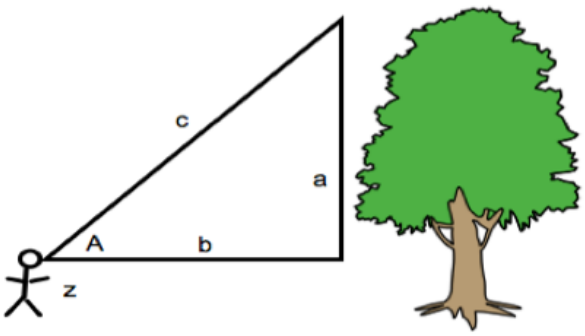
Title: The Value of a Tree, High School Version

Grade Level: 9th-12th

Topic:	**Climate Change & Our Resources**
Background:	Energy is an important and timely topic for students, consumers, policy makers, scientists and educators. With an increasing world population and decreasing supply of fossil fuels, finding a reliable and abundant source of energy is a high priority. Effort and research is being poured into creating innovative and sustainable ways to create and produce energy. One such current effort is being led by the USDA's Northwest Advanced Renewables Alliance (NARA). NARA combines private industry and educational institutions in a partnership to build an efficient supply chain for aviation biofuel. Renewable jet fuel has been of less concern compared to personal vehicles in recent news. With a goal of 50% biofuel replacement in jet fuels by 2015 set by The American Transport Association and the Western Climate Initiative to cap carbon emissions on transportation fuels by 2015, there is a new focus on aviation fuel. In addition, aviation fuel density requirements leave fewer options for planes than automobiles. NARA scientists are working on creating biofuel from forest, mill and construction waste to be refined into a jet fuel to fly commercial airlines around the globe. By using wood waste the bulk of a tree is still able to be utilized for other needs, such as lumber or paper products. This holistic approach enables all parts of a tree to be utilized. By focusing on the aim and research of NARA students are able to learn about current research efforts while critically examining a new source of energy for jets in light of carbon emissions and climate change.
Next Generation Standards:	**LS1C, LS2B, LS2C, LS2D, ESS3A, ESS3B, ESS3D, ETS1A, ETS2A, ETS2B**
Goals:	This lesson will explore the need for teaching about bio jet fuel and provide a hands-on lesson for calculating how much jet fuel can be obtained from a tree and how much carbon the tree could sequester in a year if left standing. This lesson is designed to encourage a healthy debate about how to value the trees around us and introduce various aspects in determining a tree's value.

Objectives:	Students will understand how to calculate how much carbon is in a tree. From this number students can calculate how much jet fuel can be obtained from that tree and how much carbon it can sequester a year. Students will measure the tree's height, circumference and age. Students will engage in a complex discussion of deciding how to use our local resources.
Materials:	• Materials - 1 meter tape - Increment borer (this will need to include a safety discussion and explanation on how to count tree rings) - How Much Carbon is in a Tree Chart - How Far Can I Fly in a Boeing 747 Chart
Set up:	Have a place in mind to take students where trees can be safely bored.
Classroom Time:	2 hours
Introduction (Engage):	Take students to the tree that will be studied (or group of trees). Have them examine the tree, draw a picture of it, determine what type it is and explore what creatures may be living near or in this tree. Ask students what value this tree has? What does this tree do for them? What does this tree do for the area it is in, the plants near it, the animals in the area? What are some uses for trees humans have? (Think lumber, paper, etc.) Ask students how they arrived to school today? Did that require any energy? Where did that energy come from and where did that energy come from (tracing back to the sun)? What are types of energy that can be used for transportation? (This could be an entire class period discussion or attached to previous or future discussions.) Inform students they will determine if this tree is better left to sequester carbon dioxide or to be harvested to be used for lumbar and jet fuel.

Activity (Explore):	Complete the following steps. **1. Determine the height of your tree.** Distance from base of tree out on meter tape so you can see the top of the tree (b): _____ m  Angle on clinometer from ground to top of tree (A):_____ degrees Distance from ground to observer's eyes (z):_____ m Height of tree = H = ((tanA x b) + z H = _____m **2. Measure the circumference of the tree.** Circumference of tree:_____cm **3. Determine the amount of Carbon in the tree** Using the "How Much Carbon Is in a Tree" chart Carbon in your tree:_____ kg **4. Calculate the weight of the tree.** Carbon of tree x 2 = W W = _____kg Convert to tons: 1kg = 0.0011 ton, Wkg x 0.0011 W = _____ tons **5. Determine amount of fuel available in tree**

