Learning about Forests (LEAF) Monthly Planning Guide for LINKS Chapters

February 2024

Overview

Monthly Theme	Environmental Awareness Days	Cultural and Identity Awareness Days
Forests and Climate Change	World Wetlands Day (2)	Black History Month | International Day of Girls and Women in Science (11) | Frederick Douglass Day (14)

Elementary	1. Activity 1: Understanding Forests and Climate Change 2. Activity 2: Map the Trees and Forest in Your Community 3. Activity 3: Trees and Climate Change Activity 4. Activity 4: Celebrating STEM Leaders During Black History Month
Middle and High School	1. Activity 1: Understanding Forests and Climate Change 2. Activity 2: Map the Trees and Forest in Your Community 3. Activity 3: Trees and Climate Change Activity 4. Activity 4: Celebrating STEM Leaders During Black History Month

Mentoring Moment Suggestion

Seek out passionate volunteers, activists, elders, and Indigenous members of the community, consider accessing the expertise of scientists, natural resource managers, urban foresters, climate scientists, STEM academics, public health officials, engineers, urban planners, city officials, elected leaders, policy experts, community organizers, non-profit leaders, environmental justice advocates, or journalists.

Forests and Climate Change

ELEMENTARY ACTIVITIES

SUMMARY

These activities will provide youth with an opportunity to understand how trees benefit communities and the role forests can play in mitigating the effects of climate change.

MATERIALS

- *Video:* **Understanding Forests, Carbon, and Climate**
- *Video:* **What If There Were 1 trillion More Trees?**
- *Video:* **Planting Trees: Can Trees Undo Climate Change?**
- *Reading*: What Can Trees Tell Us About Climate Change (attached)
- *Worksheet*: How to Calculate Tree Value (attached)
- *Website***:** Discover the Forest **(discovertheforest.org)**
- *Website:* Our Trees **(https://ourtrees.itreetools.org/#/)**
- *Worksheet:* Trees and Climate Change *(attached)*
- *Reading:* **Ten Black Scientists that Science Teachers Should Know About** *(attached)*
- Video: **Black Scientists and Inventors**
- *Video***: Fun Facts about Dr. Mae C. Jemison**

BACKGROUND

Forests cover about 30% of the Earth's land surface. As forests grow, their trees take in carbon from the air and store it in wood, plant matter, and under the soil. If not for forests, much of this carbon would remain in the atmosphere in the form of carbon dioxide (CO_2), the most important greenhouse gas driving climate change.

Each year since 2000, forests are estimated to have removed an average of 2 billion metric tons of carbon from the atmosphere.[1] This "carbon sink function" of forests is slowing climate change by reducing the rate at which CO_2, mainly from fossil fuel burning, builds up in the atmosphere. Careful forest management can therefore be an important strategy to help address climate change in the future. Healthy forests also provide a host of other benefits, from clean water to habitat for plants and animals that can live nowhere else.

Deforestation, and our options to reverse it

Over the past 8,000 years, humans have cleared up to half of the forests on our planet, mostly to make room for agriculture.[2] Cutting down or burning forests releases the carbon stored in their trees and soil, and prevents them from absorbing more CO_2 in the future. Since 1850, about 30% of all CO_2 emissions have come from deforestation.[3] Deforestation can also have more local climate impacts. Because trees release moisture that cools the air

around them, scientists have found that deforestation has led to more intense heat waves in North America and Eurasia.[4]

There are three ways to reverse these losses: *afforestation*, *reforestation*, and the *natural regeneration of* forest ecosystems. **Afforestation** refers to planting forests where there were none before, or where forests have been missing for a long time—50 years or more. **Reforestation** is planting trees where forests have been recently cleared. Natural regeneration, on the other hand, does not involve tree-planting.[5] Instead, forest managers help damaged forests regrow by letting trees naturally re-seed, and through techniques like coppicing, in which trees are cut down to stumps so new shoots can grow.

Forests as a climate solution

There is no doubt that these strategies can help remove CO_2 from the atmosphere, but their impact is hard to measure.

Natural regeneration of forests, on the other hand, has few unintended consequences and large potential to store carbon over the coming decades. If done worldwide, natural regeneration of forests could capture up to 70 billion tons of carbon in plants and soils between now and 2050[8]—an amount equal to around seven years of current industrial emissions. Combining natural regeneration with thoughtful afforestation and reforestation is an important option for combating climate change.

