Value of a Tree

Program Purpose:
Students will be introduced to the concept of renewable fuel sources from biomass. They will learn about where woody biomass originates and how it is used in jet planes. They will compare the amount of fuel that can be harvested from biomass to the amount of carbon that a tree has sequestered. Students will then debate the merits of harvesting the tree for timber and fuel versus leaving it standing to sequester carbon and provide habitat.

Program Length: 2-3 hours

Ages: Grades 5th - 12th

Maximum Number of Participants: 35

Objectives:
After completion of this activity students should be able to:

- Understand the renewable resource that is woody biomass
- Understand the carbon cycle and the major processes within it (photosynthesis, combustion)
- Understand the effects that carbon has within our atmosphere
- Use tools and basic math to determine the size and potential of a tree
- Debate the best usage of a tree
- Achieve several of the Department of Energy's Energy Literacy Principles (for complete list see Resources)

Preparation:
Before the class arrives:

- Ensure the appropriate equipment is prepared, chairs set up, and the ppt and TV projector set up.

Basic Outline:

I. **Introduction to VOAT project** (5 min)
II. **Concept Map in Pairs** (10 min)
III. **Concept Map Share Out** (10 min)
IV. How do plants make food? (5 min)
V. Origin of Fossil Fuels (5 min)
VI. **Carbon Cycle Activity** (15 min?)
VII. Greenhouse Gas Effect (10 min)
VIII. What is biomass? (5 min)
IX. What is a biofuel? (10 min)
X. **Evaluating a tree** (30 min)
XI. Discussion of best usage of a tree (10 min)

Materials:
Class Worksheets
Reference Charts
Clipboards
Pencils/Pens
PowerPoint with infographics
Prefabricated Clinometers
DBH Tape
Yard Tape 100'
Materials for The Carbon Cycle Game by Jennifer Ceven
    Print outs (7 station signs, 7 mov't directions)
    7 dice
    Recorder sheets for each student

Introduction:

- Introduce the VOAT Project

Introduce yourselves. Tell the students that we will be completing this lesson as part of a Wisconsin Environmental Education Board 2016 forestry grant. We will be making concept maps, exploring the carbon cycle, using forestry tools to measure trees, and calculating the available biomass in a few of our trees at Upham! Thank them for participating in the online assessments – this will help us understand how to teach these important concepts better.

- Determining Value – Concept Maps in pairs. Lead discussion and concept map making <u>outside. Being outside will allow students to be visually stimulated by tree's along with some products of trees.</u>

Ask students to create a concept map of the value of a tree. It may be necessary to frontload the idea of a 'concept map' by first explaining a simplified one. Using something like 'dog' will likely turn into students just characterizing trees and not diving into the values trees provide, which is the goal of this introduction. Try using something like 'your sibling' or 'your teddy bear' as the example so you can flesh out ideas like 'what does your bear provide you?' i.e. comfort, warmth. Not just things like furry, brown, and small. Give the students 10 minutes to complete this activity with the person they are sitting next to. Monitor and engage students during this process.

Allow up to 10 minutes for a group share out and to go over briefly the words on the instructor's concept map. Introduce the terms on this concept map and tell the students that they will learn more about all these things during this lesson.

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Inform the students that from this point on, they will be the leaders of the great energy debate. It is their responsibility to determine if the tree they examine is more beneficial left alive to sequester carbon dioxide and provide habitat or be turned into products including lumber and jet fuel. But first, we need to know a little more about this carbon story. **Hint: There is no right answer!**

---Move students to tree room Nature Center---

- Carbon Cycle

First we need to understand the carbon cycle. Refer to Images 2 and 5 in the appendix for a representation of the Carbon Cycle with respect to the forestry industry. This graphic does not include any numbers and the arrows aren't to scale, keep this in mind. Also it doesn't include an arrow for forest respiration, it otherwise describes the general flow of carbon as it relates to this lesson. Briefly go over the flow of this graphic. Things to highlight include: the presence of cycles within cycles; that plants trap gaseous carbon via photosynthesis and convert it into solid plant biomass; if plants or animals are buried quickly after death, they can turn into fossil fuels; and forests are one of the largest carbon sinks on the planet second to oceans.

- How do plants make food?

Explain the very basic process of photosynthesis. Light + CO2 + water = O2 + Sugar (*is a carbon molecule). Ask what sorts of plant sugars (carbon compounds) they can think of. Answers include any vegetable. Ask where the carbon compounds go if they are covered in soil….(see next slide)

- Fossil Fuels: how are they formed?

Briefly explain how different fossil fuels are formed by using the infographic as a tool. The main takeaway from this topic is that 1) they take a very long time to form and 2) different recipes of organic matter, heat, and pressure form different fossil fuels.

- **Activity:** Carbon Cycle Game

Directions and materials for this 15 min (?) activity is found in S/DOTS Box/NARA/Value of a tree/Lesson Components

- Carbon Sink

A carbon sink is when something takes in more carbon than it gives off over a period of time. Younger forests need more carbon. Prompt the students to answer why this could be. Younger trees are growing at a quicker rate than older trees and thus need more carbon. Refer to Image 6. Notes for this graphic: the horizontal axis is in decades and the vertical axis is in hectare. A hectare is 2.4 acres, which is almost 2 football fields (1.87). If they are having difficulty with the delay in time, talk about the need to establish a good root system before expending a lot of energy on upward growth and reproduction.

Key features include an increase in carbon sequestration during the beginning of a trees life which then tops off. Younger forests sink more carbon, which is why having a rotational system for harvesting tree plantations is beneficial to store carbon.

One of the first points of concern for a more knowledgeable audience is the soil impact. This rotational system doesn't harm the nutrient load in the soil. Longer term studies have shown little difference in soil carbon with harvest intensity except in soils that are initially very low in organic matter[7]. Refer to Image 10, 27% of the tree is below ground[1, 4] and those nutrients get recycled within the soil.

- Greenhouse gas effect

With the slideshow, explain how the greenhouse effect works. Note that too little would let our planet get too cold for life as we know it, and too much, well we're currently running that planetary experiment and may already be seeing the results: stronger storms, erratic weather, changes in phenology.

- CO_2 concentrations – Past and Present Trends

Use the visuals in the Elem_MS Youth Presentation to explain how our atmosphere is changing.

- Why do we focus on Carbon?

"Most climate scientists agree the main cause of the current global warming trend is human expansion of the "greenhouse effect"[6, 3] — warming that results when the atmosphere traps heat radiating from Earth toward space.[6]"

Carbon dioxide is released through natural processes such as respiration and volcano eruptions and through human activities such as deforestation, land use changes, and burning fossil fuels. Humans have increased atmospheric CO2 concentrations by a third since the Industrial Revolution began. This is the most important long-lived "forcing" of climate change."[6] Refer to Image 4 for how greenhouse gasses work. Images 7, 8, 9, 12, 13, and 14 show the amount of greenhouse gasses in the United States and how these levels have changed.

Image 9 takes into account the carbon sinks and shows how this process of using forests as a carbon sink is growing and how it can be beneficial.

- Functions of a tree

Before going too deep into the concept of biomass, it is first necessary to circle back to the function and values of a tree students created in their concept map. Ask the students what trees do for us. Many answers may arise: lumber, shade, habitat for animals, intrinsic value and perhaps the concept of turning carbon dioxide into oxygen. All of these are excellent examples of the benefits of trees.

Timber value is the main reason for harvesting a tree, but there are many uses for trees. Recently there has been a big push for renewable biofuels. Normally the tops and limbs of the trees, also called slash, are left on the ground near the site landing and are later burned. They burn the slash piles for site prep so it is easier when they come back to plant. It also helps remove some threat if a wildfire were to come through the area. So instead of burning the piles and releasing that CO2 to the atmosphere it is now collected and turned into aviation fuel, among other things.

Image 1 shows the breakdown of a tree per its economic value. Each tree species will have a different value for the percentage of tree used for biofuel. The value noted of 23% came from the Consortium for Research on Renewable Industrial Materials or CORRIM[5].

- What is a biofuel?

