Effects of Warming on Two Species of the Boreal-Temperate Forest Ecotone

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Introduction

The changing temperatures expected due to global climate change will have a great effect on the composition of the species that make up unique ecosystems of the planet. Ecosystems adapted to cold climates, such as the boreal forests of North America will be forced to move northeastward to escape the rising temperatures, causing a possible loss of forests on about 200,000 to 1 million km² of land. According to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change 2007, the boreal forest terrestrial ecosystem is “likely to be especially affected by climate change [...] due to its sensitivity to warming.”

The researchers of the Boreal Forest Warming at an Ecotone in Danger project (B4WARMED) studied the effects of warming on eleven species in the boreal-temperate forest ecotone, and how the composition of the species would change. My project specifically focused on two species, Quaking Aspen, *Populus tremuloides* (Figure 1, left), and Sugar Maple, *Acer saccharum* (Figure 1, right) and their responses to increased temperatures. *A. saccharum* is a temperate species (it is adapted to warmer temperatures) and is at the cool end of its range around central Minnesota—as the B4WARMED team hypothesized, an increase in warmth would theoretically enhance growth and increase the range of this species. *P. tremuloides* on the other hand, is already at the warm end of its range, so an increase in warmth may reduce growth and survival, and shrink its optimum growing range. We wanted to see if the optimum temperature at which these species conducted photosynthesis changed to accommodate the increasing temperatures.

Methods and Materials

We had six blocks of test plots at both the Cloquet Forestry Center, and the Hubbard Wilderness Research Center. Each block was comprised of eight 7m² plots, grouped in the following categories.

- Two plots of ambient temperature with soil cables, and two without
- Two plots with a heating treatment two C above the ambient temperature
- Two plots with a heating treatment four degrees above the ambient temperature

Temperature treatment adjusted with infrared lamps (Figure 2) and soil heating cable

**Samples:**
- 68 leaf samples taken from seven deciduous species 3x over the summer
- 72 samples taken from the three conifers once during the summer.

**Analysis of samples:**
- Photosynthetic and respiration rates measured to find optimum temperatures
- Measured with the LiCor 6400 gas exchange system (Figure 3) at temperatures of 12, 17, 22, 27, 32, and 37 C, with the light on and off.
- The data was then analyzed using JMP statistical analysis software.

Results

As my project specifically focused on two out of the eleven species, my results may be slightly different from the overall project. However, the results I found regarding the gas exchange were:

- Photosynthesis rate was generally increased in both species because of warmer temperatures.
- Half of the time *A. saccharum* was able to photosynthesize at a larger range of temperatures when grown under increased heat than *P. tremuloides*, even though it photosynthesized at a lower overall temperature. See (Figure 4).
- The maximum temperatures of the photosynthesis response curves shifted slightly to a warmer maximum temperature, and shifted slightly more in the open habitat (no forest cover). See (Figure 5)

**Confounding factors:**

Weather, especially in July, could have played a part in the differences of photosynthesis values, as the heating could have benefited the plants more in cool, wet conditions than in a normal hot and dry summer. The amount of shade could also have had a dampening effect on the change in the rates of *P. tremuloides*, a shade intolerant species, in the understory habitat.

Figure 1: *Populus tremuloides* and *Acer saccharum*

![Figure 1: *Populus tremuloides* and *Acer saccharum*](image1)

Figure 2: Infrared lamps around plot number K3

![Figure 2: Infrared lamps around plot number K3](image2)

Figure 3: LiCOR 6400 gas exchange system measuring photosynthesis in the lab, and in the field.

![Figure 3: LiCOR 6400 gas exchange system measuring photosynthesis in the lab, and in the field.](image3)

Conclusions

The fact that *A. saccharum* had a larger change than *P. tremuloides* indicates that the maple was slightly more adaptable to warmer temperatures. Figure 5 shows that *A. saccharum* exhibited a higher temperature optimum under the increased heat, especially when not shaded by a thick forest canopy. This could mean that *A. saccharum* is more likely to be resilient to a changing climate, and will function more effectively under a larger range of temperatures at the boreal-temperate forest ecotone, although more research will need to be done. Both species do however, adjust their photosynthesis values to adjust to warmer temperatures, showing that the responses to increased temperatures are not always the same. These results show that the heating treatment was a significant factor in the change seen in photosynthetics rates.

Implications for the Future

By knowing how different tree species will respond, it may be easier to understand how these ecosystems will change in the coming years. Understanding which trees will grow better under certain conditions could have great impacts on forest management practices — forest managers will be able to target those trees that are more adaptable, and mitigate losses from tree death due to heat stress.

This project also brings the scientific community one step closer to understanding the impacts that global climate change will have on the biodiversity of Earth’s ecosystems. As northern forests begin to change, the distribution of animal species that depend on specific forest types will also change. More research will need to be done to understand exactly how boreal and temperate forest trees will respond to increased heat, and how the composition of the northern forests will change over time.

References Cited


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