Activity 1: Understanding Forests and Climate Change

WHAT TO DO

Use these videos to help students understand the connections between forests, carbon, and climate change.

1. *Reading*: **What Can Trees Tell Us About Climate Change?** (also attached)

***2.** Video:* **Understanding Forests, Carbon, and Climate**

2. Video: [What if there were 1 trillion more trees?]

3. **Video:** [Planting Trees: Can Trees Undo Climate Change?]

Activity 2: Map the Trees and Forest—and their Benefits—In Your Community

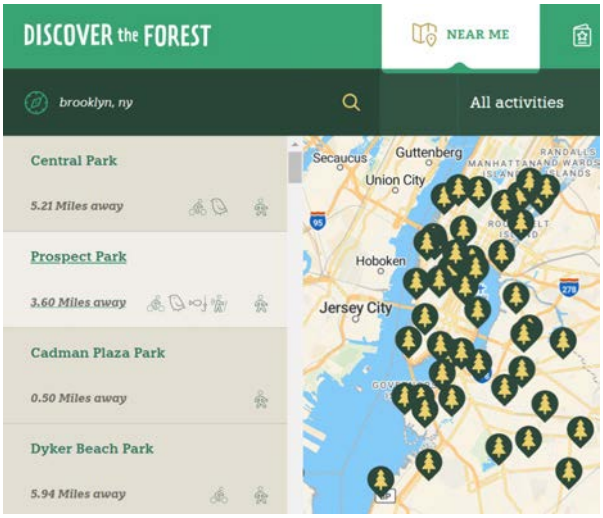
The following easy-to-use data collection and mapping tools will allow youth to view parks and tree canopy coverage in their communities and understand the benefits that trees provide.

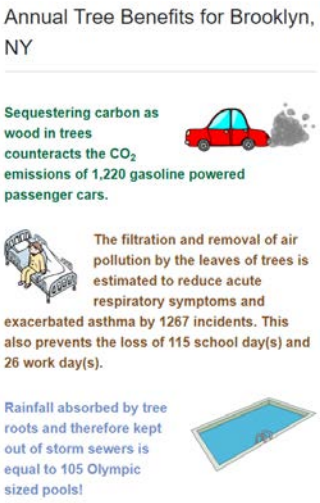
- **EcoSchools: How to Calculate Tree Value** (full worksheet attached)
  - Calculate the value of a tree by collecting data about its species, size, location, condition, and ecological benefits.
  - Complete the worksheet to determine the full value.

- **Discover the Forest (discovertheforest.org)**
  - This map will show results for all types of parks within 5 miles of your address, including botanical gardens, historical sites, national parks, natural areas, and zoos (see image below, left).
  - Enter your city, zip code, or address into the search bar.
  - You can refine the results or expand them to find parks in a greater range.

- **Our Trees (https://ourtrees.itreetools.org/#/)**
  - This mapping tool will provide the amount of carbon dioxide and air pollution a community's trees remove, as well as stormwater impacts.
  - The tool also shows demographic information for the community and provides helpful comparisons to understand the beneficial impact of trees (see image below right).

- Enter your location/city into the tool and get an estimate of the canopy coverage and the benefits of your community's trees!





Activity 3: Trees and Climate Change

Complete worksheet is attached.

WHAT TO DO

This worksheet will guide youth through readings, questions, and activities to explore the connections between trees and climate. It includes basics about tree biology and growth and background information and definitions about climate change.

Activity 4: Celebrating STEM Leaders During Black History Month

Use the following videos and reading to explore the stories and voices of Black scientists, engineers, mathematicians, and inventors.

- Reading (attached): **Ten Black Scientists that Science Teachers Should Know About**

- Video: **Black Scientists and Inventors**
  Celebrate Black History Month with this kid-friendly, animated video on the lives and legacies of Dr. Daniel Hale Williams, George Washington Carver, Madam C.J. Walker, Garrett A. Morgan, and Mae Jemison.

- **Video:** [Fun Facts about Dr. Mae C. Jemison]

Learn about Dr. Mae C. Jemison, the 1st African American Woman to go into space.

