A Dendrochronological Study of Jeffrey Pine for Drought Reconstruction in the Cascade Creek Watershed Lake Tahoe, California

Michelle Danielle Mohr
Department of Earth Science and Geography, California State University Dominguez Hills

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Advisor: Dr. Parveen Chhetri, Department of Earth Science and Geography, California State University Dominguez Hills

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ACKNOWLEDGEMENTS

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This project was made possible by my internship advisor Dr. Parveen Chhetri, who dedicated his patience and time to mentoring his students and this research.

EXECUTIVE SUMMARY

To understand how our current changing climate is impacting the forest ecosystem of northern California, I collected tree ring cores from Jeffrey Pine (*Pinus Jeffreyi*) subalpine forest in Lake Tahoe, CA. For this project I conducted a dendrochronological study of the Cascade Creek Watershed, which rests in the valley between Mt. Tallac and Maggie's Peak. The creek feeds Cascade Lake, a tributary lake that flows into the southwest corner of Lake Tahoe. The location of this watershed made it a prime area for a dendrochronology study to analyze the conditions influencing the forest ecosystem in the northern Sierras. Twenty-six Jeffrey Pine trees were cored to examine the variation in annual growth patterns. Years of restricted growth or robust growth were noted and flagged in our measurements. Specifically, narrow growth years were studied to understand how they may have correlated with known years of drought in the region. A 374-year chronology was constructed from the sample set, containing 48 cores. Standard dendrochronological procedures were used to obtain and analyze the samples. The chronology was truncated to 244 years (1775-2018) based on subsample strength and sample depth. The years 1757, 1782, 1886, 1859, 1876, 1920, 1929, 1977, 1988, 2001, 2002, 2008 exhibited low growth (narrow ring) and years 1747, 1749, 1792, 1828, 1866, 1868, 1913, 1969, 1984 exhibited robust growth (wider ring). No recent increasing trend of ring width was observed in 10 years moving average of the ring width index (RWI). However, the transformation of ring width to basal area increment (BAI) showed an increasing growth trend in recent decades. BAI also indicated that 1928-30, 1987-1989, and 2013-2014 were low growth periods associated with extreme drought events. BAI presents a better spatial correlation with monthly climatic variables than RWI. Thus, BAI has an advantage over RWI in studying tree-ring growth and climate response.

PROJECT OBJECTIVES

For this project, I set out to core three different species of trees in the Cascade Lake Watershed, in order to better understand past climate events that occurred in the region. I revised this to focus on one species, Jeffrey Pine. This species is known for its tolerance to drought-like conditions and was the dominant species in the area. This project introduced me to fieldwork and the task of adapting to the research available and bringing back data obtained firsthand from the field to analyze in the lab. This research allowed me to see the cycle of the scientific process. I was starting with a question of what would be the best way to understand past climate events in the area, studying the science of dendrochronology to understand this type of proxy data, going out into the field to retrieve the samples, and bringing it back to the lab to understand and reconstruct past climate events. This project has helped me to understand better the broad field of Paleoclimate which I hope to ultimately obtain my Ph.D. in and work with different organizations in order to understand global climate phenomena better.

PROJECT APPROACH

To start the project, I had to first learn about the science of dendrochronology. This included different literature such as reading books published about science, and various scientific papers in order to comprehend the basics of this type of proxy data. The literature review also helped to understand the research gap in this field. I met weekly to discuss the readings and plan our future trip out into the field site. I was able to start with a tutorial project on campus which allowed us our first hands-on training in the "field" with extracting cores using an increment borer and the standard dendrochronological procedures to crossdate and measure the samples. I then took these samples and got hands-on experience with generating a tree ring chronology by taking the measurements obtained using the Velmex tree measuring system and using statistical programs such as COFECHA and ARSTAN, which allowed us to crossdate, standardized and detrend samples, flagging measurements that stood out as mistakes. The output of the chronology was then put into a dplR program in R to graph Ring Width Index (RWI) chronology graph. RWI was used and converted into Basal Area Increment (BAI) quantifying the amount of biomass a tree would have accumulated each year. These two analyses, RWI being the standard used in dendrochronology, and BAI which is not widely used in dendrochronology, offer a detailed overview of climate history in the region. The goal was to compare the two outputs generated by each analysis and determine if they differed from one another. The comparison would also include a known drought history of the region, to determine if years of low growth were synchronous with years of known drought in the area.

