# Cooperative Ecosystem Studies Unit (CESU): Phenology Monitoring Technical Assistance – *Nature's Notebook* Citizen Science for Engagement and Management

A multi-year agreement between the National Wildlife Refuge System of the US Fish & Wildlife Service (USFWS) Inventory and Monitoring Program (I&M) and the USA National Phenology Network (USA-NPN).

## Phenology for Resource Management and Decision Making
## Year 4 Annual Report, December 2022

Cooperative Agreement Award F19AC00168
Project Period: February 19, 2022 – February 19, 2023
Budget: $167,448

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## Summary:

In the fourth year of our four-year funding agreement for 2019-2023, we made the following progress toward our objectives:

- Continued to support phenology monitoring efforts in three USFWS priority areas: Middle Rio Grande bosque, Mississippi River corridor for mayflies, monarch butterfly central flyway
- Expanded efforts to document the timing of flowering of nectar plants that are important for pollinators, including supporting four National Wildlife Refuges in tracking nectar plant flowering timing and new synergistic efforts *Time to Restore: Connecting People, Plants, and Pollinators,* and *Desert Refuge: Monarchs and Milkweeds in Arizona*.
- Began creating a series of eight regional info sheets to assist the USFWS in understanding phenological changes on priority species.
- Explored additional data products and information that we can provide to aid USFWS staff in their management actions.

These activities directly supported the USFWS Mission to conserve wildlife and their habitats by providing information about the seasonal cycles of plants and animals, how they are changing, and how these changes can inform management, operations, and interpretation.

We received a one-year extension to continue this partnership through January 31, 2024 so that we can complete our stated objectives. In the remaining year of the collaboration, we will work with multiple partner refuges on short articles submitted to *Fish and Wildlife News* and other outlets to describe outcomes from phenology data collection and inspire new refuges to begin phenology monitoring to meet management and outreach goals; we will create additional guidance for FWS staff to utilize our Status of Spring tool that informs individual refuges about the timing of early spring activity; we will also produce Info Sheets for each USFWS Region that will summarize the latest research on how seasonal activities for priority species have shifted as

well as provide guidance on how projected climate changes in coming decades may further impact phenology.

We believe there is great potential to continue this partnership with USFWS beyond that time to meet our shared goal of using innovative science to understand climate change impacts on the environment and provide information to managers to aid adaptation and mitigation efforts. A new agreement would offer opportunities for extended and expanded collaborations, including providing FWS with an efficient, flexible tool for monitoring seasonal changes across the NWRS and critical information that will inform strategies to respond to climate change.

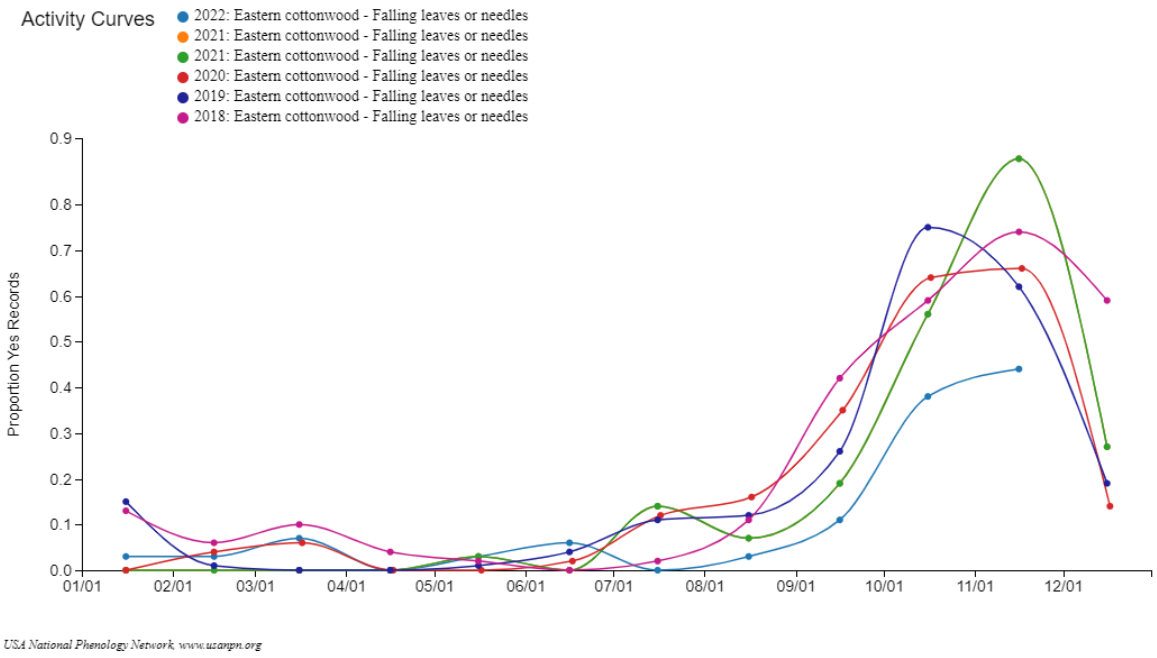
## Activities in support of fourth-year objectives:

Below, we describe our progress in 2022 toward meeting our four-year objectives as well as our partnership as a whole.

