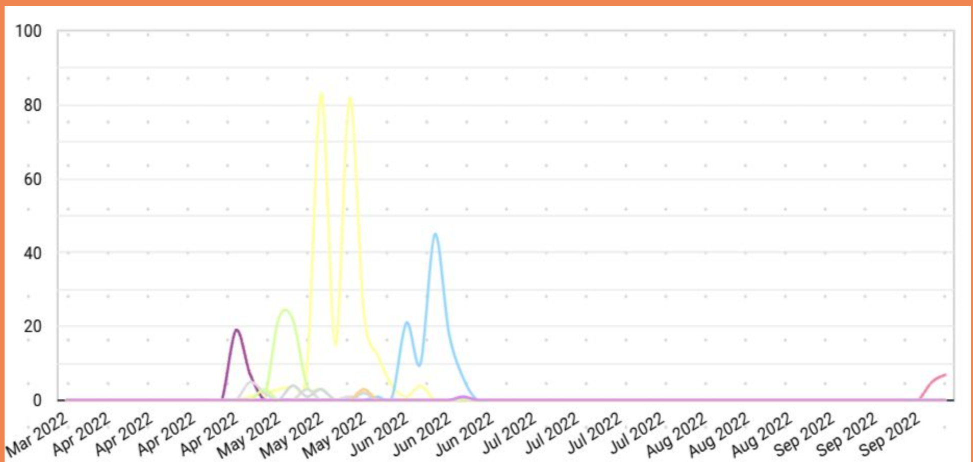
Shortgrass



Gaillardia sp.	144	*Grindelia sp.*	9
Indet. 1	89	*Indet. 3*	8
Thelesperma sp.	54	*Pyrrhopappus sp.*	7
Asclepias sp.	50	*Monarda sp.*	6
Oenothera sp. 2	49	*Linum sp.*	5
Torilis sp.	38	*Convolvulus sp.*	5
Callirhoe sp.	28	*Glandularia sp.*	4
Linheimera sp.	24	*Indet. 2*	1
Ranunculus sp.	17		
Oenothera sp. 1	9		

INTERPRETATION: Important genera such as *Oenothera* (Yellow Sundrops), *Ranunculus* (Hairy buttercup), *Callirhoe* (Winecup), and *Asclepias* (Green/Antelope Horn Milkweeds), all having been reported as important bee (Glenny et al. 2022), moth and butterfly (LBJWFC), and specifically monarch butterfly (Brym et al. 2018) resource plants, were present and dominant in this pasture early in the season, making this an **important early season pollinator habitat during from late March to early May**. As these species began setting seed, the pasture became dominated by other popular pollinator genera such as *Gaillardia* (Blanketflower), *Thelesperma* (Stiff Greenthread), and *Monarda* (Beebalm) from late April to late May. This pasture becomes significantly less diverse beginning in June, with *Oenothera* (Evening Primrose) and *Grindelia* (Gumweed) being the only floral secis captured by our camera.

