Relationships Between Climate and Growth for Northern Red Oak (*Q. rubra*), Eastern White Pine (*P. strobus*), and Eastern Hemlock (*T. canadensis*) in Northern Vermont

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Background

- Climate change poses a significant threat to the functioning of global ecosystems, and the global warming trend over the past century has resulted in a distinct shift in the ranges and distributions of important tree species (Mann, 2000; Davis & Shaw, 2001).
- Optimal climate conditions for Vermont tree species have shifted north in the past several decades (Davis & Shaw, 2001).
- This study examines how climate has influenced tree growth in northern Vermont over the last 100 years for ***Quercus rubra***, ***Pinus strobus***, and ***Tsuga canadensis*** in order to understand how these species may respond to future shifts in temperature and precipitation.
- Growth changes as a result of that shift may be reflected in ring patterns of each tree, and can be examined across a forest stand for overall impacts of climate change (Sheppard, 2010).

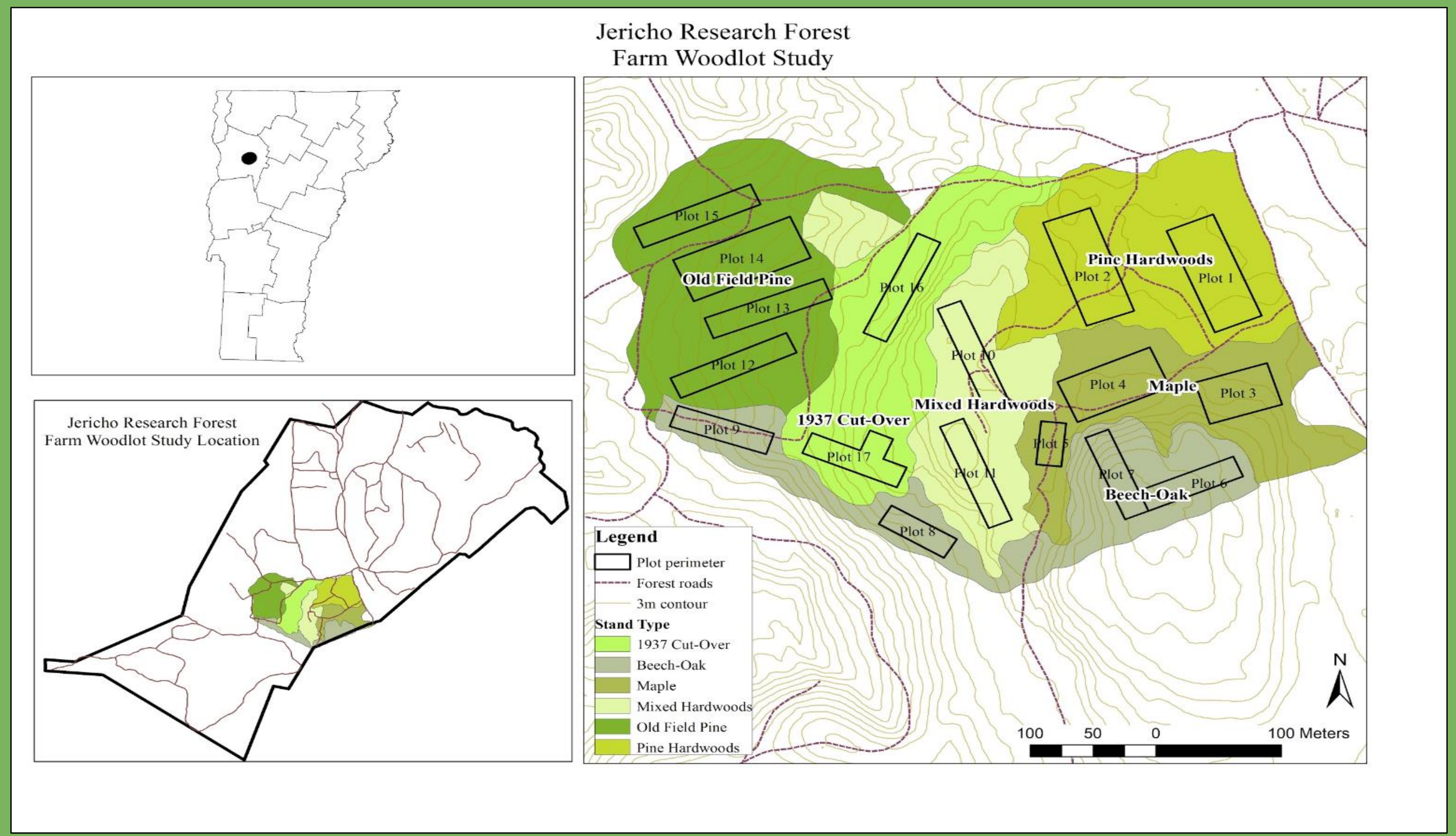

Figure 1: Map of Jericho Research Forest showing the plots sampled in the Farm Woodlot Study, of which this study is an extension.

Study Area

The University of Vermont's Jericho Research Forest is a 202.3-hectare parcel of land in Jericho, Vermont. This land is made up of five dominant forest types that became established by the 1940s, sloping hills, and varied soils.

The dominant forest types in Jericho Research Forest are northern hardwood, white pine-red maple, red oak-northern hardwood, hemlock, and pine plantations (Langlois & Carhart, 2016).

Methods

- <u>30 increment cores</u> collected from each tree species across all forest types
- Visual ring dating and ring width measurement to the nearest 0.01 mm
- Autoregressive standardization produced residual chronologies
- Climate data used from <u>1895 to 2017</u>.
- Response function analysis comparing yearly tree growth and climate parameters
- Correlations produced using the correlation coefficient *r* at significance levels 0.05 and 0.01.