### Objective 1. Continue to support existing regional projects focusing in three USFWS priority areas: Middle Rio Grande (Bosque), Mississippi River corridor for Mayflies, and Monarch Butterfly central flyway.

We continued to support existing regional projects focusing on three USFWS priority areas.
1. Middle Rio Grande Bosque forest – The Rio Grande Phenology Trail is a collaboration between multiple National Wildlife Refuges – Valle de Oro NWR and Sevilleta NWR – and other organizations along the Rio Grande. These partners have a shared interest in tracking phenology data of species that are critically important for the Rio Grande ecosystem. In 2022, we added another partner, Cottonwood Gulch Expeditions, to the Trail, bringing the total number of partners to eight.

In 2022, observers on the Rio Grande Phenology Trail collected over 29,000 phenology records (more than double the number of records in 2021) on 46 species. One key species that many partners are tracking is the Rio Grande cottonwood (*Populus deltoides wislizenii*). Knowing when this species spreads it seeds indicates the best time to flood to encourage germination. Knowing when this species drops leaves indicates the best time to collect cuttings from cottonwoods for pole planting to propagate the trees. The following activity curve from the Rio Grande Phenology Trail Dashboard on the USFWS Phenology Network website (https://fws.usanpn.org/riograndephenologytrail) shows the proportion of "yes" reports for the life cycle stage of falling leaves for cottonwoods reported on the Trail over the last six years, suggesting that the best time to collect cottonwood poles for planting is between October and November.

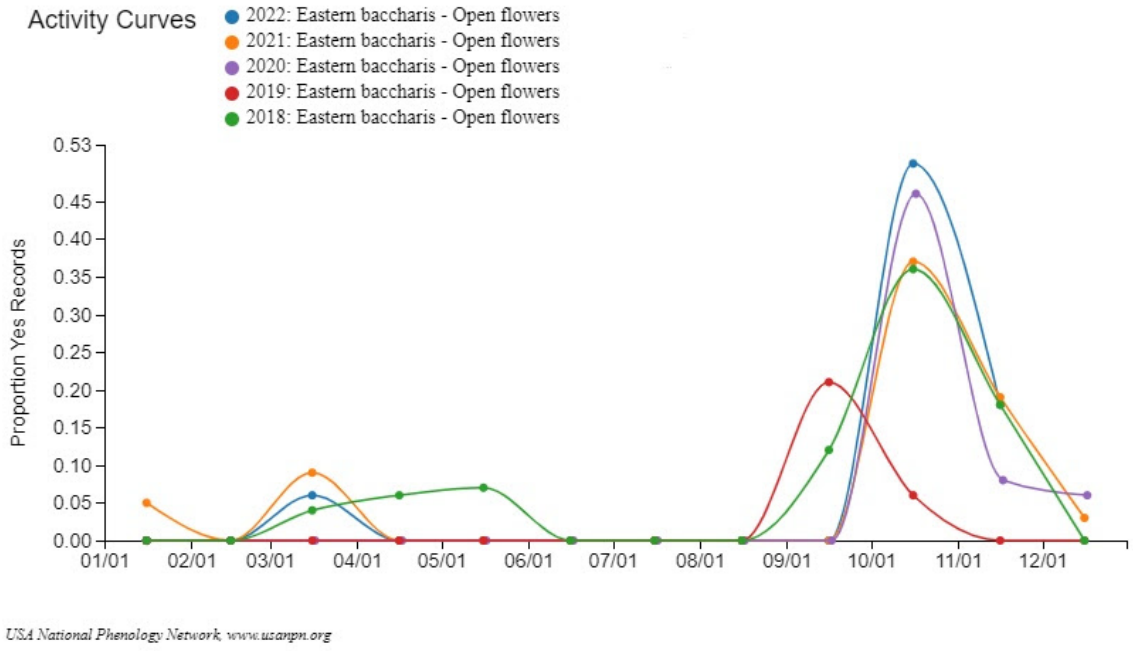



During 2022, we also had multiple meetings with staff from Valle de Oro NWR about restoration activities that are transforming the Refuge from alfalfa fields to bosque forest, wetlands, and upload grasslands. Staff see this transition period as an opportunity to re-evaluate which species are being tracked at the Refuge and to solicit input from surrounding communities including Pueblo of Isleta and the Mountain View neighborhood. We began these discussions in spring of 2022 and will continue them in 2023. We have also begun discussions with individuals from the Southwestern Indian Polytechnic Institute in Albuquerque about how we can involve their students in helping to explore the data that have already been collected at Valle de Oro NWR to inform future data collection.

