Thermophilization: Definitions and Implications

By BEF Staff

Human-caused climate change is altering ecosystems in real time. One shift that has been quantified in recent years is a change in species composition linked to temperatures and precipitation that deviate from historic norms, where plant communities become dominated by more heat tolerant species — a process known as **thermophilization.**

A **study** of California forests looked at the thermophilization of understory plants following disturbances that affected forest canopy cover, and found that thermophilization rates may speed up following large scale disturbances like wildfire (**Stevens et al. 2015**). Forests tend to have a buffering effect on the microclimates they host. In areas of contiguous, or near-contiguous forest cover, air and soil temperatures, irradiance and evapotranspiration demands all tend to be lower. The study looked at the locally abundant yellow pine-mixed conifer forests of eastern California, and examined floristic community level metrics in stands that 1) had experienced different levels of disturbance and 2) had plant communities reflecting different biogeographic affinities, ranging from more moderate "northern-temperate" to "southern-xeric" (dry) plant communities. The study found that under increased disturbance severity levels, plants with northern-temperate biogeographic affinities decrease in abundance with increased disturbance severity, while plants with a southern-xeric biogeographic affinity increased. The observed plant community composition changes are likely driven primarily by drought stress. In areas experiencing severe, frequent, or widespread disturbance, we may see a more rapid rate of thermophilization across the landscape.

This shift isn't just occurring in the understory. While it takes longer to perceive, **Rosenblad, et al. 2023** have found that thermophilization of tree communities across the Western United States is widespread, and is more prevalent in areas that have experienced higher temperatures and greater levels of drying. The authors find that "forest trees are becoming increasingly mismatched with their environments, potentially threatening ecosystem service provision" (p. 1).

Factors influencing thermophilization rates:

1. Temperature increases
2. Changes in precipitation and hydrologic variables (e.g. Vapor Pressure Deficits)
3. Forest canopy disturbance severity
4. Topographic and aspect features (e.g. hillslope orientation)
5. Presence and degree of insect driven mortality

On one hand, the community composition change known as thermophilization is an adaptive response by plant communities. This adaptive response to environmental change may preserve plant cover and ecological services as the

climate changes. On the other hand, thermophilic plants that thrive in altered conditions may or may not provide the same benefits to wildlife, hydrology, and numerous other physical and biological elements of the ecosystem. This, coupled with the fact that community level species change is not keeping pace with climate change, indicates that interventions will likely be needed to preserve the function of natural areas as providers of wildlife habitat, carbon storage, water filtration, clean air and more that we have come to rely on. Extreme weather events that disrupt pollination may further aggravate the "temporal mismatch" in which plants and pollinators become out of sync with one another.

While changes to ecosystems are happening in real time, there are actions managers and policy makers can take to reduce the impact of these changes. Habitat connectivity is not just important for wildlife. By preserving intact ecosystems, especially forests, we can retain resilience on several levels. First, large and connected forests tend to be more resilient to disturbance. **Evidence suggests** that continuous canopy cover, as well as diversity in topography and elevation, tends to foster more varied microclimates, which can have a buffering effect against extreme heat and drying, and help preserve habitat for existing species. Additionally, connectivity across geographic and elevation gradients may lead to more opportunities for **gene flow** and trait selection among plant populations, which may be helpful, especially following disturbance.

Many researchers and managers are invested in understanding opportunities and risks regarding how plants from other climates can survive and potentially provide ecosystem services in future climate scenarios through assisted population and species migration trials.

"The pace of climate warming is clearly accelerating in recent years, leading to not just increased temperatures and associated changes in things like snowpack amount and duration, but also to increasingly potent heatwaves like the record-shattering Heat Dome of late June 2021 in the US Pacific Northwest and western Canada.

Evidence from long-term forest monitoring sites in this region suggests both short-term and long-term heat stress responses in tree function and growth. These responses were influenced by a variety of factors including species composition, tree age, aspect, and topography. Specifically, the amount of leaf scorch following the Heat Dome was largely determined by sun exposure during the hottest afternoons of the event, leading to south- and west-facing slopes with the greatest leaf mortality. Tree mortality was greatest in seedlings, especially in western hemlock and western red cedar. And tree growth of mature and old-growth Douglas fir trees at multiple locations in the western Cascades was greatly reduced in both 2021 and the following year. These various impacts imply that thermophilization will be influenced by not just long-term changes in the mean temperature and drought stress, but also by extremes in temperature (heat shocks) like the June 2021 Heat Dome event."

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