PROJECT OUTCOMES

I took the results from the data, which was used to create both a Ring Width Index (RWI) analysis and a Basal Area Increment (BAI) analysis. I wanted to determine if RWI results, which is the standard analysis method used in dendrochronology, differed from the BAI results. RWI registered the years 1757, 1782, 1886, 1859, 1876, 1920, 1929, 1977, 1988, 2001, 2002, 2008 exhibited low growth (narrow rings) and years 1747, 1749, 1792, 1828, 1866, 1868, 1913, 1969, 1984 exhibited robust growth (wider rings). No recent increasing trend of ring width was observed in the 10 years moving average of RWI.

RWI was then used with DBH to quantify BAI in order to better understand if either analysis varies in climate signal strength our samples were giving off. It was determined through the comparative analysis that although RWI flagged years of known drought correlating with years of narrow growth in the trees, BAI picked up on other years also associated with drought that were not previously registered in RWI. BAI indicated that 1928-30, 1987-1989, and 2013-2014 were low growth periods associated with extreme drought events not previously detected in RWI. BAI also showed a growth trend occurring in the past decade which was not shown in

RWI. This comparison allowed for a verification of the data, and a way to understand how the climate influenced the overall bio-productivity of the trees.

This project has taught me many valuable lessons when it comes to research. The ability to adapt in the field, (and other environments) such as the lab is especially important to a new-student researcher. I learned that when it comes to accuracy, remeasuring and spending time with the data is key. Before this project, I was unfamiliar with any of the instruments used to conduct dendrochronology research. With dedicated time and multiple in-person tutorials from my mentor, I was able to conduct this research from start to finish, both in the field and in the lab. I've also had the chance to present my research multiple times, in student presentations, and class environments as a guest speaker, and at conferences as a presenter. These opportunities have allowed me to actively convey my research to others while improving my communication, presentation, and leadership skills.

CONCLUSIONS

In conclusion, a dendrochronology study highlighting the comparison between two different analyses, RWI and BAI, deemed valuable because it allows for detailed growth analysis and a way to verify the data to gain further information on overall tree response. The conversion of RWI to BAI proved useful in the reconstruction of the region's climate history. This study is essential in understanding how future changes in climate may impact us on a regional and global scale. For further research, I would want to do a detailed climate reconstruction of the region to understand how past climate variables such as precipitation and temperature have influenced the growth of trees. This would expand our current understanding of how these trees have reacted to past climate changes and how they may be susceptible to future changes in climate.

APPENDICES

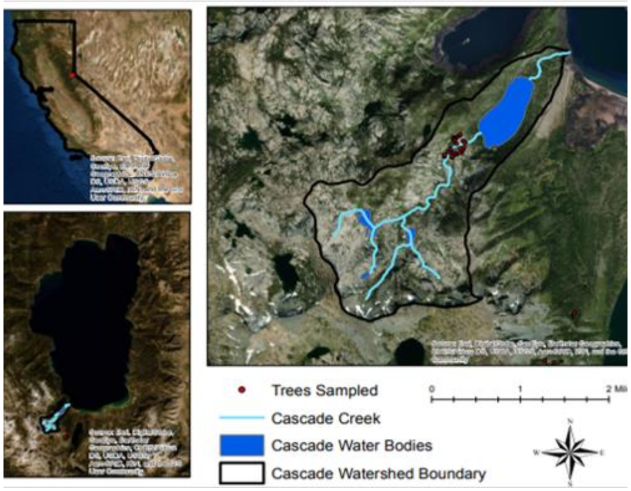

Figure 1. Study Area Map of Cascade Creek Watershed in Lake Tahoe, CA.

Figure 2. Student research Gabriel Angulo using increment borer to obtain core.

Figure 3. A photograph taken of a core with distinct rings directly after being removed from a Jeffrey Pine tree.

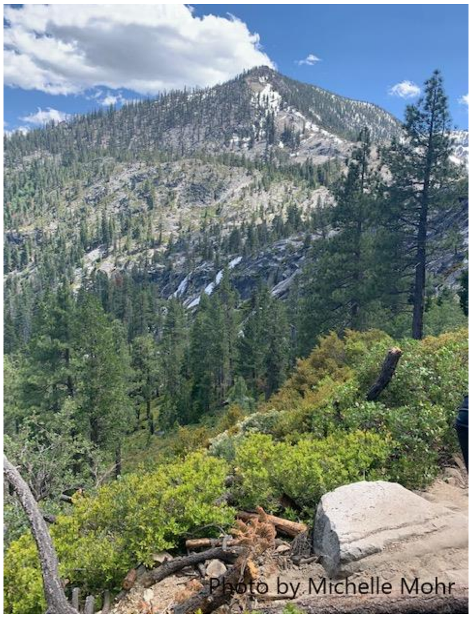

Figure 4. This is an image taken in the field of Mt. Tallac which is in the eastern portion of our study area. The picture centers Cascade Falls, which is overlaid by a dense Jeffrey Pine forest.

