Seventh Oregon Climate Assessment

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OCCRI

Published January 2025 at Oregon State University, Corvallis, Oregon.

Recommended citation: Fleishman, E., editor. 2025. Seventh Oregon climate assessment. Oregon Climate Change Research Institute, Oregon State University, Corvallis, Oregon. https://doi.org/10.5399/osu/1181.

Acknowledgments

This seventh Oregon Climate Assessment is consistent with the charge of the Oregon Climate Change Research Institute under Enrolled House Bill 3543 of the 74th Oregon Legislative Assembly.

We are grateful to the authors, other contributors, reviewers, and advisors to this assessment. We welcome readers to contact us with ideas for ensuring that the sustained assessment process is relevant to their priorities.

Thanks to Dominique Bachelet, Boone Kauffman, Tim Miller, Larry O'Neill, Raina Plowright, Holly Prendeville, Carol Trenga, and many anonymous experts for comments that strengthened the content and presentation of this assessment.

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Connecting Climate and Community Science through Oregon Season Tracker

Sarah Cameron, Mark Schulze, and Glenn Ahrens

As detailed in the sixth Oregon Climate Assessment, weather and climate mapping systems nationwide increasingly are capitalizing on the expertise and generosity of members of the public, or community observers, who measure precipitation in areas without formal observation stations. These data contribute to development of 30-year climate normals, updates to Plant Hardiness Zone maps (see *Changes in the 2023 U.S. Department of Agriculture Plant Hardiness Map*, this volume), and numerous other resources that support diverse economic, recreational, and scientific sectors. Community observations also are a rich resource for assessing variation and trends in phenology, or seasonal events in the life cycle of plants and animals, that largely reflect variability and trends in weather and climate.

Development of Oregon Season Tracker

Oregon Season Tracker, a project of Oregon State University, engages community observers in collecting, recording, and reporting data on precipitation, plant phenology, or both. Participants provide robust data for research while drawing their own inferences about environmental change. Through collaborative community science, Oregon Season Tracker connects natural resource managers, educators, researchers, and others members of the public. The initiative was launched in 2014 by Oregon State University Extension and the H.J. Andrews Experimental Forest, a member of the U.S. National Science Foundation's Long-Term Ecological Research Program, to develop collaborative climate change research and educational activities (Figure 1). The goal of the tracker is to expand awareness, knowledge, and understanding of climate variability and climate science among community members.

Figure 1. Volunteers practice plant phenology protocols at the H.J. Andrews Experimental Forest. Photograph by Jody Einerson.

Oregon Season Tracker enables participants to place their local knowledge and observations in a regional and long-term context, improving understanding of organisms' adaptations to weather and climate across diverse Oregon landscapes. Volunteers participate by monitoring manual rain gauges daily or observing the phenological events (phenophases) of native plant species selected by program staff. Observers may collect data immediately outside their homes or in woodlands, farms, schools, or other areas of interest. Participation and training are free, although those collecting data on precipitation are required to purchase a program-approved gauge (about $40–50) that meets National Weather Service standards.

A network of collaborators supports the Oregon Season Tracker program with coordination, research, and data collection and management. Oregon State University Extension is the Oregon Season Tracker's coordinating partner. Extension in Oregon and nationwide has a long and successful history of interpreting and applying science to the benefit of local landowners, managers, and residents. Climate change brings new challenges and information needs to natural resource-based communities, and requires new approaches to communication, as society seeks to mitigate and adapt to climate change.

The H.J. Andrews Experimental Forest has been a partner in Oregon Season Tracker since the program's inception. The 6,475-hectare (16,000-acre) research forest is administered cooperatively by Oregon State University, the U.S. Forest Service's Pacific Northwest Research Station, and the Willamette National Forest. Oregon Season Tracker expands the scope and clarity of results from research conducted at the Experimental Forest by making data available from many dispersed, rural areas that currently are not well represented in regional climate models and weather predictions. Oregon Season Tracker volunteers are encouraged to monitor local vine maple (*Acer circinatum*), the focal species of the program (Figure 2), to supplement ongoing research on the species at the Experimental Forest. In the absence of vine maple, western Oregon volunteers monitor bigleaf maple (*Acer macrophyllum*), black cottonwood (*Populus trichocarpa*), common snowberry (*Symphoricarpos albus*), Douglas-fir (*Pseudotsuga menziesii*), Oregon white oak (*Quercus garryana*), Pacific ninebark (*Physocarpus capitatus*), or ponderosa (valley) pine (*Pinus ponderosa*). Additional Eastern Oregon species include antelope bitterbrush (*Purshia tridentata*), big sagebrush (*Artemisia tridentata*), rabbitbrush (*Chrysothamnus* spp., *Ericameria* spp., *Lorandersonia* spp.), and quaking aspen (*Populus tremuloides*).

