Effects of spatial temperature disparity on growth of *Picea glauca*

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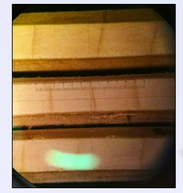

Background

- Boreal forest communities respond to temperature increases associated with climate change[1].
- Forests may experience substantial effects on growth and distribution as a 2°C threshold in global warming is crossed[2].
- Radial growth rates of white spruce (*Picea glauca*) individuals increase with higher air temperatures[3].
- Locally, regions five kilometers inland from Lake Superior can exhibit average annual temperatures up to 2°C warmer than those closer to the lake[4] (Fig.1).

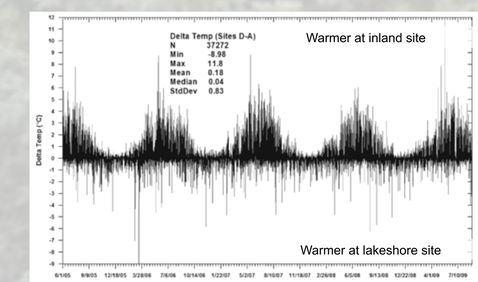

Figure 1. Difference in monthly temperature between inland (site D) and lakeshore (site A). Positive values indicate inland site was warmer than lakeshore site. From Hinkel & Nelson, 2012.

Research Questions:

1) **How does temperature variation affect growth of white spruce over large distances (>1500 km)**
2) **How does local temperature variation affect growth of white spruce?**

Methods

- White spruce cores were collected in 2012 from Michigan sites (three lakeshore, three inland) in the Huron Mountains and in 2016 from sites near North Bay, ON and Lorneville, NB (max. distance between sites was ~1700 km) (Fig. 2).
  - MI samples were collected at 30cm from ground level; ON & NB samples at breast height

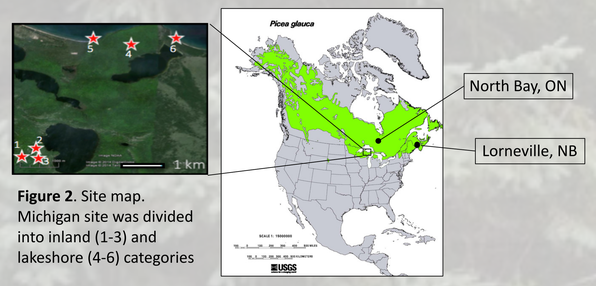

Figure 2. Site map. Michigan site was divided into inland (1-3) and lakeshore (4-6) categories

- Average growing season (April 1 – September 31) temperature data were compiled from weather stations in Big Bay, MI, North Bay, ON, and Saint John, NB
- Cores were processed for residual ring widths, using program Measure J2X and a Velmex measuring system. COFECHA and ARSTAN software were used to compile and analyze growth data at site level.

Results – Question 1: Large Distance

- Mean annual residual growth differed between sites, but the difference was not significant (One-way ANOVA, df = 157, F = 0.619, p = 0.5) (Fig. 3).
- Correlation between mean growing season temperature decreased as the distance between sites increased (Fig. 4).
- Correlation between mean annual residual growth decreased as the distance between sites increased (Fig. 5).

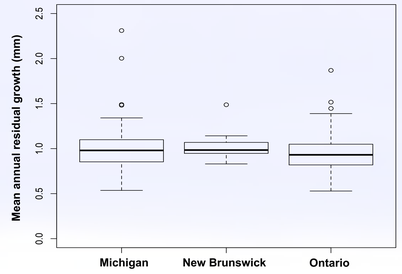

Figure 3. Mean annual residual growth per site.

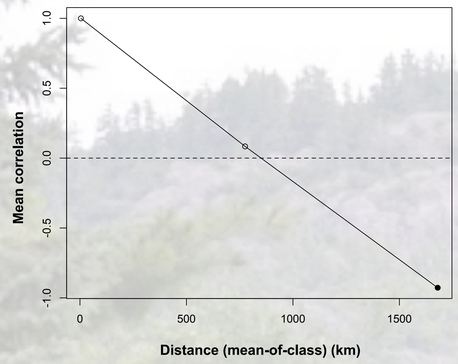

Figure 4. Correlation between mean growing season temperature at each site decreased as distance between sites increased.

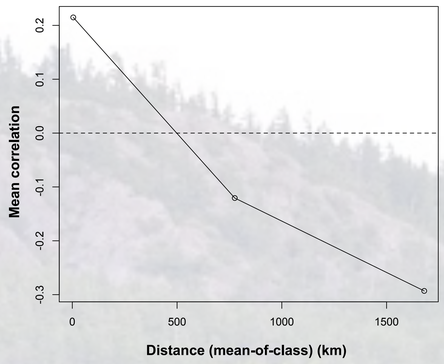

Figure 5. Correlation between mean residual growths at each site decreased as distance between sites increased.

Results – Question 2: Local Variation

- Both MI sites showed a positive relationship with mean growing season temperature, but the relationship was only significant for the inland sites (Fig. 6).
- Over a 47-year period (1965-2012), inland individuals had an average residual growth of 0.008 ± 0.32 mm greater than lakeshore sites, but the difference was not significant (two sample t-test, df = 83, t = 0.18, p = 0.86) (Fig. 7).

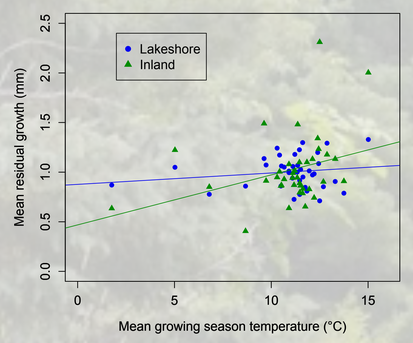

Figure 6. Mean residual growth vs. mean growing season temperature. Individuals at the lakeshore site exhibited a positive relationship with growing season temp., but the relationship was not significant (R2 = 0.026, P = 0.335.).Individuals at the inland sites exhibited a positive and significant relationship with growing season temp. (R2 = 0.109, P = 0.043).

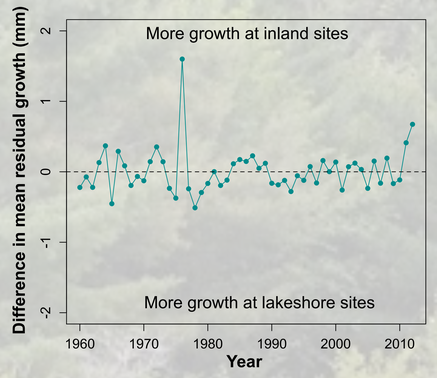

Figure 7. Difference in mean growth residuals between sites. Positive values indicate growth at inland sites was greater than at lakeshore sites. Negative values indicate growth at lakeshore sites was greater than at inland sites. The mean difference was 0.008 ± 0.32 mm.

Summary

- Mean residual growth was not significantly different over the large distance between the Michigan, Ontario, and New Brunswick sites.
- Sites further from one another featured less correlation between both temperature and mean growth of white spruce in relation to sites closer to one another.
- At both the inland and lakeshore sites, relatively high growing season temperatures corresponded with greater annual growth increments.
  - Temperature increases associated with climate change will likely increase the annual growth of white spruce near Lake Superior.
- Between 1965 & 2012, inland sites featured slightly greater annual growth than lakeshore sites.
  - The difference in growth was not significant, suggesting that there are factors other than growing season temperature affecting growth of white spruce individuals.
- Other factors, including precipitation, heterospecific competition, and access to sunlight may have more influence on growth than growing season temperature.

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