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 2 Annual Report, January 2021
Cooperative Agreement Award F19AC00168
Project Period: February 20, 2020 – February 19, 2021
Budget: $ 187,269.00

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January 11, 2021

In the second year of our four-year funding agreement for 2019-2023, we expanded tools to enable refuges to visualize phenology on a landscape scale, engaged new refuge partners, and 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.

Below, we describe our progress toward meeting our second year objectives, as well as additional accomplishments related to our four-year objectives and our partnership as a whole.

Activities in support of second year objectives:

Objective 1: Integrate existing phenological datasets from Refuges into the National Phenology Database. Work with individual Refuges to help them adjust their current data collection method to utilize the USA-NPN's phenology protocols for future monitoring.

Our long-term goal 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 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 our second year, we continued to work with Patuxent Research Refuge in Maryland (Region 5), the first refuge to request that we import their existing historical phenology data into our National Phenology

Database. Patuxent became familiar with the USA-NPN's phenology protocols when their Volunteer Coordinator and a volunteer attended a workshop that I led at the National Conservation Training Center in the fall of 2017. They were impressed with the rigor of the USA-NPN's data collection protocols, our visualization capabilities, and the access they would have to other data collected on their species of interest throughout the region. At the time, Patuxent was using Project Budburst (budburst.org) to collect first events of four focal plant species. They wished to transition their monitoring to use the USA-NPN's *Nature's Notebook* program, as well as integrate the data they collected from 2012-2019 with Project Budburst into the USA-NPN's National Phenology Database. Since the two systems utilize different phenology monitoring protocols, USA-NPN staff worked to align these datasets and import the data into our database. The data are now available for Visualization via Patuxent's Refuge Phenology Dashboard as well as other USA-NPN data visualization and download tools.

Plan for Third Year of Funding: 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. We will continue to advertise data integration as an option available to refuges across the country.

Objective 2: Inform/advise interested refuges on implementing phenological monitoring

In 2020, 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:

- USA-NPN staff were invited to facilitate multiple phenology presentations as part of a mini-webinar series entitled *Phenology: Indigenous and Western Approaches for Understanding Shifting Seasons* within the National Conservation Training Center's Conservation Science Webinar Series. Topics included Animal Migration, Climate Adaptation, and Invasive Species and speakers included USA-NPN staff as well as those representing Indigenous communities. The series was attended by hundreds of participants, including many USFWS staff. Participants gave feedback on their needs related to these topics, including the invasive species for which phenology forecasts would be most useful. These responses are summarized in the Mentimeter word cloud below.

What invasive species would you like to see forecasts for?

- For the second year, I was invited to present in NCTC's Citizen Science Course in July 2020. I presented a session on *Stakeholders, Audiences, & Building Your Team* as well as a session on *Nature's Notebook* as an example of a citizen science program that refuges can use to meet management and outreach objectives. Nine USFWS staff participated in the course.

- I was also invited to present a virtual training to Visitor Services staff at NCTC in May 2020 entitled *Engaging Volunteers and Visitors in Tracking Environmental Change Using Phenology*. The presentation included examples of how three different refuges are using *Nature's Notebook* in different ways to meet management and outreach objectives. Participants included 20 USFWS Visitor Services staff.

- In April 2020, I presented a webinar hosted by the Association of Fish and Wildlife Agencies for 80 fish and wildlife managers focused on how phenology can inform management. This webinar provided important feedback on how managers envision using phenology for management activities including knowing when to conduct treatment activities for invasive species and for vegetation beneficial to wildlife, knowing bloom times of flowering species used in restoration planting, knowing timing of generations for insects, knowing risks of false spring/late freeze events, and informing best times for prescribed burns.

- In September 2020, I presented at the Wildlife Society Annual Conference Phenology as a tool for understanding habitat change. I shared the link to the recording in the FWS Quarterly Newsletter.

- In September 2020, USA-NPN staff facilitated a 90 minute workshop at the Association of Fish and Wildlife Agencies Annual Meeting. This workshop, presented to 40 participants, focused on sharing information about phenology tools and data made available by the USA-NPN, and hearing from wildlife managers about their other phenology data and information needs. We learned a lot about manager needs for phenology data related to migratory birds, prescribed fire, invasive

grass management, timing for grazing permits, monarch and nectar plant mismatch, spawning timing of fish, planting timing for restoration activities, and forecasting species habitat range changes.

