

# Observed Changes in Phenology Across the United States - Pacific Northwest

## Washington, Oregon, and Idaho

### Background

Phenology — the seasonal timing of life cycle events in plants and animals such as flowering, hibernation, and migration — has been linked to shifts in the timing of allergy seasons, public visitation to National Parks, and cultural festivals. Change in phenology, recognized as a bio-indicator of climate change impacts, has also been linked to increased wildfire activity and pest outbreak, shifts in species distributions, spread of invasive species, and changes in carbon cycling in forests. Phenological information can and already is being used to identify species vulnerable to climate change, to generate computer models of carbon sequestration, to manage invasive species, to forecast seasonal allergens, and to track disease vectors, such as mosquitoes and ticks, in human population centers.



“Timing of snowmelt and water temperatures in lakes and streams are critical cues of phenology in the Pacific Northwest”

**This is one in a series of eight, geographic region-focused information sheets that summarizes documented changes in plant and animal phenology over the past century across the United States.** This summary is based on long-term studies (10 years or more) published in the primary scientific literature since 2001. A forthcoming manuscript synthesizes the findings of the eight regional information sheets.

This information was developed in support of the U.S. Global Change Research Program’s **National Climate Assessment** and can be used to facilitate preparation for the cascading effects of ongoing climate change.

### The Pacific Northwest

The Pacific Northwest is characterized by the Cascade Mountains dividing temperate rainforest along the Pacific coast from more arid rangeland in the western part of the region. Accordingly, climate zones range from coastal marine to high alpine, and semi-arid steppe across much of the region [1, 2]. Human population in this region has doubled since 1970 with three-quarters of the people living west of the Cascade Mountains. Mean annual temperatures have gone up 0.8°C (1.5°F) in the past century and are predicted to go up another 1.6–5.6°C (3.0 to -10.0°F) in the next century [1, 2]. The Northwest is also highly dependent on snowpack and subsequent snowmelt for regional water supplies. Higher temperatures in the cool season have resulted in more precipitation falling as rain, contributing to earlier snowmelt [1, 2]. There has already been a 25% decline in snowpack in the Northwest in the past 40–70 years [3].

### Changes in Phenology - Highlights

#### *Salmon migrating earlier in Columbia River*

Migration of sockeye salmon (*Oncorhynchus nerka*) in the Columbia River is 10.3 days earlier than in the 1940s. This change was attributed to warmer waters, with a rise of 2.6°C (4.7°F) since 1949. Salmon survival during upstream migration decreased as a function of increasing water temperatures [4].

#### *Flowers blooming earlier over the last 38 years*

Across the Northwestern and interior Western U.S. time of first bloom for lilac (*Syringa vulgaris*) and honeysuckle (*Lonicera tatarica* and *L. korolkowii*) showed a trend toward earlier flowering (average advances of 7.5 days for lilac and 10 for honeysuckle) over an almost 40-year period. Earlier blooming was especially strong from 1970 to 1994 and corresponded with the pulse of spring snowmelt. Mean annual temperatures increased 1–3°C (1.8–5.4°F) during the same time period [5].

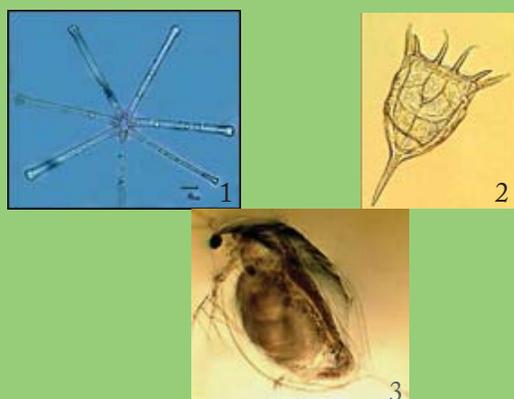
**Temperature influences timing of bird breeding behavior**

In a 12-year study of Northern Flickers (*Colaptes auratus*), birds arrived earlier at breeding sites when temperatures along the migration route rose. Temperatures at the breeding site correlated positively with initiation of egg-laying. Birds also began laying eggs earlier during the study period [6].

**Temperature and snow accumulation affect timing of breeding in toads**

Western toads (*Anaxyrus boreas*, formerly, *Bufo boreas*) in the Cascade Mountains of Oregon are breeding earlier in years with less snow pack [7]. Mean March and April air temperatures indirectly affect the onset of breeding by influencing the rate of snow melt.

**Case Study: Predator-Prey Mismatch in Lake Washington**



Spring water temperatures in Lake Washington increased an average of 1.4°C (2.5°F) between 1962—2002, and water stratification occurred 21 days earlier at the end of this period. Algal blooms in the lake paralleled this trend, advancing 27 days from the onset of the study. One algae herbivore, *Keratella cochlearis*, closely tracked the change in algal bloom time. However, another herbivore, *Daphnia pulex*, did not follow this trend and became increasingly out-of-sync with the timing of, its algal food source. The population of *Daphnia* in Lake Washington has declined dramatically during this period. This could have negative consequences for the lake ecosystem, with future algal blooms becoming more severe [9].

**References**

[1] Karl, T. R., et al. (eds). 2009. Global Climate Change Impacts in the United States. Cambridge University Press, New York.

[2] National Assessment Synthesis Team. 2000. Climate Change Impacts on the United States: The Potential Consequences of Climate Variability and Change, Report for the US Global Change Research Program. Cambridge University Press, Cambridge, UK.

[3] Mote, P. W. 2006. Climate-driven variability and trends in mountain snowpack in western North America. J Clim19: 6209-6220.

[4] Crozier, L. G., et al. 2011. Using time series analysis to characterize evolutionary and plastic responses to environmental change: a case study of a shift toward earlier migration date in sockeye salmon. Am Nat 178:755-773.

[5] Cayan, D. R., et al. 2001. Changes in the onset of spring in the western United States. B Am Meteorol Soc 82:399-415.

[6] Wiebe, K. L. and H. Gerstmar. 2010. Influence of spring temperatures and individual traits on reproductive timing and success in a migratory woodpecker. The Auk 127:917-925.

[7] Blaustein, A. R., et al. 2001. Amphibian breeding and climate change. Conserv Biol 15:1804-1809.

[8] Corn, P. S. 2003. Amphibian breeding and climate change: Importance of snow in the mountains. Conserv Biol 17:622-625.

[9] Winder, M. and D. E. Schindler. 2004. Climate change uncouples trophic interactions in an aquatic ecosystem. Ecology 85:2100-2106.



**PREPARED BY:**  
 Stacey A. Leicht-Young, Patuxent Wildlife Research Center, U.S. Geological Survey  
 Carolyn A.F. Enquist, USA National Phenology Network & The Wildlife Society  
 Jake F. Weltzin, USA National Phenology Network & U.S. Geological Survey

**CONTACT:**  
 Carolyn A.F. Enquist, Science Coordinator  
 USA National Phenology Network & The Wildlife Society  
 1955 East 6th Street, Tucson, AZ 85721  
 E-mail: carolyn@usanpn.org  
 Phone: 520-792-0571

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