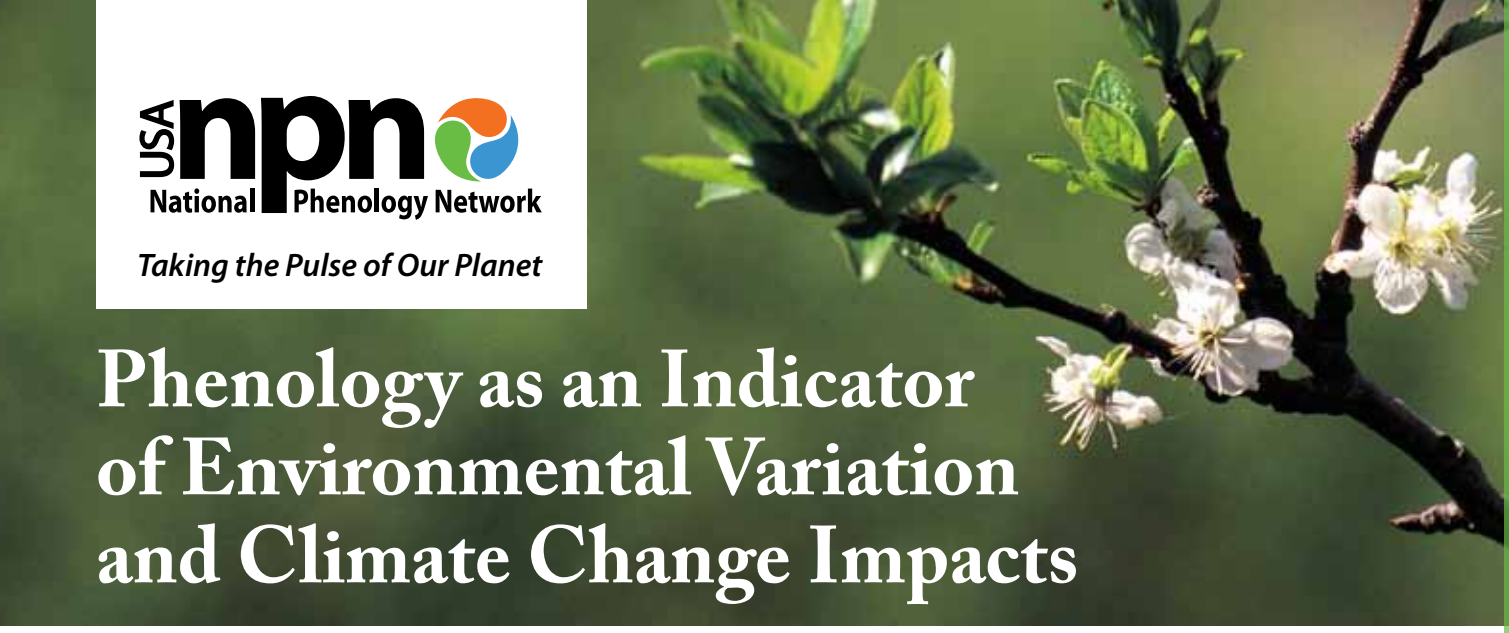
USA npn National Phenology Network

Taking the Pulse of Our Planet



Phenology as an Indicator of Environmental Variation and Climate Change Impacts

Changes in the timing of phenological events—such as flowering, migrations, and breeding—have been called a 'globally coherent fingerprint of climate change impacts' on plants and animals [1]. Climate-induced changes in phenology have been linked to shifts in the timing of allergy seasons and cultural festivals, increases in wildfire activity and pest outbreaks, shifts in species distributions, declines in the abundance of native species, the spread of invasive species, and changes in carbon cycling in forests.

"Phenology–the seasonal activity of plants and animals, is perhaps the simplest process in which to track changes in the ecology of species in response to climate change." (IPCC 2007)

The breadth of these impacts highlights the potential for phenological data and related information to inform management and policy decisions across sectors. For example, phenology data at multiple spatial and temporal scales are currently being used to identify species vulnerable to climate change, to generate computer models of carbon sequestration, to manage invasive species, to facilitate the planning of seasonal cultural activities, to forecast seasonal allergens, and to track disease vectors in human population centers.

