Forest age and disturbance pattern history at Eagle Lake, Rowan County, Kentucky

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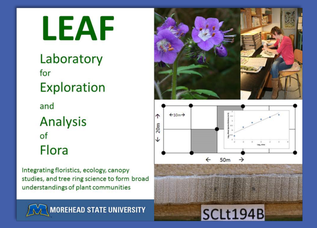


Abstract

Dendrochronology is the dating and study of annual rings in trees. It can be used to determine the history of a forest stand, better recognize past and current environmental processes and conditions, and to improve the understanding of future environmental issues. Thus, tree ring dating can help determine stand initiation dates and what environmental stresses have occurred since its establishment. Five 20x20 meter plots were randomly located and assessed within the Eagle Lake watershed. With an increment borer, two samples were taken from each tree measuring 10 cm or more in diameter at breast height (DBH). Each core was dried, glued to a mount, and sanded to expose the annual rings. The cores were examined and cross dated by at least two researchers. After cross dating, the ring widths of various species were measured using a Velmex measuring system. COFECHA, quality control software, was used to confirm ring dates. Inner ring dates and ring width values were used to determine establishment pulses and disturbance patterns. Release events were determined with a percent release calculation using the formula $[(m_2 - m_1)/m_1] \times 100$, where m = median ring width.

Introduction

Forests are large, complex ecosystems that provide habitat for a variety of organisms. Trees are an important component of forests because they provide an extra level of forest diversity, are habitats for several types of organisms, are vital in nutrient cycling, and have many socioeconomic benefits. Trees can also give us clues about past weather conditions and disturbance patterns in their environments. The study of dating tree rings and correlating them to past events is called dendrochronology.

Tree rings can vary in width, and the variation between small and large rings can indicate the occurrence of wide scale disturbance events in years past. To confidently identify these wide scale events, tree samples must be carefully extracted, prepared, examined for tree ring growth, and statistically analyzed. Samples can be compared to one another to create a master chronology, which can be used to indicate the exact year of a stand wide disturbance or weather related event. A branch of dendrochronology, dendroecology, utilizes tree rings in order to interpret past ecological events such as fire history, insect outbreaks, and release events.

Release events result from changes in a tree's environment or a disturbance. For example, a tree falling from the codominant canopy position eliminates a source of competition for the intermediate and overtopped trees. It is typical for the trees located in the forest understory to have small ring widths due to competing with other large, dominating trees. This event would cause the tree ring widths of the smaller trees to increase, allowing them to potentially achieve codominant status. The sudden increase in tree ring widths would be classified as a release event.

The objectives of this study were: (1) to determine stand initiation dates and (2) to compare the number of release events on a per tree basis for *Acer rubrum* (red maple) and *Quercus* (oaks). The null hypothesis for objective 2 was that the number of release events for *Acer rubrum* and *Quercus* would be the same.

Methods

Study Area

The study area was the Eagle Lake watershed, near Morehead, KY (Figure 1). The lower region of the Eagle Lake watershed is owned by Morehead State University, and the upper region is owned by Daniel Boone National Forest. The lake is surrounded by an oak-hickory forest dominated by white oak, black oak, mountain chestnut oak, pignut hickory, mockernut hickory, American beech, and red maple. The area receives approximately 46 inches of rain and 7 inches of snow annually. On average, 76 days experience precipitation. The July high and January low are 88 and 25 degrees, respectively. (http://www.bestplaces.net). The elevation of the Eagle Lake watershed ranges from 810-1240 feet.

Geologically, the Eagle Lake watershed is primarily composed of the Borden Formation, including the Nancy member. The Nancy is a thin-bedded siltstone in the lower slopes of the watershed (Kentucky Geological Survey, 2019).