Pavilion

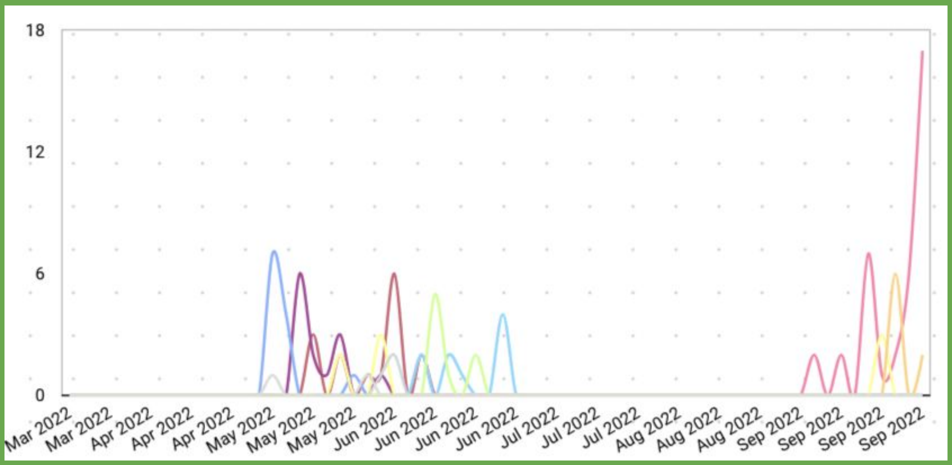


Torilis sp.	244	*Berlandera sp.*	3
Centaurea sp.	102	*Pyrrhopappus sp.*	1
Tetraneuris sp.	51	*Oenothera sp.*	1
Erigeron sp.	26	*Solanum sp.*	1
Ranunculus sp.	12		
Indet. 1	11		
Convolvulus sp.	10		
Asclepias sp.	3		

INTERPRETATION: A less florally diverse pasture than Shortgrass, we observed the Pavilion to be more dominated by tall grass species that have the potential to outcompete and shade out low-growing herbs. In this pasture, flowering largely occurred between the mid-April to late June and was dominated by *Torilis* (Wild Carrot), *Erigeron* (Fleabane), *Tetraneuris* (Bitterweed), and *Centaurea* (American Basket-flower). Of these species, Centaurea is of particular conservation important from Mid-May to late June as a generous nectar supplier for butterflies as well as a seed source for dove and quail, **making this pasture most important from mid-may to late June** (Pollinator Partnership).

Phenology Results

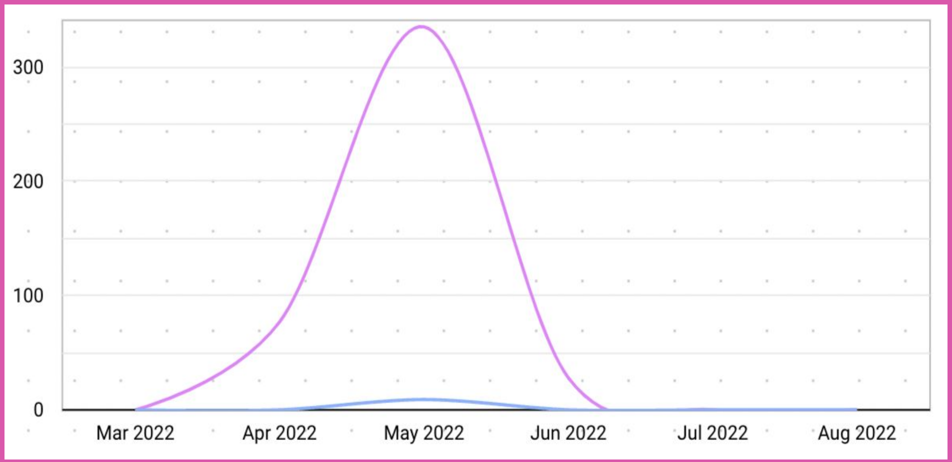
Oil Pad



Ranunculus sp.	37	*Convolvulus sp.*	3
Thelesperma sp.	15	*Indet. 1*	2
Indet. 2	13	*Achillea sp.*	1
Solanum sp.	12	*Oenothera sp.*	1
Centaurea sp.	9	*Pyrrhopappus sp.*	1
Linheimera sp.	8	*Eryngium sp.*	1
Torilis sp.	8	*Callirhoe sp.*	1
Berlandiera sp.	8		

INTERPRETATION: Surprisingly, the Oil Pad pasture, despite its management history, had the second highest floral diversity detected by our cameras and was the only pasture to have a significant post-summer bloom period. Like the two previously discussed pastures, the main bloom event from May to late June was dominated by Stiff Greenthread and American Basket-Flower, but we also detected a higher presence of "weedy" genera like *Solanum* (Silverleaf Nightshade) and *Convolvulus* (Texas Bindweed), which are indicators of highly disturbed and/or lower quality habitat (Texas Invasive Species Institute). Importantly, **this pasture showed the greatest diversity, of those studied, during the month of September** when we detected a significant bloom of *Ranunculus* (Hairy buttercup) and *Lindheimera* (Texas Yellow-star), both helpful pollinator resources.

