Dendrochronology—Tree Ring Study

Schedule (report due dates may shift if AE harvest date changes):

Sept 12: Wood anatomy lab, select class question

Sept 19: Coring trip #1. Wear clothes-toe shoes, long pants, be prepared to work in forest conditions with debris and trip hazards, in any weather.
Read on-line methods information before lab! See link off Moodle.

Sept 26: Coring trip #2. Wear clothes-toe shoes, long pants, be prepared to work in forest conditions with debris and trip hazards, in any weather.

Oct 17: Tentative date to collect tree ring data in lab

Oct 24: Tentative date to analyze data in lab

Oct 31: Draft of intro, methods, figures due in lab, complete any remaining analysis

Nov 7: Draft report due

Nov 14: Final report due

Goals and objectives for this project—students will be able to:

- describe the macroscopic and microscopic anatomy of wood
- identify a Douglas fir tree in the forest.
- use an increment borer to core a tree
- measure tree rings in cores, including preparing cores for data collection
- cross-validate cores to date annual rings
- correlate annual ring size to climate
- use statistical analyses to analyze an ecological factor that could affect tree growth
- write a professional report interpreting tree ring data

Overview of tree ring project

The tree ring project will teach you about dendrochronology, a branch of science that uses tree rings to study the past. Scientists can use dendrochronology to address a wide range of historical events. Tree rings can be used to study past climate events, including general trends (such as drought or temperature) and natural disasters (such as windstorms); this area is sometimes called dendroclimatology, and can be used to understand human history as well (e.g., Stahl et al. 1998). Tree rings are also often used to study ecological questions, including competition, succession, the effects of human activities on forest ecosystems, and patterns of disturbance over time. For example, changes in tree growth that are captured in annual rings can provide information about disturbances such as fires, logging, or insect outbreaks (Arabas et al. 2008). In this project, we will focus on questions about plant growth and forest ecology, and will also learn how tree rings are used to reconstruct climate.

For this study, we will core Douglas fir trees at a local forest that has been sustainably managed for timber for a couple decades. Douglas fir is a good species to use because these trees typically have clear annual rings. They are commonly used as a study species in western North America because they are widely distributed (Martinez, 1996). Thus, you will be able to compare your results to other studies of Douglas fir (e.g., Arabas et al. 2008, Chen et al. 2010, Littel et al. 2008).

Overview of project logistics

This project will take several weeks. During the two field trip labs, we will collect cores from Mt. Richmond, a privately owned forest that is sustainably managed by the Hayes family (see hylawoods.com for more information). After learning how to use the increment borers, each student will collect 1-2 cores. We'll bring the cores back to the lab. They may be stored in straws until you are ready to mount them. They must be mounted in the increment core holders and sanded before the first data collection lab. Mounting involves gluing them in the correct orientation into grooves in small wood blocks, securing them with masking tape while the glue dries. I will show you how to do this, and there are also instructions in the on-line reading. During the first data collection lab, you will measure and date rings (including cross validation). During the data analysis labs, you will correlate ring widths to climate data, and analyze ring widths to answer your ecological question.

We have a limited number of increment corers available, so there will be time during these trips for other activities. A good use of time would be collecting plants for the plant collection project, if this site is an appropriate place to do so. Even if you want to collect somewhere else, I will how you how to collect plants and how to use the plant press.

Literature Cited

Arabas, K. B., Black, B., Lentile, L., Speer, J., Sparks, J. 2008. Disturbance history of a mixed confer stand in central Idaho, USA. *Tree-Ring Res.* 64: 67-80.

Chen, P-Y., Welsh, C., Hamann, A. S. 2010. Geographic variation in growth response of Douglas-fir to interannual climate variability and projected climate change. *Glob. Change Biol.* 16: 3375-3385.

Littell, J. S., Peterson, D. L., Tjoelker, M. 2008. Douglas-fir growth in mountain ecosystems: water limits tree growth from stand to region. *Ecol. Monog.* 78: 349-368.

Martiniz, L. A guide to dendrochronology for educators. [Internet]. Tucson, AZ: Laboratory of Tree Ring Research, The University of Arizona; 1996 [cited 2013 15 September]. Available from http://tree.ltrr.arizona.edu/lorim/lori.html

Data sheet

Date: _____________ Site: ____

Other collecting notes:

Core ID	Collector	Tree DBH (cm)	Site category (e.g., high or low density)	Other notes

Dendrochronology Analysis Lab
17 October 2013

Today you will date and measure your tree rings, in preparation for statistical analyses next week. There are several steps to work through today.

<u>Examine the rings on your cores</u>

For each core:

1. Using a dissecting microscope to identify rings, count backwards from the outermost ring. Tentatively mark rings with a pencil dot on the core holder for 2010, 2000, 1990, and so on as far back as your core goes.
2. Make a skeleton plot. Mark the decades on graph paper, and then draw a vertical line for any ring that is smaller than its 3 neighboring rings on each side. The length of the line indicates how much smaller—if it is really tiny, it gets a line 10 squares high.