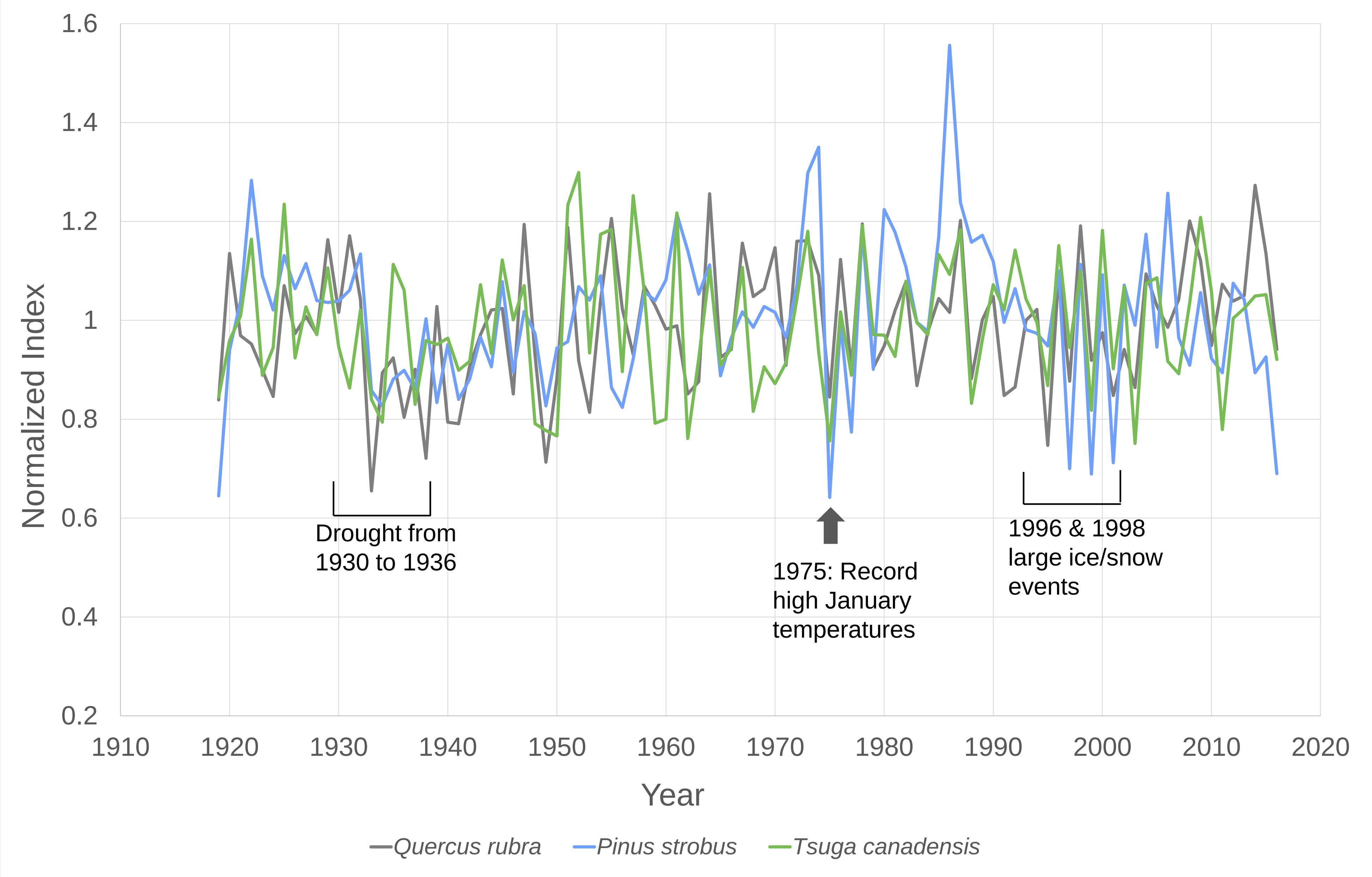

Figure 2: Master residual chronologies of *Pinus strobus, Tsuga canadensis,* and *Quercus rubra* from 1919 to 2016.

Results and Discussion

Quercus rubra yearly tree growth

- Strong positive correlations with June and July precipitation.
- Strong negative correlation with maximum June temperatures.
- Precipitation is very important to this species, and it showed greater moisture sensitivity than the other two species.
- Able to handle higher quantities of water due to its large pores, and may be negatively impacted by natural phenomena, like droughts, that become more severe as climate change worsens.

Pinus strobus yearly tree growth

- Strong positive correlation with July precipitation.
- Strong negative correlations with minimum, mean, and maximum temperatures in June.
- Vulnerable to changes in temperature, particularly shifts towards warmer temperatures.
- High temperatures in the early growing season have the potential to reduce overall *P. strobus* yearly growth.

Tsuga canadensis yearly tree growth

- Strong negative correlation with precipitation in June of the previous growth year.
- Strong negative correlations with the mean and maximum temperatures in May, and minimum, mean, and maximum temperatures in June.
- Vulnerable to changes in temperature, particularly shifts towards warmer temperatures.
- A drought-sensitive species that relies on ample moisture during its growing season.
- Of the species in this study, it is most consistently hindered by temperatures across seasons.

