

2013

GEO402/585: Field Methods; Labs 4-5 Gordon Natural Area Carbon Stock Pilot Study

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Fritschle, J. (2013). GEO402/585: Field Methods; Labs 4-5 Gordon Natural Area Carbon Stock Pilot Study. Retrieved from http://digitalcommons.wcupa.edu/gna_curr_series/1

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GEO402/585: Field Methods
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Labs 4-5 Gordon Natural Area Carbon Stock Pilot Study

The purpose of this lab is to conduct a pilot study of how carbon stock might vary according to topographic position in the Gordon Natural Area. You will work in 5 groups, where each group will be assigned a unique plot. You will establish plots and survey the trees within the plots, and then enter the data you collect into an Excel spreadsheet in order to calculate total carbon stock.

This pilot study follows the guidelines published in: Pearson, T.R.H., S.L. Brown, and R.A. Birdsey. 2007. *Measurement guidelines for the sequestration of forest carbon*. General Technical Report NRS-18. Northern Research Station, Forest Service. U.S. Department of Agriculture.

PART 1: IN THE FIELD

REQUIRED MATERIALS:

Data Sheets
Field Guide, e.g., *Peterson Guide to Trees and Shrubs*
Compass for determining azimuths
GPS Units to record plot locations
Diameter-at-breast-height (DBH) tapes for measuring tree diameters
50-meter measuring tape for laying out and mapping plots

PROCEDURE:

1. Assemble in your group and divide up the tasks: Notetaker, Compass Reader, Tape Measurers (the 50-meter tape and DBH tape). Everyone in the group will assist with tree identification. Use the forms on the last 3 pages of this handout to record the data you collect.
 2. As a group we will do a practice plot together. Then each group will go to their assigned plots:
 - Group 1: Plot 1, the Ridge Plot (at the top of the hill)
 - Group 2: Plot 2, Upper Mid-Slope Plot (second from the top of the hill)
 - Group 3: Plot 3, Mid-Slope Plot (third from the top of the hill)
 - Group 4: Plot 4, Lower Mid-Slope Plot (second from the bottom of the hill)
 - Group 5: Plot 5, Floodplain Plot (at the bottom of the hill)
 3. At every 90° within a plot change tasks so that everyone has a chance to learn how collect the data.
 4. After your group has finished surveying your plot, make sure each person in the group gets a complete copy of the data because each person is responsible for turning in their own completed spreadsheet.
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PART 2: IN THE COMPUTER LAB

Questions we will answer in this lab analysis of the data we collected in the Gordon Natural Area:

- *What is the carbon stock of the forest in Gordon Natural Area?*
- *The purpose of this pilot study was to learn the procedure and also to get a sense for how many plots we need to set up throughout the Gordon based on differences in topography. So the big question we need to answer is this: does the carbon stock of trees significantly differ from plot to plot? In other words, are the plots statistically significantly different from one another?*

PROCEDURE:

Download the data file from Blackboard and open in Excel. You should be able to do all the data analysis in Excel. Read through all of these steps before beginning step 1. All your calculations will be at the plot scale. Refer to the *Reference Sheet* for an explanation of the formulas we're using and to see exactly how to type these formulas into Excel.

First, rename your file in this format: *yourlastnameGNA1-5.xls* (e.g., FritschleGNA1-5.xls). Then create four new worksheets in your file for the following analysis: Standing Live Wood, Standing Dead Wood, Down & Dead Wood, and Summary. Copy and paste the raw data into the appropriate worksheets for analysis. *To keep things visually simple, display all numbers to two decimal places.*

STANDING LIVE TREES ANALYSIS

1. For live standing trees, delete trees with dbh > 73.0 cm. We won't include them in the analysis because of limitations in the biomass formula we used.
2. First, we need to determine **total aboveground biomass (kg)** from DBH. The formula is listed on the Reference Sheet, it has also been put into Excel for you in cell G13 on the rawdataStanding worksheet. Click on G13 and note how the formula has been typed in (e.g., it starts with an =). You can simply copy and paste this formula to finish calculating biomass in kg, but make sure that the formula is using the correct cell for DBH values.
3. Next we'll convert this total aboveground biomass from kilograms to tonnes: create a new column, divide total aboveground biomass in kg by 1000. This equals **aboveground biomass (t)**.
4. Knowing the biomass is fine, but to get at the carbon stock per unit of area, we really need to know the **aboveground biomass density** (t/ha) of each tree per plot. Our plots had a radius of 20m, which if you plug into $\text{Area} = (\pi)r^2$ and then convert square meters to hectares, each plot had an area of 0.1271 ha. So to get aboveground biomass density, divide aboveground biomass (in tonnes) by the plot area.
5. The last step in getting the aboveground carbon stock of standing live trees is to convert aboveground biomass density (t/ha) to **aboveground carbon stock (tonnes of Carbon/hectare)**. The Intergovernmental Panel on Climate Change developed a default value of 0.5 for greenhouse gas inventories (IPCC 2000). So simply multiply your aboveground biomass density (t/ha) by 0.5 to get aboveground carbon stock (t C/ha).