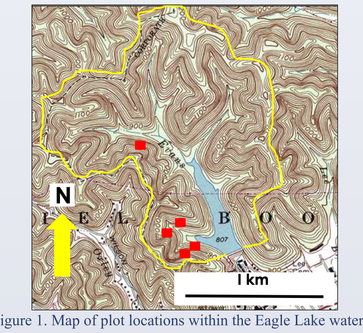


Figure 1. Map of plot locations within the Eagle Lake watershed.

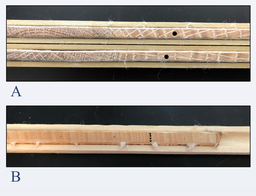
Field and Laboratory Methods

Five 20 X 20 meter plots were established randomly in the forest of the Eagle Lake watershed. With an increment borer, two samples were taken from each tree within the plots measuring 10 cm or more in diameter at breast height (DBH) (Figure 2). Each core was labeled, stored in a straw to take back to the lab, and tied to a wooden mount to dry for approximately 72 hours. After drying, the cores were all glued to the mounts and sanded using a 120, 150, and 320 grit/in sanding belt, then using 30, 15, and 6 micrometer hand sanders to expose the annual rings (Figure 3). The cores were examined, dotted, and cross dated by at least two researchers (Figure 4). Ring widths were measured using a Velmex measuring system (Figure 5). COFECHA, quality control software, was used to confirm ring dates.

Inner ring dates and ring width values were used to determine establishment pulses and disturbance patterns of the Eagle Lake watershed. Establishment pulses were determined by species, canopy position, and overall by comparing the inner ring dates of individual trees. Release events were determined with a percent release calculation using the formula $[(m_2 - m_1)/m_1] \times 100$, where m_2 = mean ring width of the superceding 10 years and m_1 = mean ring width of the preceding 10 years. Minor releases were defined as those between 25 and 50%, and major releases were 50% or greater. A Mann-Whitney U-test was used to compare the number of releases among *Quercus* and *Acer rubrum*.

obtain a core sample.

annual rings.



A

B

Figure 4. Core samples exhibiting a single dot for a decade (A) and four dots for a millennium (B).

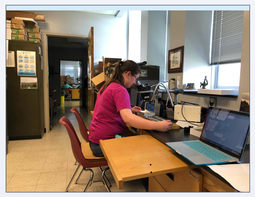


Figure 5. Measuring annual rings using a Velmex measuring system.

Results

A significant establishment pulse at Eagle Lake occurred in the 1920s (Figure 6). Codominant trees in the plots established between 1880 and 1900, with *Quercus alba* establishing between 1892 and 1900 (Figure 7).

Percent release calculations for *Acer rubrum* and *Quercus* (oaks) indicated both species experienced several major and minor releases. Most major releases occurred beginning in the 1960s, and minor releases were sporadic throughout all samples. The greatest major peak release was at 423.88% in *Quercus montana*, with the lowest major peak release at 50.48% in *Quercus alba*. The greatest minor peak release was at 49.98% in *Quercus alba*, with the lowest minor peak release at 25.04% in *Quercus montana*. *Quercus* had 12 major and 26 minor releases total, and *Acer* had 16 major and 29 minor releases total. Most *Acer rubrum* releases occurred in the 1960s, while *Quercus* releases occurred mostly in the 1980s (Figure 8). Both *Acer rubrum* and *Quercus montana* experienced peak releases in 1964 and 1980. In total, 26 major release events occurred among all trees evaluated. On average, *Quercus* and *Acer rubrum* experienced 1.22 and 1.85 major releases per tree, respectively. A Mann-Whitney U-test indicated a z-score of -1.799 and a p-value of 0.0719.

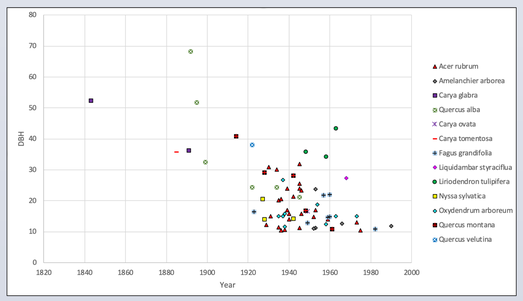


Figure 6. DBH and inner ring date for all trees from all plots.