2. **Mississippi River corridor for mayflies** – We continued to host the Mayfly Watch campaign for a seventh year in 2022. The purpose of this campaign is to document large emergences of burrowing mayflies that occur along the Upper Mississippi River corridor and its tributaries. If we can establish reliable links between mayfly emergence and water or air temperature, we can warn city managers when to turn off lights on bridges and other places where mayflies can pile up and cause hazardous road conditions. Mayflies are also an indicator of water quality, which is of interest to wildlife managers along River. With the retirement of USFWS Fisheries Biologist Mark Steingraber in 2016, there is no longer a USFWS representative intending to use the data collected by this campaign. We continue to reach out to representatives from the USFWS and Army Corps of Engineers to identify collaborators on this effort. Recently, the National Weather Service updated their website with mayfly emergences detected by radar along the Upper Mississippi River. We can leverage this information next year to prompt observers to report their sightings. We are also involved in the development of a research project led by scientists at Virginia Tech who are using radar to detect large emergences of mayflies. The Mayfly Watch campaign will be a critical part of this study, which will be submitted as a grant proposal to the National Science Foundation in 2023.

3. Monarch Butterfly central flyway – In 2022, four refuges submitted data on flowering of nectar plants important to monarchs. On the Gulf Coast Phenology Trail, three refuges continued to participate in phenology monitoring. The Trail created an Annual Report to summarize the data collected through the end of 2021. Among the 57 species observed on the Trail is eastern baccharis (*Baccharis halimifolia*), an important nectar plant for pollinators. One of the objectives of the Trail is to determine the importance of this species as a nectar source for monarchs as they pass through the Gulf Coast in the fall on the way to their wintering grounds in Mexico. Neal Smith NWR is another refuge in the monarch central flyway that is contributing to recording nectar plant flowering.

The following activity curve shows the proportion of "yes" reports for open flowers for eastern baccharis at Gulf Cost Phenology Trail locations in the past five years. Flowering consistently peaks in mid-October in all years except 2019, showing that monarchs had access to nectar at a critical period on their fall migration. Additional years of data will show if 2019 was an anomaly or if flowering can be more variable.




In 2022, we continued a synergistic project funded by the USGS South Central Climate Adaptation Center called Time to Restore: Connecting People, Plants, and *Pollinators* (usanpn.org/TimetoRestore). This project aims to assist those working in pollinator restoration by providing climate-informed guidance on flowering and seed timing of nectar plants. Several USFWS staff in the South Central region (New Mexico, Oklahoma, Texas, and Louisiana) participated in stakeholder workshops in Fall 2021 focused on identifying priority species, locations, and preferences for information delivery. This project will expand the existing Nectar Connectors campaign, adding priority nectar species for pollinators as well as provide monitoring guidelines to give recommendations on how to select plants and how frequently to monitor to understand bloom and seed timing.

*Plan for extension period*: In the remaining period of our extension, we will continue to support these three regional efforts and hope to expand the number of refuges participating in phenology data collection. As part of Time to Restore, we look forward to continuing discussions with staff at Valle de Oro NWR and their surrounding community members about future phenology monitoring.

### Objective 2 and 3. Integrate existing phenological datasets from Refuges into the USA-NPN Database and work with individual Refuges to help them adjust their current data collection method to the USA-NPN's phenology protocols for future monitoring.

The long-term goal of the USFWS is to have all phenology data collected on National Wildlife Refuges in a standardized format and hosted in a single, easily accessible database. The USA-NPN offers standardization and security for USFWS data. The USA-NPN also provides tools to summarize the data and deliver them side-by-side with seasonal climate data. Refuges also have access to visualization tools maintained by the USA-NPN which allow refuge staff to explore and visualize their own data as well as compare these to data collected by other refuges and data collected in areas off-refuge.

In 2020, we assisted Patuxent Research Refuge in migrating their phenology data collection from Project Budburst into the USA-NPN's data collection infrastructure. Now that we have a process in place for cross-walking external datasets into the USA-NPN's National Phenology Database, we can more easily ingest other datasets collected with different protocols as well as simple lists of first occurrences for species of interest.

*Plan for extension period*: We will continue to advertise data integration as an option available to refuges across the country and assist refuges in integrating their existing phenology data with the National Phenology Database, leveraging the USA-NPN protocols and infrastructure for their data collection.

