# Extending and Interpreting the Tree Ring Chronology for Lilley Cornett Woods

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**EKU Biology REU – Disturbance Ecology in Central Appalachia**

## Introduction

Anthropogenic climate change is expected to alter temperature and precipitation regimes and impact trees and forested ecosystems around the world (1,2). The state of Kentucky is expected to face more extremes in precipitation with both flooding and more severe droughts (3,4). While some trees may benefit currently and in the near future due to warmer temperatures and increased precipitation, there may be potential long-term negative effects, such as those from more severe drought and increased fire (1,3,4). A better understanding of how different forests are going to be impacted by climate change is critical for forest management to make the best decisions for our forests. Furthermore, climate change may be exacerbated if trees are unable to sequester carbon as well as they have been due to the impacts of climate change (1). One way to investigate the impact of changing climate conditions on tree growth is dendrochronology.

Dendrochronology is the study of tree rings and the events recorded in them. The growth rings of a tree reflect changing environmental conditions, including disturbance and climate. Old trees provide the tree-ring data necessary to (1) examine change over long time periods, (2) give context to the current climate crisis, and (3) reveal how trees are being impacted by climate change. In the state of Kentucky, however, such old trees are hard to find. Lilley Cornett Woods (LCW) represents one of few old-growth tracts in the state. Edward Cook constructed a tree-ring chronology for white oak (*Quercus alba*) from LCW, but this chronology only extends to 1982 (5). To examine how the last four decades of climate and environmental change have impacted trees in LCW, more data are necessary. The objectives of this REU project were to (1) extend the tree-ring chronology for LCW to the present and (2) investigate the climate-growth response of LCW trees over time. We expected that as Kentucky has become wetter overall, trees have become less responsive to precipitation changes.

## Methods

We collected two cores from each of 36 downed trees at LCW using an increment borer. The species included *Quercus alba* (white oak), *Quercus prinus* (chestnut oak), *Quercus velutina* (black oak), *Quercus rubra* (red oak) and several other non-oak species. After the cores dried, we mounted them on wooden mounts with white glue and sanded down to make visible the cells of the wood (6). Because the trees sampled were dead, we first relatively dated the tree rings on each sample, placing a pencil mark on every 10th ring observed through a microscope. We measured the ring widths using CooRecorder and Cdendro (7, 8).

We performed relative and absolute dating of the tree-ring samples using moving correlation analyses in the software COFECHA (9). We first crossdated the unanchored or “floating” series from each dead tree against the others and then dated all of the floating series against Cook’s LCW chronology from 1982 (5). Many of the trees were old and contained suppressed growth, making them more difficult to crossdate well. For the purposes of the REU, we selected paired series (i.e. two from the same tree) that crossdated well to develop a final tree-ring chronology from all four species of oak and conduct climate-growth analysis. To minimize age and ecology-related growth trends and maximize the climate signal, we standardized the data using a 32-year spline in the R package dplR (10). We then conducted climate-growth analyses in the R package treeclim (11).

## Results

The final oak tree-ring chronology had a series intercorrelation of 0.512, included 42 series from 21 trees, extended from 1688 to 2020, and contained 53 flagged segments of a total 319 segments. We checked the problem segments to make sure they were accurately dated and corrected identified measurement errors. We identified significant, temporally-stable relationships between tree-ring widths and some climate variables (Table 1). The strongest correlations were with May and June precipitation and drought-related variable (Figure 1).

| Month and variable | Coefficient, r |
|---|---|
| May, precip<br>June, precip | 0.337*<br>0.330* |
| June, Tmean | -0.269 |
| (Aug), Tmax<br>June, Tmax | -0.182<br>-0.292* |
| June, VPDmax<br>Oct, VPDmax | -0.244*<br>0.193 |

**Table 1.** *Month, climate variable, and coefficient r. * indicates the correlation was temporally stable. T indicates temperature, and VPD indicates vapor pressure deficit* (12)

