Sean Hoy-Skubik
S.hoyskubik@gmail.com
330-347-6687

Heat stress responses of whitebark and limber pine seedlings in the GYE

Sean L. Hoy-Skubik | Danielle E.M. Ulrich | Montana State University

Topic choices:

1. Ecosystem Resiliency
2. Wildland Fire, Drought, and Climate Change Adaptation

ABSTRACT:

Background/Questions:

Whitebark (*Pinus albicaulis*) and limber pines (*P. flexilis*) are foundational and keystone species that protect watersheds and provide forage and habitat for a multitude of wildlife species. Within the GYE, these species have experienced high degrees of mortality, and climate change is expected to reduce their suitable habitat. The future persistence and distribution of these species is dependent upon the ability of seedlings to establish and survive through the most vulnerable stages of development. One constraint to establishment and development these seedlings face is thermal extremes. While these species mostly inhabit cool, high-elevation environments and are not traditionally thought to be limited by heat stress, the biophysical properties of the soil boundary layer can create elevated air temperatures of up to 80 ºC in open canopy subalpine forests. As such, the heat stress responses of seedlings represent an underappreciated and poorly understood limitation for the future distribution and survival of these species.

Methods:

To better understand responses of these species to heat stress, we used a combination of experimental greenhouse and modeling approaches. In the greenhouse, we used a growth chamber to expose seedlings of both species to a heat treatment (a series of five heat waves of 8 ºC above ambient conditions) and an ambient treatment. We measured seedling leaf and air temperature, leaf heat tolerance curves, gas exchange (C assimilation, stomatal conductance), and non-structural carbohydrates. We then used these measured traits as inputs in a leaf energy balance model in conjunction with climate and soil data to map in situ maximum leaf temperature (T_{MIS}), thermal safety margins (TSM), and carbon dynamics for the two species across the GYE.

Results/Conclusions:

The output of our leaf energy balance model showed T_{MIS} elevated 2-8 ºC above air temperatures on the hottest day of the warmest month within the GYE. The calculated CF_T_{50} (temperature where 50% of maximum quantum efficiency is lost) of both species was found to

be 50.2 ºC. Using the modeled T_{MIS} and measured CF_T_{50} , we found that needles of the upper canopy have an average TSM of 21 ºC. We are still parameterizing the model for the soil surface boundary layer, which can be well above upper canopy temperatures. Lab work is still under way to determine the effects of heat stress on growth and carbon dynamics. These results demonstrate the importance of considering leaf temperatures, especially for vulnerable seedlings stages, rather than just air temperatures when predicting future species distributions. Additionally, these results demonstrate the increasing importance of microsite conditions and climate refugia in determining future distributions and establishment of these species in the context of a warming climate.