

Wildlife Watchers Aid Climate Research

A NEW EFFORT TO MONITOR CHANGES IN WILDLIFE PHENOLOGY

By Abraham J. Miller-Rushing, Ph.D.



Credit: Richard Howard

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In March of this year the USA National Phenology Network (USA-NPN), in partnership with The Wildlife Society, U.S. Geological Survey, and U.S. Fish and Wildlife Service, launched a new program that enables citizen scientists and professionals across the U.S. to monitor wildlife phenology—changes in plant and animal life cycles caused largely by variations in climate conditions. Based on existing protocols for monitoring plant species, and tested through a pilot program in 2009, this new program will make wildlife phenology data widely available to biologists and managers on the front lines of addressing climate change.

Tracking the comings and goings of birds and flowers is something of a national pastime, and has been for centuries. Scores of people follow the arrivals of the first warblers in the spring, the flashing of fireflies in the summer, and the turning of the leaves in the fall. The USA-NPN—a collaboration among governmental and nongovernmental agencies and citizen-science and education programs—capitalizes on this latent expertise by encouraging citizens and professionals alike to observe and record natural phenomena.

Working with the USA-NPN, volunteers are trained to record their observations in the field. They enter their data through an online interface called [Nature's Notebook](#), where they access a single database that contains observations about nesting, pollination, blooming, and other life-cycle phenomena. The online system also includes historic handwritten observations that USA-NPN researchers and volunteers have entered into the database.

Building the System

The USA-NPN was launched in 2007 in response to concerns about rapid changes in phenology and uncertainty about their impacts. Changes in phenology are one of the most sensitive biological responses to climate change ([IPCC 2007](#)), and because timing is a critical part of nearly all ecological relationships, these changes have widespread impacts on plants and animals. Accessible long-term phenology data are rare, however, which limits our ability to understand what changes are taking place and to forecast their likely impacts. The USA-NPN was formed to overcome that limitation.

Analyzing historical ecological data can be an ordeal, in part because they were often collected in a variety of different ways. While some people monitored marked individuals, for example, others monitored populations. Most used different definitions when recording phenological events such as migration or breeding dates. To address this issue, USA-NPN has created a set of standard methods and definitions of phenological phases that citizens and professionals can use to record observations in a consistent way.

The system's methods and data storage and sharing techniques have been through a rigorous review process involving more than 100 scientists, natural resource managers, and educators. These methods were also fine-tuned in 2009 during a series of pilot programs, when USA-NPN and National Park Service staff recruited dozens of volunteers to work at northeastern parks including Acadia National Park, the Appalachian National Scenic Trail, and Boston Harbor Islands National Park Area. Volunteers visited their sites a couple of times each week



Credit: Abraham J. Miller-Rushing

Settled in a subalpine meadow in Gothic, Colorado, Ellie Johnston, a student of the University of North Carolina in Asheville, makes observations about plants and insects. Her work is part of a long-term project to explore changes in plant-pollinator relationships and other aspects of phenology that may be related to climate change.



to monitor common plants such as red maples and speckled alders, and animals, such as bumblebees and green frogs. They answered a series of yes-or-no questions—Was the frog calling? Was it mating? Was it on land?—and entered their observations into the new online interface, which was shared with scientists, park managers, educators, and the public.

The system's standards are flexible enough to be implemented in a variety of situations, therefore enabling a person to observe flowers and butterflies in a backyard garden in Florida or at a long-term research site in Alaska. In addition, participants make repeated observations of a specific site over time, noting the phenological state of plants and animals, such as whether a plant is in bloom or an animal is building a nest. The resulting data can be integrated across a variety of sites and with other phenology data sets including historical data and data from automated sensors such as cameras, acoustic recording devices, and remote sensing imagery obtained by satellites.

Using the System

With its new website, USA-NPN is pursuing its mission of promoting a broad understanding of plant and animal phenology and its relationship to environmental change. Citizens or scientists who wish to contribute data to the system can access Nature's Notebook website, register as an observer, select a species they want to observe, and begin recording their observations. The data are then stored in the National Phenology Database and are freely available for download. Among the website's features:

- **User Interface.** Users can find information customized to their interests and can locate resources available from participating organizations, including other phenology monitoring groups such as [NestWatch](#) and [Monarch Watch](#).
- **Data Registry.** To improve access to the variety of data already available, people can report historical data sets or search for them using a new data set registration tool on the USA-NPN website.
- **Data-Sharing Mechanisms.** The network currently stores a searchable catalog of phenology data sets, including data sets collected by Henry David Thoreau and Thomas Jefferson.
- **Educators Clearinghouse.** Educators and other interested groups can find links to education programs and materials, as well as descriptions of other participatory monitoring programs.
- **Mapping.** The network is developing mapping and data analysis tools to help users visualize phenology data at a variety of scales. For example,

a user could map changes in first flowering for a plant across the country or the timing of salmon runs in a particular region.