6. We're almost done with our standing live trees calculations. Trees store carbon in their trunks and leaves, but also in their root systems. So you need to figure out the below-ground biomass of each tree. In temperate forests, the US Forest Service estimates that trees have approximately 15% less biomass belowground. Plug in the formula for **belowground biomass density (t/ha)** that's listed on the Reference Sheet. Make sure your formula references the correct cell for aboveground biomass density (t/ha). Once you've done this, create a new column for **belowground carbon stock (t C/ha)** by multiplying belowground biomass density (t/ha) by 0.5.
7. Last step: add aboveground and belowground carbon stock to get the **total carbon stock (t C/ha)** of each tree. Display your values to two decimal points.

DOWN & DEAD TREES ANALYSIS

1. To get at the carbon stock of the down and dead trees you measured, you first need to calculate the volume (meters³/hectare) of sound, intermediate, and rotten Down & Dead wood for each plot. We will use the diameter of these trees to calculate this estimate. Create three columns: **volume of sound wood (m³/ha)**, **volume of intermediate wood (m³/ha)**, **volume of rotten wood (m³/ha)**.

The d_1 , d_2 , etc. in the formula simply refers to the diameter of trees in that category. So for calculating volume of sound wood, d_1 = diameter of the first tree in the plot that was categorized as sound, d_2 = diameter of the second tree in the plot that was categorized as sound, etc. Sometimes you may have only one tree in a category (e.g., rotten trees in plot 1). That's fine, only put that diameter in the formula. Because there are different numbers of trees in each category within a plot, these formulas cannot be automatically copied and pasted from one plot to another. (Don't forget that these diameter numbers are squared in the formula!)

Final product of this step, each plot will have one number for each wood category: e.g., volume of sound wood (m³/ha) in plot 1, volume of intermediate wood (m³/ha) in plot one, volume of rotten wood (m³/ha) in plot one.

2. Next, create a new column for calculating the **biomass stock (t/ha)** of each plot. The formula is on the Reference Sheet. There are different constants for sound, intermediate, and rotten wood that the US Forest Service has developed to approximate wood density at various stages of decay. So make sure to plug your volume numbers for sound, intermediate, and rotten wood into the correct place in the formula.
3. Lastly, convert biomass stock (t/ha) into **carbon stock (t C/ha)** by multiplying by 0.5.

STANDING DEAD TREES ANALYSIS

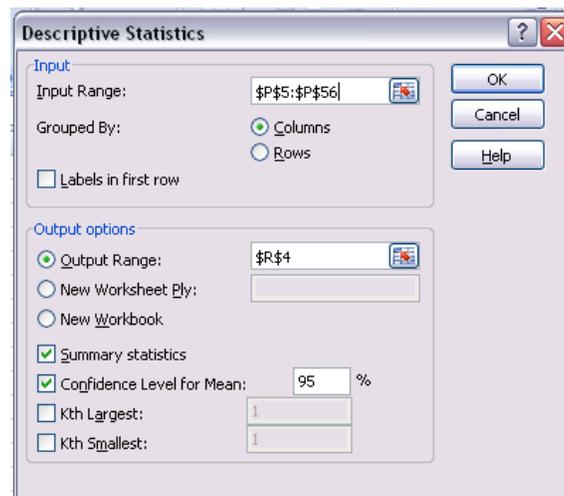
1. This procedure is similar to what we did for Standing Live Trees, except that we won't differentiate between aboveground and belowground biomass. First create a column and plug in the formula from the Reference Sheet for **biomass (kg)**. Please note this formula is slightly different than what we used for live trees.
2. Then convert to **biomass (t)**, **biomass density (t/ha)**, and **carbon stock (t C/ha)** using the same procedure that you did for live trees. The only difference is that instead of dividing biomass (t) by the plot area, you should multiply biomass (t) by an expansion factor of 7.96 in order to get **biomass density (t/ha)**.

ARE THE PLOTS WE SAMPLED STATISTICALLY DIFFERENT FROM ONE ANOTHER?

This is the big question we are trying to answer with our pilot study. Does the carbon stock of the vegetation vary significantly according to topography? Is the ridgetop vegetation statistically significantly different from the floodplain? Do differences in aspect and slope steepness lead to significant changes in the vegetation? There are several statistical analyses you can do to answer this question. We're going to keep things simple and just look at the 95% confidence intervals of mean carbon stocks for each plot. This won't tell us which topographic factors (e.g., slope position, steepness, aspect) are most important in why the vegetation might be different, but it will tell us if the plots are different along our transect.