Forests and Climate Change

MIDDLE AND HIGH SCHOOL ACTIVITIES

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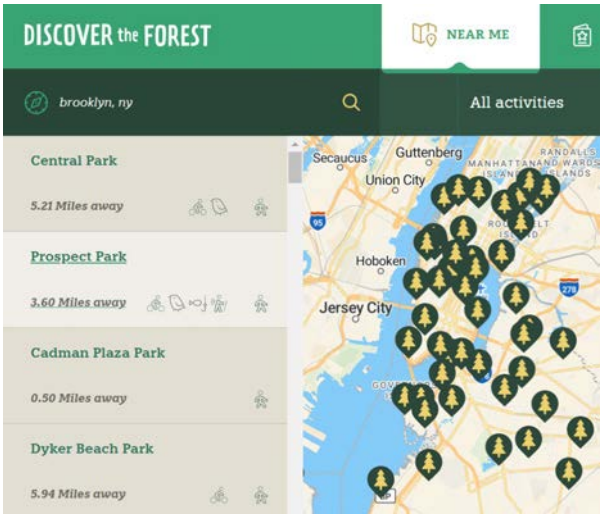

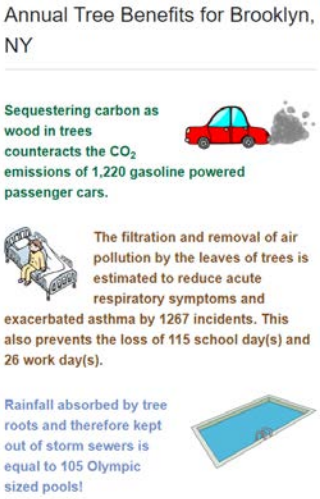

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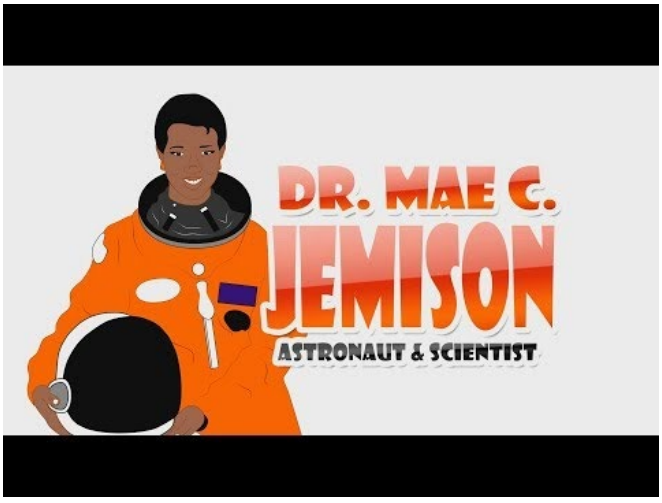


What Can Trees Tell Us About Climate Change?

3-4 minutes

The Short Answer:

The characteristics of the rings inside a tree can tell scientists how old a tree is and what the weather conditions were like during each year of that tree's life. Very old trees can offer clues about what the climate in an area was like long before measurements were recorded.

Image credit: Flickr user Bernard Spragg. NZ

Quite a lot, actually!

But to understand what the trees tell us, we first have to understand the difference between weather and climate.

