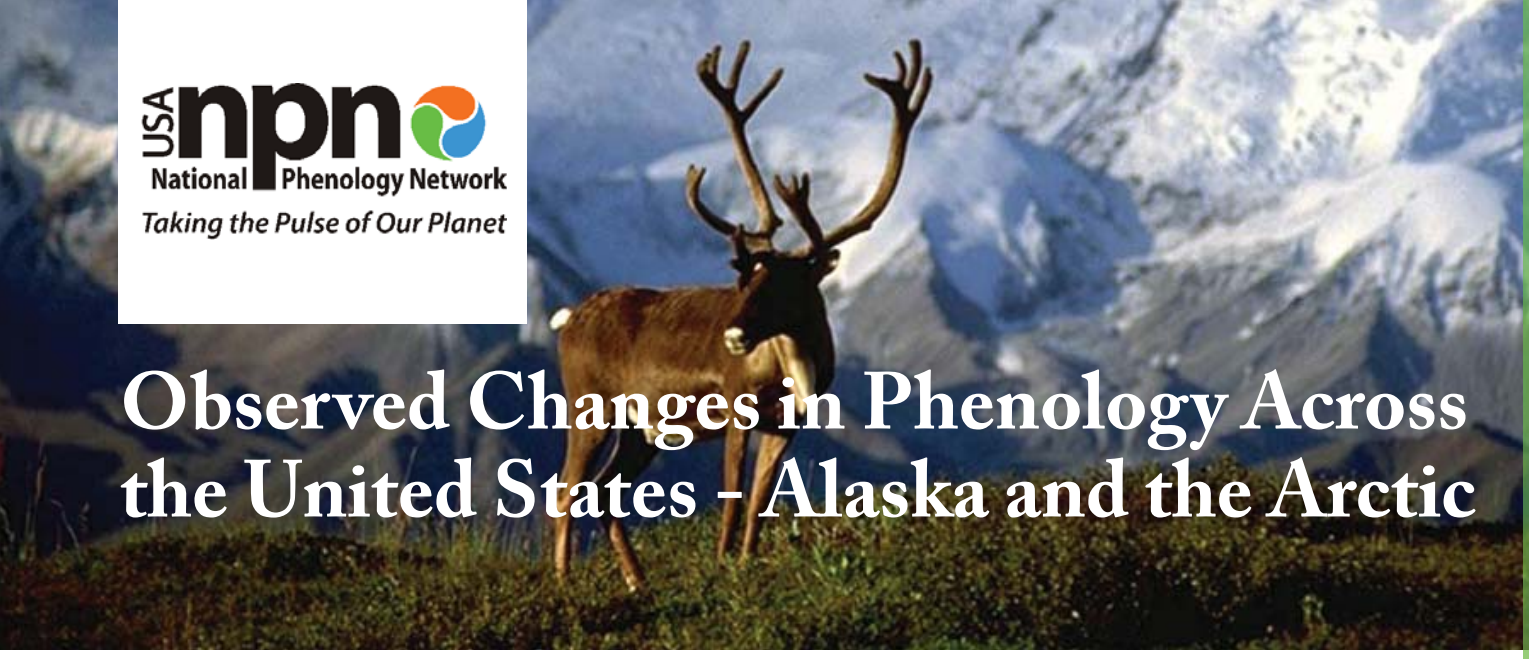
USA npn National Phenology Network
Taking the Pulse of Our Planet



Observed Changes in Phenology Across the United States - Alaska and the Arctic

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.

"Alaska and the Arctic have experienced warming at twice the rate of other regions in the U.S. over the past century."

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.

Alaska and the Arctic

Alaska's diverse terrain includes high mountains, meadows, tundra, boreal and rainforests, and coastal zones. The climate is mostly subarctic, with smaller areas of arctic and marine west coastal climates. Relative to other regions of the United States, Alaska and the Arctic have experienced twice the rate of warming over the past century, with mean annual summer temperatures increasing 1.9˚C (3.4˚F) and mean annual winter temperatures increasing 3.5˚C (6.3˚F), compared with 0.8 – 2.0˚C in other regions [1, 2]. Temperatures are expected to rise another 1.9 – 3.9˚C (3.5 – 7.0˚F) in the next half century. Longer summers with drier conditions have already occurred, resulting in an increase of drought and wildfires [1, 2].

Changes in Phenology - Highlights

Timing of snowmelt affects phenology of plant species

Researchers used remotely sensed data to show that plants are greening-up earlier and exhibiting higher productivity with advanced spring thaws [3]. In the short-term, earlier green-up and longer growing seasons may benefit species by providing a longer window for photosynthesis and resource acquisition. However, it is unclear how this increased period of growth will interact with increasingly dry conditions in Alaska [3]. A recent evaluation suggested that while green-up is occurring earlier in the Eurasian Arctic, this might not be the case in the Alaskan Arctic [4]. These inconsistencies suggest that additional research will be required to discern long-term changes in timing of green-up in this region.

Two species of mountain-avens (*Dryas* spp.) exhibited earlier flowering with earlier snowmelt. Plants in regions where snowmelt occurred later than other regions were more sensitive to changes in snowmelt than those that grew in areas where snow melted earlier. The relationship between flowering and snowmelt was non-linear, suggesting that other environmental factors such as pre-flowering

environmental conditions are also important [5].

Ecological mismatches result from changing bird migration patterns

Researchers found that population declines in migratory birds in the Nearctic are likely caused by a climate-induced ecological mismatch. This mismatch occurs when temperatures at wintering grounds change more slowly than at spring breeding grounds. This may cause birds to delay their departure from winter grounds, which may lead to late arrivals at the breeding grounds, after food resources have already peaked [6].

Fry of pink salmon migrate earlier

In a 34-year study of an Alaskan creek, fry of pink salmon (*Oncorhynchus gorbuscha*) emigrated increasingly earlier over time. Higher water temperatures and earlier arrival of adults may have contributed to this change. The study also suggested that earlier migration of pink salmon could result in fish arriving too early to take advantage of optimal foraging conditions [7].

Trumpeter swans expand range due to longer breeding season

Trumpeter swans (*Cygnus buccinator*) in Alaska have responded positively to s longer growing season by extending their breeding season. In addition to the longer breeding season, habitats that were previously inhospitable to this species have become available as a result of an extended ice-free period. This range expansion, however, may result in competition with the tundra swan (*C. columbianus*) for breeding areas [8].

Case Study: Caribou and Their Forage Out of Sync

Researchers examined the relationship between plant phenology and caribou (*Rangifer tarandus*) calving and found that the calving season has become out of synchrony with the phenology of plants they use for forage. An advancement of two weeks in the onset of the growing season resulted in a fourfold decline in calf production, most likely as a result of caribou missing peak foraging opportunities. In addition, the research found an 80% difference in geographic variability in plant leaf-out between the coldest and warmest years, with warmer years having less variability. Reduced variability in new growth resulted in a reduction in forage quality. This study of a migratory species highlights the mismatches in species interactions (called 'trophic mismatch') that may result from changes in the timing of plant growth, ultimately leading to decline in species population [9, 10].

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