Lowland



Oenothera sp.	440
Solanum sp.	9

INTERPRETATION: The Lowland pasture displayed the lowest diversity of floral species throughout the season and we only detected a significant Evening Primrose bloom from late March to June. This species, among the present grasses, was the dominant floral species, likely because of the wet soil conditions at this site, which are unfavorable for many prairie forb species (Loughmiller et al. 2018). Although *Oenothera speciosa* has been cited as being a resource to a variety of species from specialized bees, to hawk moths, to providing seeds to birds and small mammals, it has also been reported as not an ideal species to support pollinators, as it sometimes can become too dominant in native prairies, crowding out rarer native species due to its aggressive growth habits (LBJWFC).

Floral Guide

All data from this project is publicly available through our online data dashboard.

Gaillardia sp.

Torilis sp.

Monarda sp.

Castilleja sp. 1

Thelesperma sp.

Asclepias sp.

Callirhoe sp.

Solanum sp.

Grindelia sp.

Convolvulus sp.

Oenothera sp. 1

Berlandiera sp.

Glandularia sp.

Eryngium sp.

Solanum sp.

Centaurea sp.

Senna sp.

Erigeron sp.

Castilleja sp. 2

Hedeoma sp.

Achillea sp.

Oenothera sp. 2

Lindheimera sp.

Ruelllia sp.

Ranunculus sp.

Cnidoscolus sp.

Pyrrhopappus sp.

Tetraneuris sp.

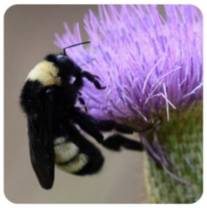
Rudbeckia sp.

Linum sp.