Figure 2. Open flowers phenophase on a vine maple, the focal species of Oregon Season Tracker. Photograph by Declan O'Hara.

To centralize data collection and management, Oregon Season Tracker works with two national organizations, the Community Collaborative Rain, Hail, and Snow Network (CoCoRaHS) and the USA National Phenology Network (USA–NPN). CoCoRaHS, operated by the Colorado Climate Center, began as a local community project following a flash flood in 1997. It now has over 26,000 active observers in all state, territories, and provinces in the United States and Canada (Daly and Newman 2023). The National Phenology Network collects, organizes, and shares phenological data, information, and forecasts to support decision making, scientific discovery, and wide understanding of phenology. Since 1999, it has operated Nature's Notebook, which monitors the phenology of plants and animals across the country. Partnership with CoCoRaHS and the National Phenology Network allows Oregon Season Tracker to centralize and provide open access to data, which in turn expands the research power of the program and allows training materials to be shared.

In the 10 years since Oregon Season Tracker was initiated, over 500 volunteers in 21 counties have been trained in the program protocols. Many volunteers are actively engaged in ongoing Extension programs including Master Gardener, Oregon Naturalist, and Land Stewards. Participants include formal and informal educators employed by local schools and nature centers. Training sessions initially were held in-person in cooperation with county Extension agents. Most training is now conducted online, with skill-building sessions designed to reinforce training outcomes and refresh the expertise of active volunteers. We estimate that 200 volunteers currently monitor precipitation and 35 monitor plant phenology, although the number fluctuates by season and year. Although the flexibility of program participation is appealing to prospective volunteers, it can complicate tracking the number of active observers at a given point in time.

Figure 3. Master Gardeners in Jackson County, Oregon, monitor a rain gauge in their native plant garden. Photograph by Grace Florjancic.

Applications of Oregon Season Tracker Data

Data collected through Oregon Season Tracker have many applications, in part due to the project's partners. Via collaborations with CoCoRaHS on collection of precipitation data and USA–NPN on collection of plant phenology data, data from Oregon Season Tracker volunteers contribute to ongoing local and national research.

CoCoRaHS and the USA–NPN offer open-source data with a wide range of practical applications for research and management. Data visualization tools provided by these partners have user-friendly interfaces that enable the public to engage with the data as well. Precipitation data compiled by CoCoRaHS are used by the National Weather Service; meteorologists; hydrologists; emergency managers; city utilities responsible for water supply, water conservation, and storm water; insurance adjusters; the U.S. Department of Agriculture; engineers; mosquito control districts; ranchers and farmers; teachers; and students (CoCoRaHS n.d.). USA–NPN phenology data also are widely used among researchers and decision makers affiliated with entities including the National Park Service, U.S. Fish & Wildlife Service, USDA Forest Service, National Ecological Observatory Network, and Indigenous Phenology Network (USA–NPN n.d.). More than 170 peer-reviewed scientific publications and 45 graduate theses have used USA–NPN data since the program began in 1999.

Precipitation data collected by Oregon Season Tracker also contribute to the work of Oregon State University's PRISM Climate Group, the source of the most widely used spatial climate data in the United States. PRISM simulates how weather and climate vary spatially as a function of Earth's topography (Daly and Newman 2023). The PRISM climate mapping system regularly incorporates information from thousands of community observers. The most comprehensive community science network contributing to PRISM is the Oregon Season Tracker's partner in precipitation monitoring, CoCoRaHS. PRISM provides monthly (1895–present) and daily (1981–present) time series of variables including precipitation, temperature, dew point, vapor pressure deficit, and solar radiation at 800 m and 4 km resolution (Daly et al. 2021, Rupp et al. 2022). Additionally, the PRISM Climate Group revised and updated the most recent version of the USDA Plant Hardiness Zone maps, released in November 2023 (see *Changes in the 2023 U.S. Department of Agriculture Plant Hardiness Map*, this volume). The updated zones are based in part on average extreme minimum temperature as reflected in PRISM's 1991–2020 U.S. Climate Normals, and cover all 50 states and Puerto Rico.

