

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 3 Annual Report, December 2021

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Project Period: February 20, 2021 – February 19, 2022

Budget: \$159,169

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Summary:

In the third 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
- Shared examples of how refuges are using phenology data to inform management, including an article in *Fish and Wildlife News* describing phenology monitoring efforts at Neal Smith National Wildlife Refuge.
- Expanded efforts to document the timing of flowering of nectar plants that are important for pollinators, including supporting six National Wildlife Refuges in tracking nectar plant flowering timing and new synergistic efforts with our South Central Climate Adaptation Science Center-funded project, *Time to Restore: Connecting People, Plants, and Pollinators*.
- 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 believe there is great potential for a continued long-term partnership with USFWS 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.

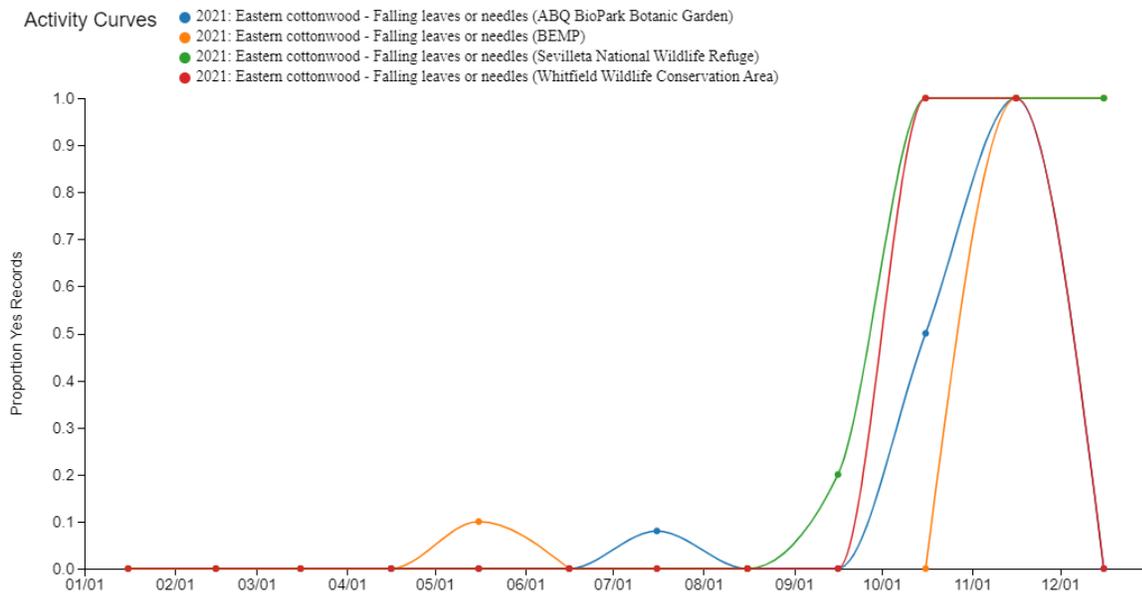
Below, we describe our progress toward meeting our third-year objectives as well as our partnership as a whole.

Activities in support of third-year objectives:

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 2021, observers on the Rio Grande Phenology Trail collected over 14,000 phenology records on 28 species. One key species that many partners are tracking is the Rio Grande cottonwood (*Populus deltoides wislizenii*). Knowing when this species spreads its 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 by four Trail partners in 2021, suggesting that the best time to collect cottonwood poles for planting is between October and November.



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2. Mississippi River corridor for mayflies – We continued to host the [Mayfly Watch](#) campaign for a sixth year in 2021. 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 XX in 20XX, 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. 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 2022.

3. Monarch Butterfly central flyway – In 2021, six refuges submitted 4,557 records on flowering of nectar plants important to monarchs. On the Gulf Coast Phenology Trail, three refuges continued to participate in phenology monitoring in 2020. The Trail created an [Annual Report](#) to summarize the data collected through the end of 2020. Among the 57 species observed on the Trail is eastern baccharis (*Baccharis halimifolia*), 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 Patuxent Research Refuge in Virginia.

Plan for Fourth Year of Funding:

We will continue to support these three regional efforts, and hope to expand the number of refuges participating in phenology data collection.

Objective 2 and 3. Integrate existing phenological datasets from Refuges into the National Phenology 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.

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 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 Fourth Year of Funding: 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 data infrastructure for their data collection.

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

In 2021, 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:

- In an effort to share examples of how refuges are using phenology monitoring to inform management and engage volunteers and visitors in science, I collaborated with Neal Smith NWR Biologist Karen Viste-Sparkman on an article for the Fall 2021 edition of *Fish and Wildlife News* (<https://www.fws.gov/home/fwn/pdf/Fall-News-2021.pdf>, pg 2). The article featured data collected by volunteers and interns at the refuge on monarch butterflies, milkweed, and nectar plants.
- For the third year, I was invited to present in NCTC's Citizen Science Course in February 2021. 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 2021. 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 2021, and also shared information about the program in a training given at NCTC in February of 2021.