**Please note: if you do this section on your personal computer, you will need to make sure the Analysis Toolpak has been added into your Excel program. Relatively easy-to-follow instructions for doing this can be found in the Excel help files – just do a search for Add-Ins and load the Analysis Toolpak. This has already been done for you in the Ruby Jones GIS lab.*

1. Go back to your Standing Live Trees worksheet. For our analysis, we will only be concerned with the total carbon stock of standing live trees. In Excel, go to *Data/Data Analysis* (in older versions of Excel, you may have to go to *Tools/Data Analysis*). Select *Descriptive Statistics*. Your input range is the total carbon stock of plot 1 (click on the arrow to the right of the input range box to go to the worksheet and highlight what data you want analyzed, hit “enter” when you’ve highlighted the correct cells). Select an empty cell with plenty of room below and to the right for your output range. Select summary statistics and a confidence interval of 95%.



Your results should look like this:

Plot1	
Mean	3.161454
Standard Error	0.547529
Median	1.713478
Mode	0.098504
Standard Deviation	3.948288
Sample Variance	15.58898
Kurtosis	2.08185
Skewness	1.67594
Range	15.24953
Minimum	0.06657
Maximum	15.3161
Sum	164.3956
Count	52
Confidence Level(95.0%)	1.09921

The two numbers to pay attention are your Mean and Confidence Level. From the above example, we can be 95% confident that the mean carbon stock of plot 1 is 3.16 ± 1.10 . So while we found our carbon stock for plot 1 had an average of 3.16, this number could actually range anywhere from 2.06 ($=3.16-1.10$) to 4.26 ($=3.16+1.10$). If this range for plot 1's average carbon stock overlaps with the range of another plot, then those two plots are not significantly different from one another.

2. Repeat step 1 for plots 2-5.

SUMMARY AND INTERPRETATION OF RESULTS

1. Create a table that will allow you to compare results and easily see if the plots are different from one another. Add the total carbon of standing live trees, dead and down trees, and standing dead trees to come up with a grand total of carbon stock per plot (disregard the means in your grand total).

Plot no.	Total Carbon Stock of Standing Live Trees (t C/ha)	Mean of Carbon Stock (t C/ha)	Mean of Carbon Stock - 95% C.I.	Mean of Carbon Stock + 95% C.I.	Total Carbon Stock of Dead & Down Trees (t C/ha)	Total Carbon Stock of Standing Dead Trees (t C/ha)	GRAND TOTAL Carbon Stock of Plot (t C/ha)
1	164.4	3.16	2.06	4.26	2.0	2.6	169.0
2							
3							
4							
5							

2. Write up and interpret the results of your analysis. Discuss any differences in plots that may be due to certain topographic influences on the vegetation (if any). Answer the questions posed at the beginning of the lab write-up. What are your recommendations for determining the carbon stock of the Gordon Natural Area based on this pilot study? What further observations or experiments would be useful in continuing this research or further answer our questions?

Deliverables: turn in a hard copy of your Word file that includes your summary table and write-up; upload your Excel file to Blackboard (under Assignments folder).

Deadline: please see the schedule on the syllabus for when the lab is due.

REFERENCE SHEET

Standing Live Trees Analysis:

- **Aboveground Biomass (kg)** = $\text{EXP}(-2.0127+(2.4342*\text{LN}(E5)))$, where E5 is the cell for DBH
- **Belowground Biomass Density (t/ha)** = $\text{EXP}(-1.0587+(0.8836*(\text{LN}(L5)))+0.284)$, where L5 is the cell for Aboveground Biomass Density

Dead & Down Trees Analysis:

- **Volume of Sound Wood (m³/ha)** = $\text{PI}()^2*(((C5)^2+(C8)^2)/(8*200))$, where C5 and C8 are cells for diameters of sound wood in plot 1, and 200 is the total length of the east-west transect.
- **Volume of Intermediate Wood** and **Volume of Rotten Wood** calculated in the same way as Volume of Sound Wood
- **Biomass Stock of Dead & Down Wood (t/ha)** = $((I10*0.43)+(J10*0.34)+(K10*0.19))$, where I10 is the Volume of Sound Wood, J10 is the Volume of Intermediate Wood, and K10 is the Volume of Rotten Wood.

Standing Dead Trees Analysis:

Biomass (kg) = $(\text{EXP}(-2.0127+(2.4342*\text{LN}(E5))))*0.85$, where E5 is the cell for diameter

