California Phenology Project

A growing network of partners in science & education dedicated to tracking how California landscapes are responding to climate change

Historically, human societies have kept careful track of local plants and animals. Our familiarity with the seasonal appearance of wild plants and animals has allowed us to harvest or to hunt them at optimal times, to plan for their sustainable use, and to prepare for natural hazards such as wildfire and pest outbreaks.

Given our growing awareness of the threats to natural ecosystems brought by climate change, tracking how plants and animals respond to year-to-year climatic variation is an important goal. One of the simplest ways to do this is to record each year the timing of seasonal events such as flowering, leaf-out, insect emergence, and animal migration. The seasonal schedule of plant and animal activities – their **phenology** – changes with local environmental conditions, but how different species or landscapes will respond to climate change is largely unknown.

Although many aspects of monitoring climate change can be automated (e.g., using climate towers, weather stations, webcams, and satellites), tracking the phenology of most plants and animals requires frequent observations made by people. Moreover, in order to record phenology at the large scales and high frequency necessary to detect and to predict how wild or managed species are responding to climate change, scientists need far more data than they are able to generate on their own.

In California, scientists, policy makers, and educators are working together to solve this problem by recruiting and training volunteers to collect phenological data on the wild species around them.

The California Phenology Project—The California Phenology Project (CPP) is a collaborative scientific and educational network of observers who are focused on tracking the effects of climatic variation and climate change on California's flora. CPP members participate in a coordinated phenological monitoring program that is replicated across the state at national and state parks, wildlife reserves, botanical gardens, biological field stations, school yards, and back yards. The CPP uses standardized monitoring protocols developed in collaboration with the USA National Phenology Network (USA-NPN) to track the phenology of 30 wild plant species across California's desert, coastal, valley, foothill, and montane regions.

Established in 2010 with support from the National Park Service *Climate Change Response Program* and in partnership with the USA-NPN, the California Phenology Project was designed to guide coordinated, long-term phenological monitoring and education in California national parks. While conducting ~50 training workshops at seven national parks, the CPP and National Park Service (NPS) recruited many other individuals and organizations, including state agencies, non-government organizations, outdoor education institutions, botanical gardens, and local schools and universities.

After attending CPP training workshops, some organizations continued to work closely with the CPP to develop phenological monitoring and education programs. As a result, California residents have contributed >1,200,000 phenological observations to the USA-NPN's national database through the user-friendly online interface, *Nature's Notebook*. Each of these programs recruits new observers, can provide guidance on establishing new phenological monitoring programs, and may be interested in developing new partnerships for grant proposals, scientific research, and environmental education. See panels 1 and 3 to locate and contact a CPP partner in your region.

The value of CPP partnerships—CPP partner organizations are distributed across a wide variety of climatic zones, giving us the ability to study how targeted species respond to spatial variation in climate. Understanding this relationship for each species allows us to forecast how future changes in climate will affect their phenology. The first steps have been taken in this direction with the CPP's recent article in the peer-reviewed journal, *Ecosphere*.

In this article (summary available here), CPP scientists analyzed phenological data collected by citizen scientists and staff at seven national parks and a University of California natural reserve from 2011-13. They found many strong relationships between winter climatic conditions and the phenology of four widespread and abundant California native species – valley oak, blue

Panel 1. California Phenology Project partner monitoring locations.

elderberry, coyotebrush, and California buckwheat). These results permit cautious predictions about how each of these species will either shift or maintain their phenology in response to predicted warmer and drier winter conditions. The CPP's approach to large-scale ecological research would not be possible without the help of trained and dedicated observers across the state.

Mutually beneficial relationships—The CPP is extending the long legacy of observations recorded by well-known American naturalists such as John Muir, Henry David Thoreau, and Aldo Leopold. To continue their practice of detailing year-to-year changes in the seasonal activities of wild plants, the CPP aims to create new generations of sharp-eyed Californians who are attentive to their day-to-day natural surroundings.

To achieve this goal, the CPP works with partner organizations to help them to design and initiate phenological monitoring and education programs that are tailored to their own needs and goals. While conducting on-site training workshops, CPP staff also coach organizations to lead future workshops with training materials developed by CPP staff and partners. The CPP's "train the trainer" approach empowers organizations to develop unique programs and materials while recruiting and training observers to use standardized protocols.