Phenological Indicators of Climate Change

Phenology is widely accepted as a robust ecological indicator of the impacts of environmental variation and climate change on biodiversity and ecosystem processes across scales from individuals to landscapes [2, 3]). Depending on the application, phenology can be used as an indicator of species sensitivity to climate change, or can be combined with climatological data as an integrated indicator of climate change.

Species as indicators of climate change: Phenology is one of the most sensitive biological responses to environmental variation, which is important because changes in phenology serve as both forcing and constraint on ecological processes [1]. Phenological datasets have been critical to documenting impacts of climate change on biological systems at both global [2] and national scales [3]. However, phenological datasets for the United States are relatively sparse, and by their nature, tend to be place-based, short-term, and species-poor.

Synthetic indicators of climate change: Local to regional climatology is a critical driver of phenological variation of organisms across scales from individuals to landscapes. Accordingly, the U.S. EPA recently designated two phenology derived variables as climate change indicators: length of the growing season and leaf and bloom dates [4]. Large-scale integrative phenological indices such as the Spring Index, derived from minimum and maximum daily temperatures and validated with a continental-scale network of lilac and honeysuckle plants [5], enable us to leverage existing data into synthetic indices of climate change impacts across a variety of scales. Additional research is required to better understand mechanistic connections between climate indices (e.g., growing degree days) and organismal phenology. Therefore, it will be critical to develop a national observing platform for organismal phenology that explicitly incorporates considerations of scale and climate-informed monitoring.

An Integrated National Network for Phenology

The USA National Phenology Network (USA-NPN; www.usanpn.org), established in 2007 as a partnership-driven program with leadership by USGS, is a national network that organizes and facilitates the collection and integration of phenological observations across space and time. Partners

include citizen scientists, resource managers, educators, and scientists from public agencies, Native American tribes, non-governmental organizations, specialized networks, and academic institutions.

The primary goals of the USA-NPN are to understand how plants, animals and landscapes respond to environmental variation and climate change, and to develop tools and techniques to facilitate climate change adaptation by humans and natural systems. The Network will meet these goals through the development of information management systems, creation of partnerships, facilitation of research and development of decision-support tools, and promotion and implementation of education and outreach activities.

Indicator species: Since 2007, the USA-NPN has focused on the development of a national biological observation program with scientifically rigorous monitoring protocols for over 500 plant and animal species. USA-NPN partnered with NatureServe and The Wildlife Society to develop and vet criteria for selection of indicator species, including known or presumed sensitivity to climate change, and to develop the initial species list [6].

Protocol development: The USA-NPN has partnered with several science and monitoring programs (e.g., NatureServe, NEON, LTER) to develop, vet and test standardized monitoring protocols for observing species. Contemporary protocols were designed to be concordant with existing and historic phenology observation programs and protocols where possible. The data generated using these protocols can be combined with climatological data to generate phenology-relevant climate indices. These indices can be used to investigate ecological responses to climate change at appropriate scales.

Implementation: Standardized phenology monitoring protocols, documentation [6], and an on-line user interface for data entry, visualization and download are now available as part of the USA-NPN program Nature's Notebook. We are collaborating with several partners to implement and test-bed the monitoring protocols in the field. In the northeastern U.S. and in California, USA-NPN is collaborating with the National Park Service to test methodologies for engaging a variety of national park audiences, including staff, volunteers and K-12 students. Similarly, the National Ecological Observatory Network (NEON) will implement and test USA-NPN protocols in its phenology research and monitoring program.

Future Directions for Phenology Indicators

Recent investigations of relationships between phenology, demography and distribution suggest that phenology can serve as a bellwether or indicator of species vulnerability. USA-NPN is collaborating on a project to understand and ultimately predict species sensitivity to environmental variation and climate change based on retrospective analyses of phenological and climatological data within a phylogenetic context. Results will contribute to a framework for the selection of additional indicator species for monitoring. In addition, the Network will work to facilitate the development of climatologically based indicators, and will promote the investigation of community- or ecosystem-based indicators (e.g., trophic mismatch, carbon flux) that can serve as integrated indicators of climate change at regional to national scales.

References:

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[5] Schwartz et al. 2006. Onset of spring starting earlier across the northern hemisphere. Global Change Biology 12:343-351.

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