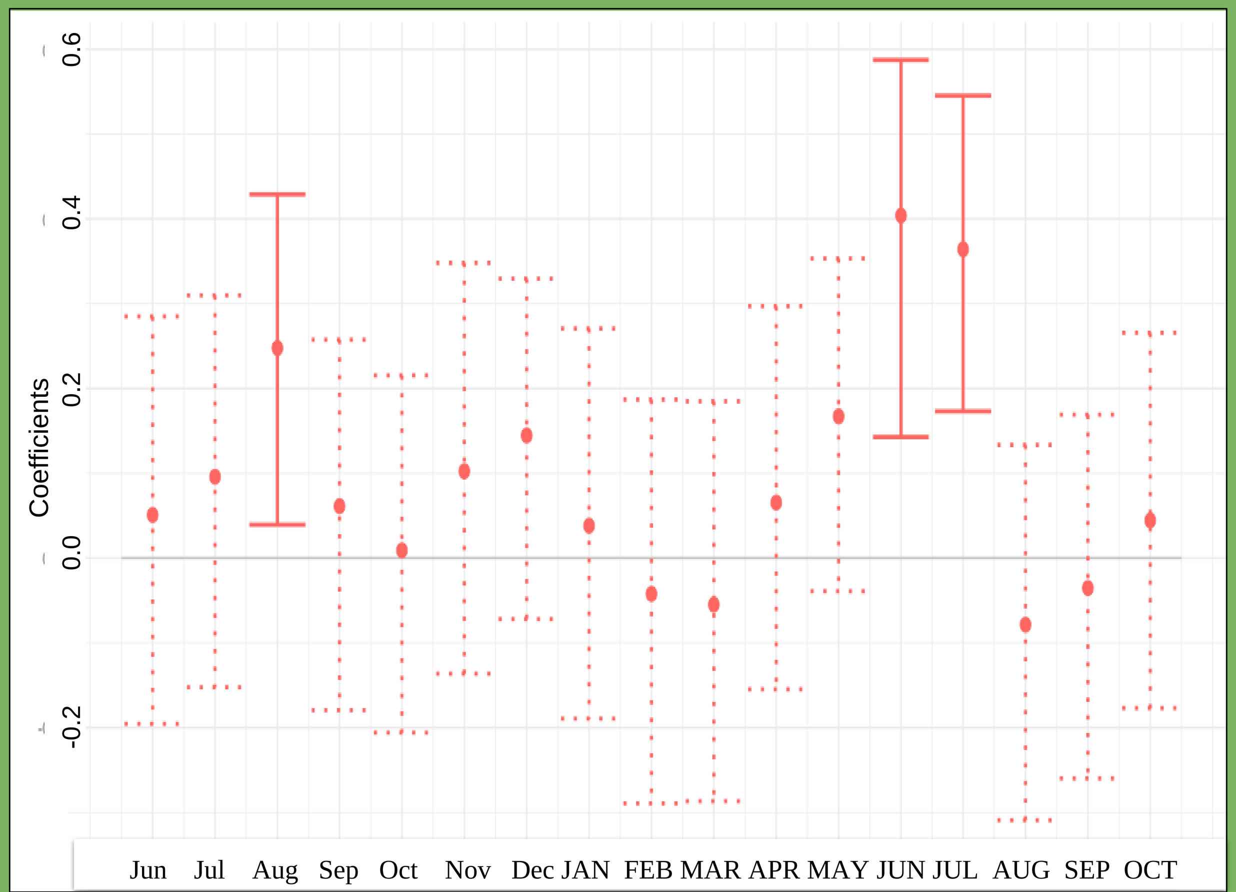

Figure 3: Response function analysis using the residual chronology for *Quercus rubra* and monthly precipitation. Solid lines indicate a significant correlation at p < 0.01. Months in lowercase letters are from the previous growth year and those in uppercase are from the current growth year.