### Objective 4: Inform/advise interested refuges on implementing phenological monitoring

In 2022, our staff offered multiple opportunities for refuge staff and volunteers to learn to use USA-NPN's data collection platform, *Nature's Notebook,* as well as the other phenology tools and products that we offer. These included:

- For the fourth year, I was invited to present in NCTC's Citizen Science Course in April 2022. I presented a session on *Nature's Notebook* as an example of a citizen science program that refuges can use to meet management and outreach objectives. Fourteen USFWS staff participated in the course.
- USA-NPN staff facilitated a 10-week, 80-hour Local Phenology Leader Certification Course (https://www.usanpn.org/nn/LPLCertification) in spring and fall of 2022. This comprehensive course is designed to help establish a *Nature's Notebook* phenology monitoring program. The course guides participants through program planning activities to ensure sustainable, long-term programs. We promoted the Certification Course and

summer short course in each of our USFWS Quarterly Newsletters in 2022, and shared information about the program in the NCTC Citizen Science Course in April 2022.

- I met with a staff member from the Mid-Columbia River National Wildlife Refuge Complex about their interest in implementing a phenological monitoring program. That person has now transferred to a refuge in another state but is still considering taking the Local Phenology Leader Certification Course in 2023.

*Plan for extension period*: We will continue to look for ways to reach new refuges that are interested in collecting phenology data to meet management and outreach needs. In 2023, we plan to write multiple articles for *Fish and Wildlife News* or similar outlets that will highlight what refuges that have five or more years of data collection have learned to support their management actions.

### Objective 5: Provide training to Refuge staff on how to participate in Nectar Connectors (www.usanpn.org/nn/NectarConnectors) - a platform for monitoring leafing of milkweed and flowering of nectar plants in areas planted to support monarchs

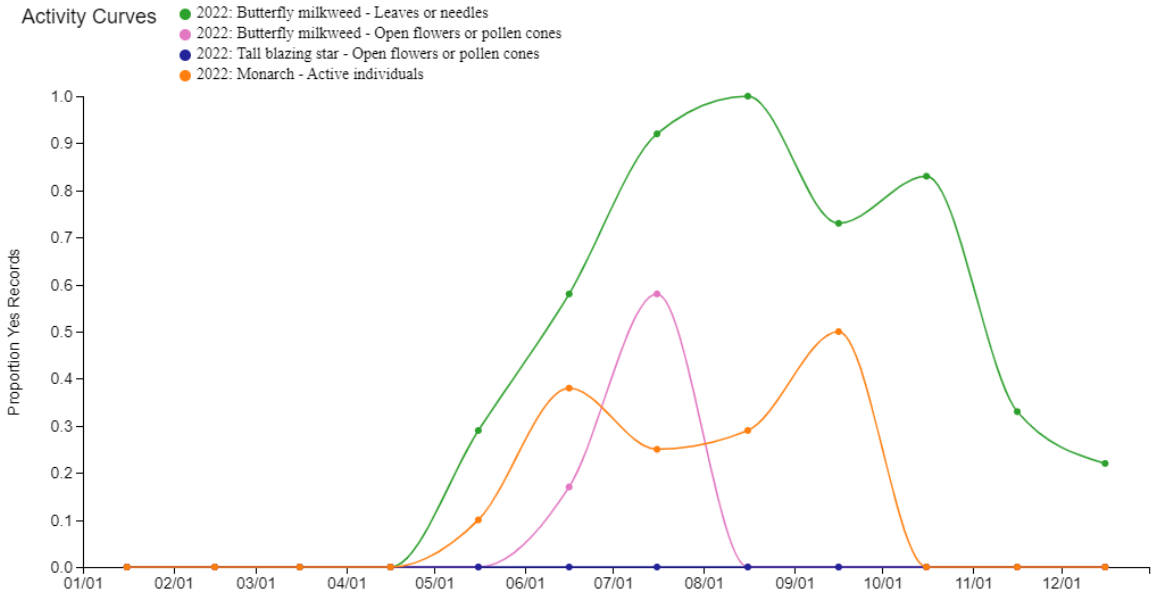
Nectar Connectors is one of eleven data collection campaigns run by the USA-NPN to engage observers in monitoring species of special interest to researchers and natural resource managers. Campaign participants are given instructions on how to participate, identification resources for species and life cycle stages of interest, reminders and encouragement to observe throughout the season, and results of their data collection at the end of each year.

We started the Nectar Connectors campaign in 2017 to assist the USFWS and other natural resource managers concerned about monarchs and other pollinators in better understanding the temporal distribution of nectar resources across the United States. This campaign will provide an accurate picture of where and when nectar resources are located, and how this corresponds to the migration and breeding needs of monarchs and other pollinators. These data will help the USFWS evaluate habitat quality and landscape-scale connectivity in space and time.