Many students may not grasp the concept of biofuel so it is important to cover this step. Biofuels refers to any energy made from renewable plant and animal materials. To be technical, a biofuel could be something as simple as burning the leftover biomass to create power. However, the biofuels we are talking about and the energy we would like to create require a bit more processing than that. First, it is important to remember that plants are made from cellulose. Cellulose is a long, linked chain of sugar molecules that give plant cell walls their strength. To harvest biofuels from the woody biomass, these sugars must be extracted and broken down. This is not humanly possible, so we turn to microorganisms and fungi to help us. Just like how bakers use yeast to make their bread rise, scientists are turning to microbes to break down the cellulose into a usable fuel product.

The NARA process of turning forest residues into biofuel is depicted in Image 11.

- What is biomass?

The focus of this lesson will be on the renewable energy source that students understand the least- biomass. It is simple enough for most students to acknowledge that the sun, wind, water, and even the Earth are sources of energy. However, many do not think of the energy that is stored in living things. Biomass can be defined as the material taken from living, or recently living, organisms. The difference between biofuel and biomass is that biomass is used to produce biofuel. Using biomass as a renewable energy source is not a new concept, however much of the technology advancing it is new.

When talking about turning woody biomass into a fuel source, it is important to note that we are referring only to those parts of a tree that remain after logging. When loggers come through, they were previously only interested in the main trunk of the tree. The tops and branches that remained will be the source of energy that we are interested in.

- Assessment of understanding of energy

Assess the students understanding of the concept of energy. What is energy? Scientifically speaking, energy is the ability to do work. Gauge the students' grasp of the usage of energy by asking them one way in which they used energy today. Hopefully some will say useful things like: getting to camp, washing my face, brushing my teeth, my breakfast was cooked with it, etc.

Ask the students if energy can always be observed. No, it is present but not always visible. However, with close inspection there can be evidence of energy all around them. Challenge the students to inspect the room they are in for signs of energy. They may hear, detect motion, or feel heat produced. All of these are evidence of energy being used. Remind them that movement requires energy. In their bodies, food is the source of energy.

Continue their assessment with asking what sources of energy their families/schools use. Are they renewable or nonrenewable? Renewable energy sources are those that can be used for generations without running out. These include solar, biomass, wind, geothermal, and hydropower. Nonrenewable energy sources are those that exist in limited supply and which humans have no means to recreate – like coal, oil, and natural gas.

Wouldn't it be cool if we could get this energy that we are noticing now, from trees?!? Well we can! Lots of countries use trees to provide their energy and more and more people are using wood to heat their homes.

- Brief history of logging

Currently the U.S. forest products industry produces $200 billion in sales a year and employs about one million workers[9]. The United States is the world's largest producer of industrial roundwood, sanwood, and fibre furnish[10]. Industrial roundwood is all wood used for any purpose other than energy[10]. It comprises: pulpwood; sawlogs and veneer logs; and other industrial roundwood (e.g. used for fence posts and telegraph poles) [10].

Evaluating a Tree

- Evaluating a tree

For the sake of this experiment, we will see how much jet fuel is required to transport the Packers via 747 from Lambeau Field to Soldier Field to play against the Bears (roughly 175 miles). The students will calculate how much fuel can be harnessed from a single tree and determine how many trees would be needed to fuel the Packers' flight.

Break the students into groups of 3-4. Head outside to the designated trees and give each group a tree to work with. If the weather does not allow for long amounts of time outside practice using the tools inside first. At Upham Woods, the trees are located at the edge of the playing field near where the cross country ski trail enters the woods. Each tree is labelled with a tree cookie that says "Value of a Tree" and the number of the tree. If there are more groups than there are trees, you may have to double up and have multiple groups examining one tree. Alternatively, you may have the groups choose their own tree that they think could be the biggest.

- Measuring Height

There are multiple ways to measure the height of a tree. For younger groups; stand next to the tree and tell them that you are about 2 meters tall, about 6 feet tall, and then have them guess how many of you would it take to be the same height as the tree. Remind them that you would have to be stacked head to toe. Ensure measurements are made in meters.

A more advanced method is to use angles and length measurements. There are multiple ways to do this. One method is to make a 45, 45, 90 triangle out of a piece of paper. This method is good if you have a large open space to work with that is flat. It requires you to walk back the distance equal to the height of the tree. The distance measurement needs to be taken in meters or converted to meters. Make sure to add in the distance from the ground to the measuring person's eye so you get the full height of the tree. See how to make this clinometer in the resources section if more information is needed[2].

Another option for exact calculation if the group is old enough to understand the trigonometry behind triangles have them use the protractor method. Students can either use a printable protractor version or an actual protractor. This method you need to measure the angle from your spot to the top of the tree, then measure the distance to the tree from the spot where the angle was recorded. Make sure this distance is measured in meters or is converted to meters. You will need a device that has a TAN option to calculate the height. Tangent is the opposite side over the adjacent. We will be solving for the opposite side, which in this case is the height of the tree. After this is solved make sure to add in the distance from the ground to the measuring person's eye so you get the full height of the tree. See how to make a clinometer in the resources section if more information is needed[2].

If you are lucky enough to have an actual clinometer, it might be best to start with the cheaper options so they gain some understanding of what it going on within the clinometer. Otherwise follow step for using the protractor version for measurements and instructions.

- Measuring Circumference

Next, in groups have the students determine the circumference of a tree. The easiest way to do this is either give them a tape measure to hold around the tree or use a piece of yarn and then measure the yarn against a meter stick. Both the height and the circumference of the tree should be in meters.

Have the students use the "How Much Carbon is in a Tree" table to determine how the total carbon held within their tree. Remember that only a portion of the tree will be used for biofuels. The number we are going to use is 23% of the above ground mass (carbon) will be used for fuel. Multiply your above ground number by 0.23. This number is representative of the amount of carbon being used for biofuel. The rest will be used for timber or other products. Half (50%) of the biomass is locked up in the trunk, or bole, of the tree. The remaining 27% of the tree is the root system.[1, 4]

Look at the chart called "How Far Can I Fly in a Boeing 747?" to determine how many miles a jet plane can fly with the fuel produced by the leftover biomass from a particular tree. Also have the students identify the total number of trees identical to theirs that would be needed to complete the 175 mile flight from Lambeau to Soldier Field.

On the "How Far Can I Fly in a Boeing 747?" chart, students should determine how much carbon the tree has sequestered. Remember carbon sequestration is the process by which plants can uptake carbon and store it.

Prompt the students to start thinking about what the best usage is for this tree? Is it more important for this tree to remain standing and sequestering excess carbon from the atmosphere, or to be harvested for lumber and some jet fuel?

Clean Up

Come back inside and return all material to the class box. Have the students get settled and make sure they stay with their groups.

Discussion of best usage of a tree

It is now the students' turn to be the decision makers. In their groups, give them a few moments to reach a decision about whether the tree should be cut down for lumber and fuel or remain standing to sequester carbon and provide habitat. After the allotted time, call the whole class together again. Each group should state their opinion about their tree and why they believe that is the best course of action. Allow for discussion between groups if there are differing opinions.

Conclusion:

Ask the students why the information they gathered today was important.

- In a few short years, they will be the ones responsible for policy and decision making.
- What jobs might renewable energies and biofuel productions impact? How might it affect their personal lives?
- What are the benefits or negatives of using biomass derived from trees versus corn?