- USA-NPN Education Coordinator LoriAnne Barnett facilitated a [Local Phenology Leader Certification Course](#) three times in 2020 that was designed to help establish a *Nature's Notebook* phenology monitoring program. The course walks participants through program planning activities to ensure sustainable, long-term programs. The 10-week online course is offered in the spring and fall; an additional 3-week summer short course is also offered for those who do not have time for the full Certification Course. We promoted the Certification Course and summer short course in each of our USFWS Quarterly Newsletters in 2020, and also shared information about the program in a training given at NCTC in May of 2020 as well in the Citizen Science Course at NCTC in July of 2020.

We had contact with 2 new refuges interested in beginning phenology monitoring programs in 2020:
1. Silvio O Conte NFWR, Region 5 – Their Wildlife Biologist is planning to launch a phenology trail along the Connecticut River using refuge lands. Her goals are to better understand how climate change is impacting species and their habitat on refuge lands and educate local communities about climate change.

2. White Horse Hill National Game Preserve, Region 6 – This will be the first refuge to use *Nature's Notebook* in Region 6. A member of the Refuge Friends group is collaborating with a Refuge staff member to start an environment education effort to allow 5th grade students to adopt a tree on the refuge and record phenology data in *Nature's Notebook*. They will record how phenology changes from year to year for focal tree species.

We also maintained contact with the staff from four refuges we advised on creating programs in 2019:
1. Buenos Aires NWR, Region 2 – The Wildlife Biologist at this refuge began monitoring agave flowering to support the [Flowers for Bats campaign in 2019](#). Unfortunately this staff person left her position and the monitoring is not expected to continue in 2021. I am working with current staff to determine whether another staff person or intern can take over the monitoring.

2. Northern New Mexico NWR Complex, Region 2 – Their Visitor Services Manager participated in the Local Phenology Leader Certification Course in the spring of 2019. She is developing a plan for monitoring grasses at the refuges that engages refuge staff, visitors, and members of their Friends group. Rio Grande Phenology Trail Coordinator, Liz Gallagher, an employee of Valle de Oro NWR partner Bosque Ecosystem Monitoring Program, is helping her implement her program.

3. Yukon Flats NWR, Region 7 – In 2019, I was contacted by a Wildlife Biologist at Yukon Flats NWR who is interested in engaging the 1,200 community members who live in villages near the Refuge to collect phenology data on the Refuge. The COVID-19 pandemic has slowed down their planning, but they are hoping to collect pilot data in 2021.

4. Bon Secour NWR, Region 4 – The Gulf Coast Phenology Trail Coordinator, Gail Bishop, a part time contractor for the USA-NPN, has begun talks with the Refuge Biologist at Bon Secour NWR in Alabama about joining the Gulf Coast Phenology Trail. We will continue to support their efforts to determine if any of the Trail focal species are relevant to their management priorities or if they have other species of interest that we can incorporate into the Trail.

And I also assisted our existing Refuge partners to finalize their Refuge Phenology Data Dashboards on our fws.usanpn.org site, so that all 24 Dashboards are completed. The [Rachel Carson NWR Dashboard](#) in particular includes almost 10 years of phenology data collected at the Refuge.

Plan for Third Year of Funding: We will continue to assist these new refuges to implement phenology monitoring and create their Phenology Dashboards on the USFWS Phenology Network web portal. We also began the process of creating multiple short analyses with accompanying write-ups to demonstrate the usefulness of data collected on refuges as well as data collected in areas surrounding refuges.

Objective 3: 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 nine 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 this campaign in 2017 to assist the USFWS and other natural resource managers concerned about monarchs and other pollinators to better understand 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.