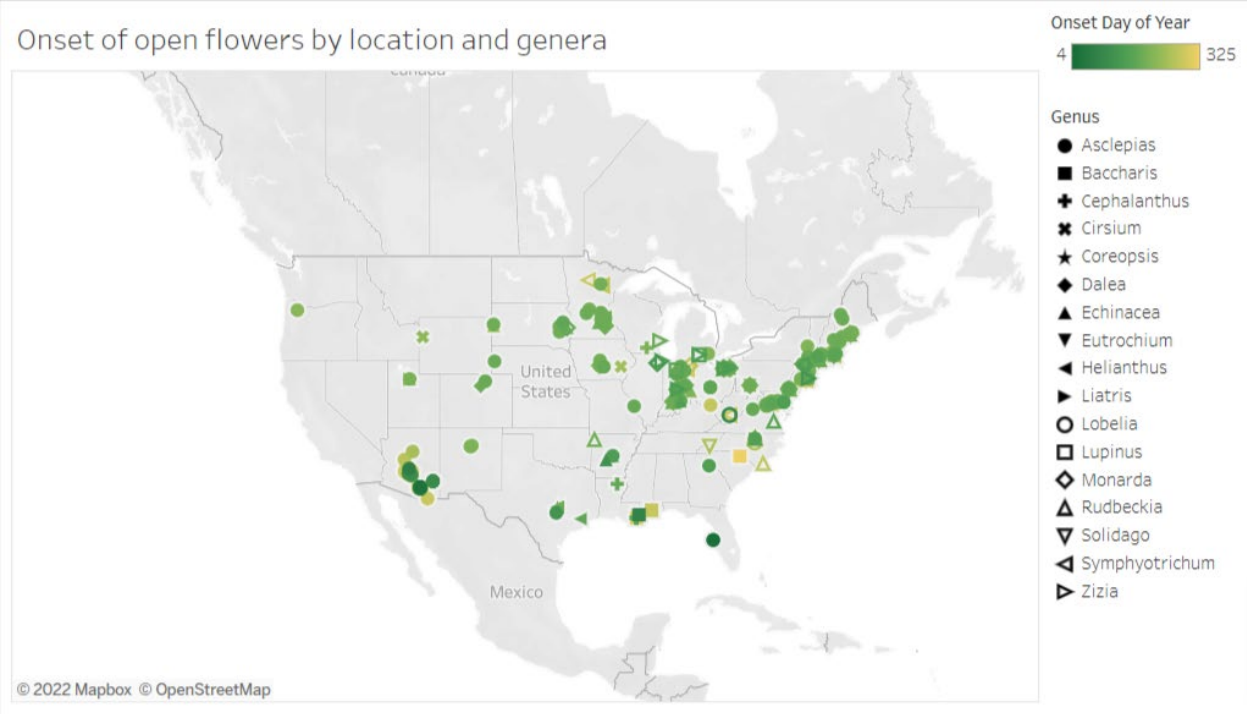
We continue to support refuges that are collecting data as part of this campaign. In 2022, 375 observers representing members of 54 organizations including six refuges reported on Nectar Connectors species.

- In Region 3, Neal Smith NWR in Iowa recorded 1,581 records on three individuals of butterfly milkweed (*Asclepias tuberosa*) and two individuals of tall blazing star (*Liatris aspera*).
- In Region 4 in Mississippi, Mississippi Sandhill Crane NWR recorded 722 records on three individuals of eastern baccharis and one individual of tall blazing star, Bayou Sauvage NWR recorded 745 records on two individuals of eastern baccharis, and Grand Bay NWR/NERR recorded 11 records on one individual of eastern baccharis.

Neal Smith NWR was in the top 10 organizations in *Nature's Notebook* submitting data for the campaign for the third year in a row. The activity curve below shows 2022 reports from Neal Smith NWR of monarch butterflies, milkweed leafing and flowering, and flowering of another nectar plant.




As seen on the map below, reports of first flowers in the Southeast were documented in both the spring and fall, supporting monarchs during their migration through that area. In the Midwest and Northeast, observers reported onset of flowering throughout the spring, summer, and fall. In the West, reports were throughout the year with both early and late-blooming plants.



More results are available for exploration on our Nectar Connectors Campaign Results dashboard.

In 2022, we launched a new synergistic project that supports monarch conservation, *Desert Refuge: Monarchs and Milkweeds in Arizona* (usanpn.org/nn/DesertRefuge). This project is a collaboration with Desert Botanical Garden in Phoenix, Arizona and is funded by Monarch Joint Venture and US Forest Service International Programs. The aim of the project is to better understand the overwintering phenology of monarchs and milkweeds in the state of Arizona, where monarchs are known to overwinter in both the wintering grounds of the eastern and western monarch populations as well as remain residents in the state year-round. This project will provide additional information to the USFWS on overwintering activity of Arizona monarchs and contribute to our understanding of how monarchs may respond to climate change more broadly.