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Curriculum developed with support from Agriculture and Food Research Initiative Competitive Grant no. 2011-68005-30416 from the USDA National Institute of Food and Agriculture

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Department of Energy's Energy Literacy Principles, http://energy.gov/eere/education/downloads/7-energy-literacy-principles

Department of Energy's Energy Literacy Principles
Bolded are strongest alignments
1.1 Energy is a physical quantity that follows precise natural laws.
1.4 Energy available to do useful work decreases as it is transferred from system to system.
1.5 Energy comes in different forms and can be divided into categories.
2.3 Earth's weather and climate are mostly driven by energy from the Sun.
2.6 Greenhouse gases affect energy flow through the Earth system.
2.7 The effects of changes in Earth's energy system are often not immediately apparent.
3.1 The Sun is the major source of energy for organisms and the ecosystems of which they are a part.
3.4 Energy flows through food webs in one direction, from producers to consumers and decomposers.
3.5 Ecosystems are affected by changes in the availability of energy and matter.
3.6 Humans are part of Earth's ecosystems and influence energy flow through these systems.
4.1 Humans transfer and transform energy from the environment into forms useful for human endeavors.
4.2 Human use of energy is subject to limits and constraints.
4.3 Fossil and biofuels are organic matter that contain energy captured from sunlight.
4.4 Humans transport energy from place to place.
4.5 Humans generate electricity in multiple ways.
4.6 Humans intentionally store energy for later use in a number of different ways.
4.7 Different sources of energy and the different ways energy can be transformed, transported, and stored each have different benefits and drawbacks.
5.1 Decisions concerning the use of energy resources are made at many levels.
5.2 Energy infrastructure has inertia.
5.3 Energy decisions can be made using a systems-based approach.
5.4 Energy decisions are influenced by economic factors.
5.5 Energy decisions are influenced by political factors.
5.6 Energy decisions are influenced by environmental factors.
5.7 Energy decisions are influenced by social factors.
6.3 Human demand for energy is increasing.
6.4 Earth has limited energy resources.
6.5 Social and technological innovations affects the amount of energy used by human society.
6.6 Behavior and design affect the amount of energy used by human society.
6.7 Products and services carry with them embedded energy.
6.8 Amount of energy used can be calculated and monitored.
7.1 Economic security is impacted by energy choices.
7.2 National security is impacted by energy choices.
7.3 Environmental quality is impacted by energy choices.
7.4 Increasing demand for and limited supplies of fossil fuels affects quality of life.
7.5 Access to energy resources affects quality of life.
7.6 Some populations are more vulnerable to impacts of energy choices than others.

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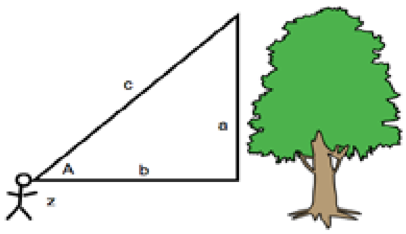
Making a simple clinometer, WikiHow

Appendix A

Value of a Tree class Worksheet
Print out enough for the class beforehand

What is the Value of this Tree?

1. Determine the height of your tree.



Find a place to stand where you can see the top of your tree. Measure the distance from the base of the tree to where you stand with the meter tape.

(b): __________________ m

Find the angle on clinometer from your eye to the top of your tree

(A):__________ degrees

Measure the distance from ground to observer's eyes

(z):_________ m

Height of tree = H = (tan(A))*b + z

H = ________________m

2. Measure the circumference of the tree at chest height.

Circumference of tree: _____________m

(1 inch = 0.0254m)

3. Determine the amount of Carbon in the tree (C)

Use the "How Much Carbon Is in a Tree" chart with the height and circumference of your tree.

Total carbon in your tree (C) :_________ kg

Value of a Tree Worksheet (Back)

4. Determine the amount of Carbon Dioxide Sequestered by your tree

Using "total C in your tree" from <u>question 3</u> and knowing that:

500 kg of C is equal to 1,833 kg of sequestered CO_2, then

(C*1833)/500 = _______ kg of Sequestered CO_2 in your tree

5. Only 23% of the top of the tree will be used for biofuel

Using "total C in your tree" from <u>question 3</u>

C*.23 = _______ kg of potential biofuel

6. Determine the amount of jet fuel (in miles travelled) (M) based on the tree

Using kg of potential biofuel from <u>question 5</u>

And knowing that 500 kg of C can fuel a jet to fly 11 miles, then

(C*11)/500 = (M) __________ miles your tree can fuel

7. How many identical trees are needed for the 175 mile flight between Lambeau Field and Soldier Field?

175/M (<u>from question 6</u>) = _________ trees

Lambeau Field to Soldier Field =175 miles

Image from maps.google.com

Appendix B

Value of a Tree class student reference sheet
Print out enough for the class beforehand

Front

HOW MUCH CARBON IS IN A TREE? (kg)

Circumference at Breast Height (m) across; Tree Height (m) down

Tree Height (m)	0.25	0.5	0.75	1.0	1.25	1.5	1.75	2.0	2.25	2.5	2.75	3.0	3.25	3.5	3.75	4.0	4.25	4.5
2.0	10	14	19	26	36	48	61	77	95	115	138	162	189	217	248	281	316	353
4.0	11	18	28	43	62	86	113	145	181	221	266	315	368	425	486	552	622	696
6.0	13	22	38	60	89	124	165	213	267	327	394	467	547	633	725	823	928	1,040
8.0	14	26	48	77	115	162	217	281	353	433	522	620	726	840	963	1,095	1,235	1,383
10	15	31	57	94	142	200	269	349	439	539	651	773	905	1,048	1,202	1,366	1,541	1,727
12	16	35	67	111	168	238	321	416	525	645	779	925	1,048	1,256	1,440	1,638	1,848	2,070
14	17	39	76	128	195	276	373	484	610	751	907	1,078	1,263	1,464	1,679	1,909	2,154	2,414
16	18	43	86	145	221	315	425	552	696	857	1,035	1,231	1,443	1,672	1,917	2,180	2,460	2,757
18	19	48	95	162	248	353	477	620	782	963	1,164	1,383	1,622	1,879	2,156	2,452	2,767	3,101
20	20	52	105	179	274	391	529	688	868	1,069	1,292	1,536	1,801	2,087	2,394	2,723	3,073	3,444
22	21	56	114	196	301	429	581	756	954	1,175	1,420	1,688	1,980	2,295	2,633	2,994	3,379	3,787
24	22	60	124	213	327	467	633	823	1,040	1,281	1,549	1,841	2,159	2,503	2,872	3,266	3,686	4,131
26	23	64	133	230	354	505	685	891	1,126	1,387	1,677	1,994	2,338	2,710	3,110	3,537	3,992	4,474
28	24	69	143	247	380	544	737	959	1,211	1,493	1,805	2,146	2,517	2,918	3,349	3,809	4,298	4,818
30	25	73	152	264	407	582	789	1,027	1,297	1,599	1,933	2,299	2,697	3,126	3,587	4,080	4,605	5,161
32	26	77	162	281	433	620	840	1,095	1,383	1,705	2,062	2,452	2,876	3,334	3,826	4,351	4,911	5,505
34	27	81	172	294	460	658	892	1,163	1,469	1,811	2,190	2,604	3,055	3,541	4,064	4,623	5,217	5,848
36	28	86	181	315	486	696	944	1,231	1,555	1,917	2,318	2,757	3,234	3,749	4,303	4,894	5,524	6,192
38	29	90	191	332	513	734	996	1,298	1,641	2,023	2,446	2,910	3,413	3,957	4,541	5,166	5,830	6,535
40	31	94	200	349	539	773	1,048	1,366	1,727	2,129	2,575	3,062	3,592	4,165	4,780	5,437	6,137	6,879
42	32	98	210	366	566	811	1,100	1,434	1,813	2,235	2,703	3,215	3,772	4,373	5,018	5,708	6,443	7,222
44	33	103	219	382	592	849	1,152	1,502	1,898	2,341	2,813	3,368	3,951	4,580	5,257	5,980	6,749	7,565
46	34	107	229	399	619	887	1,204	1,507	1,984	2,448	2,960	3,520	4,130	4,788	5,495	6,251	7,056	7,909
48	35	111	238	416	645	925	1,256	1,638	2,070	2,554	3,088	3,673	4,309	4,996	5,734	6,522	7,362	8,252

Reproduced from Project Learning Tree's Exploring Environmental Issues: Focus on Forests.
Estimates based on the formula M_c (mass of carbon in the tree) = 0.5 x M_w (mass of the wood), where M_w = 0.55 x V (volume of tree) x D_w (density of wood); V = 0.0567 + 0.5074 x $(CBH/\varpi)^2$ x H. It assumes that D_w = 0.6 g/cm³, and that water makes up 45 percent of the tree's mass
http://www.plt.org./focus-on-forests-activity-8---climate-change-and-forests

