MEASURING CARBON UPTAKE BY TREES

PURPOSE: To showcase the role that trees in urban areas play by taking in carbon dioxide in the atmosphere and using the carbon in it for growth.

BACKGROUND: Trees grow by taking in carbon dioxide from the atmosphere during photosynthesis and converting it into structural material (biomass) such as leaves, flowers, fruit, limbs, and trunks. Scientists and foresters can quantitatively measure this growth by setting up study plots within a forest to monitor trees and the larger forest. The plot can be re-measured every year to determine the amount of carbon taken in, or sequestered, annually and over longer periods of time. This can help us to understand how forests help to mitigate the effects of increasing levels of carbon dioxide in our atmospheres and the impacts of climate change. In this activity, participants will learn how to establish a study plot, identify trees, collect data on tree species, and analyze the data for forest growth and productivity and carbon sequestration over time.

VIRGINIA STANDARDS OF LEARNING

LS.6- Students will investigate and understand that within an ecosystem things are dependent on one another and on nonliving components of the environment. Key concepts include the carbon cycle and the relationship between terrestrial and

HOW TO SET UP YOUR OWN FORESTRY PLOT

OBJECTIVES:

- Students will work as a team to establish a forestry plot on school grounds or in a local forest.
- The teacher will guide students through the plot set-up, and help them to learn and apply forestry skills. Teacher oversight will ensure quality data collection and monitoring efforts.
- In the first year, students will establish a baseline dataset for their plot. The data set will include tree species, diameter at breast height (DBH), and tree status. In subsequent years, students will monitor these factors annually or biannually, and note any changes.

Time: 30minutes in field; 45 minutes in classroom

MATERIALS:

- 50 meter transect tape
- 2 – 4 DBH tapes (a DBH or 'diameter at breast height' tape is designed for forestry applications and directly measures the diameter of a tree. Tapes are available at Forestry Suppliers or Ben Meadows)***
- Compass
- Tree identification book (http://www.dof.virginia.gov/resources/edu/pub_Native-Trees-Va_2009.pdf)
- Pen(s) or pencil(s)
- Data sheet or notebook to record data
- Aluminum tree tags (available at Ben Meadows)
- Aluminum nails (used to secure tree tags)
- Hammer
- 5–10 Survey or pin flags
- GPS unit or GPS cell phone app

***A standard measuring tape can be used for this step, but will involve measuring the circumference of the tree and converting that measurement to diameter. The equation is:

$d = \frac{C}{\pi}$ where d = diameter; C = circumference; and π(Pi) = 3.14.

PREPARTION

When selecting your plot, it is important to consider these questions. How easy is it to access? And how representative is it of the entire forest stand? (A "stand" is a structurally and compositionally homogenous unit of forest.) This will depend on the goal of your study. It is best to identify an area that is easy to access (e.g. near trails, roads, or parking lots) and that is located in an area of intact forest as large as is reasonable or available.

Before going out, the teacher should have a brief safety talk with the class to cover issues that may arise while working in the forest. Be specific to the forest in which you are working. Some calamities, such as poison ivy, black flies, mosquitos, etc. vary in their severity.

ACTIVITY

Plot establishment

1. First, mark the plot center. This can be done temporarily using pin flags or permanently using a stake or marker (metal rebar is an affordable option and will last for many years). If you have the option of painting the marker a bright orange or pink color, this will be handy in finding the plot center in the future.
2. Record the GPS coordinates of your plot center in your notebook or on your data sheet and give the plot a name. If you are creating more than one plot, each plot should have its own name or identification system.
3. Mark out your plot. (Most forestry plots are circular in shape and tend to be 15 – 20 m in radius—for this let's use 16 m radius plots.) From plot center, run the transect tape out and place a flag at 16 m. Do this a few times until you can establish the outer edge of the plot. *See resources for more detailed plot design information.
4. Divide the students into groups of 2-3 and divide the plot into sections. Assign each group to a section and give each person a job. Groups should begin with the tree located closest to the center and work out to the section's outer edge.