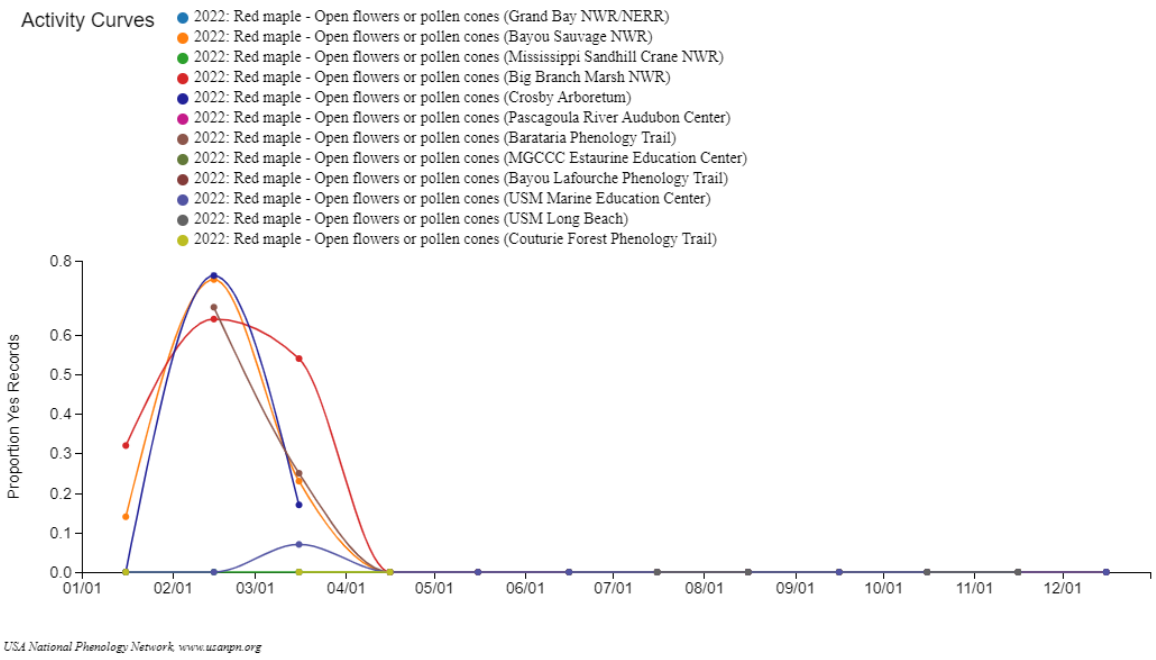
*Plan for extension period*: We will continue to engage participants in Nectar Connectors to add another year to this valuable long-term dataset. The *Time to Restore* and *Desert Refuge* projects provide in depth monitoring guidelines for collecting phenology data on monarchs and their food and habitat resources as well as new ways to connect with USFWS staff in the region. We can use these projects to invite new refuges to participate in the Nectar Connectors campaign.

**Objectives 6 and 7: Create interactive Phenology Trail Dashboards, including dynamically updating visualizations to allow Refuges to compare phenology between Refuges and non-Refuge sites and ensure the Dashboards are hosted on the USFWS Phenology Network website and will build upon the current Refuge Dashboards for individual refuges.**

We completed these objectives in year two of our funding in 2020. The full list of refuge dashboards and our two Phenology Trail dashboards are accessible on the USFWS Phenology Network website (https://fws.usanpn.org/phenology-refuges). In 2021, we continued to assist our partner refuges in creating and using their refuge dashboards to understand patterns in the data and share their findings with staff, volunteers, and visitors.

In 2021, we were awarded a USGS Shoemaker Award in the website category for the USFWS Phenology Network website, specifically the addition of the Phenology Trail Dashboards. This award signifies the and helps to gain publicity for the USFWS Phenology Network website among other DOI agencies.

The graph below shows on the timing of open flowers in red maple collected at four refuges on the Gulf Coast Phenology Trail as well as at eight other partner locations on the Trail spread across the Gulf Coast. The Trail Dashboards provide a landscape-level look at seasonal activity of focal species and allow refuges to evaluate how the timing of key life cycle events compares to other refuges as well as locations off-refuge. The Dashboards allow refuges to understand whether they are meeting their mission of providing needed resources for species of interest.




*Plan for extension period*: We will continue use the examples of these first two Phenology Trails to encourage additional refuges to create collaborations with partners to investigate changes in phenology at a landscape scale.