In 2020, 255 observers representing members of 45 organizations including eight refuges reported on Nectar Connectors species, up from five refuges participating last year. In Region 3, Minnesota Valley NWR in Minnesota recorded 1,333 records on 3 individuals of common milkweed and 3 individuals of wild bergamot and Neal Smith NWR in Iowa recorded 1,106 records on 3 individuals of butterfly milkweed and 2 individuals of tall blazing star. In Region 5, Canaan Valley NWR in West Virginia recorded 49 records on 1 individual of common milkweed, Patuxent Research Refuge in Maryland reported 70 records on 1 individual of black-eyed Susan, 1 individual of common milkweed, and 1 individual of New England aster, and Rachel Carson NWR in Maine recorded 21 observations on 3 individuals of seaside goldenrod. In Region 4 in Mississippi, Bayou Sauvage NWR recorded 968 records on 3 individuals of eastern baccharis, Mississippi Sandhill Crane NWR recorded 510 records on 3 individual of eastern baccharis and Grand Bay

NWR/NERR recorded 55 records on 1 individual of eastern baccharis. Minnesota Valley NWR, Neal Smith NWR, and Bayou Sauvage NWR were among the top 10 groups submitting data for the campaign.

Generally, reports of first flowers in the Southeast were documented throughout the year, supporting monarchs migrating through the region in the spring and fall. 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 a higher number of plants with flowers in the fall.

Number of plants with open flowers by region
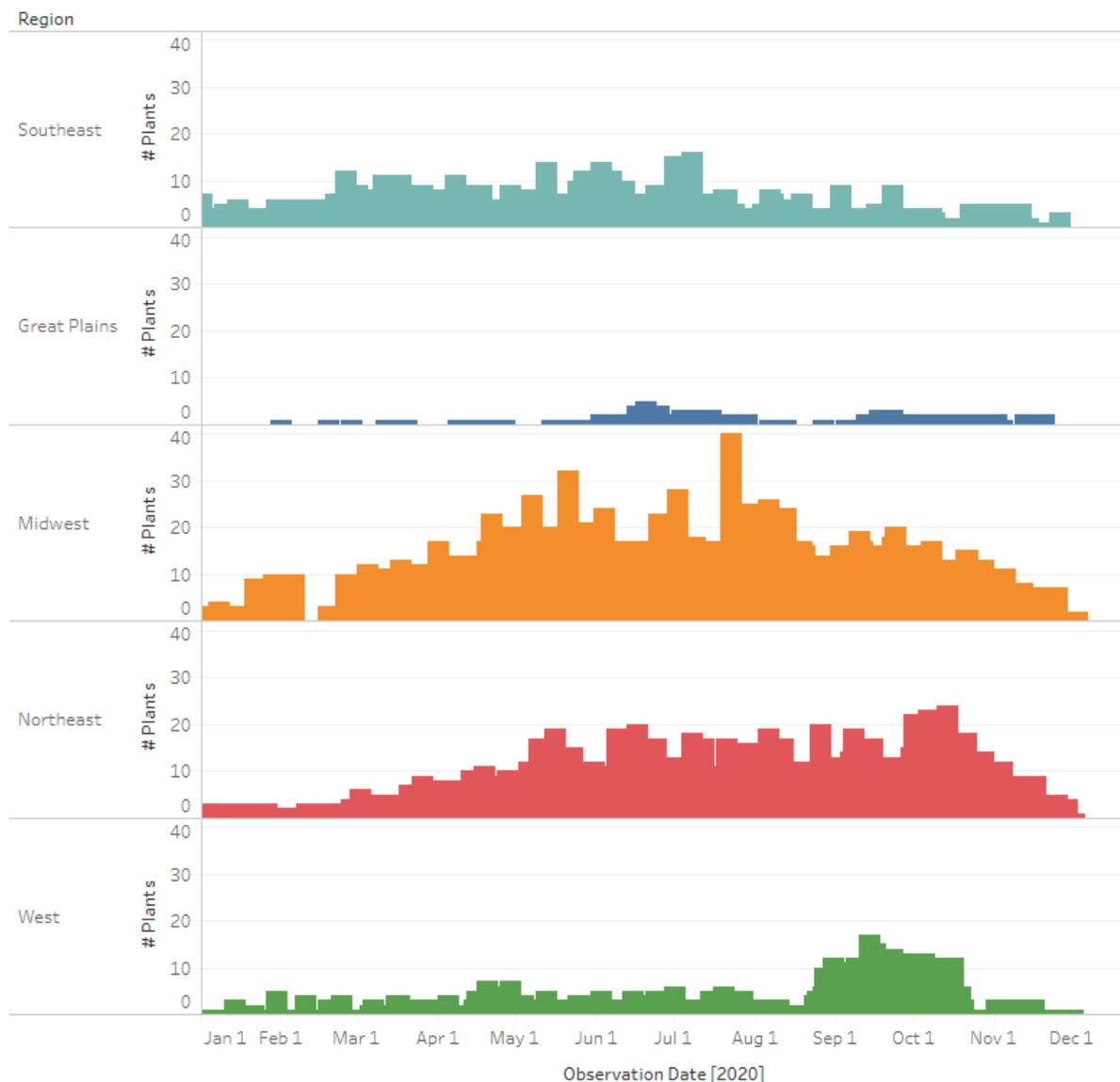
More results are available for exploration on our Nectar Connectors Campaign Results dashboard.