Tagging, identifying, and measuring a tree

On the side of the tree facing the center of the plot, nail an aluminum tree tag into the tree between 0.5 and 1 m off the ground. Be sure to use an aluminum nail. Do not drive the nail all the way into the tree so that the nail head is flat against the tree trunk, as the tree will grow around it and cover it up.

1_

Place all tree tags on the side of the tree facing the center of the plot. This will help in finding all of the tags in the future and will speed up resurveys.

6. Record the ID tag number in your data sheet or notebook. Identify the species of tree and record it on your sheet. Use your tree identification book(s) or guide(s and the leaves, bark, twigs, fruit, etc. to identify the tree species. Binoculars may be helpful to identify leaves on high branches. Fallen leaves in the leaf litter below the canopy may also help.

7. Measure the DBH or diameter of the tree (1.4 m above the ground or ~4ft) and record on the data sheet.

8. In the status column of your data sheet, record the status of each tree using one of these the three status options:

Healthy – A healthy tree is a live tree with no apparent damage from wind, fire, insects etc.

Damaged – A damaged tree is one that has some type of notable damage to it from wind, fire, insects, or other source. Examples would include a tree with significant damage to the crown from a wind or ice storm.

Dead – A dead tree is a tree that is no longer producing new growth. In the notes section, you may want to indicate if the tree is standing or fallen. Let's take a quick look at an example data sheet:

PLOT ID	North Plot One	Observation Date		7/19/2016
Latitude and Longitude		45.5586 N, -84.6774 W		
Observer's Names		Jeff, Ben, Cynthia, Chris, Ellen, Benjiman		
Tree ID Tag No.	Tree Species	d.b.h. (cm)	Status	Notes
345	*red oak*	*27.4*	*healthy*	
346	*white oak*	*20.1*	*damaged*	*notable crown damage*
347	*loblolly pine*	*12.3*	*healthy*	

From Jenkins et al., 2003

8. Repeat steps 5-7 for each tree in the plot working outwards until you reach the outer edge of the plot.

Calculating biomass

Total tree biomass is calculated using the following equation, which can be modified based on the tree species. e = Exponent

$$biomass\ (kg) = e^{(a+b \times \ln(dbh))}$$

Example calculation:

Let's consider an example of a scarlet oak tree with a dbh of 23.4 cm. From the chart below, for a scarlet oak *a* = -2.0127 and *b* = 2.4342. Let's do the math:

$$biomass\ (kg) = e^{(-2.0127+2.4342 \times \ln(23.4))}$$

$$biomass\ (kg) = e^{(-2.0127+2.4342 \times 3.15)}$$

$$biomass\ (kg) = e^{(-2.0127+7.67)}$$

$$biomass\ (kg) = e^{(5.6573)}$$

$$biomass = 286.37\ kg$$

Dbh is the diameter at breast height of each tree in cm and ***a*** and ***b*** are species specific coefficients from the table below:

Coefficient and Exponent Values for Biomass Equation		
Tree Groupings	**a**	**b**
Maple/birch	-1.9123	2.3651
Oak/hickory/beech	-2.0127	2.4342
Other mixed hardwoods	-2.48	2.4835
Pine/Softwoods	-2.5356	2.4349

Values taken from Jenkins et al. 2003 (http://www.ingentaconnect.com/content/saf/fs/2003/00000049/00000001/art00002)

Resources

* Detailed plot design information can be found online. The United States Forest Service Forest Inventory and Analysis program and the National Ecological Observation Network (NEON) are excellent examples. The Maine Forestry Inventory Growth Project is another excellent source.

FIA - http://www.fia.fs.fed.us/library/fact-sheets/data-collections/Sampling%20and%20Plot%20Design.pdf

NEON - http://www.neonscience.org/science-design/spatiotemporal-design

Maine Forestry Inventory Growth Project - http://mainefig.org/resources/level-1/

References

Jenkins, JC, DC Chojnacky, LS Heath, and RA Birdsey (2003) *National-Scale Biomass Estimators for United States Tree Species.* Forest Science, 49.1.

SCIENCE IN THE PARK

PLOT ID		Date and Time		
Latitude and Longitude				
Observer's Names				
Tree ID Tag No.	Tree Species	d.b.h. (cm)	Status	Notes