At the local level, the Oregon Season Tracker collaborative illustrates the power of combining geographically extensive community science with site-specific long-term study. Researchers at the H.J. Andrews Experimental Forest have been studying climate and plant phenology in the Lookout Creek Basin since the 1950s and 1970s, respectively. This research foundation enables detailed spatial modeling of variation in microclimate in forested mountains and investigation of the effects of regional climate change on environmental conditions at scales relevant to forest species (Daly et al. 2007, 2010; Frey et al. 2016; Rupp et al. 2020, 2021; Wolf et al. 2021).

A Closer Look at Phenology Research

Many species are highly sensitive to variation in climate and microclimate across space and time (Frey et al. 2016, Betts et al. 2018, Schmidt 2019, Finn et al. 2022). For example, budburst dates for a given plant species can vary by up to 60 days within the 6,400-hectare (15,815 acre) Lookout Creek basin, and by up to 80 days between years for an individual plant (Ward et al. 2018). In warm winters with low snowpack, an increasingly common circumstance, the expected variation in budbreak across elevational gradients is muted or nonexistent (Ward et al. 2018). Combining spatial models of microclimate and predictive models of budbreak makes it possible to model phenology accurately within the H.J. Andrews Experimental Forest (Ward 2018, Taylor et al. 2019), but modeling phenology across a larger region is difficult.

A comparison of the performance of phenology models that were based on data from the H.J. Andrews Experimental Forest and other long-term ecological research (LTER) sites versus those based on distributed USA–NPN (including Oregon Season Tracker) observations indicated that models based on LTER data excelled when predicting phenology in the areas from which the data were collected, but the USA–NPN-based models were better able to predict phenology across the large areas in which those observations were made (Taylor et al. 2019). Both local and regional data and models are needed to fully understand how climate variability and change is impacting fundamental life history processes and ecological interactions.

Phenological information has been important in understanding and responding to major disturbances and weather events in Oregon in recent years. Factors that affect the pace of tree regeneration following wildfire include cone production in the year of the fire, timing of the fire in relation to cone maturity, and cone production by surviving trees in subsequent years. Seed production by the mast-seeding conifer species that dominate Oregon forests is highly variable from year to year (Figure 4), and failure of cone crops tends to be synchronized across large geographic areas. Therefore, seed availability for natural regeneration and seedling production can vary by orders of magnitude from one fire to the next within a given area. Seed and seedling limitation was an impediment to restoration efforts after the historic Labor Day fires in 2020. Forest susceptibility to weather extremes can be influenced by the phenological stages of forest organisms at the time

Figure 4. Ripe Douglas-fir cones with recent seed drop. Photograph by Brad Withrow-Robinson.

of the extreme event. Thus, a better understanding of potential shifts in phenology can improve prediction of natural regeneration after disturbance, or suggest the necessity for intervention.

Another extreme example, the June 2021 heat wave in the Pacific Northwest, occurred at the peak of the growing season and prior to full development and hardening of new foliage and buds. Spatial patterns of canopy needle scorch were related to phenological variation across the region, with higher levels of canopy scorch in areas where needle and bud development of the dominant canopy species were not as advanced as in other areas with similar maximum air temperatures during the record-breaking heat wave (Still et al. 2022, Sibley et al. unpublished manuscript). The timing of this heat wave, and a less-severe heat wave relatively early in the 2015 growing season, resulted in early cessation of tree-diameter growth, which reduced annual forest productivity (Ford et al. 2017, Harrington et al. 2023). Similarly, atmospheric heat and drought stress can be strong predictors of latewood formation and annual tree growth (Jarecke et al. 2023, 2024). An increase in the number and magnitude of atmospheric stress events, as is expected as climate change accelerates, may have substantial impacts on forest productivity and condition.

As extreme weather events become more common, winter snowpack declines, and summer heat and drought stress increase, regional climate drivers will influence local environmental conditions and ecological processes in complex ways. Collaborative community science has the potential to fill in gaps in knowledge and predictive ability as society attempts to adapt to global climate change at the local level.

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