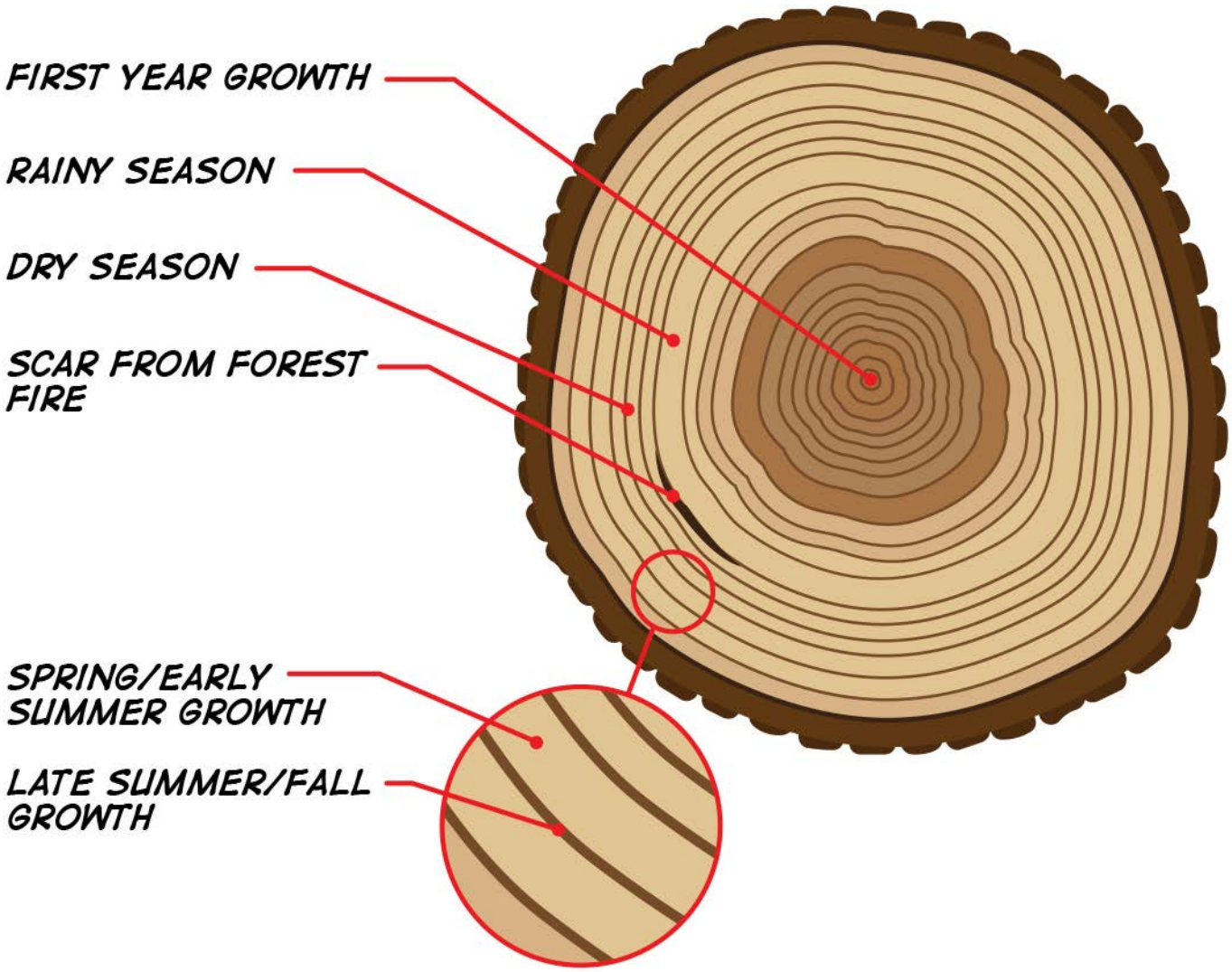
Weather is a specific event—like a rain storm or hot day—that happens over a short period of time. Weather can be tracked within hours or days. **Climate** is the average weather conditions in a place over a long period of time (30 years or more).

Scientists at the National Weather Service have been keeping track of weather in the United States since 1891. But trees can keep a much longer record of Earth's climate. In fact, trees can live for hundreds—and sometimes even thousands—of years!

One way that scientists use trees to learn about past climate is by studying a tree's rings. If you've ever seen a tree stump, you probably noticed that the top of the stump had a series of rings. It looks a bit like a bullseye.

The light and dark rings of a tree. Image credit: Flickr Creative Commons user Amanda Tromley

These rings can tell us how old the tree is, and what the weather was like during each year of the tree's life. The light-colored rings represent wood that grew in the spring and early summer, while the dark rings represent wood that grew in the late summer and fall. One light ring plus one dark ring equals one year of the tree's life.



The color and width of tree rings can provide snapshots of past climate conditions.

Because trees are sensitive to local climate conditions, such as rain and temperature, they give scientists some information about that area's local climate in the past. For example, tree rings usually grow wider in warm, wet years and they are thinner in years when it is cold and dry. If the tree has experienced stressful conditions, such as a drought, the tree might hardly grow at all in those years.

Scientists can compare modern trees with local measurements of temperature and precipitation from the nearest weather station. However, very old trees can offer clues about what the climate was like long before measurements were recorded.

