Tree Biomass and Phenology

Authors: Noam T. Altman-Kurosaki, Emily R. Brown, Sarah H. Roney, and Emily G. Weigel, Georgia Institute of Technology

Focus: The students will generate, plot, and fit curves for basic phenology data using large datasets.

Overview: This lesson centers around understanding the connection of tree biomass and phenology with climate change, visualizing data to find patterns in the data, and understanding how *a priori* knowledge about where data comes from can assist when fitting the data to a curve. Students will work through calculating some elements by hand via a worksheet alongside working in R. The prelab swirl lesson goes step-by-step to show students how to do basic data and data frame manipulations as they work an example dataset of tree size data based on the measurements they will take during the class time. In class, the first LearnR lesson (Data Visualization) guides students to build on their knowledge to visualize the phenology data to look for patterns. In the second LearnR lesson (Time Series), the students practice fitting different curves to the tree phenology dataset.

Although this lesson could be adapted for any set of tree biomass and phenology information, this lesson uses data collected by students from trees on the campus of Georgia Tech, a Level II Arboretum (http://carto.gis.gatech.edu/gttree-arboretum/). The csv file provided for the prelab swirl lesson includes data from August 2012 through March 2016 and the data included in the LearnR lessons spans August 2017 to March 2020.

Learning objectives:

- 1. Define basic tree measurements and changes expected in tree phenology with season
- 2. Practice basic data manipulation in R
- 3. Practice tree measurements and biomass calculations and connect these measurements to climate change
- 4. Practice coding elements necessary to visualize datasets; generate hypothesizes based on patterns found in the data
- 5. Practice coding elements necessary to fit different curves to data; use and apply *a priori* knowledge to choose the best method for fitting a curve

Lesson sequence:

- 1. Prelab Swirl lesson (Campus_Tree_Data.swc)
 - a. Introduction
 - b. Objects, Vectors, Matrices
 - c. Dataframes
 - d. Making Functions
 - e. Importing and Manipulating Data Frames
- 2. Prelab worksheet/quiz
- 3. In-class worksheet (Taking tree measurements and calculating biomass)
- 4. LearnR lesson: Data Visualization (Learn R_TechTrees_DataViz.Rmd)
 - a. Basic plotting
 - b. Plotting with gaplot
 - c. Visualizing tree phenology with ggplot
- 5. Creation of a figure based on the rationale and code learned in the LearnR lesson
- LearnR lesson: Time Series (R_TechTrees_TimeSeries.Rmd)
 - a. Analyzing trends in tree phenology
 - b. Examining canopy cover change over time with GAMs
 - c. Accounting for temporal autocorrelation
 - d. Fit an oscillatory model to the data

Pre-lesson activities: The pre-lab swirl lesson is designed as a refresher of coding and data frame manipulation in R which will be built upon in the LearnR in-class lesson. In order to complete the prelab worksheet/quiz, the students will need to review the lab materials including the videos and detailed written instruction on how to take tree measurement ahead of class. This will greatly expedite the field portion of the lab. The goal is that students familiarize themselves with the basic coding in R and background information about tree measurements and seasonal changes in plant populations *before* coming to lab.

Post-lesson activities: Students are to submit their in-class worksheets and a short summary of which model best fit the phenology data and why.

Implementation notes:

This lesson was designed such that the in-class field activity and first LearnR lesson can both be completed within a 3-hr laboratory. The second LearnR lesson will take an additional hour either in another laboratory session or as a post class assignment. However, it is subdivided into several subparts to facilitate students stopping and starting, as well as review of critical elements when students begin writing their own code. The second LearnR activity is advanced and may be skipped as skills and time necessitate, but we do not recommend its use without completing the prior lessons.

During the swirl and LearnR portions of the lesson, encourage students to go slowly and keep a document open in which to paste the code with notes in their own words as they work. This will make it easier for them to generate their own R code, plot, and statistics for the end of the worksheet and other projects. Additionally, this lesson uses some packages that can occasionally stall the program. If a student gets stuck, restarting R and/or installing the package and opening it before running the document generally fixes the problem.

Setting-up and loading the Swirl Prelab:

- 1. Install swirl using:
 - install.packages("swirl")
- 2. Run swirl and install the course using:
 - install_course()
 - and navigate to where you downloaded the .swc file
- Type swirl() to run swirl and select the number of the "Campus_Tree_Data.swc" course to start it.

Using the LearnR lessons:

- Open the Learn R_TechTrees_DataViz.Rmd or Learn R_TechTrees_TimeSeries.Rmd file in Rstudio
- 2. Click on "Run Document" at the top of the script
- 3. After a moment the lesson will open in a new window (it will look similar to a webpage)
- 4. Use the Tutorial menu on the left to read through each of the sublessons. Use the 'Run Code' button to see example code produce the resultant plots as you go through the lesson