

Research Brief: *Citizen Science in the National Parks*



Relationships between plant phenology and winter climate in water-limited environments: what we are learning from regional monitoring.

Following three years of phenological monitoring in seven national parks and several UC Natural Reserves, California Phenology Project (CPP) scientists published an article in *Ecosphere* describing the relationships between winter climatic conditions and the phenology of four widespread and abundant species across California.

Mazer SJ, KL Gerst, ER Matthews, and A Evenden. 2015. Species-specific phenological responses to winter temperature and precipitation in a water-limited ecosystem. *Ecosphere* 6(6):98 <http://dx.doi.org/10.1890/ES14-00433.1>

Understanding how natural resources respond to climatic variation has become an integral component of resource management and stewardship of public lands. **Phenology** is the study of the seasonal cycles of plants and animals, which are influenced by climate and affect species' interactions and the seasonal availability of food and shelter. Changes in phenology due to climate change are likely to affect when resource managers conduct critical activities such as fire management, pest and invasive species control, seed collection, climate adaptation planning, and public engagement programs.

Several community-level studies in the U.S. have documented phenological responses to climatic variation and climate change. However, few studies have monitored species simultaneously across ecoregions and climatic zones, particularly in water-limited ecosystems characteristic of the southwestern U.S.

To assess phenological responses of California's flora to climatic variation, the California Phenology Project (CPP; www.usanpn.org/cpp) was established in 2010 with



Management implications

- A coordinated phenological monitoring program has been successfully established in several California national parks and additional partner sites. With extensive resources and tools for monitoring and education, the California Phenology Project can be used as a model for detecting potential ecological consequences of ongoing climate change on public land and reserves.
- Resource managers can augment monitoring efforts with data collected by trained citizen scientists, improving both the geographic and temporal breadth of phenological data while expanding opportunities for public engagement and STEM education.
- Observations recorded up to twice per week by national park staff, interns, and citizen scientists are of sufficiently high resolution to detect associations between local climatic conditions (temperature, precipitation) and the onset of several vegetative and reproductive phenophases. These relationships between climate and plant life cycle phases provide excellent interpretive opportunities.
- Species and phenophases varied in the strength and the direction of their response to recent climatic conditions, yielding preliminary predictions for how individual species may respond differently to future winter warming and intensifying drought. Panels 1 and 2 show targeted species and phenophase-specific predicted responses to climate change.

Panel 1. Monitoring programs contributing data to the CPP article in *Ecosphere*. Additional national parks and partner institutions with ongoing data collection, volunteer training, and education activities were not included in this paper. [NP: National Park. N&SP: National and State Parks. NHS: National Historic Site. NRA: National Recreation Area. UC-NRS: University of California Natural Reserve System].

| | Valley Oak <i>Quercus lobata</i> | Coyotebrush <i>Baccharis pilularis</i> | Blue elderberry <i>Sambucus nigra</i> | California buckwheat <i>Eriogonum fasciculatum</i> |
|----------------------------|-------------------------------------|-------------------------------------------|------------------------------------------|-------------------------------------------------------|
| Redwood N&SP | | X | | |
| Lassen Volcanic NP | | | X | |
| John Muir NHS | | X | X | |
| Golden Gate NRA | | X | | |
| Sedgwick Reserve (UC-NRS) | X | X | | X |
| Santa Monica Mountains NRA | X | X | X | X |
| Joshua Tree NP | | | | X |



funding from the National Park Service *Climate Change Response Program*. The CPP developed, tested and implemented monitoring protocols, tools, and training materials to support coordinated, long-term phenological monitoring and education in California national parks and partner institutions.

The primary goals of the CPP have been to 1) initiate coordinated phenological monitoring programs across national parks and partner institutions; 2) recruit, train, and engage scientists, educators, and the public in the collection of phenological data, establishing baseline data to which future data can be compared and that inform stewardship of public lands; and 3) assess how vegetative and reproductive phenology are linked to climatic variation in the short term and across the state in order to predict how species will respond to future climate change.

Analyzing the first three years of data, CPP scientists published an article in *Ecosphere* reporting the relationships between winter climatic conditions and the vegetative and reproductive phenology of four plant species that are widespread and abundant in California.

