Future Fuels From Forests Unit

By Sherry Claflin
Target: 9th grade Earth Science

Content Benchmarks
Earth Science
E1 Inquiry, Reflection and Social Implication;
E1.2 Scientific Reflection and Social Implications;
E2.2 Energy in Earth Systems;
E2.3 Biogeochemical cycles;
E2.4 Resources and Human Impacts on Earth Systems, E2.4A, E2.4B, E2.4d;

Geometry
G1 Figures and Their Properties,
G1.6.1 Solve multistep problems involving circumference and area of circles;
G2.2 Relationships between Two Dimensional and Three Dimensional Representations;
G2.2.2 Identify or sketch cross sections of three dimensional figures. Identify or sketch solids formed by revolving two dimensional figures around lines.

Unit Overview: As part of a renewable resources unit students will research and learn about Biomass Fuels. Through laboratory activities students will learn to measure and calculate the amount of biomass in trees on school property, determine tree age by counting tree rings and calculate the amount of carbon the trees sequester over a particular period of time, and research the potential for the area in biomass production from trees. Through discussion and cooperative learning students will investigate the forests of the world. This six day unit can be stretched out to accommodate more time in the school forest if needed for either tree identification or measuring tree diameters.

Day One: Journal writing assignment as they come into the classroom; What is a forest? Journal answers must be at least one paragraph 5-7 sentences. 3-5 minutes. Discuss their answers. Students will then be given the **Forests of the World Opinionnaire** from the Project **Learning Tree Global Connections: Forests of the World.** They will complete the student page in about 3-4 minutes and then discuss the questions at their group, table of 4 students for 5 minutes. Groups will pick one particular topic in the Opinionnaire to present to the class. (15 minutes max) Using the **Project Learning Tree World Forest Tour** students will discuss differences in forest uses in small groups. They will make a poster on newsprint outlining particular use of forests. Have the small groups present their information to the rest of the class.

Materials needed: Project Learning Tree World Forest Cards, Newsprint, markers, Opinionnaire

Day Two: Journal writing assignment as they come into the classroom; What is bioenergy? Journal answers must be at least one paragraph 5-7 sentences. 3-5 minutes. Students will research bioenergy from the internet to learn about this alternative energy source.
Students will use the mobile lab to access the internet to look up bioenergy, biofuel, and biomass using the following websites: http://nrs.fs.fed.us/niaca/opportunities/bioenergy
http://www.aboutbioenergy.info/ and http://biomass.forestencyclopedia.net/

Materials needed: Laptops, research worksheet and internet access.

Day Three: Journal writing assignment; What benefits do trees contribute to the health of the environment? Journal answers must be at least one paragraph 5-7 sentences. 3-5 minutes. Discuss their answers. **Identifying trees species**. In groups of two or three, students will use field guides to identify common varieties of trees on the school property forest area. Students will be mainly looking for aspen, pine, maple and oak trees to identify.

They will compile a list of the tree species which they can identify and the number of each particular species identified.

Materials needed: tree identification field guides, clip boards and pencils.

Day Four: Journal writing assignment; How do you measure trees? How do you measure the carbon in one tree? How do you measure the biomass of a tree? Journal answers must be at least one paragraph 5-7 sentences. 3-5 minutes. Discuss their answers. **Measuring Standing Trees.** In the same groups as day two, have students determine the circumference of a circle. Give them some sample problems first and ask them to then calculate the circumference of a circle with a diameter of 6 ft. They will need this figure to mark out a 6 ft circle in the school forest area to measure the standing trees within their circle. Once all the groups have figured out the circumference for their circle give them either rope or yellow caution tape (or whatever is convenient to use) to cut to the correct length for their 6 ft diameter circle. Have them draw a 6 inch circle on a plain white sheet of paper to make a proportional sketch of their circle. Go out to the forest area, have students mark off their 6 ft diameter circle and begin sketching out their circle. Using the measuring tape they will begin measuring the diameter of the trees within their circle. They should have a minimum of one large tree in their area to measure. Students must be able to identify the species of tree inside their circle. They then need to add information to the sketch, the tree species, locations and tree sizes inside the circle. Using a tape measure students will determine and record the diameter of the trees by measuring 4 ½ ft above ground level to measure the diameter of the tree. U.S. Forest Service has diagrams for proper measurement, if the tree has an irregular trunk. Record the diameters for future use.