Back

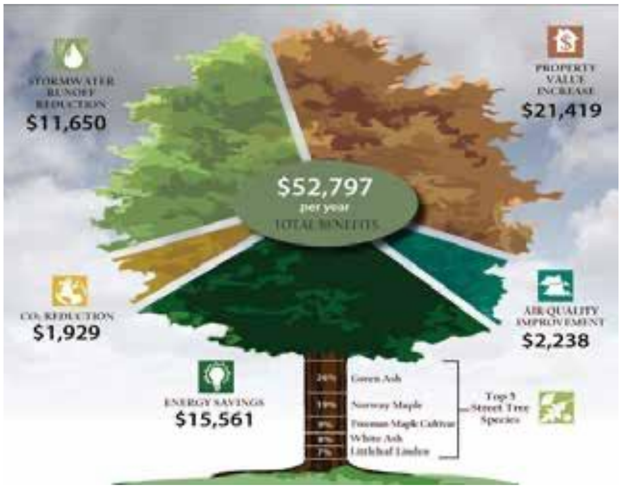
How Far Can I Fly in a Boeing 747? Chart		
Amount of carbon (kg)	**Distance flown (mi)**	**Amount of CO_2 sequestered (kg)**
0-500	0-11	1,833
501-1,000	12-22	3,666
1,001-1,500	23-33	5,499
1,501-2,000	34-44	7,333
2,001-2,500	45-55	9,166
2,501-3,000	56-66	10,999
3,001-3,500	67-77	12,832
3,501-4,000	78-88	14,665
4,001-4,500	89-99	16,498
4,501-5,000	100-110	18,331
5,001-5,500	111-121	20,165
5,501-6,000	122-132	21,998
6,001-6,500	133-143	23,381
6,501-7,000	144-155	25,664
7,001-7,500	156-166	27,497
7,501-8,000	167-177	29,330
8,001-8,500	178-188	31,164

Boeing. 2014. 747 Family: 747-8 Intercontinental fun facts.
www.boeing.com/boeing/commercial/747family/pf/pf_facts.page

Reproduced from Project Learning Tree's Exploring Environmental Issues: Focus on Forests.
Estimates based on the formula M_c (mass of carbon in the tree) = 0.5 x M_w (mass of the wood), where M_w = 0.55 x V (volume of tree) x D_w (density of wood); V = 0.0567 + 0.5074 x $(CBH/\varpi)^2$ x H. It assumes that D_w = 0.6 g/cm³, and that water makes up 45 percent of the tree's mass
http://www.plt.org./focus-on-forests-activity-8---climate-change-and-forests

Appendix C
Images

1.



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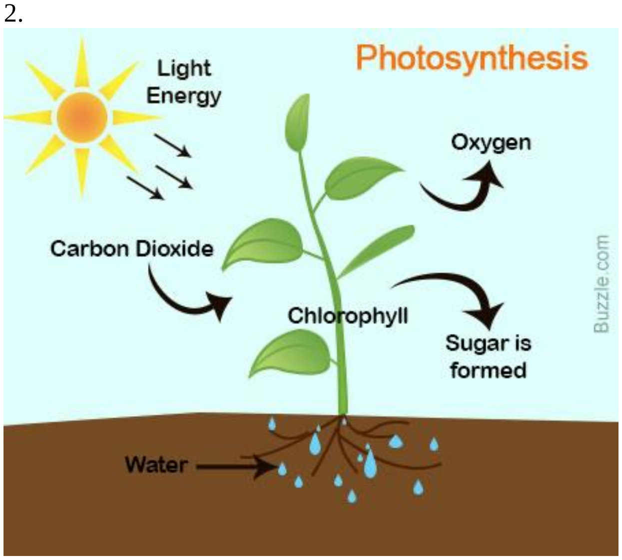

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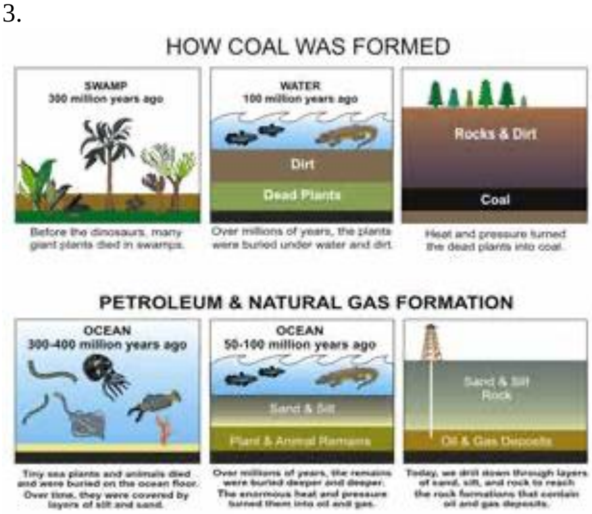

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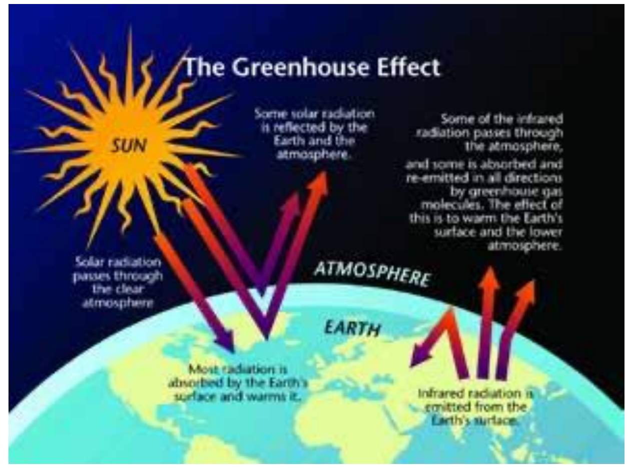

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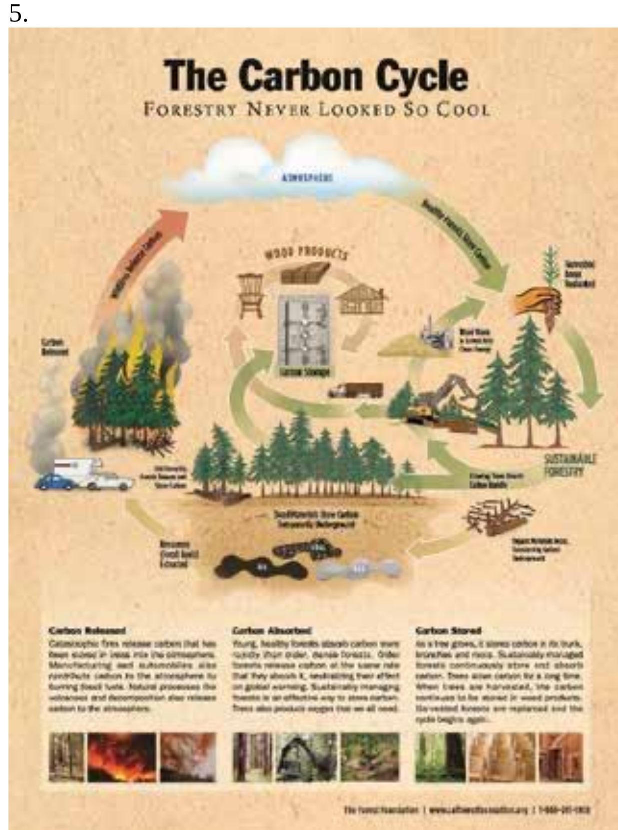