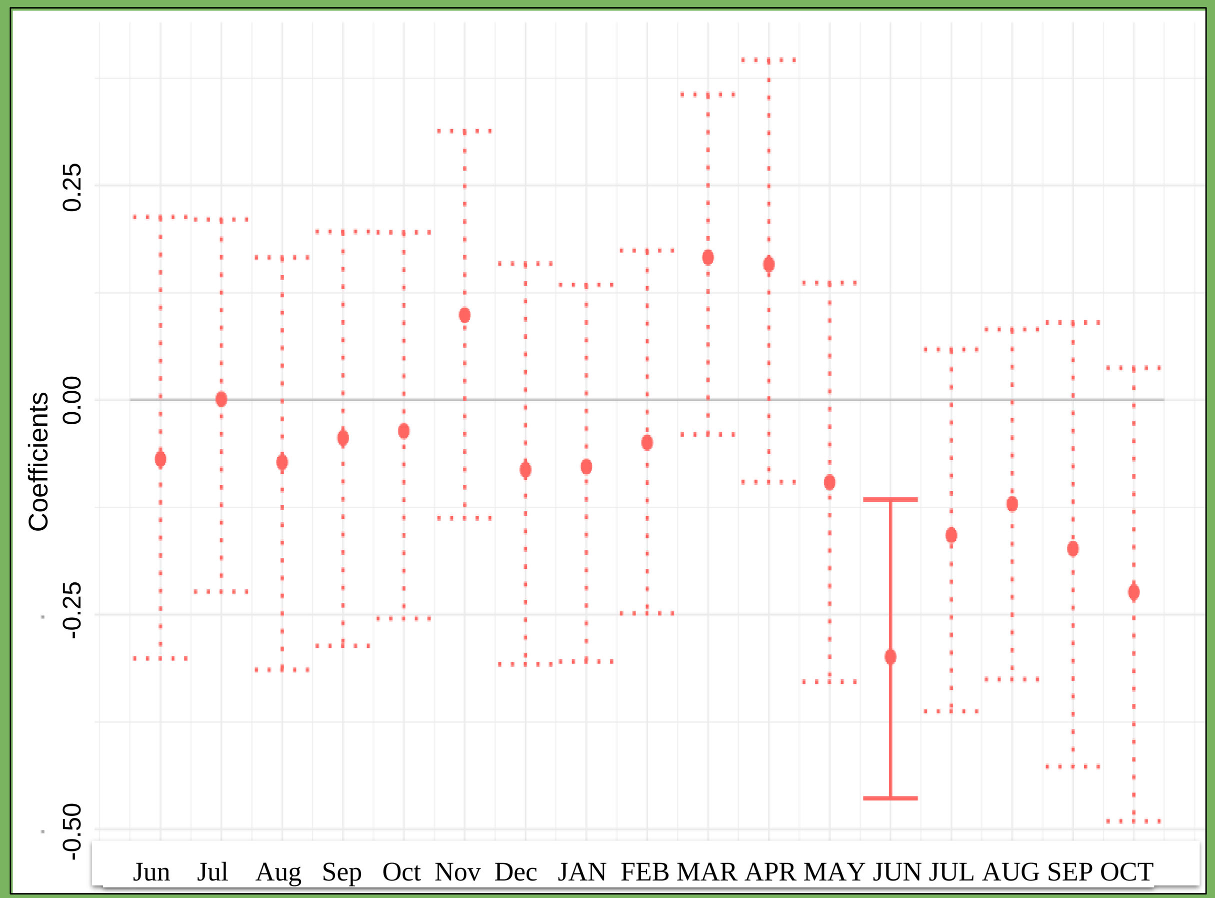

Figure 4: Response function analysis using the residual chronology for *Pinus strobus* and mean temperature. Solid lines indicate a significant correlation at p < 0.01. Months in lowercase letters are from the previous growth year and those in uppercase are from the current growth year.

