Shrub/Sapling Biomass & Carbon Analysis

Purpose

- To provide students with an opportunity observe and understand patterns and trends in their field measurement data and the additional data achieved by using allometric equations to determine biomass and carbon storage.

Overview

Students will work with a partner or small group and will explore the field data as analyzed and synthesized by GLOBE. Students will consider a variety of questions that directly address the calculations in the spreadsheet and will discuss how these findings relate to further explorations of the local carbon cycle.

Student Outcomes

Students will be able to:

- Examine their field data and how it was used to calculate shrub/sapling biomass and carbon storage
- Students will work with a partner or small group to answer a variety of application type questions help them analyze and interpret their data
- Students will communicate their understanding of the field data analysis in a class discussion
- Students will be prepared to use their data to complete their research questions

Questions

Unit (Examples)

- Student research questions
- Example: How do carbon stocks at our sample site relate to our study of the global carbon cycle?

Content

- What is the current carbon stock of shrubs/saplings in our sample site?

Science Concepts

Grades 9-12

Scientific Inquiry

- Design and conduct a scientific investigation
- Use appropriate tools and techniques to gather, analyze, and interpret data
- Use mathematics in all aspects of scientific inquiry

NGSS (Black-covered directly, gray-addressed, but not directly covered)

- *Disciplinary Core Ideas*
  - Gr.6-8: ESS3.A
  - Gr.9-12: ESS3.A
- *Science and Engineering Practices*
  - Developing and using models
  - Analyzing and interpreting data
  - Using mathematics and computational thinking
  - Constructing explanations

Time/Frequency

50 minutes

Level

Secondary (High School)

Materials and Tools

- At least one computer with Excel, or a smiliar spreadsheet program.
- Analyzed data spreadsheet downloaded from GLOBE (http://datasearch.globe.gov - *see instructions below*)
- Markers for white board
- LCD projector
- Copies of *ShrubSapling Biomass Analysis Questions*

Prerequisites

- Familiarity with spreadsheets
- Understanding of unit concepts: how is carbon stored in vegetation, allometry, biomass units

Preparation

- Gather all materials.
- Field Data Entry completed
- Write essential, unit, and content questions somewhere visible in the classroom.
- Download your data with completed analysis from GLOBE (http://datasearch.globe.gov). **Note: The spreadsheet may be easier for students to understand if you rename the headers before giving it to them. See CarbonBiomassDataExample.xls on the webpage.*

Background

Scientists use electronic spreadsheets, such as Microsoft Excel, in many fields of study. In general, the purpose of spreadsheets is to help improve the scientists' understanding of the data and to allow for an in-depth exploratory analysis. In addition, scientists can use spreadsheets in order to produce a variety of graphs to further analyze compiled and raw data.

This kind of analysis allows scientists to develop an understanding of their data, as well as further the development of additional research questions. As this lesson is taught it may be helpful to emphasize the GLOBE Model for Student Scientific Research (where have students arrived at in the research cycle?).

For scientific background of the concepts addressed in this activity see the introductory lessons: *BiomassUnits* and *Allometry: Not A Llama Tree.*

*Keep in mind that this spreadsheet analysis was designed by Prichard et al. 2011 to be a ballpark estimate of biomass and carbon stocks, but if you want to learn more about species in your area you may want to work with local scientists. Scientist you might want to contact include: terrestrial ecologists, wetland ecologists, foresters.