Question to consider: For each core, decide whether you think it shows sensitive or complacent tree ring growth. What might cause one or the other?

<u>Composite skeleton plot</u>

Once your skeleton plots are complete, compare them with everyone else's in the class. We want to identify distinctive years so that we can determine whether there are any false or missing rings in your cores. We will create a composite skeleton plot that identifies years when particular patterns of tree rings occur.

If you are waiting for others to finish, you may set up a data sheet, or a data file in Excel, to record your tree width data. You will be measuring tree ring diameters for each year from each core, and will need to keep track of where the tree was growing.

<u>Measuring tree ring diameters</u>

1. Compare your skeleton plots/cores to the composite skeleton plot. Determine whether there are any anomalies in your core (such as extra or missing rings).
2. Finalize the dates—mark the decade points on your core holder with a probe (you can write on them too).
3. Under the dissecting microscope, measure your tree rings. Use the mechinist's ruler, and record measurements to the nearest 0.1 mm (you will have to estimate the last digit).

<u>Preparing for next week's analysis</u>

If you finish measuring your cores before lab is done, start to work on the analysis for next week's lab. Assuming the government has re-opened and the NOAA climate data is once again available, next week we will test the relationship between tree ring width and some aspect of climate (such as drought). We can't use the actual tree ring widths, however, as they vary from tree to tree. Instead, we need to standardize them in some way. We will use a method that looks at the relationship between tree ring width and year called a simple least squares regression. This analysis fits a straight line through the data, and determines the equation of that line. Then you can calculation something called the residuals, which tell you how far away from that line each actual data point is. The line represents “average growth,” and the residuals represent how far away from average growth the tree was that year. We do this separately for each tree, which accounts for individual tree differences in growth (due to genetics, microsite differences, etc.). We can then analyze the residuals themselves to see whether there are general trends—for example, did many trees have higher or lower than average growth in a given year? Was that associated with some climate variable?

To do this analysis, you need to set up a data table with year in one column and ring widths in another. We will run the regression in SPSS, which will give us the residuals. You will need to do this separately for each one of your trees. Eventually, you will need to set up a spreadsheet in Excel with columns for year and the residuals for each one of your trees. This is the data we’ll use next week in our climate analyses.

Dendrochronology Analysis Lab 2
24 October 2013

Today you will analyze our tree ring data from last week. By the end of today, you should have:

- Correlated tree ring width data (using residuals) to at least two climate variables.
- Produced graphs to illustrate the correlations you tested between tree ring width data and climate variables.
- Tested for differences in tree ring widths for trees growing in low and high density sites.
- Produced a graph to illustrate the density comparison.

Remember that you will be writing a formal report for this study. A draft of the introduction, methods, and figures are due next week, the full report the following week (with an exam in between). If you're feeling busy or stressed, getting started early might be a good idea! I've put some papers up on Moodle that you may use in your report. I expect you to cite at least two peer-reviewed papers in your final report.

Correlating tree ring width to climate data

1. Write down the biological question for these analyses. This will go in your report.
2. Write down the biological hypothesis and prediction for these analyses. This will go in your report.
3. Write down statistical hypotheses (null and alternatives) for these analyses. This does not go in your report, but helps you be sure you understand what you're doing with the analyses.
4. Create a worksheet in Excel that has the following columns.
   a. year
   b. a column with the residuals for ***each tree***. There will be a lot of columns! You will need to collect these residuals from other students. We will discuss whether to create separate worksheets for high and low density trees (or young and old trees).
   c. a column where you calculate the average of the residuals (for all trees) in that year
   d. columns with climate data, cut and pasted from the Google Docs spreadsheet. Make sure your years match!
5. Import your data into SPSS.
6. Analyze the data in SPSS
   a. Go to the Analyze drop-down menu, and select Correlate→Bivariate
   b. Select the variables. You should use the mean residuals for one of them, and your climate variables for the others.
   c. Make sure Pearson and two-tailed are selection
   d. Run the correlation, and talk to me about how to interpret them.
   e. Write down your statistical results in the sentence that would appear in your report. Check it with me.
7. Make graphs to illustrate the correlations. These should be scatter plots (Excel is fine), with mean residuals on the x-axis and the climate variable on the y-axis. If you have time, write a figure caption to go with it.

Testing for effects of density on tree ring width.

1. Write down the biological question for these analyses. This will go in your report.
2. Write down the biological hypothesis and prediction for these analyses. This will go in your report.
3. Write down statistical hypotheses (null and alternatives) for these analyses. This does not go in your report, but helps you be sure you understand what you're doing with the analyses.
4. Create a worksheet in Excel that has the following columns. Note that this file will be different than the climate data set-up—you will stack trees in a single column rather than having separate columns for each tree
   a. year
   b. site (high or low density—enter as a number since that's required by SPSS)
   c. tree ring width
5. Import your data into SPSS.
6. Analyze the data in SPSS. I will walk you through the menus for this analysis once the data is set up.
7. Make a graph to illustrate the results. If you have time, write a figure caption to go with it.