Forest Responses to Climatic Change: Photosynthetic Temperature Optima Adjust to Warming

Contact: Carla A. Gunderson, 865-458-6238, gundersonca@ornl.gov
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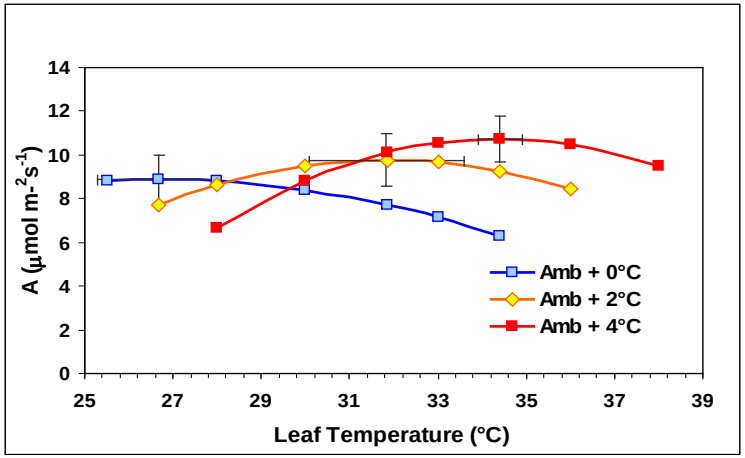
- Vegetation response models often predict major changes in the function and composition of temperate forests as climates warm beyond the adapted temperature limits.
- A four-year field experiment exposed young trees from contrasting climates to elevated growing temperatures. We evaluated variability and plasticity in temperature sensitivity, and explored assumptions common to current models.
- Temperature optima shifted with prevailing mid-day temperatures, maintaining normal CO_2 uptake across treatments and seasons. Optima did not reflect climate in a species' place of origin.
- The observed high potential for physiological acclimation suggests that survival or replacement of forest communities may not be closely tied to the maintenance of a positive carbon balance with warming as is often assumed in models.



U.S. DEPARTMENT OF ENERGY

OAK RIDGE NATIONAL LABORATORY
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Abstract:

The increasing air temperatures of global climate change predictions have the potential to alter forest ecosystems by exceeding the temperatures optimal for carbon gain, threatening survival of sensitive species, and leading to local extinctions, range migrations, and altered forest composition. This study investigated physiological sensitivity to temperature, and the potential for photosynthetic acclimation, in relation to the climatic provenance of five species of deciduous trees, *Liquidambar styraciflua*, *Quercus rubra, Q. falcata, Betula alleghaniensis*, and *Populus grandidentata*. Open-top chambers supplied three levels of warming (+0, +2, and +4°C above ambient) over three years, tracking natural temperature variability, and exposing plants to otherwise natural conditions. Optimal temperature for CO_2 assimilation was strongly correlated with the daytime temperature of the treatment, and assimilation rates at the optimal temperatures were comparable. Adjustment of thermal optima was confirmed in all species, whether temperatures varied with season or warming treatment, and regardless of the climate in the species' range or provenance. Temperature optima from 17° to 34°C were observed over the course of the experiment. Across species, acclimation potentials varied from 0.55 to 1.07°C per degree change in daytime temperature. Responses to the temperature manipulation were not different from the seasonal acclimation of mature indigenous trees, suggesting that photosynthetic responses to warming should not be modeled with a static temperature function, but should incorporate a degree of temperature adjustment. The high degree of homeostasis observed indicates that direct impacts of climatic warming on forest productivity, species survival, and range limits may be less than predicted by previous models.

Citation:

Gunderson CA, O'Hara KH, Campion CM, Walker AV, Edwards NT (2010) Thermal plasticity of photosynthesis: the role of acclimation in forest responses to a warming climate. *Global Change Biology 16:2272-2286* DOI: 10.1111/j.1365-2486.2009.02090.x