Making Use of Phenology Data

A primary goal of the USA-NPN is to provide data that can help inform natural resource management decisions. Many existing recommendations for the timing of management practices are based on the assumption that phenological events take place at roughly the same time each year. We now know, however, that the phenologies of many species are changing, and changing at different rates ([Parmesan](#)



Credit: Abraham J. Miller-Rushing

A monarch caterpillar (above) inches across a milkweed leaf, and a carpenter bee (below) feeds on goldenrod flowers in Concord, Massachusetts. Research shows that a change in flowering patterns of several native wildflowers across Concord has led to declines in some species. Pollinator phenologies are also changing, another sign of nature in transition.



Credit: Abraham J. Miller-Rushing



2007, Primack *et al.* 2009). Phenology data can help managers cope with shifting environmental conditions and make informed management decisions in a number of ways. For example:

Identifying vulnerable species. Evidence suggests that in many locations species with phenologies that do not track changes in climate conditions may be particularly vulnerable to climate change. Research in Europe has shown that the population sizes of bird species with migration times that do not track changes in spring temperatures have tended to decline (Møller *et al.* 2008). Research in the U.S. has shown similar declines in plants with flowering times that do not track changes in spring temperatures (Willis *et al.* 2008). Because phenology is relatively easy to measure, it may be a particularly effective in-

dicator of vulnerability. The National Park Service's Northeast Temperate Inventory and Monitoring Network (NETN), a major partner on this project, hopes to use observations of bird migration and breeding phenology (along with plant, insect, and bat phenology) to help park managers identify species that are vulnerable to certain aspects of climate change.

Identifying potential mismatches. By examining the phenology of species that interact—such as plants and pollinators or predators and prey—researchers and managers may be able to identify pairs of species that are becoming mismatched. For example, in the western United States, the larvae of Edith's checkerspot butterfly are active after its host plants have already gone dormant, leading to local population extinctions in the southern portion of the butterfly's range (Parmesan 2003).

Anticipating effects on water resources. The timing of leaf emergence and fall can alter water quantity, shading, temperature, and nutrient concentrations in streams and wetlands. In eastern Tennessee, for example, spring leaf-out is associated with rapid declines in in-stream primary productivity and grazer growth, and increases in nutrient concentrations (Hill *et al.* 2001).

Modeling carbon sequestration. Spring phenology is believed to have a major influence on the carbon balance of temperate and boreal ecosystems. Longer growing seasons could change how much carbon is sequestered in forests, depending on the balance of photosynthesis and respiration. In northeastern forests, for example, earlier leaf-out in the spring is associated with increased net ecosystem productivity (Richardson *et al.* 2009).

Timing habitat treatments. Phenology data can allow managers to set optimal times for mowing, burning, and herbicide applications to ensure minimal negative impacts on wildlife. For example, phenology data could be used to map nesting times for ground-nesting birds, helping managers set recommendations for when to mow or burn in certain habitats.

Planning for recreation. Phenology data can provide important information about outdoor recreation linked to phenological events such as the blossoming of wildflowers, coloring of leaves, or mating seasons and migrations of mammals and birds. Natural resource managers can improve the accuracy of their forecasts of the arrival of these events by tracking the phenology of animals and their habitat.



Credit: Anica Miller-Rushing

In Gothic, Colorado, a Gillette's checkerspot butterfly (above) feeds on a sneezeweed and a yellow-bellied marmot (below) stands alert in a meadow. These are some of many species found in this montane community, where phenologies and species distributions are changing rapidly in response to changes in the timing of snowmelt.



Credit: Abraham J. Miller-Rushing




Health planning. Many health problems, such as allergies and Lyme disease, are linked to wildlife phenology. Managers can therefore use phenology data to plan disease-prevention campaigns at parks or refuges and post precautionary information for visitors.

Ongoing Pilots

The USA-NPN national coordinating office at the University of Arizona is working with government agencies to conduct additional pilot programs to study and improve its monitoring methods in parks, refuges, and other natural areas. In Alaska, for example, the network is working with the Tetlin and Kenai National Wildlife Refuges, among others, on monitoring key food chains to test for changing predator-prey and plant-herbivore relationships. In addition, a network of national parks in California is planning to use plant phenology monitoring as both an outreach education tool and to gather information about important plant species such as Joshua trees. Lessons from these pilots will help refine monitoring standards and develop decision support

tools that other parks, refuges, and land management agencies can adopt.

The USA-NPN is creating a community of phenology monitoring, research, and education that incorporates, rather than replaces, other phenology monitoring programs that tend to focus on a few specific species or behaviors. Through its strong programs that couple citizen and professional monitoring, USA-NPN aims to facilitate the collection of high-quality phenology data that can be gathered as part of any local, regional, or national monitoring program. The key is that the data are presented in a form that is useful for present and future generations of researchers, natural resource managers, educators, and others faced with adapting to climate change and mitigating its impacts on wildlife. ■



For additional references and a bibliography, go to www.wildlife.org.

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