Pollinator Results

38
pollinator species observed
73
individuals collected

Apis mellifera



Bombus pensylvanicus

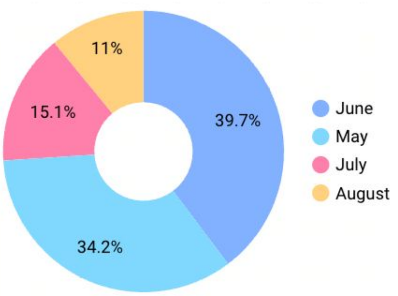
Ceratina cobaltina

Papilio polyxenes

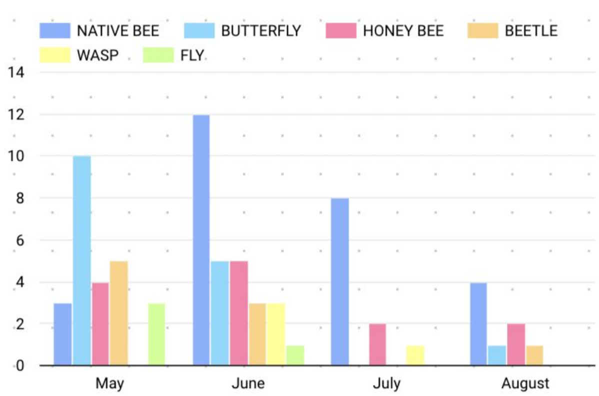
Strangalia sexnotata

Junonia coenia

Pollinator abundance by Month

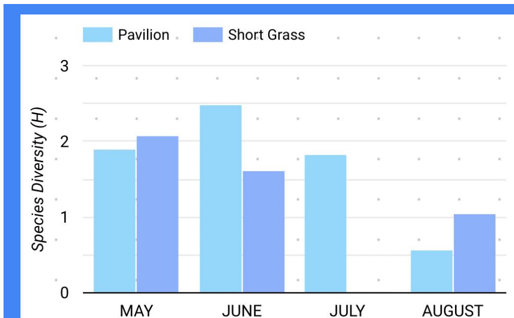


Pollinator Abundance by Month/Order

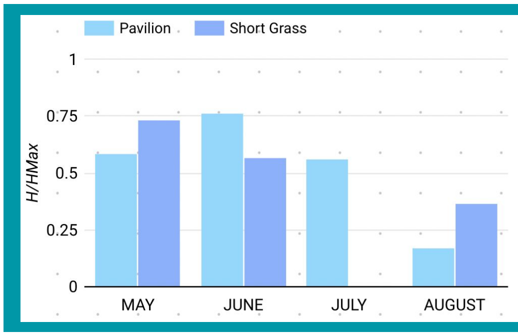


Pollinator data was collected and analyzed at the per pasture level at Dixon Water Foundation Leo Unit's Shortgrass and Pavilion pastures (google map). As per the aforementioned pollinator transect protocol (page 7), four collection periods from May to September of 2022 yielded observations of 38 different pollinator species and a total of 73 individuals that were collected and identified largely to family/genus and some to species. From these specimens, we were able to calculate pollinator abundance, species richness, diversity (Shannon-Weiner Index(H)), and the potential max diversity ratio (species diversity/potential max diversity (Hmax)).

At the Dixon Water Foundation Leo Unit, due to the late spring and hiring a field crew member, we were not able to do sufficient pollinator collections until May, therefore pollinator data from March and April have not been included. Overall, the most pollinators were collected during June (~39%), despite this not being the month with the highest floral abundance and diversity. While the Shortgrass pasture supported more pollinators in May and August, the Pavilion pasture hosted a significantly higher diversity of species in June and more importantly in July, when floral species diversity was at its lowest and we were only able to collect one pollinator at Shortgrass. Importantly, it should be noted that in July and August both pastures had incredibly low floral species diversity, with both pastures largely hosting a single floral species during that observation period: *Euphorbia bicolor* (Snow on the Prairie) at Shortgrass and *Stenosiphon linifolius* (False Gaura) at Pavilion, both of which were undetected by our cameras. Lastly, depending on the month, both pastures hosted a pollinator community approaching 75% the potential max species diversity indicating that when floral resources are more abundant (in May and June) these pastures are well on their way to supporting healthy pollinator communities, but in July and August pollinators will require much more substantive floral resources to continue utilizing these pastures as habitat.



Pollinator Species Diversity (H)

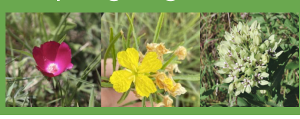


Potential Max Species Diversity Ratio (Hmax)

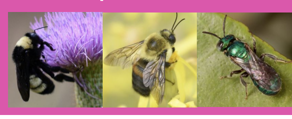
Recommendations

DISCLAIMER: All recommendations here are made taking pollinators into consideration but are not meant to be prescriptive. We are aware that sometimes these recommendations may come into conflict with other needs on the ranch, therefore we acknowledge that these suggestions are helpful in understanding where pollinators are present on the ranch and when, but that collaborative conversations among project stakeholders will help us better understand how feasible these recommendations will be at the Dixon Water Foundation and beyond. Additionally, we would like to acknowledge that these observations were only made over 1 study year, therefore additional years of data will be needed to codify these recommendations. Potential future recommendations could look like the following:

March to May:
Potentially avoid grazing the Shortgrass pasture to protect important floral resources for early season native bees and monarch butterflies spring migration.



Late May to June:
Potentially avoid grazing the Pavilion pasture as this period of time supports the highest observed diversity of pollinators in this pasture.



July to August:
All pastures, except Pavilion in July and Shortgrass in August are potentially suitable for grazing with possible low impact on pollinators. Potential to support more pollinators with additional seeding of appropriate floral species.

September (Fall):
Potentially avoid grazing the Oil Pad pasture to protect floral resources while pollinators are resource stressed after low resource months of July and August.

Caveats, Future Directions, and New Questions:

- These observations were only made during 1 study year, therefore we need to perform additional years of observations and combine these data with historic records to surmise long-term trends.
  - We will continue to develop a methods paper for this project and aim to pursue future funding to potentially pursue this continued work on participating ranches and additional ranches, so we can produce ecological publications and interactive online resources).
- Cameras need to be laced closer to the ground to get finer data resolution - we had issues balancing image quality and accuracy of some plant ID's - particularly in the several species of yellow flowers we had in this project.
- Pollinators are indicator species, they tell us about the quality of the habitat we are managing, therefore we want to pursue future collaborative questions like:
  - How do we make pollinator conservation a normal part of rotational grazing cycles?
  - If we aim for conserving pollinators, what other wildlife species may benefit?
  - Are these practical goals on all ranches or just some?
- Continued collaborative conversations with our participating ranchers will help us understand how to develop more feasible recommendations.