Plan for Fourth Year of Funding: We will continue to look for ways to reach new refuges that are interested in collecting phenology data to meet management and outreach needs, including sharing additional examples in *Fish and Wildlife News* and other outlets that reach NWRS staff.

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

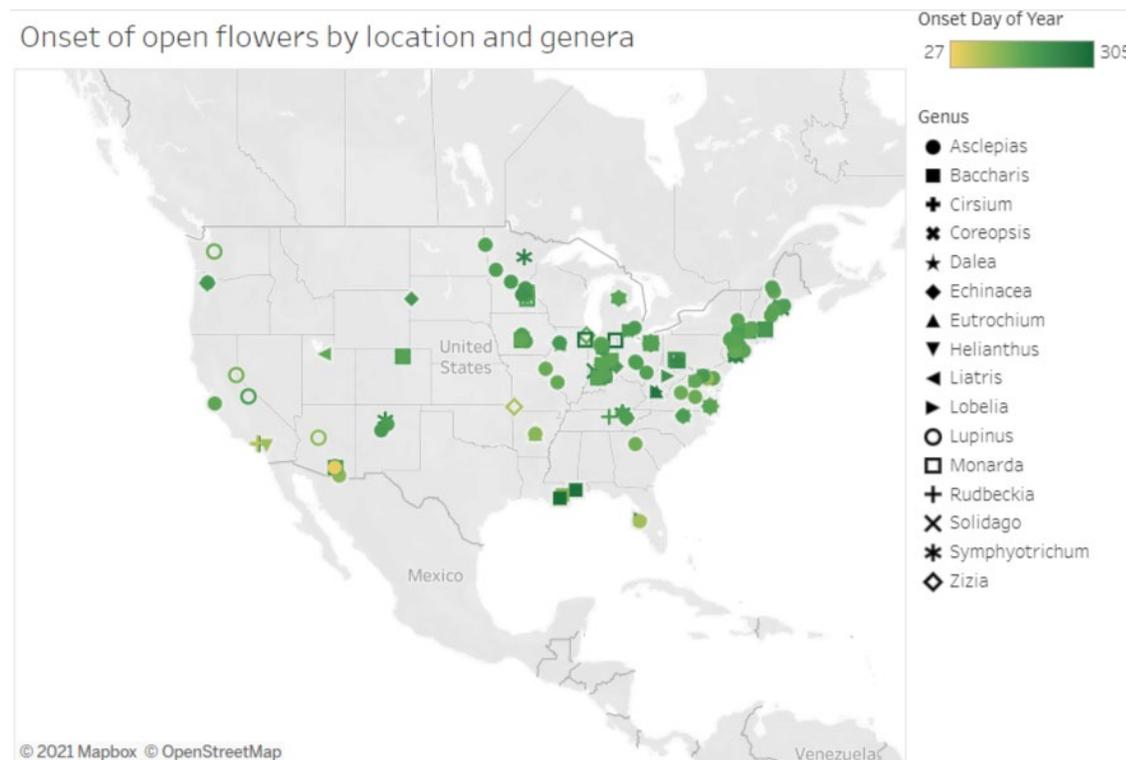
breeding needs of monarchs and other pollinators. These data will help the USFWS evaluate habitat quality and landscape-scale connectivity in space and time.

We continue to support refuges that are collecting data as part of this campaign. In 2021, 309 observers representing members of 45 organizations including six refuges reported on Nectar Connectors species.

- In Region 3, Minnesota Valley NWR in Minnesota recorded 1,188 records on 5 individuals of common milkweed (*Asclepias syriaca*) and 3 individuals of wild bergamot (*Monarda fistulosa*) and Neal Smith NWR in Iowa recorded 1,085 records on 3 individuals of butterfly milkweed (*Asclepias tuberosa*) and 2 individuals of tall blazing star (*Liatris aspera*).
- In Region 4 in Mississippi, Mississippi Sandhill Crane NWR recorded 1109 records on 3 individual of eastern baccharis, Bayou Sauvage NWR recorded 997 records on 3 individuals of eastern baccharis, and Grand Bay NWR/NERR recorded 129 records on 1 individual of eastern baccharis.
- In Region 5, Patuxent Research Refuge in 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 (*Rudbeckia hirta*), 1 individual of common milkweed.

Minnesota Valley NWR, Neal Smith NWR, and Bayou Sauvage NWR were among the top 10 groups in *Nature's Notebook* submitting data for the campaign for the second year in a row.

As seen on the map below, 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 both early and late-blooming plants.



More results are available for exploration on our [Nectar Connectors Campaign Results dashboard](#).