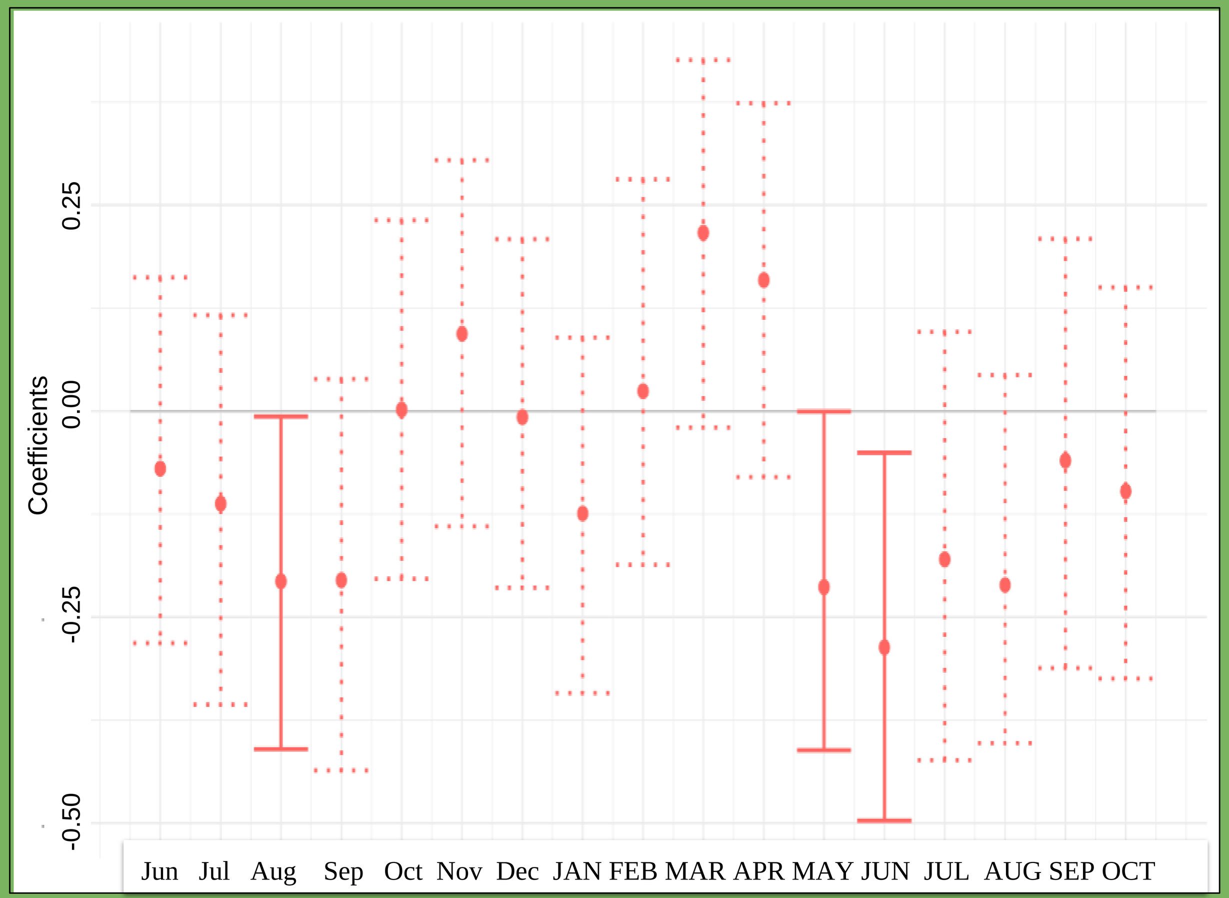

Figure 5: Response function analysis using the residual chronology for *Tsuga canadensis* and mean temperature. Solid lines indicate a significant correlation at p < 0.01. Months in lowercase letters are from the previous growth year and those in uppercase are from the current growth year.

Conclusions

These results highlight the importance of diverse species forests in conferring resilience to future climate change, as these represent a range of potential climate responses and sensitivities. Maintaining mixtures of these and other species may be an effective management strategy for ensuring a wide range of climate responses are present across the landscape. Future work on a wider range of sites and species will be critical for expanding the results of this study to the broader landscape of Vermont to inform conservation efforts and identify vulnerable trees species.

Acknowledgements

I want to thank Anthony D'Amato and Peter Clark for their contributions and guidance throughout this project. I'm also grateful for the help and continued support of Allan Strong, Jennifer Pontius, Rebecca Stern, and Paula Murakami.

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