Plan for Third Year of Funding: Due to the COVID-19 pandemic in 2020, refuge capacity was limited and we were unable to work with refuges to determine best practices for monitoring nectar plants. In 2021,

we will create an example site-monitoring protocol to provide instructions on site set-up and sampling design for other refuges who wish to use Nectar Connectors to track changes in flowering phenology of nectar plants.

Objective 4: Create interactive Phenology Trail Dashboards, including dynamically updating visualizations to allow Refuges to compare phenology between Refuges and non-Refuge sites. These Dashboards will be hosted on the USFWS Phenology Network website and will build upon the current Refuge Dashboards for individual refuges.

In early 2020, we finalized the Phenology Trail Dashboards, which are customized, dynamically updating sets of visualizations that display the phenology data collected by groups of refuges and the partners they are working with toward a shared goal of better understanding phenology. Currently we have two groups of refuges that are collaborating with nearby organizations in Phenology Trails, the Gulf Coast Phenology Trail and the Rio Grande Phenology Trail. These Trails allow refuges to leverage the data collected by partners in nearby areas to assess patterns in phenology of shared species of interest.

The graph below shows a comparison of data on flowering of red maple collected at two refuges on the Gulf Coast Phenology Trail as well as at four other partner locations on the Trail spread across the Gulf Coast.
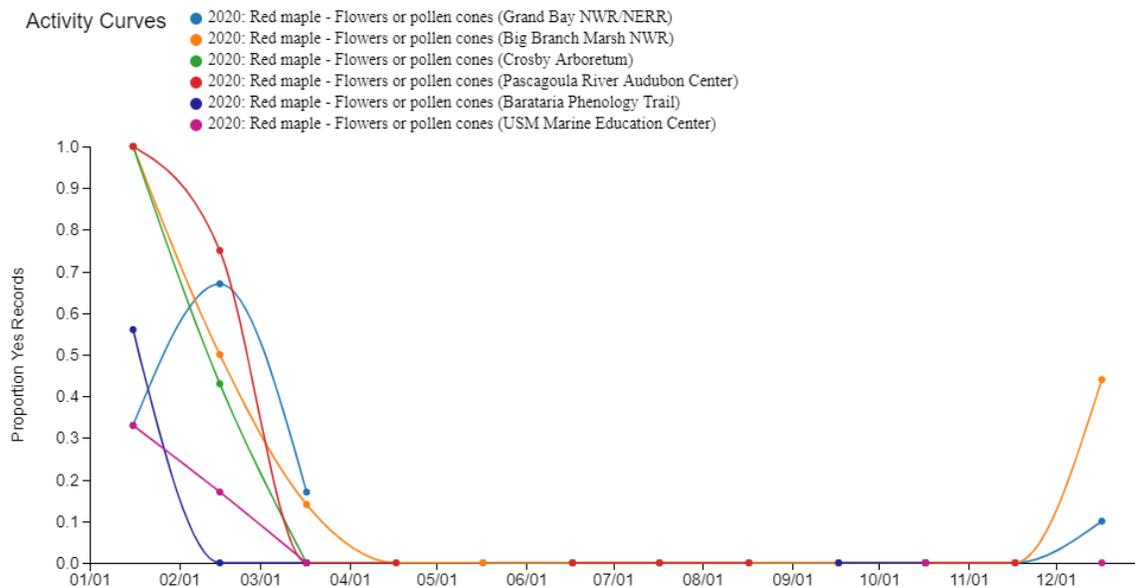
USA National Phenology Network, www.usanpn.org