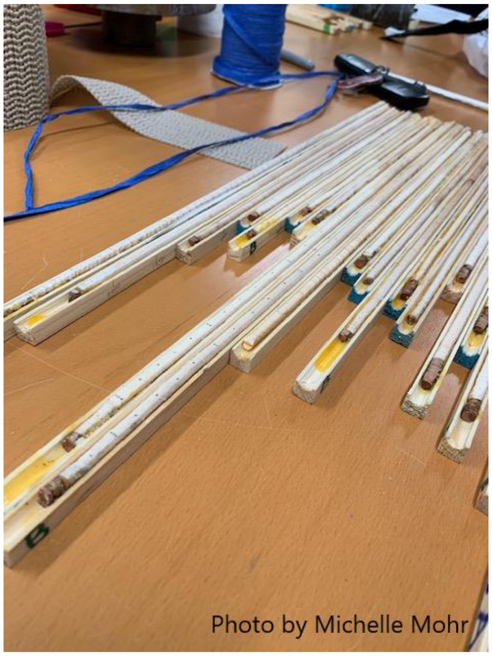

Figure 5. Samples were mounted onto wooden structures, which were custom made by CSUDH students in the Tree Ring Lab.

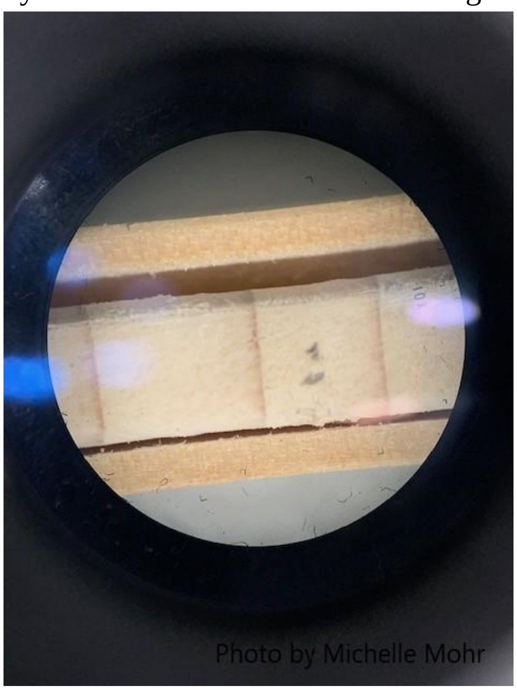

Figure 6. Samples were first dated by hand-counting each ring, giving each decade one dot, half a century two dots, and a full century received three dots.

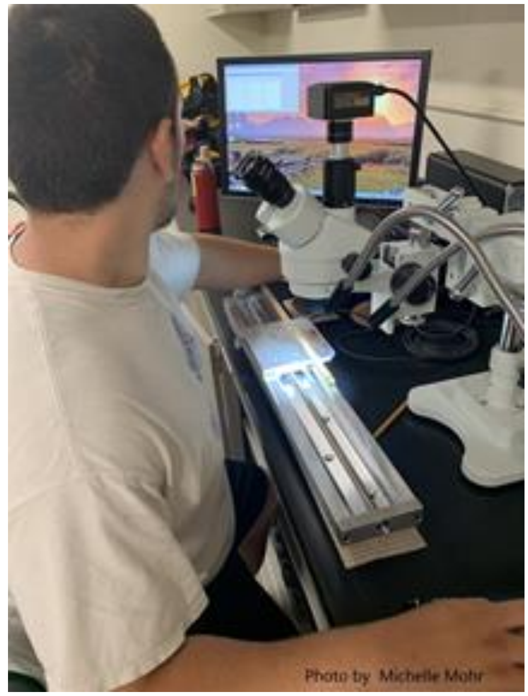

Figure 7. Student researcher Gabriel Angulo recording measurements of a sample using Velmex Tree-Ring Measuring System.

Variables	
No. of trees (cores)	20(30)
Chronology length	371 (1648–2018)
Mean ring width (mm)	1.51 (SD =0.63)
Mean sensitivity (MS)	0.24
Standard Deviation (SD)	0.40
Series inter-correlation (Rbar)	0.51
Autocorrelation (AR1)	0.69
Signal-to-noise ratio (SNR)	3.79
Expressed Population Signals	0.96
(EPS > 0.85)	1680

Figure 8. Data table describing variables used for the study.