CPP MONITORING PROGRAMS & DATA



The CPP uses standardized monitoring protocols developed in collaboration with the USA National Phenology Network (USA-NPN) to track the phenological status of 30 plant species across geographic and environmental gradients (e.g., latitude, elevation, temperature, and precipitation). The monitoring programs contributing data to this paper

are listed in **Panel 1** and include coastal, desert, foothill, and montane ecoregions. At each site, multiple individuals of several species were selected along existing trails for repeated monitoring. Following the selection of sites and plants, ~50 workshops were conducted to train park staff, seasonal interns, educators, volunteers, and community members how to record and report the phenological status of CPP species using the program *Nature's Notebook* (www.nn.usanpn.org).

From March 2011 - April 2014, over 860,000 phenological records collected by trained citizen scientists, natural resource managers, park staff, and interns were contributed to the [National Phenology Database](http://www.usanpn.org). The monitoring records for each individual plant enable the identification of the day of the year on which a particular vegetative phenophase (e.g., breaking leaf buds) or reproductive phenophase (e.g., open flowers) was initiated. Climatic data extracted from [PRISM](http://www.prismclimate.org) for each site were used to associate climate with the dates of phenophase onset.

RESULTS & OUTCOMES The authors examined the effects of winter monthly climatic conditions – e.g., monthly minimum temperatures and precipitation – from December to March on the onset date of four phenophases, for each of four species. Monthly conditions explained a high proportion (30-99%) of the variation in the onset date of each phenophase. Species and phenophases differed, however, in the strength and the direction of the relationship between monthly conditions and their onset dates.

By quantifying these complex responses to climatic variation, it is possible to make tentative predictions regarding how phenophases of interest will respond to previous winter conditions. Moreover, these patterns

permit preliminary predictions regarding how these species will respond to future winter warming and intensifying drought (**Panel 2**).

The CPP approach to monitoring the seasonal status of natural resources can provide insight into the effects of climatic variation and climate change not just on these particular species but also for the surrounding ecological community. For example, valley oak is predicted to leaf out later in response to warmer winter temperatures, which is likely to alter the seasonal availability of nesting and shelter sites for many species of birds (whose own phenology may or may not shift). Similarly, warmer winter temperatures are expected to delay flowering in California buckwheat, which could have a variety of effects on the highly diverse arthropod food webs that their flowers support.

Observers trained by CPP staff continue to accrue ~300,000 observations per year. Ongoing contributions to the National Phenology Database hold the promise of revealing further responses to climatic variation of additional target species that are widespread and abundant across California’s landscape.

Given that strong relationships between phenology and climate are detectable over the short-term for several phenophases for each species, and with data generated by trained citizen scientists and park staff, the CPP is a strong model for nationwide monitoring of natural resources and public lands.

**Interested in opportunities to get involved at your national park unit? Learn more at www.usanpn.org/nps.
Want to bring phenology to a UC natural reserve, wildlife reserve, or botanic garden? Contact the CPP below.**

Panel 2. Predicted phenological responses to future climate in California, based on 40 months of CPP monitoring data. All factors are statistically significant, except NS. † indicates that the direction of effects are month specific (e.g., for valley oak, drier February is predicted to cause later leaf out while drier March is predicted to cause earlier leaf out).

| | Phenophase | Warmer winters | Drier winters |
|------------------------------------------------------------------------------------------------------------------|-----------------|----------------|---------------|
|  Valley oak | Leaf out | Later | † |
| | Flowering | Later | Later |
| | Pollen release | Later | Later |
| | Fruit drop | Later | † |
|  Coyotebrush | Leaf out | NS | Earlier |
| | Flowering | † | Earlier |
| | Pollen release | † | † |
| | Ripe fruits | † | † |
|  Blue elderberry | Leaf out | † | NS |
| | Fruits ripening | Earlier | Earlier |
| | Ripe fruits | † | Earlier |
| | Fruit drop | † | Later |
|  California buckwheat | Leaf out | NS | Earlier |
| | Flowering | Later | † |
| | Fruits ripening | Later | Later |
| | Ripe fruits | Later | Earlier |

Contact information

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