OBJECTIVE 5:
Practice collaborative conservation approaches to develop resources and management recommendations. Disseminate these practices to new audiences and expand our network.

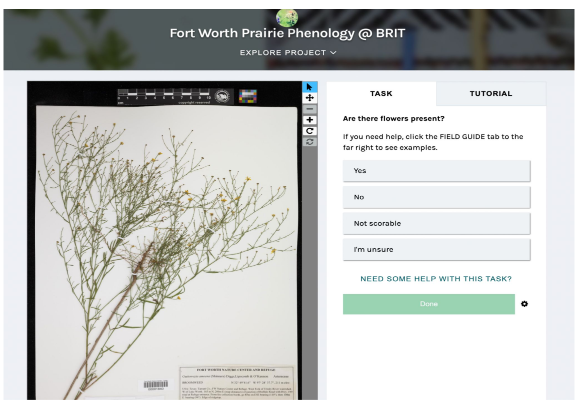
- What parts of this project were vital and which parts are impractical or can be left behind?
- Are there more effective alternative approaches to collecting the same data?
- How can we engage more producers in these conversations and in utilizing future resources we may develop?
- Camera and weather station management: partners to discuss future management plan for continued camera functioning and weather station cellular service.

Community Science

OBJECTIVE 3:
Practice simple ecological monitoring protocols to aid regenerative ranchers in assessing their progress and combine contemporary and historic data to inform conservation tools.

OBJECTIVE 4:
Develop a community science campaign to engage the public in phenological data tracking to amplify the data collection capacities of conservationists and ranchers.

OBJECTIVE 6:
Present and share data and resources used to compile and developed from this project in publicly accessible, open source, and engaging formats for a variety of audiences and shareholders.



In the fall of 2022, with the collaboration of TCU's Andrews Institute for Research in Math & Science Education and Institute for Ranch Management we set about developing a community science pilot program to address our need to quantify historical phenological data. Through this pilot our aims were two-fold: to crowdsource the collect historical phenological data from BRIT herbarium specimens, and to study how participatory community science research models shift public perceptions of conservation and regenerative agriculture (Wandersman 2003).

In a semester-long undergraduate course for non-science majors, *Challenges of Global Food Production & Distribution*, students engaged in a series of surveys, lectures, and activities related to our project. Using the Zooniverse platform, we shared images of historic specimens of selected species known to grow in the Fort Worth Prairie from which students helped us assess their phenology digitally. The digitization of information from phenological records is time consuming, therefore the task of digitizing when a specimen was collected and whether it was in flower or fruit is a simple task to crowdsource and use as a public engagement opportunity. Thus far we have had a total of 30 students help score >1200 historic records and had 10 of these students participate in the first pilot round of our education research study to assess the impact of their participation in the project.

Non-science majors reported increases in their belief that they personally can help solve environmental issues and a shift toward a better understanding of the interconnectedness of the environment, agriculture, and an individual's actions. This pilot will continue next fall to incorporate more students in a variety of courses so we can refine our community science protocols to incorporate broader audiences, such as the network of ranch-owning alumni from the Institute of Ranch Management and public high school classes, and develop publications regarding the impacts of our community science work.

Citations & Support

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Many thanks are due for the generous support of our funders and collaborators:

Dixon Water Foundation

North Texas Community Foundation

Fort Worth Botanic Garden | Botanical Research Institute of Texas — Center for Botanical Exploration & Discovery

TCU Ranch Management, Since 1956

TCU College of Education — Andrews Institute

Burgundy Pasture Beef — 100% Grass Fed. Sustainable. Wholesome.