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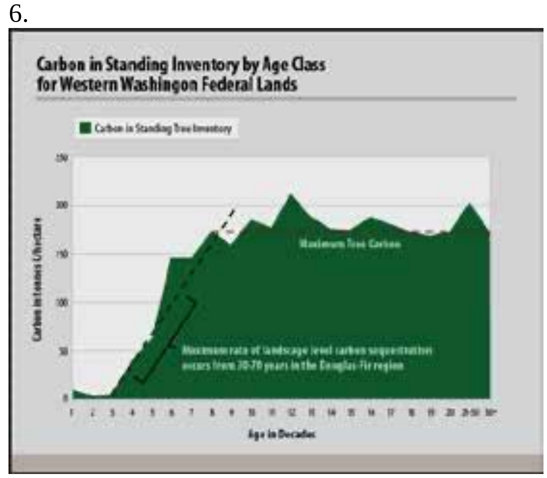
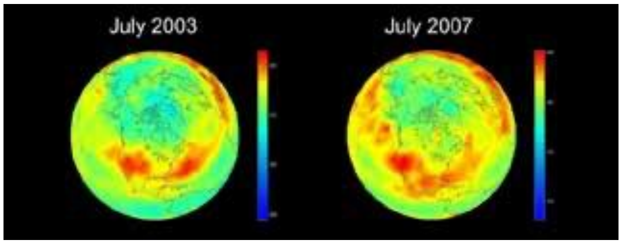
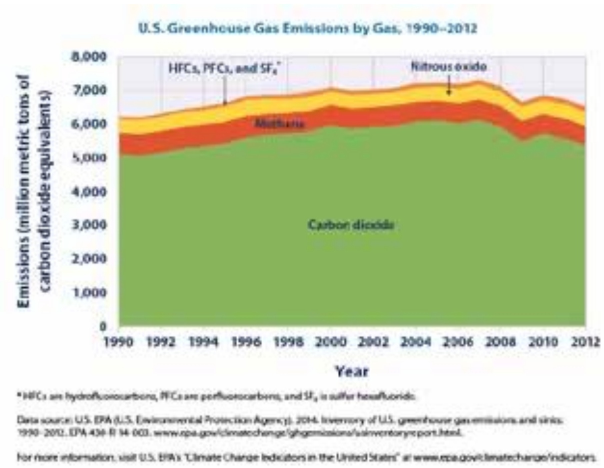


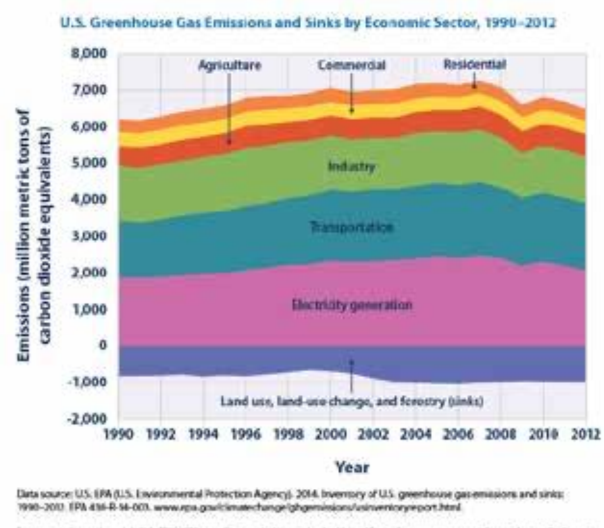
7.


July 2003
July 2007

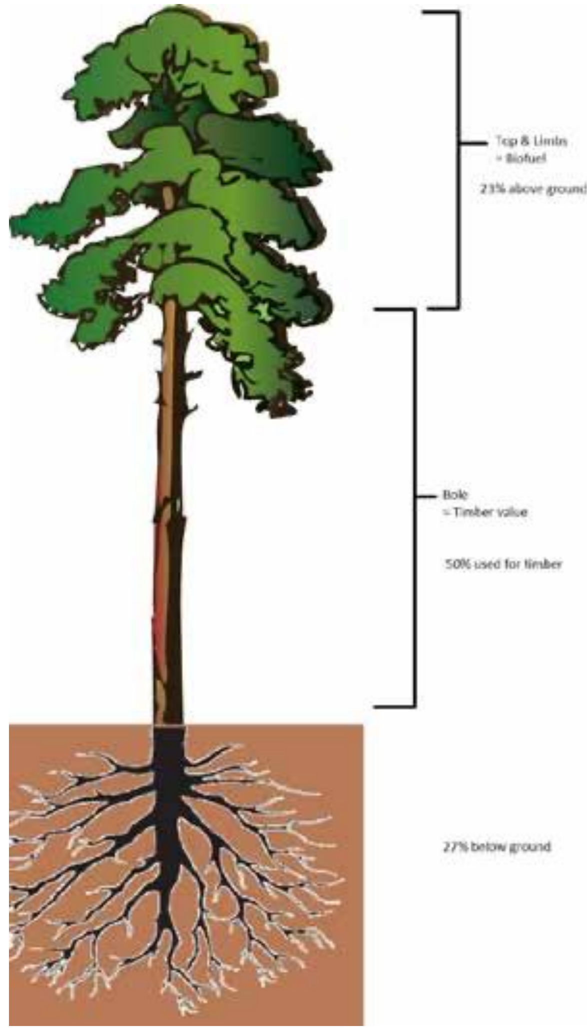
8.


U.S. Greenhouse Gas Emissions by Gas, 1990–2012
Emissions (million metric tons of carbon dioxide equivalents)
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
HFCs, PFCs, and SF₆*
Nitrous oxide
Methane
Carbon dioxide
1990 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012
Year
* HFCs are hydrofluorocarbons, PFCs are perfluorocarbons, and SF₆ is sulfur hexafluoride.
Data source: U.S. EPA (U.S. Environmental Protection Agency). 2014. Inventory of U.S. greenhouse gas emissions and sinks: 1990–2012. EPA 430-R-14-003. www.epa.gov/climatechange/ghgemissions/usinventoryreport.html.
For more information, visit U.S. EPA's "Climate Change Indicators in the United States" at www.epa.gov/climatechange/indicators

9.


U.S. Greenhouse Gas Emissions and Sinks by Economic Sector, 1990–2012
Emissions (million metric tons of carbon dioxide equivalents)
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
-1,000
-2,000
Agriculture
Commercial
Residential
Industry
Transportation
Electricity generation
Land use, land-use change, and forestry (sinks)
1990 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012
Year
Data source: U.S. EPA (U.S. Environmental Protection Agency). 2014. Inventory of U.S. greenhouse gas emissions and sinks: 1990–2012. EPA 430-R-14-003. www.epa.gov/climatechange/ghgemissions/usinventoryreport.html
For more information, visit U.S. EPA's "Climate Change Indicators in the United States" at www.epa.gov/climatechange/indicators

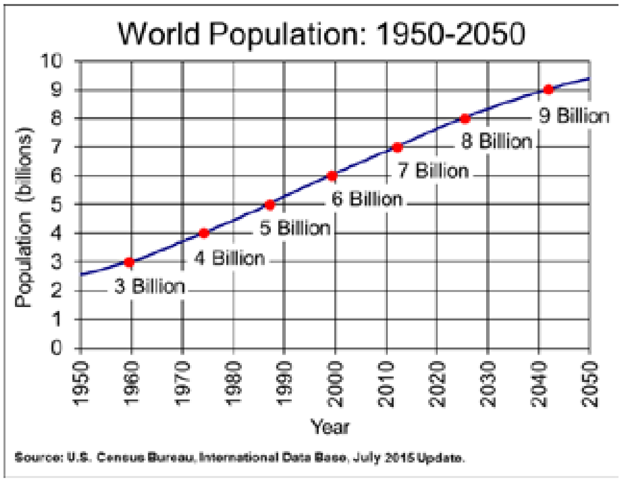
10.


Top & Limbs
= Biofuel
23% above ground
Bole
= Timber value
50% used for timber
27% below ground

11.

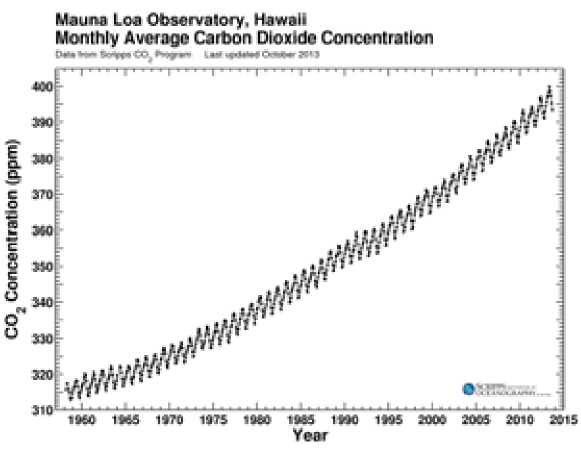

NARA
SUPPLY CHAIN
USDA

12.



13.

14.



15.

