# <u>Minnesota drought history reconstructed from bur oak (*Quercus macrocarpa*)</u>

## Introduction

Climate change poses a defining challenge in the 21st century and its environmental impacts continue to be examined. In Minnesota, rising temperatures associated with climate change are expected to exacerbate drought and moisture loss due to evapotranspiration (Cook et al., 2014). Heightened frequency and severity of drought in Minnesota will increase plant stress (Williams et al., 2013), and will thus be a concern of agriculturalists, forest resource managers, and citizens throughout the state. Understanding how historical drought patterns varied in Minnesota is key to assessing current drought status and predicting future climate across the area. Dendroclimatology, the study of the relationships between tree growth and climate, has been a useful tool in research on drought and climate change. Tree-ring chronologies serve as powerful natural proxy archives, allowing researchers to utilize long records of climate sensitive annual tree-rings to compare the climate of today to the past (Sheppard, 2010).

Climate reconstructions from tree rings play a prominent role in understanding historical climatic variability and drought. Although traditional weather stations serve as accurate climate records, tree-ring chronologies uniquely capture climatic conditions over hundreds of years and can be extended further into the past using statistical models. Several studies have assessed the dendroclimatic potential for tree rings in Minnesota (Kipfmueller et al., 2010; Wertz et al., 2013). However, these papers did not explore drought specifically and were focused solely in Northern Minnesota. In contrast, Cook et al. (2004) reconstructed regional soil moisture from tree-rings to study drought, a project termed “The North American Drought Atlas”. The Drought Atlas spans across Minnesota, but is notably limited by a lack of tree-ring data in southern regions of the state. Working alongside Professor Daniel Griffin, I will research *Quercus* *macrocarpa*, an oak tree species that is native to prairies and stream edges in southern Minnesota. I will develop a chronology of this species to determine the extent to which current drought patterns in Minnesota are analogous to droughts in the pre-instrumental period. Considering recent anthropogenic climate change, I hypothesize that droughts in the pre-instrumental period were generally not as frequent or severe as recent droughts. Prior research findings by Daniel Griffin demonstrate that dendrochronology is a suitable field to study the relationship between tree-rings and climate in this respect.

**Methods**

Appropriate site selection will be determined using the Minnesota DNR Forest Stand Inventory, a GIS shapefile that identifies pockets of old-growth forest in Minnesota. Sampling sites will be targeted in southern Minnesota at selected Scientific Natural Areas and State Parks (Figure 1). Building upon previous field research experience, I will accompany Daniel Griffin in the field to collect *Quercus macrocarpa* samples in Fall 2017. I will collect approximately 40 tree-ring series using an increment borer and standard dendrochronological techniques (Fritts, 2001).

I will prepare tree-ring core specimens using laboratory analysis techniques standard in dendrochronology (Fritts, 2001). Core samples will be dried, mounted upon a block, and sanded using progressively finer grit. I will assign precise calendar dates to each annual ring using cross-dating, a process whereby ring-width patterns are compared within and between trees at the site. Using a stage micrometer, I will measure the width of each annual growth ring to the nearest 0.001 mm. COFECHA software will statistically check the assignment of calendar dates and serve as quality control.

With guidance from Daniel Griffin, I will use ARSTAN software to standardize my created time series to remove trends in tree-ring widths such as bole geometry and age-related vigor, trends unrelated to climate variations. Using Pearson correlations, I will identify the climate variable that most strongly controls ring-width variation. Climate and tree-ring data over only the common period will be used to calibrate the tree-growth record. After assessing the growth-climate relationship with a series of verification statistics, I will project the time series into the past to determine historical drought patterns in Minnesota.

I am requesting $272 in additional funds for this project. These additional funds would be solely used to purchase a Haglöf 16”, 2-Thread, 5.15 mm increment borer. The increment borer is the primary tool used to extract tree-core samples, making it essential equipment for my project. Increment borers frequently break while coring due to tree knots and imbedded metal objects in trees, and are thus considered expendable.