This is said to be the Methuselah Tree, one of the oldest living trees in the world. Methuselah, a bristlecone pine tree in White Mountain, California is thought to be almost 5,000 years old. Image credit: Oke/Wikimedia Commons

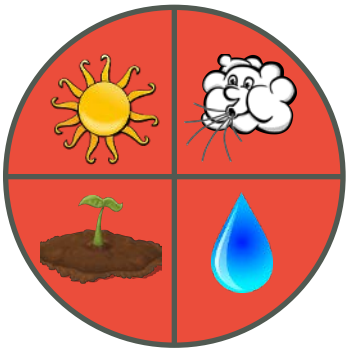
In most places, daily weather records have only been kept for the past 100 to 150 years. So, to learn about the climate hundreds to thousands of years ago, scientists need to use other sources, such as trees, corals, and ice cores (layers of ice drilled out of a glacier).

TREES & CLIMATE CHANGE

Before we get to climate change and what it is, let's start with trees.

HOW DOES A TREE GROW?

A tree needs four things to grow: sun, air, soil, and water. Each of these elements provides something for the tree.



SUN: ENERGY
AIR: CARBON DIOXIDE
SOIL: NUTRIENTS
WATER: HYDRATION

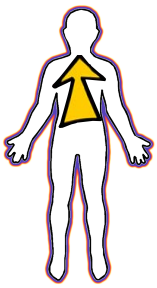
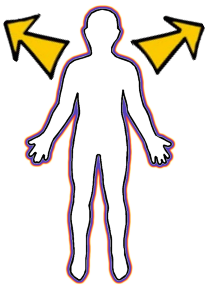
What is carbon dioxide?

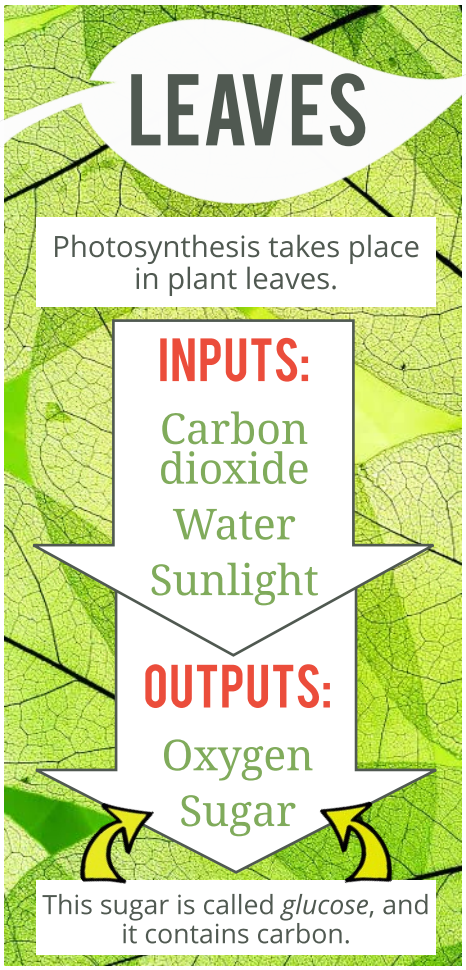
Carbon dioxide is a kind of gas in Earth's atmosphere (the air around the planet). It is made up of one part carbon and two parts oxygen. Trees use carbon dioxide in the process of **photosynthesis.**

WHAT IS PHOTOSYNTHESIS?

Photosynthesis is the process trees and plants use to make their own food. A tree can't grow unless it has food to nourish it, just like you! You can think of this like cooking: ingredients go in to make the dish (inputs), and at the end you have a meal (output).

What are two *inputs* that you need to live and what *outputs* do they provide you with? Think of outputs in terms of energy, oxygen, nutrients, and hydration.

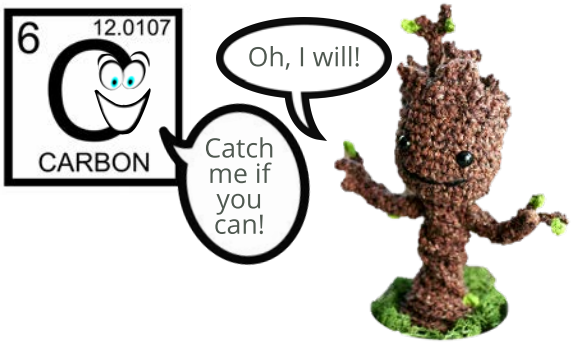
INPUTS:	OUTPUTS:
	
Example: bowl of salad	*Energy to play soccer*



HOW DO TREES HELP WITH CLIMATE CHANGE?