Cougar Hollow Ranch

G Bar C Ranch

Quivira Coalition

Camera Management

Enlaps Tikee 3 Camera

- 100% self-sufficient - solar panel and battery
- 100% connected- Wifi & 4G
- Weatherproof & designed for outdoor use
- Compact - 21 x 18 x 7 cm - 1,5 kg
- Photos: 4K & 220° panoramic

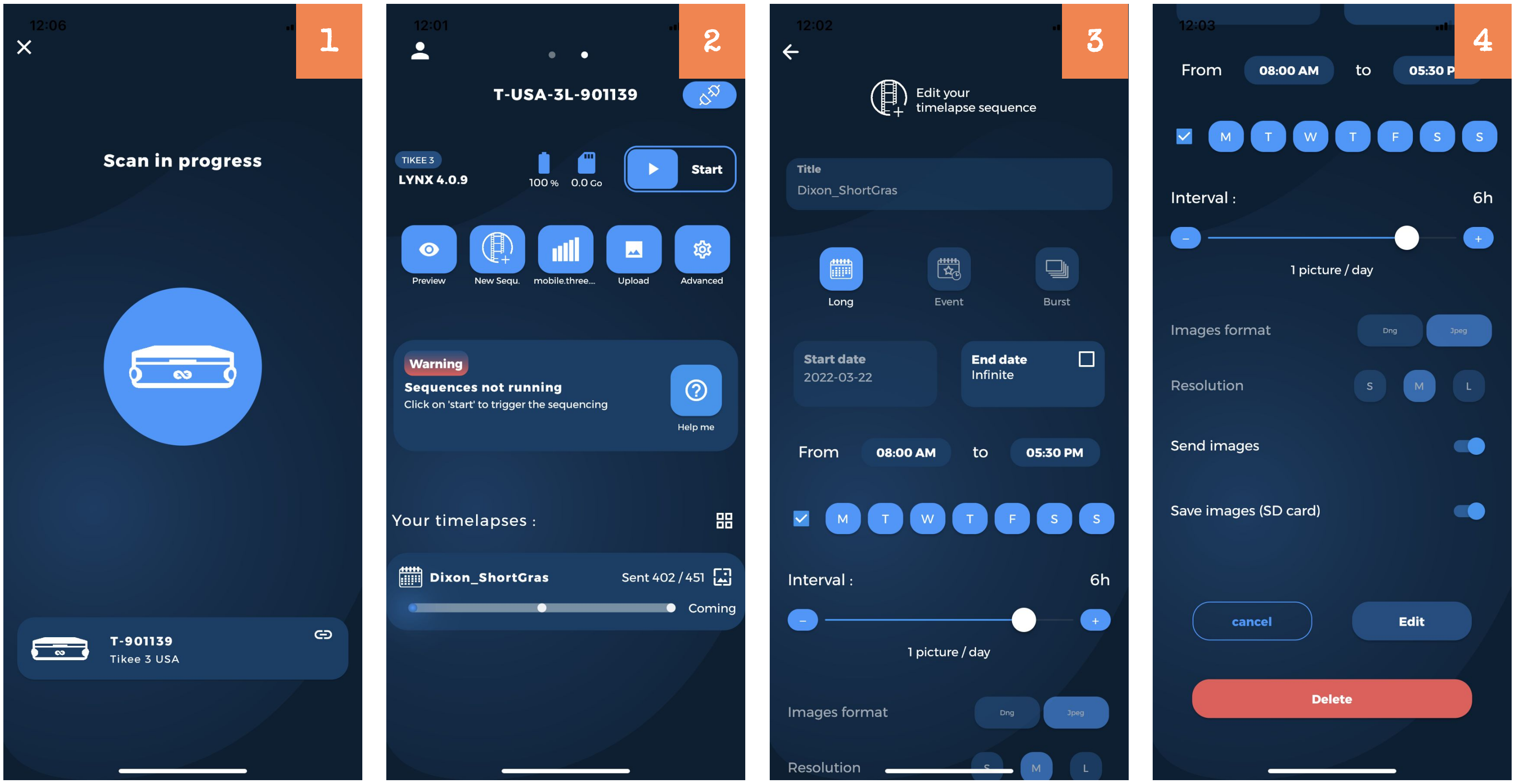
The cameras used to collect phenological images for this project were 10 Tikee 3 timelapse cameras from Enlaps, a French startup offering long-term timelapse cameras that combine hardware and software to capture images remotely that are managed through their online SaaS platform: myTikee.