In addition to the Phenology Trail Dashboards, we made improvements to the Refuge Phenology Dashboards, which are customized Dashboards that we make available for each refuge that contributes phenology data to *Nature's Notebook* (see Valle de Oro NWR example). These improvements included the ability to compare phenology data collected on the refuge to data collected at nearby *Nature's Notebook*

locations within a buffer of set distances including 10, 25, and 50 miles. These comparisons allow the refuge to determine if the refuge is fulfilling its management goals as a sanctuary for species of concern.

In early 2020, we also solicited feedback from Jana Newman on the completed Trail and Refuge Dashboards and made improvements based on her suggestions. These included (1) adding the option of "current year" to all visualizations to remove the need for refuge staff to manually update their dashboards at the start of each year with the most current data, (2) the ability for visitors viewing the dashboards to have more control over the settings on the visualizations, including toggling the negative data on and off the phenology calendars and controlling the opacity of the base layer maps on our spring leaf onset and accumulated growing degree day maps, and (3) other improvements to make the dashboards easier to navigate such as adding titles to the visualization icons so that a user can learn more about each visualization before making a selection.

Feedback on the Trail Dashboard and Refuge Dashboards has been overwhelmingly positive. Following the launch of the USFWS Phenology Network website, I offered tutorials for refuge staff to assist them in setting up Refuge and Phenology Trail Dashboards. During these tutorials the USFWS staff shared overwhelmingly positive feedback; many remarked on the ease of use and great variety of visualizations available. USFWS staff stated that they could use the Dashboards to quickly see patterns in their phenological data and make decisions such as when to begin construction activities so as not to disturb bird nesting, or know when to flood fields to encourage seed germination of focal tree species. Other staff said that they anticipated downloading and sharing their graphs with volunteers to maintain enthusiasm for data collection, as well as point out potential errors in data collection and instruct their observers on how to fix them.

Plan for Third Year of Funding: We will 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 5: Generate periodic communications materials.

Newsletters:
We sent out a quarterly USFWS Newsletter to 147 contacts, including 74 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 20 USFWS staff, received instructions on how to participate, tips on species and life cycle stage identification, encouragement to observe, and patterns in the data collected.

The Rio Grande Phenology Trail, which includes 2 refuges, sent out their quarterly Cottonwood Correspondence eNewsletter to keep Trail participants informed about training opportunities, resources, and results of data collection.

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 2019 data collection.

Each year since 2017, the Gulf Coast Phenology Trail completes an annual report to describe their progress toward Trail objectives laid out by refuge staff and their partners. They completed the 2019 Annual Report in 2020.

In 2020 I worked with USA-NPN and USGS colleagues to create a USGS Fact Sheet entitled *Nature's Notebook—A Tool for Recording the Timing of Seasonal Activity of Plants and Animals*. The Fact Sheet describes how *Nature's Notebook* can be used as a customizable monitoring platform to meet natural resource management goals, and cites Valle de Oro NWR's phenology monitoring as a case study.

Research publications:
In 2019, to share how phenology monitoring was used for invasive species management on Midway Atoll NWR, I collaborated on a research manuscript with colleagues who collected data at Midway, including one refuge staff member, one former staff member of the National Wildlife Refuge Association, and a former Americorps member who worked as the technician on the project. This manuscript describes the efforts at Midway to use phenology monitoring to improve the timing of treatment of *Verbesina encelioides*, an invasive plant that hinders seabird nesting areas. The manuscript was published in *Ecological Solutions and Evidence* in 2020.

Several colleagues at the USA-NPN as well as two colleagues at the Northeast Climate Adaptation Science Center are collaborating on a manuscript to describe our efforts around coproduction – a process where creators and users of information collaborate in its generation. The manuscript includes several case studies of knowledge coproduction including our analysis of the change in the timing of spring onset across National Wildlife Refuges and migratory flyways that we published in Plos One in 2018. We submitted the manuscript to Conservation Science and Practice in 2020 and were asked to revise and resubmit the article, which we are currently doing.