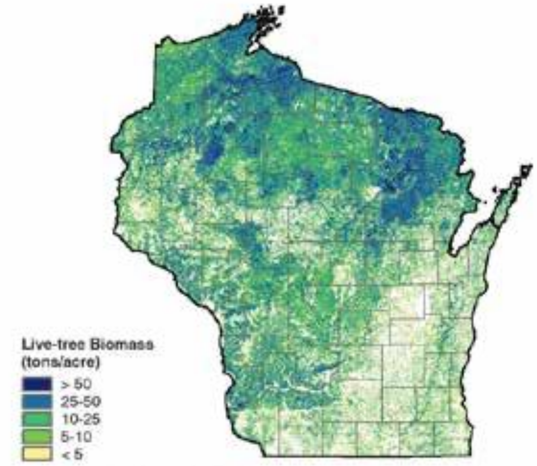
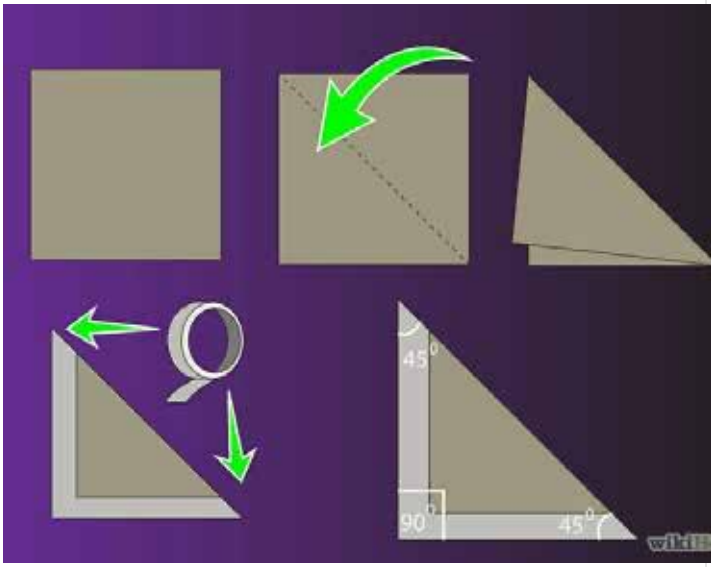
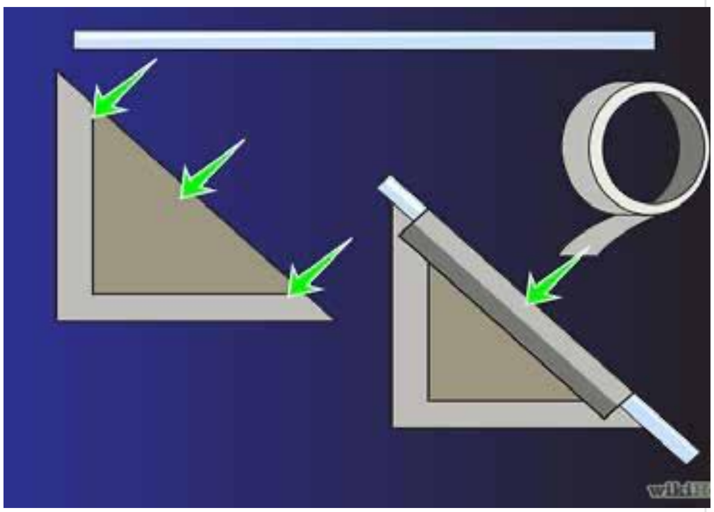
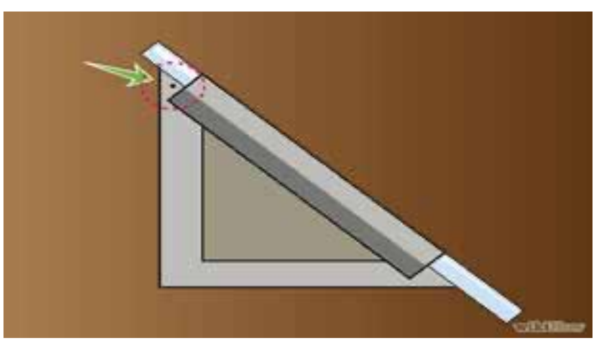


Figure 15.—Spatial distribution of live-tree biomass on forest land, Wisconsin, 2009.

Making a Simple Clinometer

1. 

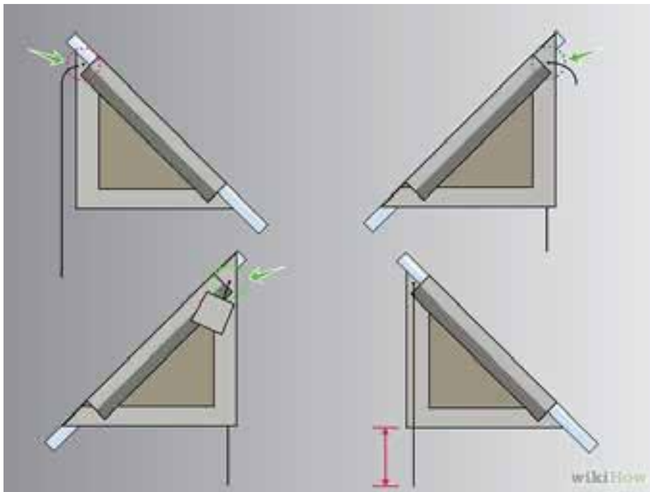
2. 

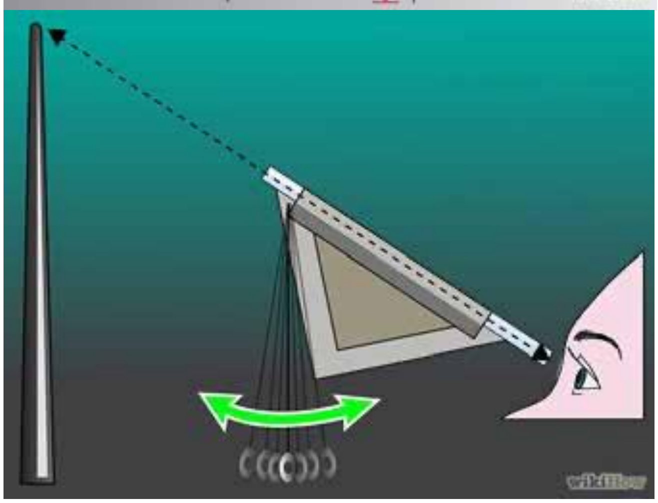
3. 

1. Fold a piece of paper into a triangle. Fold the bottom right corner over to touch the left side of the paper, lining up the sides exactly to form a triangle. If you are using an ordinary rectangular sheet of paper, there will probably be an unfolded "extra" section above this triangle. Cut or tear this section off. What you are left with is an equilateral right triangle, with one 90º angle and two 45º angles. Construction paper will make a more durable clinometer, but you can use any sheet of paper. You may want to tape or glue the triangle together to make it sturdier.

2. Tape a straight drinking straw to the triangle's longest side. Position a drinking straw along the longest edge of the triangle, or hypotenuse, so that one end extends slightly out from the paper. Make sure the straw isn't bent or crushed, and runs straight along the hypotenuse. Use tape or glue to secure it to the paper. You will be looking through this straw when using the clinometer.

3. Punch a small hole next to the end of the straw. Choose the end of the straw that is level with the corner, not the one where the straw extends beyond the paper. Use a hole punch or a sharp pen to make a hole in the triangle near this corner.

4. 

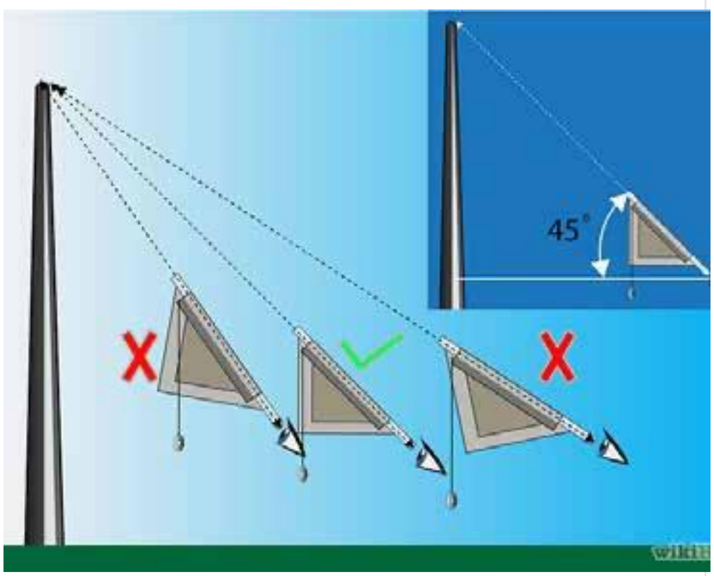
5. 