The Tikee 3 camera is operated through a proprietary app, Tikee Remote, on the user's cell phone via a bluetooth connection and is fairly straightforward to operate, although occasionally has issues connecting to the cameras; sometimes we had to restart the app several times to get it to connect properly to cameras. Through the app, the cameras can be programmed to turn on/off and take a series of long-term timelapse images at various personalized intervals and can also be programmed to take videos, and upload these images to cloud storage. Cloud storage capacities are only accessible if the user purchases SIM cards and pays for data plans that connect to cellular networks with local service in the area. Images on these cameras are taken with two 4k cameras and can be stored on in-camera SD cards (~$15/card) as two separate images the user will need to stitch together manually, but images uploaded to cloud storage are automatically stitched together via the myTikee software and are stored on the myTikee platform.

All images uploaded to cloud storage can only be accessed through the myTikee software, but can be downloaded from this site and utilized for analyses on the user's IOS, although even the "high quality" stitched/uploaded images appear to have reduced quality compared to the images stored on the SD card. The myTikee platform also allows the user to process rudimentary timelapse videos from their images and track camera battery levels, cellular connectivity, and most recent image upload to inform users if any of their cameras have gone offline and need attention.

While the cameras are fairly cost-effective for their capacities, hardiness, and reliability, there are other associated costs to operating this equipment that users should be aware of before employing Enlaps equipment. To access the myTikee platform, users can use very rudimentary camera management and image processing functions on the platform for free, but if they'd like to need to pay for a software subscription that can range from $200 for 3 months of access to $500 for 12 months of access. Additionally, we found affordable SIM cards and data plans through IoT SIM cards that connect to nearby cellular networks (i.e. AT&T and T-Mobile) that users can affordably pay for smaller quantities of data (i.e. $36 for 2.5 GB over 6-12 months which generously covered our per camera upload needs for this project). Lastly, equipment insurance is needed to ensure that these cameras can be replaced if any circumstances come up in the field, for example we had one camera infested with fire ants that ate the electrical wiring and rendered the camera inoperable. Due to the nature of equipment, the policy recommended to us was called an inland marine policy and we chose to receive coverage from an insurance provider called CoverWallet that insured all 10 cameras for $650/year (all cameras are currently insured through the end of 2023).

Camera Management



Tikee Remote App User Guide:

1. Download the Tikee Remote app from your app store.
2. On the back of the camera you would like to set up, press the power button in until the power light flashes blue.
3. Make sure your bluetooth is on on your cell phone, then open the Tikee Remote app and tap the blue circle to scan for nearby cameras. *If the camera is properly turned on it will appear at the bottom of your screen as in panel 1 above.*
4. You will then be connected to your camera's interface where you can check the cameras battery level, cellular connectivity, the last time it uploaded an image, and whether it has a timelapse running currently (panel 2 above).
5. To set up a timelapse, look down under your timelpases as in panel 2 above and click on the current timelapse or set up a timelapse.
6. As in panel 3 above, you will see options to edit your timelapse: you can name it, decide if you are running an infinite long-term timelapse or only want to take images for a certain period of time. You can set the window of time each day you want the camera to take pictures, how much time you want between each picture, and what days of the week you would like it to take pictures.
7. In panel 4 you see that you will have options to control the image format, quality, and whether it both uploads and saves images to the in camera SD card.
8. Press start timelapse. You will know the camera is successfully taking images if you go onto the myTikee software on your computer and find an uploaded image.
9. NOTE: You will want to make sure that the upload rate is set to daily uploads if you want to see new images online daily. To do this you will need to go to the upload settings (found in panel 2) and set the upload threshold to 1 image. This way the camera will upload each image as it is taken. *Depending on the cellular service in your area this could take 2-24 hours.*