Phenological changes in the National Wildlife Refuge System

Region 8: California, Nevada, Oregon

Observations of phenology — the seasonal timing of life cycle events in plants and animals such as flowering, hibernation, and migration — describe key aspects of ecological variability, and serve as indicators of climate change impacts on refuge ecosystems.

WHY PHENOLOGY?

Phenology is used to improve our understanding of which climate cues and other factors trigger key biological events such as migration and breeding, and the resulting impact on ecosystem dynamics such as water availability, carbon cycling, and disturbances such as fire and insect emergence. Knowing whether flowering is becoming decoupled from pollinator activity, or whether leaf production tracks with earlier snowmelt, helps managers understand the threats to ecosystem integrity.

The USA National Phenology Network (USA-NPN) has partnered with the USFWS since 2014 to provide a standardized data collection platform for National Wildlife Refuges (NWRs) to track phenology of wildlife and their habitats, as well as inform management with synthesized phenology data products such as maps forecasting spring and activity of species of interest.

PHENOLOGY PERSPECTIVES

Nature's Notebook provides a simple yet rigorous method for volunteer scientists to track seasonal activity of birds and other wildlife. Three Audubon Chapters and a National Audubon Sanctuary in California have tracked the phenology of birds, butterflies, and their habitats since 2015. Observers record the timing of feeding, mating, and nest building, as well as the number of nestlings and fledged young.

"These observations made with the USA-NPN's protocols are making for more detailed data collection as well as a better understanding of the eight bird species we are studying."

— Bettina Eastman, Local Phenology Leader with Sea and Sage Audubon

SHIFTS IN PHENOLOGY

Globally, animals have advanced their phenology by nearly three days per decade since 2050[1]. Many phenological events are influenced by temperature, particularly in areas that have experienced more climate change[1], though authors of a study that used USA-NPN data found that in northern ecosystems, decreasing precipitation also plays a role in earlier leaf out in plants[2].

CHANGING CLIMATE IN THE REGION

This region is expected to see increased annual temperature, warm nights, heavy precipitation, and flooding, and a decrease in annual precipitation[5].

The timing of reproduction, migration, hibernation in animals, and the timing of flowering and seeding in plants are all shifting in response to climate change, in many cases with negative impacts on fitness[3]. The relative timing between interacting species has changed significantly over the last 35 years, though there has been no consistent trend in the direction of the changes[4]. Smaller organisms and ectotherms may track change better than larger ones and herbivores may track temperature changes more closely than carnivores. The arrival timing of migrating animals tracks changes the least compared with peak seasonal abundance and breeding activities[1].

Differential changes in plants and animals may lead to mismatches, with significant decreases in reproductive fitness observed for some species. Tri-trophic systems, such as those of oak trees, caterpillars that eat their young leaves, and insectivorous birds that feed on caterpillars, have increased potential for mismatches[3].

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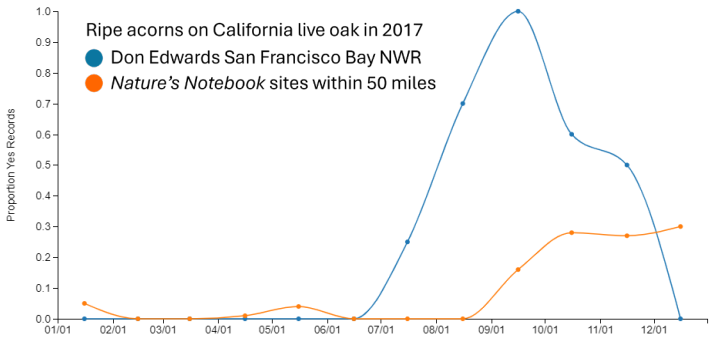

Proportion of "yes" records reported for ripe acorns of California live oak (*Quercus agrifolia*) at Don Edwards San Francisco Bay NWR and at other *Nature's Notebook* sites within 50 miles of the Refuge in 2017. Photo of acorns by Gary Hundt.

UNDERSTANDING PHENOLOGICAL CHANGES

In 2012, Don Edwards San Francisco Bay National Wildlife Refuge began collecting observations on seasonal activity of a number of species including California live oak (Quercus agrifolia), which is observed by several USA-NPN partners across the state. Live oak is an evergreen tree native to coastal California that is used by wildlife for food and shelter. The timing of acorn production is critical as these fruits are an important food source for many animals. The curve above shows when acorns were ripe at the Refuge and at other nearby locations in 2017.

This example provides a landscape-level look at resource availability of a focal species on and off refuge lands. The data collected from these shared standardized protocols allow refuges to understand whether they are meeting their mission of providing needed resources for species of interest.

PHENOLOGICAL MONITORING, BY THE NUMBERS: A CASE STUDY FROM DON EDWARDS SAN FRANCISCO BAY NWR

What does it take to establish a phenology monitoring program at a refuge? Don Edwards San Francisco Bay NWR tracked phenology of California native species to teach the public about climate change impacts.

How long has the Refuge been participating? From 2012-2020.

Who collects the data? Three Refuge staff and eight volunteers

What is the time investment? Weekly observations were made on eight different species at two sites. Site visits took an average of 30 minutes for travel, 20 minutes for data collection.

What does the Refuge plan to do with the data? Data are used to create interpretive signs, teach the public about the potential impacts of climate change, and show the power of citizen science to collect meaningful data. They have also used the data to help decide what species to plant in restoration sites.

OPPORTUNITIES FOR ACTION

Refuges are invited to use USA-NPN's scientifically-vetted, species-specific monitoring protocols, data management infrastructure, and data visualization tools. The *Nature's Notebook* app enables crowdsourcing of data collection to leverage the power of visitors to record observations on many different species. A refuge can track shifts in phenology and develop more focused monitoring on the species that demonstrate shifts of concern.

Refuges can capitalize on USA-NPN's Local Phenology Program partners as well as data collected by independent observers in areas near refuges to understand changes at landscape scales, supporting the USFWS Climate Change Action Program (2021).

Phenology can be used in the Resist, Accept, Direct framework to inform the timing of invasive species management and prescribed fire or to provide guidance on planting species for future climate conditions (for example, to support pollinators during a particular season, knowing the flowering timing for a suite of plant species can guide species selection).

Phenology can also be used in vulnerability assessments to assess species sensitivity to climate changes[6]. It can also be used for targeted land acquisition to guide selection of new areas that will match the phenology of protected areas that are no longer suitable due to shifts in climate.

Visit the USFWS Phenology Network hub at fws.usanpn.org or email info@usanpn.org to learn more.

THE UNIVERSITY OF ARIZONA

Photo credits: Bettina Eastman (front top and bottom), Gary Hundt (back top) USFWS (back bottom)

REFERENCES: [1]Cohen J.M. et al. 2018: A global synthesis of animal phenological responses to climate change. Nat. Clim.Change, 8, 224–22; [2]Wang, J. et al. 2022: Decreasing rainfall frequency contributes to earlier leaf onset in northern ecosystems. Nat. Clim. Change, 12, 386–392; [3]Inouye, D.W., 2022: Climate change and phenology. WIREs Climate Change, 13, e764; [4]Kharouba, H.M., et al., 2018: Global shifts in the phenological synchrony of species interactions over recent decades. Proc Natl Acad Sci USA, 115, 5211–5216; [5]USGCRP, 2023: Fifth National Climate Assessment. Crimmins, A.R., et al. Eds. U.S. Global Change Research Program, Washington, DC, USA; [6]Enquist, C.A. et al. 2014 Phenology research for natural resource management in the United States. Int J Biometeorol. 58, 579-89

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