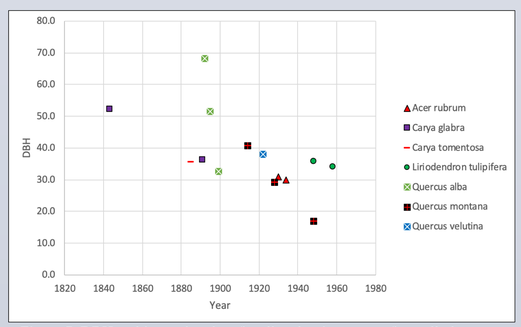


Figure 7. DBH and inner ring date for all codominant trees from all plots.

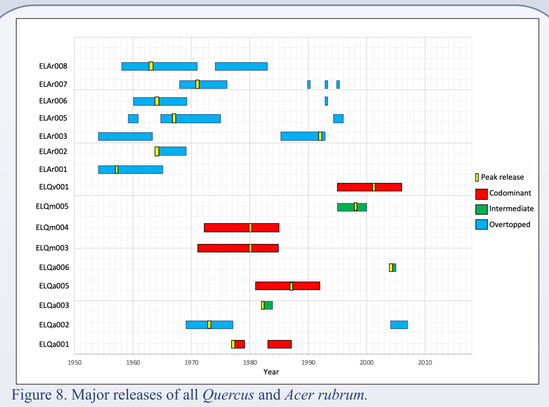


Figure 8. Major releases of all *Quercus* and *Acer rubrum*.

Discussion

The establishment pulse of the Eagle Lake forest suggests the stand originated after a stand-initiating disturbance, such as clear cutting, occurring around 1920. This pulse is consistent with establishment pulses in Murphy Tract, Wrights Woods, and Watter Smith State Park located in West Virginia and Pennsylvania, where the oldest trees dated back to well-defined time periods of 1650, 1665, and 1690, respectively (Rentch et al., 2003). Results indicated *Carya glabra* was the oldest tree established within the plots at Eagle Lake, but *Quercus alba* showed a prevalent establishment pulse in the 1890s. Rentch et al. suggest that oak establishment tends to be fixed in time or continuous, which is consistent with the forest establishment at Eagle Lake forest (figure 6).

The major release events of *Quercus* indicate some disturbance occurred that enabled oaks to reach a codominant canopy position, based on their releases occurring an entire decade after *Acer rubrum*.

Peak releases were sporadic, suggesting trees experienced local asynchronous release events rather than a stand-wide disturbance. Though two peak releases occurred simultaneously in 1964 and 1980, this is not enough synchronicity to state there was a large disturbance to allow these trees to release. In the Cumberland Plateau forest, 88 release events were detected from 53 trees, but other than in 1980, the disturbance regime was characterized by small-scale release events (Hart and Grissino-Mayer, 2008). The data collected at the Cumberland Plateau was similar to results concluded at Eagle Lake.

Because the p-value for the Mann-Whitney U-test was greater than 0.05, the number of release events in red maple and oaks were not significantly different. Though this is similar to results for Cumberland Plateau forests (Hart and Grissino-Mayer, 2008), the lack of significance may be due to a small sample size.

Literature Cited

Hart, J. L., Grissino-Mayer, H. D., 2008. Vegetation patterns and dendroecology of a mixed hardwood forest on the Cumberland Plateau: implications for stand development. Forest Ecology and Management 255: 1960-1975.

Morehead, Kentucky Climate. (n.d.). Retrieved April 10, 2019, from http://www.bestplaces.net/climate/city/kentucky/morehead

Rentch, J.S., Fajvan, M.A, Hicks Jr., R. R., 2003. Oak establishment and canopy accession strategies in five old-growth stands in the central hardwood forest region. Forest Ecology and Management 184: 285-297.