How To Download Data From GLOBE

Once your data are entered on the GLOBE website (for help with this, see the *Carbon Cycle eTrainings* and the *Data Entry* guide on the Carbon Cycle webpage), **the calculations to convert your raw data to biomass and carbon storage values will be completed for you.**

To download your data, complete with carbon and biomass estimates:

1. Go to http://datasearch.globe.gov (*Can also be found from globe.gov by clicking 'GLOBE Data' - 'Retrieve Data')*
2. Read through the instructions to familiarize yourself with this tool.
3. Under Data Filters, click 'Select Protocols'
4. Scroll down to find the Biosphere section, click 'Carbon Cycle', and click 'Add Protocols'
5. Select a data range that includes the date in which you collected data.
6. Under Site Filters, click 'School or Teacher', and select your school.
7. If you have multiple Carbon Cycle field sites, select the individual site in which you are interested under 'Site Name'
8. Click the green 'Apply Filter' button in the top left.
9. Click 'Obtain Measurement Data' *(Note, data will be downloaded for the whole list you see, if your school is not the only one listed, refine your filters).*
10. The button will update, and you can click 'Download Measurement Data' to download a .csv, which can be opened in a spreadsheet tool such as Excel.

** Note, you can also use the GLOBE Visualization System (vis.globe.gov) to view your and other school's Carbon Cycle data on a map. Use the Layers feature to choose Biospere, then Carbon Cycle, and then select the Protocol(s) in which you have interest. Widen your data range (top-center) to see all available data.*

What To Do and How To Do It

ENGAGE	**Grouping:** Class	**Time:** 10 Minutes

- Using field investigation data sheets and all handouts concerning shrub/sapling biomass, allometry, fieldwork, and the schoolyard have students consider the research or unit question written on the board: example - How does our sample site's carbon stock relate to our study of the global carbon cycle?
- Ask students to list the kind of calculations (in general) that they will need to do in order to answer this question. For example, students should identify that shrub/sapling measurements will have to be converted to biomass using appropriate allometric equations. Students should list ideas using a flow chart or rough procedure, and record questions in

their science notebook.
- Students share their ideas and questions. During this whole class discussion, review any of the following concepts students still seem to be struggling with before moving on: how carbon is stored in shrubs/saplings, primary factors that limit shrub/sapling growth and carbon uptake, the units of biomass, and why biomass is calculated using allometry.

EXPLORE	**Grouping:** Pairs	**Time:** 35 Minutes

- Give students a brief tour of the spreadsheet, reminding them that the GLOBE System used percent cover and average height in allometric equations based on plant type, and gave an output of total biomass in g/m2, which was then converted to g C/m2 of carbon. This is explained in more detail in the Student Worksheet.
- Students use the *Shrub/Sapling Biomass Analysis Questions* to become familiar with the spreadsheet and outcomes of the data analysis.
  - **NOTE:** The questions are fairly basic, but this is a great opportunity to get students thinking about what they have learned and what it means. Encourage students to use graphs/figures to display their data in a meaningful way. These questions also prepare students to answer the broader essential and unit questions or their own research

EXPLAIN	**Grouping:** Class	**Time:** 10 Minutes

- Discuss student responses to the initial questions, using the white board to document the range of student responses and to clarify concepts and skills.
  - Suggestion: have a few "math minded" students present their methods for making calculations and conversions.

ELABORATE	**Grouping:** Pairs	**Time:** Varies

- If your students collected tree and/or herbaceous vegetation data and have not yet investigated that data using the associated analysis questions, do so now.

EVALUATE	**Grouping:** Individual	**Time:** 35 Minutes

- Students thoughtfully respond to *Field Wrap-up Questions* (on the GLOBE Carbon Cycle webpage in the Resources section), which are designed as a formative assessment.
- Collect and read, or hold a class discussion to discover errors in thinking that need to be addressed before a summative assessment such as the *Field Unit Assessment* (also on the GLOBE Carbon Cycle webpage in the Resources section).

Assessment

- *Field Unit Assessment* (written questions)

Extensions

- Emphasize the inquiry cycle, and to encourage students to develop their own researchable question based on the field plot data and calculations available through the Excel spreadsheet. Offer students time to pursue their own question, providing access to additional resources, including the library and internet. (See *Pose Research Questions, Data Interpretation,* and *Identify New Research Questions* in the Resources section of the GLOBE Carbon Cycle webpage.)
- Work with the *Biomass Accumulation Model* to estimate biomass and carbon storage for your location. How do model results compare to field results?