4. Attach a string through the hole. Push a string through the hole, then tie a knot or tape it to keep it from slipping back out. Use enough string that you have at least a few inches (several centimeters) dangling at the bottom of the clinometer.

5. Tie a small weight to the bottom end of the string. Use a metal washer, a paper clip, or another small object. The weight should dangle 2 inches (5 cm) or more below the corner of the clinometer so that the string will swing freely.

Using a Simple Clinometer

1. 

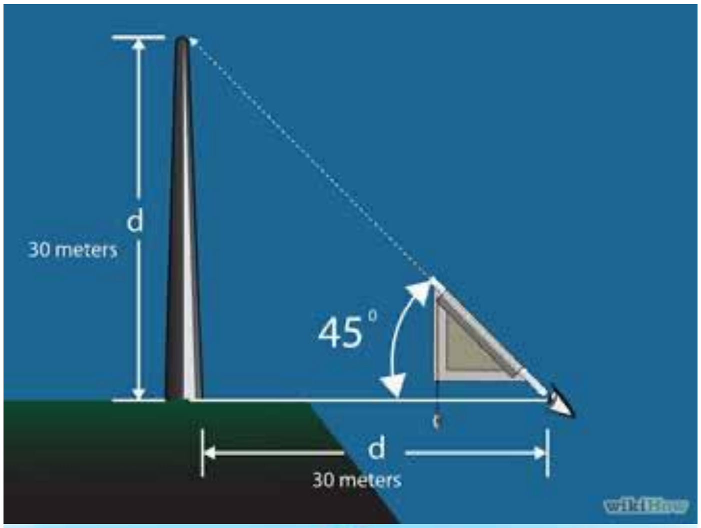
2. 

1. Sight the top of a tall object through the straw. Hold the longer end of the straw next to your eye and point it at the top of a tall object you want to measure, such as a tree. Most likely, you'll have to tilt the triangle in order to see the top of the object you're aiming for.

2. Move forward or backward until the string lines up with the triangle. In order to measure the tree, you need to find a spot to stand where you can hold the triangle completely flat and still see the top of the object through the straw. You can tell when the triangle is flat, because the weight will pull the string down exactly in line with one of the triangle's short sides.

•When this happens, it means the angle of elevation between your eye and the top of the object is 45 degrees.

•If you crouch or stand on an object to find a better position, you'll need to measure your height at eye level while in that position, instead of when standing normally as described in a later step.



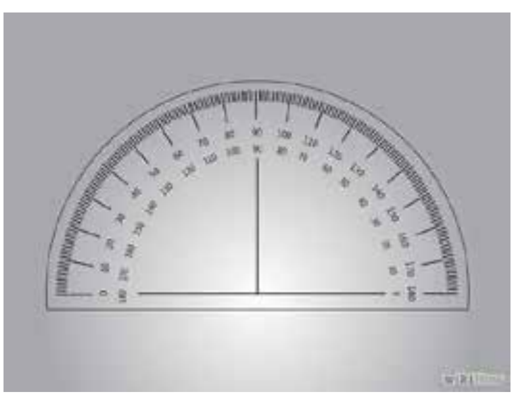
3.

4.

3. Use a tape measure to find the distance between this position and the base of the tall object. Just like the triangle you're holding, the giant triangle formed by you, the base of the tall object, and the top of the object has two 45º angles and one 90º angle. The two shorter sides of a 45-45-90 triangle are always the same length. Measure the distance between the position you were standing in at the end of the last step, and the base of the tall object you are measuring. The result is almost the height of the tall object, but there's one more step to get your final answer.

4. Add your height at eye level to get the final answer. Because you held the clinometer at eye level, you actually measured the height of the object starting at your eye's height above the ground.[1] Use a tape measure to find out how tall you are from the ground to your eye level, add the result to the number you measured in the last step. Now you know the full height of the object!

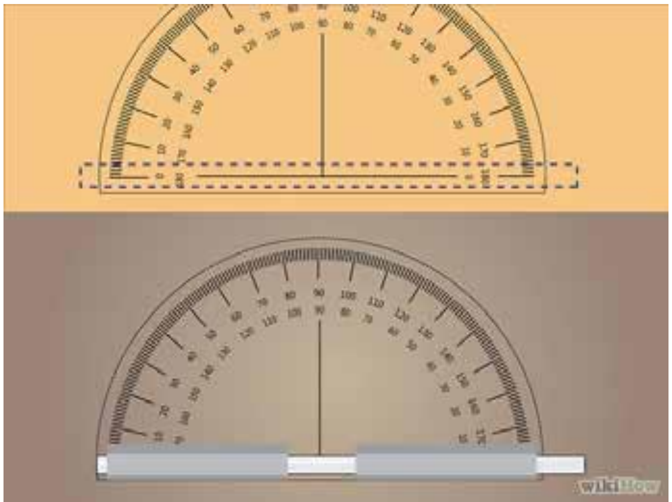
Making a Protractor Clinometer



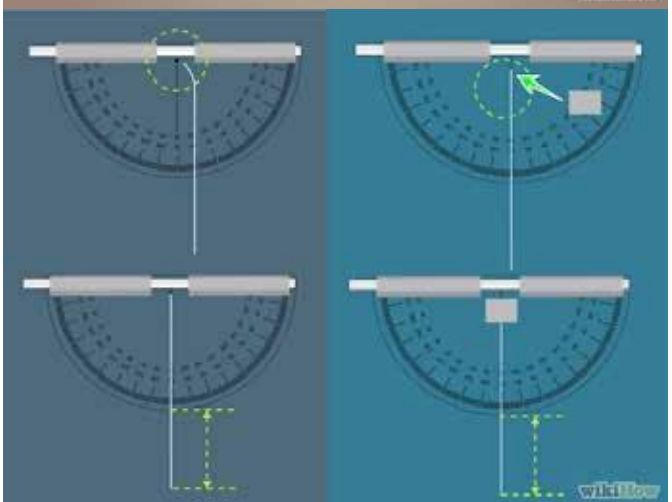
1.

1. Find a 180º protractor. This type of protractor is shaped like half a circle, with angles marked all around the rim. You can buy them anywhere that sells school supplies. Ideally, choose a protractor with a small hole near the center of the protractor, along its straight base.

•If you don't want to buy one, you can search online for a printable protractor. Print it out, cut it very carefully along its outline, and glue the paper protractor to something a little sturdier, such as construction paper or an index card.



2.



3.

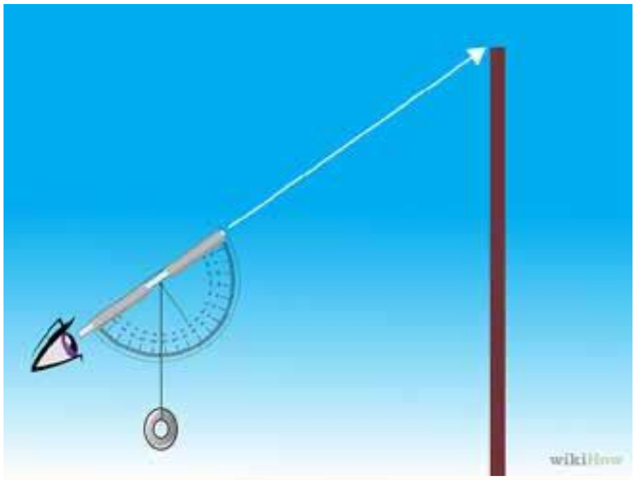
4.

2. Tape a straw along the straight edge. Tape a straight, plastic drinking straw on or near the straight edge of the protractor. Make sure the straw passes through the two 0º or zero marks on opposite ends of the straight edge.
•If you don't have a straw, roll a piece of paper into a tight cylinder and use that instead.