In 2021, we began a synergistic project funded by the South Central Climate Adaptation Center called Time to Restore: Connecting People, Plants, and Pollinators (<https://www.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 Fourth Year of Funding:

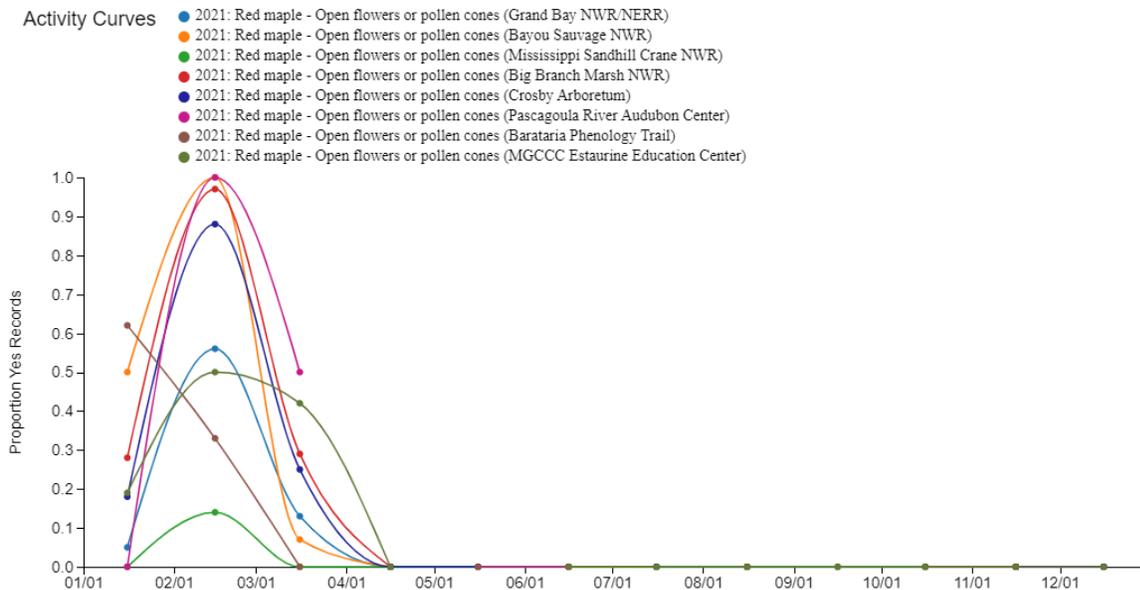
The Time to Restore project will provide enhanced monitoring guidelines for participating in the Nectar Connectors campaign as well as new ways to connect with USFWS staff in the region. We can use this project to invite new refuges to participate in the Nectar Connectors campaign.

Objective 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 is 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 four 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 Fourth 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 8: Generate periodic communications materials.

Newsletters:

We sent out a quarterly USFWS Newsletter to 143 contacts, including 68 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 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 2020 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 [2020 Annual Report](#) in 2021.

Plan for Fourth 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.

Additional work in support of fourth-year objectives:

In addition to the third-year objectives described above, we made progress toward several fourth-year objectives:

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 the fourth year of our funding. 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. We believe these models will be of great interest to refuge partners to help them understand how phenology of local species is shifting.

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 2020, we began 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 2021, 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. This year, we worked with refuge staff at Neal Smith NWR to publish an article in *Fish and Wildlife News* that describes one example use of phenology data. In the fourth year of our funding, we will summarize flowering phenology data collected 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 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 2022, we will collaborate with researchers at the US Geological Survey and Bureau of Land Management to explore the creation of forecasts of cheatgrass and red brome, two problematic grasses for public lands in much of the western United States.

Future Directions

In our partnership with I&M, we are tasked with working at the Refuge scale, and we have many examples of how the National Wildlife Refuge System as well as Arizona Ecological Services have been able to use the data they collected to inform management decisions. We also recognize the need from USFWS for larger-scale data and information products to understand climate change impacts at the regional and national levels. We've become familiar with the administrative priorities that FWS and other DOI agencies are being asked to address around climate modeling and prediction, and we see that this necessitates taking a larger perspective in understanding change. Phenology is just one piece of the puzzle, but we see it fitting in several ways.

1. Understanding changes in vegetation green-up, and whether green-up is in sync 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. There could be potential to leverage these data to determine areas where new land should be acquired to meet the resource needs of birds when they need it.

2. Long-term (decadal) projections of timing of leaf out, flowering, seed ripening of native species to help understand whether current species will provide needed habitat and food resources, or whether alternative species should be considered for planting in areas of concern.
3. Validating remote sensing data with on-the-ground observations of plants. Thus far this has been the most common use of our phenology data, with over a dozen publications that have used our observed phenology data for validation.
4. Measures of phenotypic plasticity for species of concern to inform vulnerability assessments. We now have many plant species with a decade of data. These data could be used to understand variability in leaf out, flowering, and fruiting timing and could also be combined with climate projections to understand frost risk, drought tolerance, and other measures of risk.

We look forward to continuing conversations about these and other ideas with USFWS staff both within I&M as well as in other program areas. We believe there is great potential for long-term partnership with USFWS 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.