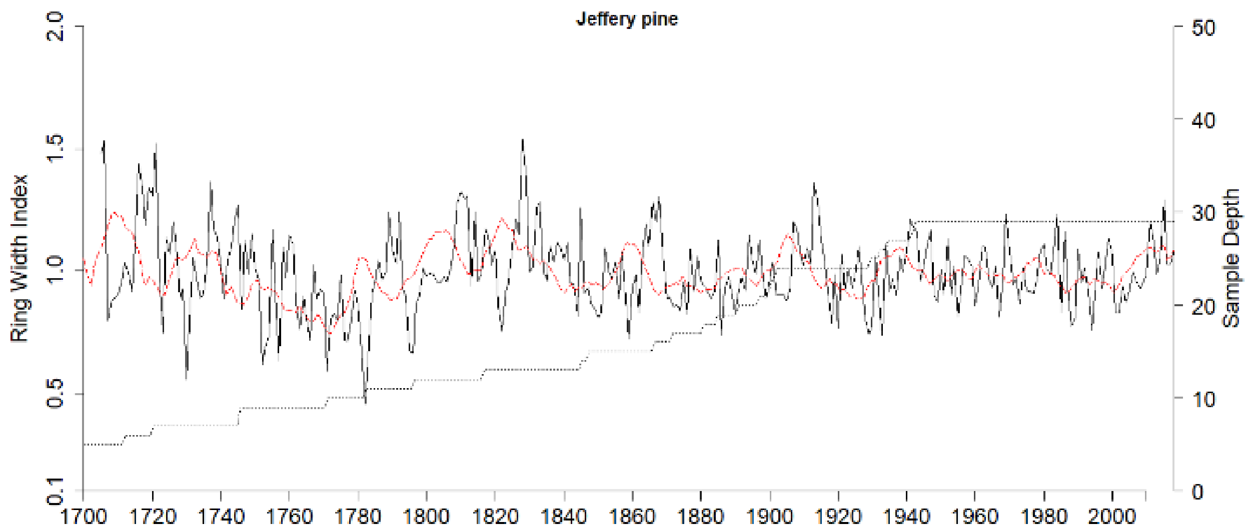

Figure 9. Graph of Ring Width Index created with R program. Showing years of robust and narrow growth with a trend line indicating a decadal moving average.

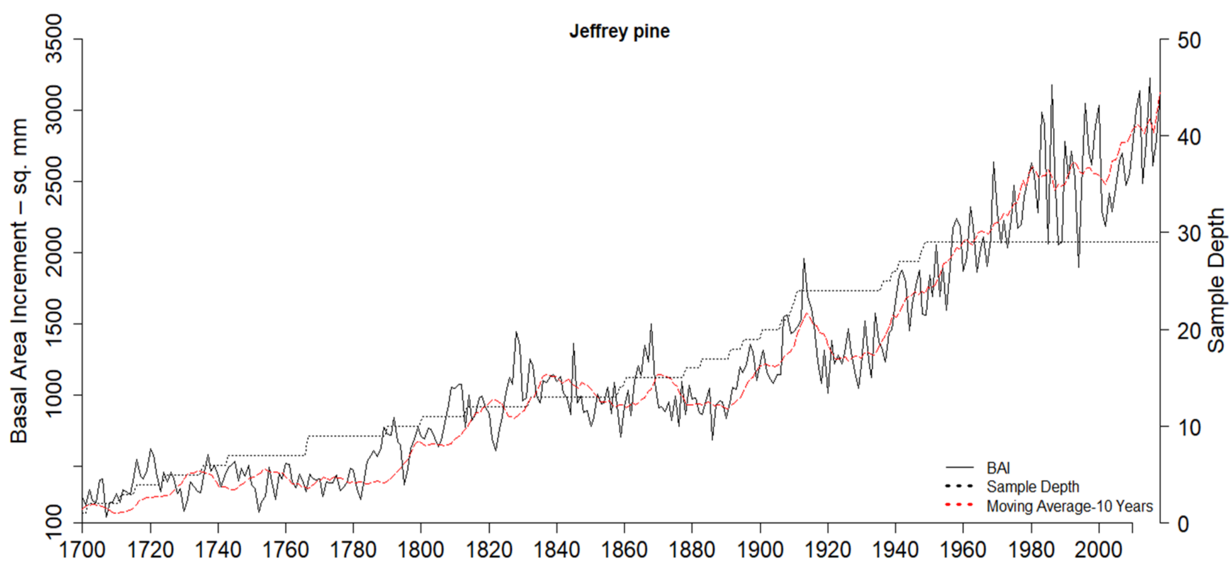

Figure 10. Graph of Basal Area Increment created with R program. Showing years of robust and low radial growth years and a trend line indicating a decadal moving average.