Social media:
I worked with the US Geological Survey Communications Team to develop a series of social media posts sent out through their official social media accounts during the week of March 16-20, 2020. The posts highlighted the work of refuges that are participating in phenology monitoring, including the three refuges involved in the Gulf Coast Phenology Trail as well as Minnesota Valley NWR.

Popular articles and media:

To generate more interest in the USFWS-focused data collection campaign, [Flowers for Bats](), I took part in a radio program, [Arizona Spotlight](), on Arizona Public Media in April of 2020.

Awards:
To gain publicity for the USFWS Phenology Network web portal among DOI agencies, we submitted the website for a USGS Shoemaker Award in the website category in 2019. We were not successful in our submission, so we resubmitted the website, with the addition of the Phenology Trail Dashboards, for an award again in 2020. We should hear the results of our application in 2021.

Other Communications:
In spring of 2020, I assisted Susan Morse at USFWS Communications with materials on animal migration for a booth and presentation for National Science Teachers Association STEM conference and some online phenology resources for NWRS Learn page.

Plan for Third Year of Funding: 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 6: Convene focus groups to determine how refuges can utilize phenology data and information to achieve management goals.

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. In order 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, sustained reduced capacity of refuge staff and resources has prevented many refuges from starting or maintaining phenology monitoring programs.

In 2020, we began the process of determining 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. We established several avenues to explore:

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 2020, we started to summarize flowering phenology data on nectar plants important for monarch butterflies and other pollinators in the Midwest, Southwest, and Southeast Regions. These summaries will be turned into short articles and submitted to *Fish and Wildlife News* as well as other outlets.

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've applied for funding through the National Geographic and Microsoft AI for Earth Program 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. With the assistance of Jana Newman at I&M and Jason Goldberg at Science Applications, we identified a Landscape Ecologist with the NWRS to be part of our End User Group to give feedback on the product if the grant is awarded.

Forecasts of activity of species of concern to USFWS: The USA-NPN makes available 13 Pheno Forecasts which use established models to predict the activity of problematic insect and invasive plant species. We have started discussions with 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.

Plan for Third Year of Funding: We will continue to make progress in these three identified areas, as well as seek out other areas where we can deliver needed phenology data and information to USFWS.

Additional Progress toward four-year objectives:

We continued to support existing regional projects focusing on three USFWS priority areas.
1. Middle Rio Grande Bosque forest – Observers on the Rio Grande Phenology Trail collected over 39,000 phenology records on 39 species in 2020. In order to communicate the origin and goals of the Trail, one volunteer participant worked with the RGPT to create a video about the Trail. The video is posted on the [RGPT webpage](#).

2. Mississippi River corridor for mayflies – We continued the [Mayfly Watch](#) campaign for a fifth year in 2020. 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. There is no longer a staff person at the USFWS who is interested in using the data collected by this campaign. We continue to reach out to representatives from the USFWS and Army Corps of Engineers to determine if they have a use for the data we are collecting. We have also been in contact with a group of researchers based out of Oklahoma State University who are researching the use of radar to detect large swarms of mayflies who may have use for these data.

3. Monarch Butterfly central flyway – In 2020, eight refuges submitted 4,112 records on flowering of nectar plants important to monarchs. On the Gulf Coast Phenology Trail, four refuges continued to participate in phenology monitoring in 2020. The Trail created an [Annual Report](#) to summarize the data collected through the end of 2019. Among the 57 species observed on the Trail is eastern baccharis, a

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. Other refuges in the monarch central flyway contributing to recording nectar plant flowering included Neal Smith NWR in Iowa, Minnesota Valley NWR in Minnesota, and Canaan Valley NWR in West Virginia.

Future Directions

In the coming year, we look forward to continuing our partnership by building on our second year activities as outlined above – supporting refuges with existing phenology data to move their data into our National Phenology Database, explore new ways to communicate our existing phenology data and tools such as the Status of Spring on the NWRS, demonstrate the usefulness of phenology data by creating summaries of phenology data at locations near refuges, and create a site-level monitoring protocol for nectar plant phenology.

We will also continue to support the USFWS in their work to expand the use of citizen science in the Agency, utilize decision-making tools such as Structured Decision Making, and explore how phenology can inform climate adaptation planning activities.