**Merits of Research**

This project would deepen the skills I have developed in the field of dendrochronology over the previous semester. After developing a *Quercus macrocarpa* chrononology, I intend to store my data publically through the International Tree-Ring Databank. In addition, my project would help address the dearth of tree-ring data in southern Minnesota. An updated North American Drought Atlas would benefit from increased tree-ring coverage in this area. Finally, understanding historical drought patterns are essential to managing the risks of climate change induced drought. I believe this project could play a small part in developing such an understanding.

**References Cited**


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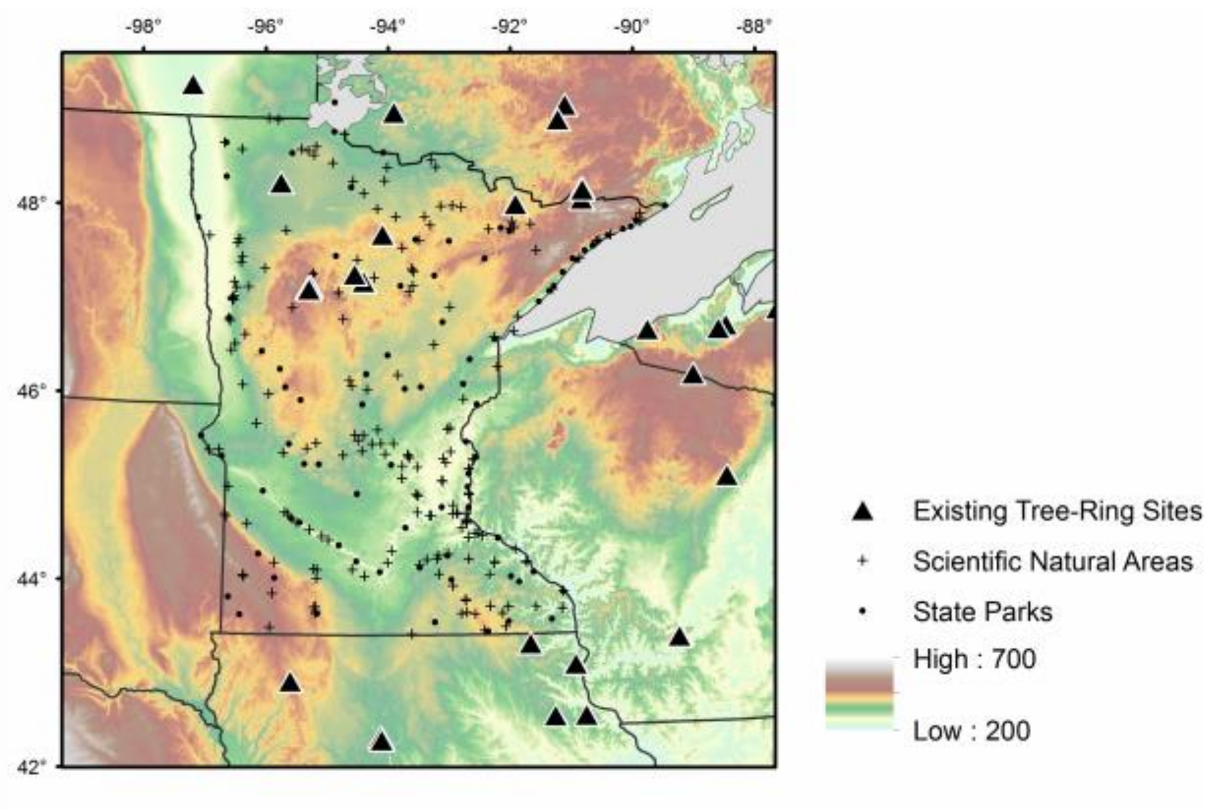


*Figure 1. Map of Minnesota Study Area*
Triangles indicate existing tree-ring sites, none of which are in southern Minnesota. *Quercus macrocarpa* samples will be specifically targeted in southern Minnesota at Scientific Natural Areas (crosses) and States Parks (dots).
*(courtesy Daniel Griffin)*