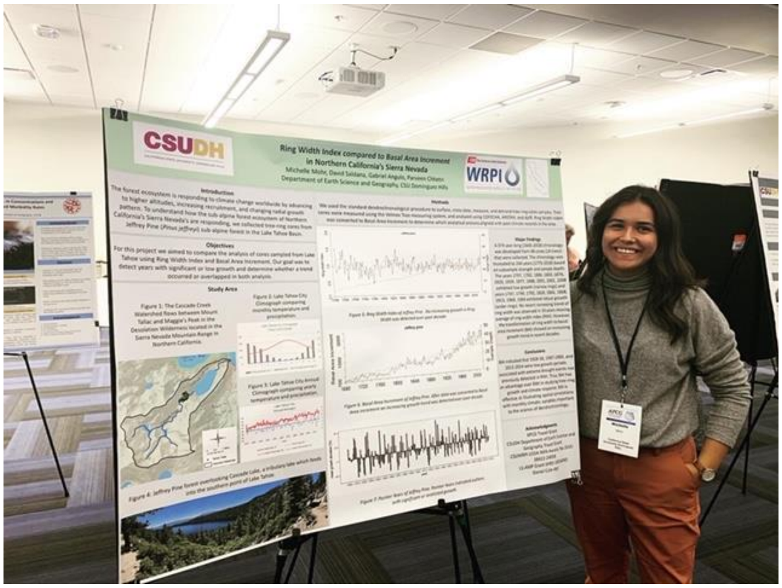

Figure 11. Took my preliminary results to the Association of Pacific Coast Geographers which was held at Northern Arizona University in Flagstaff, Arizona in October of 2019.

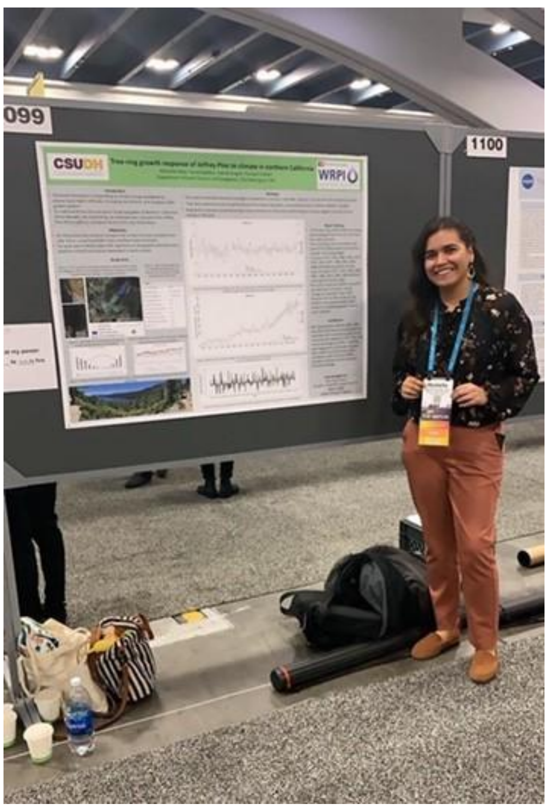

Figure 12. Presented my final results in a poster presentation to the American Geophysical Union Conference in San Francisco, California in December of 2019.

List of Conference Presentations

Mohr M. Saldana D. Angulo G. Chhetri P.K. Is Basal Area Increment (BAI) More Useful than the Ring Width Index (RWI) to Study Severe Drought Events? CSUDH Student Research Day, 12-13 Feb. 2020, Carson, CA, USA (Oral)

Mohr M. Saldana D. Angulo G. Chhetri P.K. Tree-ring growth response of Jeffrey Pine to climate in northern California. Fall meeting of American Geophysical Union (AGU), 9-13 Dec. 2019, San Francisco, CA, USA (Poster)

Saldana D. **Mohr M**. Angulo G. Chhetri P.K. Understanding severe drought events using dendrochronology in Cascade Lake Watershed, California. Fall meeting of American Geophysical Union (AGU), 9-13 Dec. 2019, San Francisco, CA, USA (Poster)

Mohr M. Saldana D. Angulo G. Chhetri P.K. Ring Width Index compared to Basal Area Increment in response to climatic variables in Northern California's Sierra Nevada's. Annual meeting of Pacific Coastal Geography (APCG), 16-19 Oct. 2019, Flagstaff, AZ, USA (Poster)