The personal and professional relationships that form the backbone of the CPP generate many mutually beneficial opportunities for everyone involved. Individual observers receive hands-on training from experts, contribute high-quality data that enable scientific discovery, and hone their skills in botany, ecology, species identification, and natural history. At the same time, research scientists and resource managers can develop both local and large-scale research programs to forecast the effects of climate change on ecologically important species. Educators, citizen science practitioners, and natural history interpreters also can use or build on the CPP's education resources – including CPP interpretive guides, data-driven lesson plans, and outdoor inquiry games and activities – to inspire and train new generations of scientists and nature enthusiasts.

Organizations that develop phenological monitoring and education programs in partnership with the CPP also benefit in many ways from having access to a strong network of government, nongovernment, and academic collaborators. Whether their goals are in research, environmental education, or public engagement programming, CPP partners gain:

- field guides and California-focused support in the use of the standardized USA-NPN monitoring protocols that are used throughout the U.S.;
- access to data contributed by all CPP and USA-NPN participants;
- an internet-based platform for archiving and sharing scientific and educational materials;

- the ability to address local and large-scale ecological research questions using USA-NPN data and protocols (see Panel 2);
- access to a robust collection of activities and educational tools that engage students and adults in discovery of their natural world;
- opportunities to achieve STEM education goals and to teach critical thinking and inquiry skills aligned with national education standards and core curricula; and
- a network of potential partners with whom to collaborate in developing new programs.

Partner organizations also provide helpful feedback to improve CPP and USA-NPN monitoring protocols.

Become a CPP observer or partner organization — Whether you're an educator, land steward, research scientist, or park ranger, do consider becoming an active member of the CPP. Consult the CPP website to become familiar with the species that community members are monitoring in your neck of the woods, along with the tools that the CPP has created to make your job easier. Explore the CPP website to be introduced to the national parks in California where phenological monitoring has been a part of their seasonal activities since 2011, and to examine the maps, data sheets, and photographs developed to orient new observers. Examine the resources available at the CPP website to learn more about its history and accomplishments. And, to get hands-on experience in the very near future, write to the CPP contacts at partner sites near your home (see Panel 3) to learn the ropes by joining volunteers at these sites as they monitor their targeted species.

Panel 2. Special opportunities for targeted research at individual monitoring locations.

Organizations that develop phenological monitoring programs in partnership with the CPP have many opportunities to develop compelling research projects that may serve a number of scientific and educational goals. Generally, within a given location, partner organizations have opportunities to link local phenological variation to local changes in climate, and with minimal investment of resources may answer questions such as the following with 1-3 years of data:

- Which species are more sensitive to climate from year to year compared to others? This sensitivity may influence the productivity of each species, and may be an indicator of the local effects of climate change.
- Are early flowering species more sensitive to winter temperatures or rainfall than late flowering species? The scientific literature shows that this often is the case, but there are few examples from semi-arid climates.
- Can you detect an elevation gradient using space as a proxy for climate variation? Understanding how local climate influences phenology is the first step in predicting species' responses to future climate.
- How does plant phenology affect resources for animals in the community? If plants flower extremely early or late, it may reduce the floral resources available for pollinators, as well as the fruits and seeds available for birds, rodents, and deer.

Panel 3. Contact CPP partners – usanpn.org/cpp/about/contact

CPP partners can be found in many regions of California. Many of them recruit new observers, can provide guidance on establishing new phenological monitoring programs, and may be interested in developing partnerships for grant proposals, research, and education. Visit the above website and contact CPP partners if you would like to:

- learn how to monitor CPP plants in your region;
- take a school group or nature club to their site for a phenology tour;
- find outdoor opportunities for youth, students, and interns needing community service;
- develop outdoor education activities for informal or formal science education;
- develop grant proposals to fund scientific or educational programs related to phenology and climate change; or
- link outdoor activities like nature photography and wildflower observations to a broader scientific effort.

Contact the California Phenology Project

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Acknowledgments

National Park Service – Climate Change Response Program • University of California – Office of the President

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