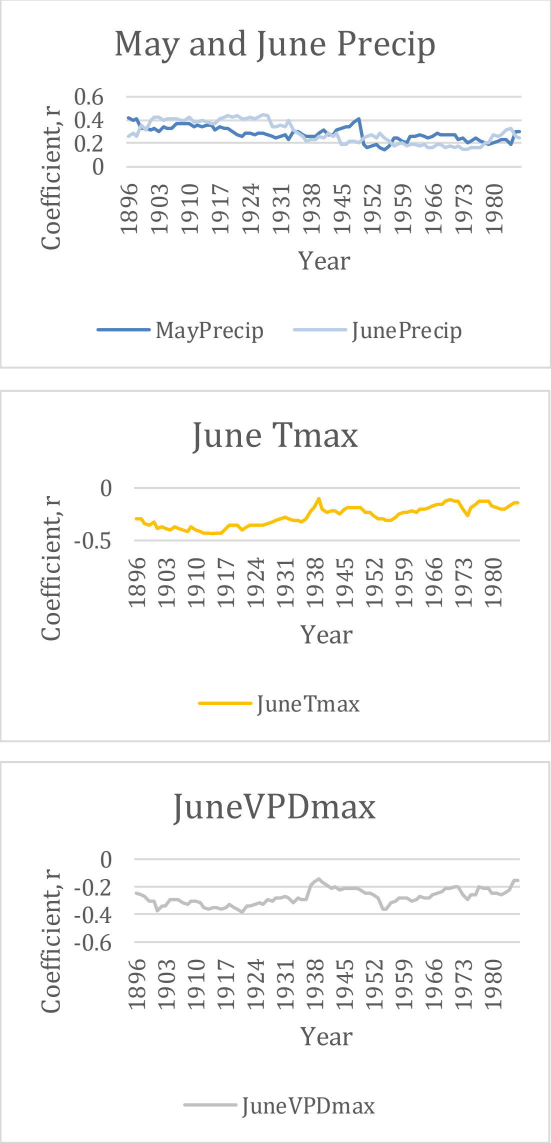

**Figure 1.** *Correlation between variables, months, and tree-ring widths through time. Year indicated on graph represents the first year of the moving window (35 years) (12).*

## Discussion

Through this project, we extended the tree-ring chronology for Lilley Cornett Woods into the present. Furthermore, we found that May and June precipitation were positively correlated with tree-ring widths, while June maximum temperature and maximum vapor pressure deficit were negatively correlated with tree-ring widths. Higher temperatures coupled with lower precipitation increase drought stress on trees during early portion of the growing season. This indicates that the early growing season being wet and cool is the most beneficial for the trees, while it being drier and warmer can put drought stress on the trees and limit their growth that year.

Based on the findings from this preliminary work, we reject the hypothesis, as relationships between tree growth and precipitation remained stable over time, with some variability. The correlations between May and June precipitation, maximum temperature, and maximum VPD may fade out for periods of time, but have returned or remained temporally stable over the full instrumental period (Figure 1).

## Conclusions and Next Steps

Overall, we extended the tree-ring chronology for LCW and in performing climate-growth analysis, found that the main climate drivers of tree growth are early growing season moisture conditions. We also found that the climate signal is not fading, as we had predicted. However, while trees may benefit from increased precipitation immediately, it could eventually become too wet. Additionally, increased precipitation may benefit other threats such as insects and invasive species, and more extreme weather events could damage trees.

We will continue to build LCW chronologies and use tree-ring data to analyze past and present climate and ecological disturbances at LCW. Such work remains important as Kentucky forests face ongoing climate change and can inform forest management decisions.

## References

(1) Keenan, R.J.. (2015) Climate change impacts and adaptation in forest management: A review. *Annals of Forest Science*, 72, 145-167.

(2) Stocker et al. (2013) Climate change 2013: The physical science basis. *Intergovernmental Panel on Climate Change*.

(3) United States Environmental Protection Agency (2016) What climate change means for Kentucky. Accessed July 2021.

(4) Runkle, J. and Kunkel, K.E. (n.d.) Kentucky state climate summary. *NOAA National Centers for Environmental Information*. Accessed 12 July 2021.

(5) Cook E.R. (n.d.) NOAA/WDS Paleoclimatology - Cook - Lilley Cornett Tract - QUAL - ITRDB KY003. *NOAA National Centers for Environmental Information*. Accessed 14 June 2021.

(6) Speer, J.H. (2011) Fundamentals of Tree Ring Research. *The Arizona Board of Regents*.

(7) Cybis. (2021) CooRecorder. Accessed 2021.

(8) Cybis. (2021) CDendro. Accessed 2021.

(9) Holmes, R.L. (1983) Computer-assisted quality control in tree-ring dating and measurement. *Tree-Ring Bulletin,* 44, 69-75.

(10) Bunn, A., et al. (2021) Dendrochronology program library in R. Accessed 29 July 2021.

(11) Zang, C., & Biondi, F. (2015) treeclim: an R package for the numerical calibration of proxy-climate relationships. *Ecography*, 38(4), 431–436.

(12) Northwest Alliance for Computational Science and Engineering. (2021) PRISM climate data. *Oregon State University*. Available at <u>https://prism.oregonstate.edu/</u>. Accessed 29 June 2021.