### Objective 8: Generate periodic communications materials.

Info sheets:
In 2022, we began a project to produce eight info sheets, one for each of the USFWS regions, to summarize phenological changes in species that are of priority to USFWS. We are employing an undergraduate intern at the University of Arizona who has begun compiling a list of priority species, exploring the scientific literature for research that documents changes occurring in phenology of these species, and summarizing the climate projections for the region including changes to temperature, precipitation, and extreme events. In 2023, we will synthesize this research as well as include examples of existing phenology datasets in the USA-NPN's National Phenology Database as well as relevant USA-NPN data products, projects, and partnerships for the region. These info sheets will serve to provide guidance about how phenology is shifting in each region and how USA-NPN's data and data products can help refuges in understanding these changes.

Newsletters:
We sent out a quarterly USFWS Newsletter to 133 contacts, including 63 fws.gov emails. We used the newsletter to communicate achievements of refuges collecting phenology data, new tools and resources relevant for refuge staff, and upcoming training opportunities in how to use *Nature's Notebook* for phenology monitoring. USFWS Phenology Network Newsletter archive.

We also sent regular messages for the three *Nature's Notebook* campaigns we created at the request of USFWS – Nectar Connectors, Flowers for Bats, and Mayfly Watch. Participants, including over 25 USFWS staff, received regular instructions on how to participate, tips on species and life cycle stage identification, encouragement to observe, and patterns in the data collected.

Reports:
As a requirement to renew our data collection permit with Pima County, AZ for one of our Flowers for Bats data collection sites, we created a report summarizing our 2021 data collection.

Each year since 2017, I have assisted the Gulf Coast Phenology Trail in preparing an annual report to describe their progress toward Trail objectives laid out by refuge staff and their partners. We completed the 2021 Annual Report in 2022.

*Plan for extension period*: We will complete the eight regional info sheets focused on shifts in phenology of priority species. We will continue to add to our list of contacts for the Quarterly Newsletter by advertising it via various webinars and trainings at NCTC and in other channels. This spring, we will seek out opportunities to share the Status of Spring Tool via USFWS social media, articles in newsletters and other publications such as *Fish & Wildlife News*.

### Objective 9: Assist stations in employing the Spring Index and other tools developed for the Service to calculate the historical range of variability and trends in the onset of spring for each refuge unit.

In previous years, we have supported refuge staff in using the Status of Spring tool on the USFWS Phenology Network website (https://fws.usanpn.org/status-spring) to understand changes in the onset of spring biological activity. The Status of Spring Tool provides both a historical look at how the start of spring leaf and spring bloom in early season plants has changed over the last century as well as predictions of when spring activity will begin in the present year. Once spring leaf out and bloom has arrived, refuge staff can see how the current year compares to a 30-year average to determine if spring activity was earlier or later than recent decades.

We have found that refuge staff still have difficulty applying the Spring Indices to local species and management actions. In 2021, we began looking into local species that refuges manage to determine the temporal link between the Spring Indices and species of concern. We will continue this work in 2023. We also are collaborating with a post-doctoral researcher at the University of Wisconsin-Milwaukee who is developing models of spring phenology for a suite of native species through a project funded by the National Science Foundation. We believe these models will be of great interest to refuge partners to help them understand how phenology of local species is shifting.

*Plan for extension period*: We will continue to explore applications of predictive models of phenology, particularly models of spring phenology for native species.

### Objective 10: Convene focus groups to determine how Refuges can incorporate phenology monitoring with *Nature's Notebook* into existing monitoring activities. Educate Refuge staff on example uses of phenology data collected through *Nature's Notebook*.

One of the key goals of our partnership with USFWS is to aid refuges in collecting phenology data to understand patterns in the phenology of plants, animals, and landscapes, especially in response to climate change. To support refuges in this goal, we have long focused on giving refuge staff the resources they need to monitor phenology on their refuges. However, the long-term reduced capacity of refuge staff and resources has prevented many refuges from starting or maintaining phenology monitoring programs.

In 2022, multiple USA-NPN staff met with USFWS staff from the Northeast Region who expressed interest in the data and data products produced by the USA-NPN. We are planning a half-day workshop with interested USFWS staff from the Northeast region in winter of 2023. In this workshop, we will describe how phenological information has been used to inform management, from tactical decision-making to contextual information for scenario planning. We will highlight the USA-NPN's data collection and visualization resources, including the *Nature's Notebook* phenology observation program. We look forward to hearing from the audience on the phenological changes that you are seeing, and where we should focus our efforts to better support refuges in the northeast region. This input will inform the development of USA-NPN's future tools and products.

We have begun the process of identifying other phenology data and information that we can offer to refuges to meet their management goals without the need to dedicate their own staff time and resources to collecting refuge-level phenology data. In 2023, we continued to make progress in these areas:

*Summaries of data collected in areas near refuges*: One of the benefits of *Nature's Notebook* is the thousands of annual active observers documenting phenology of plants and animals across the country. By summarizing data from sites nearby refuges on species of concern, refuges can benefit from a better understanding of phenology patterns at the landscape scale. In 2023, we will summarize flowering phenology data collected on nectar plants important for monarch butterflies and other pollinators in the Midwest, Southwest, and Southeast Regions. We will also summarize data from the seven years of data collection at Sevilleta NWR in New Mexico. These summaries will be turned into short articles and submitted to *Fish and Wildlife News* as well as other outlets to demonstrate how refuges can understand phenology patterns occurring on their refuge and in surrounding areas.