TEACHER VERSION

(Suggested student responses included)

Shrub/Sapling Biomass Analysis Questions

Part 1: Understanding the Data

Using the shrub/sapling biomass data in the datasheet provided by your teacher, explore the biomass and carbon of your sample site. You will need to continually refer back to the spreadsheet while answering these questions. Your previous work on biomass units and allometry may also be helpful in understanding the data.

Record plot summary data. Remember to include units.

Deciduous Biomass	Evergreen Biomass	Shrub/Sapling Biomass	Shrub/Sapling Carbon Storage

1. Describe or show the calculations for the relationship between biomass and carbon storage.

   Biomass (g/m^2) x 50% = Carbon storage (gC/m^2)

2. Define allometry. Explain how allometry was used to calculate shrub/sapling biomass.
   Allometry is the study of an organism's parts in relation to its whole. We used allometric equations for different plant types to relate the overall height and percent cover of shrubs/saplings to their biomass.

3. Using the basic allometric equation for biomass, provided on the last page of this worksheet, provide an example of how the equation works. Select one plant type (Deciduous or Evergreen) from your sample site and show your work below.
   (See the equations a the end of the worksheet.)

4. For the same height and percent cover is there more total biomass in evergreen or deciduous shrubs/saplings? Will this always be the case? Why?
   Yes. Have students look at the equations to help them answer this question.

5. What is one additional thing you notice about the data?

6. Name one thing that interests or surprises you about the data.

7. What questions do you have about the data? Be thoughtful.

Name: Date:

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2. Define allometry. Explain how allometry was used to calculate shrub/sapling biomass.

3. Using the basic allometric equation for biomass, provided on the last page of this worksheet, provide an example of how the equation works. Select one plant type (Deciduous or Evergreen) from your sample site and show your work below.

4. For the **same height and percent cover** is there more total biomass in evergreen or deciduous shrubs/saplings? Will this always be the case? Why?

5. What is one additional thing you notice about the data?

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How was Biomass Calculated?

Example Data:

Deciduous % Cover	Deciduous Avg Height (m)	Deciduous Biomass (g/m^2)	Evergreen % Cover	Evergreen Avg Height (m)	Evergreen Biomass (g/m^2)
30	2.1	463.34	17	3	562.63

Deciduous Shrubs/Saplings:

You will use the Deciduous Shrub Biomass Equation*:
Biomass (tons/acre) = Average Height (ft) x (Percent Cover/100)

1. Convert measured height in meters to height in feet:
Height = **2.1m** x (3.2808399 ft/m) = 6.8897639 ft

2. Use a Calculator:
Biomass (tons/acre) = 6.8897639ft x (**30**/100)
Biomass = 2.06693 tons/acre

3. Convert tons/acre to g/m^2
Biomass (g/m2) = (2.06693 tons/acre) x (907184.74g/ton) x (1 acre/4046.87m^2)
Biomass (g/m2) = 463.34243 g/m^2

4. Check the spreadsheet to check your work.

Evergreen Shrubs/Saplings:

You will use the Evergreen Shrub Biomass Equation*:
Biomass (tons/acre) = Average Height (ft) x (Percent Cover/100) x 1.5

1. Convert measured height in meters to height in feet:
Height = **3m** x (3.2808399 ft/m) = 9.8425197 ft

2. Use a Calculator:
Biomass (tons/acre) = 9.8425197 x (**17**/100) * 1.5
Biomass = 2.50984 tons/acre

3. Convert tons/acre to g/m^2
Biomass (g/m2) = (2.50984 tons/acre) x (907184.74g/ton) x (1 acre/4046.87m^2)
Biomass (g/m2) = 562.63009 g/m^2

4. Check the spreadsheet to check your work.

**Prichard et al. 2012*