Materials needed: Rope or tape roll of some length, clip boards, pencils, paper, measuring tape and calculators

Day Five: Journal writing assignment; How do you measure the carbon in one tree, in a forest? Journal answers must be at least one paragraph 5-7 sentences. 3-5 minutes. Discuss their answers. Explain that all plants sequester carbon throughout their life cycle. After students have gathered their records from the previous day, their tree diameters and sketches, they will need to complete the **Activity: The Carbon in Trees.** Go over the calculations with students on **The Carbon In Trees** activity first to make sure they remember how to do the calculations. Using precut tree cookies; sections of tree trunks cut into 1-2 inch thickness, have students complete the **Activity: Putting on Pounds** from the Future Fuels From Forests Institute. Go over the instructions and calculations with students and give them time in class to finish these assignments.

Day Six: Journal writing assignment; How can biofuels help solve our energy problems? Journal answers must be at least one paragraph 5-7 sentences. 3-5 minutes. Discuss their answers. Show powerpoint presentation Bioenergy & biofuels: A low-carbon response to climate change? By Maria Janowiak. Discuss the individual slides with students. Final assessment will be a bioenergy poster designed by the student.

Materials needed: Powerpoint presentation, poster boards and markers.

Activity: Putting on Pounds

By Amber Roth <amroth@mtu.edu>, Michigan Tech School of Forest Resources & Environmental Sciences

Description: As forest resources are increasingly being used for bioenergy and biofuel industries, foresters must be able to calculate the amount of mass, or biomass, for standing trees in a forest. To do this, foresters calculate the biomass of individual trees and project these estimates across a forest stand. For this activity you will estimate the tree biomass accumulated during the lifetime of a student in your class.

Objectives: Estimate tree biomass and average annual growth rate

Materials Needed:

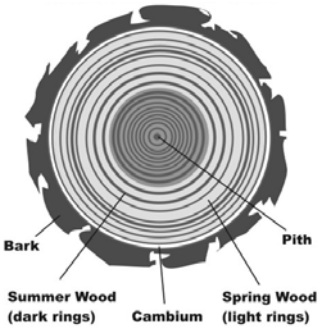
Tree cookie (from tree older than your student)

Metric ruler and/or tape measure

Calculator

Pencil

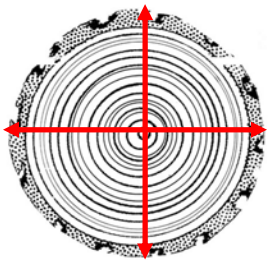
Allometric equation for tree species of cookie used



Instructions:

Part 1: Calculate biomass for whole tree

Step 1: With pencil, draw two perpendicular lines that pass through the cookie's pith as indicated in the diagram. Make all measurements in this activity along those lines (guides). Measure the two diameters in cm and calculate an average. This is the average diameter at breast height, D.



Diameter 1: _____ cm

Diameter 2: _____ cm

Average Diameter: _____ cm

Step 2: Calculate biomass for whole tree.

To calculate tree biomass, we use a standard allometric equation of the form $M=aD^b$ where M is aboveground tree biomass (dry weight; kg), D is the diameter at breast height (cm), and "a" and "b" are species specific coefficients.

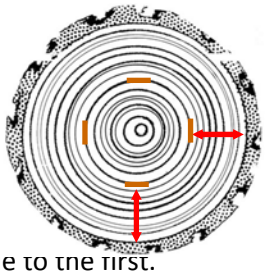
For **aspen** cookies, use the equation $M=0.08\ D^{2.35}$

For **balsam fir** cookies, use the equation $M=0.17\ D^{2.16}$

Insert your total tree biomass (M) estimate in Part 3.

<u>Part 2:</u> Calculate biomass accumulated prior to the birth of your student (pre-birth tree biomass).

Step 1: From the bark inward, count the number of summer wood (dark) rings equal to the age of your student. Mark this ring with a pencil mark at the four places where it intersects your guides.

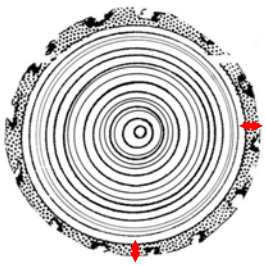


Step neter of the wood between your pencil marks. Take a second measurement at a right angle to the first.

Inner diameter 1: _____ cm

Inner diameter 2: _____ cm

Step 3: Measure width of bark. Take a second measurement 90 degrees from the first.



Bark Width 1: _____ cm

Bark Width 2: _____ cm

Step 4: Add together all measurements from Steps 2 and 3 and divide by two. This is the average diameter at breast height estimate for this tree when your student was born.