*Long-term projections of spring leaf and bloom onset*: The products that we currently produce related to the start of spring leaf and bloom in early season plants provide historical context about how the start of spring has changed over time, as well as provide a 6-day prediction of the current year's spring and how the current year compares to long-term averages. We continue to seek funding to support the development of long-term projections of our Spring Indices. This would entail using climate models to project how the onset of spring will change at locations

across the country in the coming decades. This information will be critical for climate adaptation planning, helping refuge staff to translate climate projections into real biological impacts on the timing of spring seasonal activity.

*Forecasts of activity of species of concern to USFWS*: The USA-NPN offers 13 Pheno Forecasts which predict the activity of problematic insect and invasive plant species. We continue to solicit input from USFWS staff and other natural resource managers to determine other forecasts that would aid USFWS in their management activities related to insect pests and invasive plants. In 2023 we will collaborate with researchers at USGS and Oregon State University to produce forecasts of cheatgrass and red brome, two problematic grasses for public lands in much of the western United States, as well as new forecasts for emerald ash borer and spotted lanternfly, two insect pests that are expanding their range across the US.

*Plan for extension period*: We will host a workshop with interested USFWS staff from the Northeast region to hear about their needs for phenology data and products. We will continue to explore how we can deliver phenology data and information to the USFWS that does not require data collection on individual refuges.

## Future Directions

Since 2014, USFWS and the USA-NPN have collaborated to collect and use phenology information to support management. We have worked with 24 individual refuges to implement long-term standardized phenology monitoring to meet their management goals; created two Phenology Trails to provide a landscape context to phenological change on and off refuges; conducted three regional and national data collection campaigns to support USFWS species of concern including monarchs and bats; and developed tools that leverage phenology forecasts, including Status of Spring maps that display the timing of early spring activity on refuges and how the current year compares to a long term average, and predictions of insect pest and invasive plant species activity to inform treatment timing.

A continued partnership between USFWS and the USA-NPN could expand these efforts and further support management activities in multiple ways, including assisting the USFWS to increase efficiencies in monitoring by leveraging the USA-NPN's flexible, public friendly phenology protocols and providing phenology data to inform decision making in a Resist, Accept, Direct framework. First, we will continue to offer our expertise on phenology monitoring protocols to assist I&M in enabling data collection that can be conducted by staff and volunteers and visitors across the NWRS. The USA-NPN protocols can be incorporated into apps such as those utilized by USFWS and imported into the USA-NPN's phenology database at regular intervals. For example, USA-NPN partner Adventure Scientists is currently using USA-NPN phenology observation protocols to track white oak in a custom ArcGIS Survey123 app; the data will be imported annually into the USA-NPN database. In a similar fashion, the National Ecological Observatory Network (NEON) collects plant phenology observations USA-NPN protocols and these data are imported to the USA-NPN database on a bi-weekly basis. Through a continued partnership with USFWS, we envision piloting new engagement strategies to increase

visitor participation at refuges and relieve the burden of USFWS staff conducting surveys. We are also developing data analysis guidance tools to empower those with limited expertise to analyze and interpret data that they collect, which could complement the efforts of NWRS volunteers.

We also see untapped potential to work with USFWS staff to develop relevant tools and interpretive materials using USA-NPN data and data products that will inform decision-making in a Resist, Accept, Direct framework. Opportunities include:

- Understanding changes in vegetation green-up and whether green-up is temporally synced with bird resource needs as bird ranges shift in time and space. We have a large amount of data on dominant overstory trees such as maples, oaks, and poplars, which provide critical habitat for insect-eating neotropical migrant birds. These data can support efforts to determine areas where new land should be acquired to meet birds' changing resource needs.
- Long-term (decadal) projections of timing of leaf out, flowering, and seed ripening of native species to better anticipate future habitat and food resource needs, or whether alternative species should be considered for planting in areas of concern and for restoration efforts.
- Measures of phenotypic plasticity for species of concern to inform vulnerability assessments. USA-NPN phenology data can support efforts to understand variability in leaf out, flowering, and fruiting timing; these can be combined with climate projections to understand frost tolerance, drought tolerance, and other measures of risk.
- Validating remote sensing data with on-the-ground observations of plants.

A new agreement would offer opportunities for extended and expanded collaborations, including providing FWS with an efficient, flexible tool for monitoring seasonal changes across the NWRS and critical information that will inform strategies to respond to climate change.