	1 ton = 50 gallons of jet fuel Wton x 50 = _____gallons of fuel **6. Calculate how far does that get you.** A Boeing 747 burns 5 gallons per mile and can carry about 450 people Use the Miles from McCall Chart How far can your tree get you? _____miles Half of a tree is used for other purposes (wood, paper), half is used for jet fuel. Multiply the above number by 0.50 _____miles **7. Calculate the amount of carbon dioxide sequestered in the tree.** Weight of CO_2 = weight of carbon x 3.6663 Weight of CO_2= _____ kg of CO_2sequestered **8. Calculate the amount of CO_2sequestered per year.** Use the increment borer to determine the age of the tree: _____years Kg of CO_2sequestered / age of tree = kgs of CO_2sequestered per year. Amount of CO_2 sequestered each year = _____kg Convert to tons: 1kg = 0.0011 ton, Wkg x 0.0011 W = _____ tons of CO_2 sequestered per year Use the Household Emissions Chart to compare.
Explanation	Explain to the students the following information about the equations: • The equations used to determine the amount of carbon in a tree are listed below the chart. It is assumed that 50% of the weight of a tree is carbon. So the weight of the carbon can be multiplied by 2 to give the entire weight of the tree. This also takes into consideration the below ground mass of the tree. • The miles per gallon a plane can get varies greatly by how much weight is on the plane (both from luggage and people), how many people are onboard, cruising altitude and winds. The value of gallons per mile was

	obtained from Boeing's website (June 2012). • CO_2 is composed of one molecule of Carbon (C) and 2 molecules of Oxygen (O). The atomic weight of Carbon is 12.001115. The atomic weight of Oxygen is 15.9994. The weight of CO_2 is 2 x O + C=43.999915. • The ratio of CO_2 to C is 43.999915/12.001115=3.6663. • Therefore, to determine the weight of carbon dioxide sequestered in the tree, multiply the weight of carbon in the tree by 3.6663.6 • From the Environmental Protections Agency (EPA), the average car uses 581 gallons (2,199 liters) of gasoline a year. A gallon of gas contains 2.4kg of carbon. Define and discuss the meaning of the following words: **Carbon footprint** calculators can be used to see how much CO_2 one person emits annually. The Nature Conservancy Carbon Footprint Calculator, Cool Climate Calculator and EPA Household Emissions Calculator. * A side activity can be for students to determine their carbon footprint. The following are students friendly: http://epa.gov/climatechange/kids/calc/index.html http://www.cooltheworld.com/kidscarboncalculator.php http://www.planet-positive.org/how_2_kidscalc.php **Carbon offsetting** is way to compensate for the CO_2 emissions by purchasing credit that is used to plant trees or develop alternative energy plants. **Carbon sequestration** is the process of plants removing CO_2 from the air, which is stored as biomass. **Carbon sinks** are forest, crops, pastures that absorb more carbon then released over a period of time.
Elaboration:	Discuss with students the following aspects:

	The rate of carbon sequestration depends on the growth characteristics of the tree species, the conditions for growth where the tree is planted, and the density of the tree's wood. It is greatest in the younger stages of tree growth, between 20 to 50 years. We can roughly estimate the amount of CO_2 sequestered in a given tree, and if we divide by the tree's age, get a yearly sequestration rate. Is our tree in it's prime of sequestration? Does that matter in determining it's value? Why? Carbon dioxide is one of many greenhouse gases. Methane and nitrous oxide are more effective at trapping heat, but are less prevalent then carbon dioxide. The largest source of CO_2 is from burning fossil fuels to run cars, industrial equipment and power plants. The second largest source is deforestation. Why is harvesting trees a source of CO_2 ? Trees' parts used for biofuel include the waste, or slash, from harvesting trees for lumber or paper use. Weyerhaeuser says that 50% of a tree is wasted or left behind from harvesting. The purpose of the Northwest Advanced Renewables Alliance is to use that waste for jet fuel. The parts of trees used in making jet fuel would be left on the ground otherwise. What are the benefits of using this slash as fuel? What are the negative impacts of using this slash as fuel? If we didn't use the source of jet fuel where else would we get jet fuel from?
Evaluation:	Have students complete the following: Your tree can fly _____ miles, sequester _____ kg of CO_2 which is equal to about _____ days of a school bus driving. What's the best use of your tree? Student's ability to answer the question will reflect their understanding of the assignment and the complexity of the question. There is no right answer in deciding to use slash from harvested trees for biofuel and lumber material or to leave them for carbon sequestering. The important concept

	is to understand that there needs to be a balance and that the answer is not an easy one.

Additional resources:

Climate change related lessons

http://www.facingthefuture.org/

http://www.nsta.org/middleschool/

Carbon Footprint Calculators

http://epa.gov/climatechange/kids/calc/index.html

http://www.cooltheworld.com/kidscarboncalculator.php

http://www.planet-positive.org/how_2_kidscalc.php