Average diameter: _____ cm

Step 5: Calculate biomass for tree growth before your student was born (pre-birth tree biomass). Use the same allometric equation as in Part 1.

For **aspen** cookies, use the equation $M=0.08\ D^{2.35}$

For **balsam fir** cookies, use the equation $M=0.17\ D^{2.16}$

Insert your pre-birth tree biomass estimate (M) in Part 3.

Part 3: Calculate biomass accumulated during your student's lifetime and the average annual growth rate during that time.

Step 1: To calculate the total biomass accumulated during a student's life, subtract the pre-birth tree biomass from the total tree biomass.

Total tree biomass from Part 1: _____ kg x 2.2 lbs/kg = _____ lbs

Pre-birth tree biomass from Part 2: _____ kg x 2.2 lbs/kg = _____ lbs

Tree biomass accumulated during a student's life: _____ kg x 2.2 lbs/kg = _____ lbs

Step 2: To calculate the average annual growth rate during a student's life, divide the tree biomass (lbs) accumulated during the student's life by the age of your student (used in Part 2).

Average annual growth rate during a student's life: _____ lbs/yr

Activity: The Carbon in Trees

Description: Recent interest in the use of forests for carbon sequestration and bioenergy require knowledge about the amount of carbon stored in a tree or forest. For this activity, you will estimate the amount of carbon stored in a nearby or favorite tree.

Objectives: Measure tree diameter; calculate biomass and carbon mass

Materials Needed: Tree(s); Diameter tape and/or tape measure; Calculator and/or spreadsheet software; Pencil; Allometric equation for tree species

Wrap tape measure around tree 4.5 ft above the ground. On a leaning tree, make sure the tape is perpendicular to the trunk.

Instructions:

Step 1: Measure Diameter

If using a tape measure, measure the circumference of the tree at breast height (4.5 feet off the ground; see figure). If necessary, convert this value to cm. Then, using the tree circumference, calculate the diameter.

Circumference: _____ cm Diameter: _____ cm

If using a diameter tape, the tree is measured the same way but it is not necessary to calculate diameter since the tape already does that for you. If necessary, convert this value to cm. Diameter: _____ in

Step 2: Calculate biomass for whole tree.

To calculate tree biomass, we use a standard allometric equation of the form $\mathbf{M=aD^b}$ where M is aboveground tree biomass (dry weight; kg), D is the diameter at breast height (cm), and "a" and "b" are species specific coefficients. Locate the coefficients for the species of tree that you have in the table and calculate tree biomass (M). Biomass (M): _____ kg

Species	a	b
Ash	0.16	2.35
Aspen	0.05	2.51
Balsam fir	0.07	2.50
Basswood	0.09	2.35
Beech	0.20	2.39
Eastern hemlock	0.10	2.36
Northern white cedar	0.09	2.23
Red maple	0.16	2.31
Red oak	0.13	2.42
Red pine	0.78	2.42
Sugar maple	0.17	2.36
White birch	0.12	2.43
White oak	0.20	2.16
White pine	0.75	2.38
Yellow birch	0.09	2.59

Step 3: Determine carbon content

Since carbon is the major building block for life, a tree contains a large portion of carbon (about half its biomass). To determine how much carbon is in your tree:

Multiply biomass (M) by 0.521 for **hardwood** trees.

Multiply biomass (M) by 0.498 for **softwood** trees. Carbon content: _____ kg C

Multiply by 2.2 to convert to lbs. Carbon content: _____ lb C

Bonus Question: One lb of C is equal to 3.67 lbs of CO_2. Also, a car emits 19.6 lbs of CO_2 for each gallon of gas. If a person uses 400 gallons of gas a year, then their CO_2 emissions from driving would equal the amount of carbon sequestered in _____ of these trees.

Bioenergy Research **Name _____**

Using the following websites: http://nrs.fs.fed.us/niaca/opportunities/bioenergy

http://www.aboutbioenergy.info/ and http://biomass.forestencyclopedia.net/ answer the following with complete sentences.

1. **What is bioenergy?**

2. **What is ethanol?**

3. **How is ethanol made?**

4. **How is ethanol used?**

5. **What is biomass?**

6. **How is biomass measured?**

7. **What is carbon sequestration?**

8. **How can bioenergy help the environment?**

9. **Can biofuels solve our energy problems?**

10. **What are the advantages to using bioenergy?**

11. **Are there any drawbacks to bioenergy?**