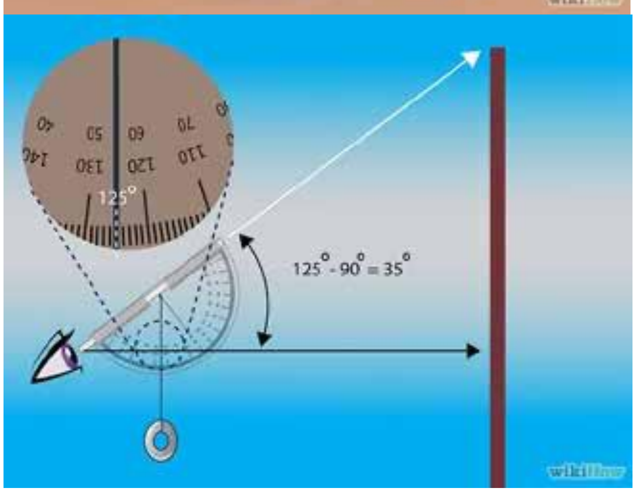
3 Tie a string through the small hole on the straight edge. Many protractors come with a small hole directly between the 0º marks on the protractor, across from the 90º mark on the curved edge of the protractor. If your protractor does not have a small hole here, or if the hole is not situated correctly, tape or glue the string to the protractor where the hole should be. Make sure the string dangles a few inches (several centimeters) below the protractor.
•If you are using a paper protractor, you can punch the hole yourself with a sharp pen or hole punch. Do not try to punch a hole in a plastic protractor, as it is probably made from weak plastic and could shatter.

4. Attach a small weight to the dangling end of the string. Tie a paper clip, metal washer, or other small weight to the end of the string. When you hold the clinometer so the string falls past the circular rim of the protractor, the weight will pull the string straight down past an angle mark on the protractor, such as 60º. This tells you what angle the clinometer is being held at, which can be used to find the heights of distant objects as described in the section below.

Using a Protractor Clinometer

1. 

2. 

3. 

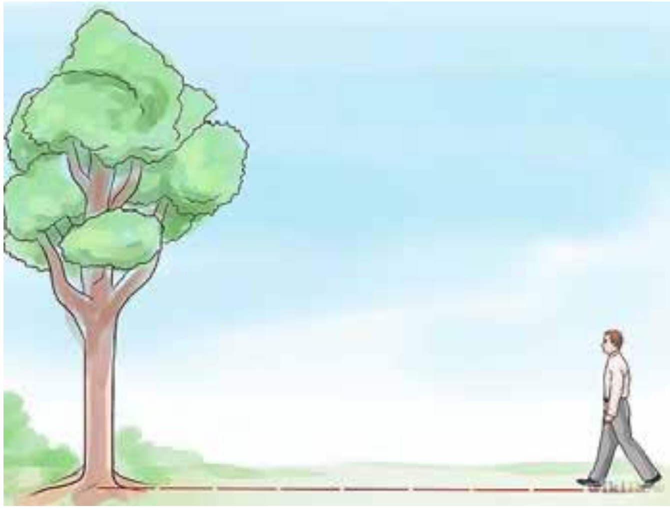
1. Sight the top of a tall object through the straw. Hold the clinometer so the curved rim of the protractor is facing downward. Tilt the clinometer until you can look through the straw or paper tube and see the top of a tall object you want to measure, such as a building. You can use this method to measure the angle between you and the top of that object, or the object's height.

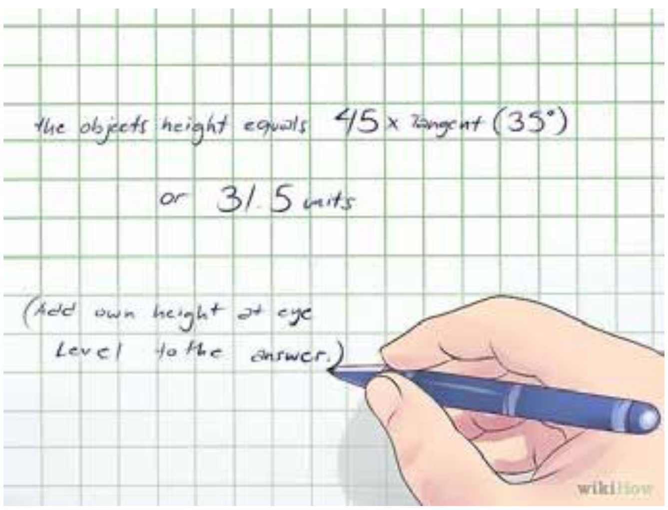
2. Measure the angle using the protractor. Keep the clinometer steady in that position, until the dangling string becomes still. Calculate the angle between the midpoint of the protractor (90º), and the point where the string crosses the rim by subtracting one from the other. For example, if the string crosses the rim at 60º, the angle of elevation between you and the top of the object is 90–60=30º. If the string crosses the rim at 150º, the angle of elevation is 150-90=60º.

•The angle of elevation will always be less than 90º, since 90º is straight up in the sky.

•The answer will always be positive (greater than 0º). If you subtract the larger number from the smaller and get a negative number, just cross out the minus sign to get the right answer. For example, if you calculate that 60-90=-30º, the actual angle of elevation is +30º.

3. Calculate the tangent of this angle. The tangent of an angle is defined as the side of a right triangle opposite the angle, divided by the side adjacent to the angle. In this case, the triangle is formed by three points: you, the base of the object, and the top of the object. The "opposite" side from this angle is the height of the object, and the adjacent side is the distance between you and the object's base.
•You can use a scientific or graphing calculator, an online tangent calculator, or a chart listing tangents for various angles.
•To calculate the tangent on a calculator, press TAN and enter the angle you found. If the answer is below 0 or above 1, set your calculator to degrees instead of radians and try again.

4. 

5. 

4. Measure your distance from the object. If you want to find out how tall the object is, you'll need to know how far away you are from its base. Measure using a tape measure. If you don't have one, count the number of ordinary steps it takes to get to the object, then measure the length of one step once you find a ruler. The total distance is the length of one step multiplied by the number of steps you took.

•Some protractors have rulers marked along the straight edge.

5. Use your measurements to calculate the height of the object. Remember, the tangent of your angle is (object's height) / (distance between you and the object). Multiply the tangent by the distance you measured, and you'll be left with just the object's height!

•For example, if the angle of elevation was 35º, and your distance from the object was 45 units, the object's height equals 45 x tangent (35º), or 31.5 units.

•Add your own height at eye level to your answer, since that's how far your clinometer was above the ground.

Appendix D
Standards Alignment

<u>Next Generation Science Standards</u>
CC – Curriculum Connections
MS-PS Matter and its Interactions – CC
MS-PS1-3
MS-LS From Molecules to Organisms: Structures and Processes – CC
MS-LS1-6
Ecosystems: Interactions, Energy, and Dynamics - CC
MS-LS2-3
MS-ESS Earth and Human Activity – CC
MS-ESS3-3
MS-ESS3-4
MS-ESS3-5

HS-LS From Molecules to Organisms: Structures and Processes – CC
HS-LS1-5
HS-LS1-6
HS-LS1-7
Ecosystems: Interactions, Energy, and Dynamics - CC
HS-LS2-3
HS-LS2-4
HS-LS2-5
HS-ESS Earth and Human Activity – CC
HS-ESS3-2
HS-ESS3-3
HS-ESS3-6

<u>Common Core State Standards</u>
RST.6-8.1
RST.6-8.2
RST.11-12.1
6.EE.B.6
6.EE.C.9
MP.4
HSN.Q.A.1
SL.8.5
SL.11-12.5

<u>Wisconsin's Model Academic Standards:</u>
Agriculture, Food and Natural Resources
ESS4.a.4.m: Identify alternative energy sources
ESS4.a.5.h: Compare and contrast the use and environmental impact of the burning of fossil fuels (conventional energy sources).
ESS4.a.6.h: Compare and contrast the use and environmental impact of alternative energy sources.
ESS4.b.3.m: Explain the importance of surveying and mapping for environmental service systems.
ESS4.b.4.m: Demonstrate proper use and maintenance of hand tools.
ESS4.b.5.h: Explain and demonstrate surveying principles with identification of forestry equipment.
NR1.a.3.m: Differentiate between renewable and nonrenewable natural resources.
NR1.b.6.m: Describe morphological characteristics