What does this have to do with climate change? Well, the key is in the *carbon*. Trees take in carbon dioxide through their leaves from the atmosphere, which is known as **carbon capture**. They then use the carbon to grow their trunks, branches, and roots. This is called **carbon storage**.

Carbon that is stored in a tree remains there, even after the tree is cut down. That means that if you have a desk, bed, chair, or anything made of wood, it has stored carbon in it.



WANTED: CLIMATE CHANGE CRIMINALS

CO_2 CARBON DIOXIDE
Making up a whopping 84% of all man-made greenhouse gases, CO_2 is the bad boy of the bunch.

CH_4 METHANE
Methane is a dangerous sidekick, making up 9% of man-made greenhouse gases.

N_2O NITROUS OXIDE
Not to be underestimated, nitrous oxide accounts for 5%.

HFC, PFC, SF_6, NF_3 FLUORINATED GASES
Hoping to one day be as cool as their friends above, fluorinated gases currently make up 2%.

DEFINING CLIMATE CHANGE

Climate change is defined as a significant and long-lasting change in the Earth's climate and weather patterns. Some climate change is normal, but some change is driven by our behaviors. Too much change can threaten animal habitats, cause sea levels to rise, and increase catastrophic storms and natural disasters.

Some of the biggest culprits of climate change are greenhouse gases (GHGs). **Greenhouse gases** are gases in Earth's atmosphere that absorb heat energy from the sun and radiate it back to Earth's surface, thus warming the planet. One such gas is carbon dioxide.

Though natural processes also release GHGs, most are released by human activities (see the list to the left).

How does a tree's ability to store carbon affect climate change?

HUMAN ACTIVITIES

What are the human activities that release the greenhouse gases above? We can trace an overwhelming amount of our emissions back to fossil fuels. **Fossil fuels** are carbon-rich reserves of plant and animal remains that have decomposed over millions of years. Fossil fuels include the coal that we burn in power plants to create electricity for our homes, the natural gas that we burn to heat them, and the oil that we use to power our cars and planes. Fortunately, trees help absorb the carbon dioxide emissions from these activities, which is why we need to keep planting and protecting them!

HOW DO YOU MEASURE CARBON IN A TREE?

That is what you are going to learn now!

The amount of carbon that a tree can store depends on the size of the tree. Think of it like a suitcase: the larger the suitcase, the more you can put in it. To figure out how much carbon is in a tree, you have to measure the size of the tree. Two measurements are important: circumference and height.

Because tree trunks are different shapes and sizes, **arborists** (tree specialists) had to come up with a consistent way to measure the circumference. They decided to measure the circumference of all trees at 4.5 feet from the ground, called "**standard height.**"

First, describe the tree:

Materials:

Long string	**Meter stick**
Activity page or notebook	**Pencil and marker**
Another person	**Tape**

Instructions:

Gather the materials listed above, and go find a tree outside that you can measure. Look for a tree in your own yard, a park, or another public space.

HOW TO MEASURE CIRCUMFERENCE:

- Use the meter stick to find where standard height is on the tree.
- Mark that height with a piece of tape.
- Take your string and wrap it around the trunk of the tree at the marked spot.
- Use your marker to draw on the string at the point where it has encircled the tree.
- Measure the length of string up to the marked point using the meter stick.
- Record below.

Tree circumference: _____ meters

HOW TO ESTIMATE HEIGHT:

- Have the person who is with you stand next to the tree and hold the meter stick on the ground.
- Step far enough away from the tree that you can see the bottom of the trunk and the top of the branches.
- Use your thumb and index finger to approximate the size of the meter stick.
- Keep your fingers in that same position and count up the tree to estimate how many meters the tree is in height.
- Record below.

Tree height: _____ meters

HOW MUCH CARBON IS THAT?

Use the chart on the next page to find out approximately how much carbon is stored in the tree that you measured, and record it below.

This tree stores: _____ kilograms **of carbon.**

HOW MUCH CARBON CAN ONE TREE STORE?

Use this table to find a rough estimate of the amount of carbon stored in a tree on the basis of the tree's circumference at standard height and your estimation of the tree's height. The estimated amount of carbon is in kilograms (kg).

Circumference at Standard Height (in meters)

Tree Height (in meters)	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
2	10	14	19	26	36	48	61	77	95	115	138	162	189	217	248	281
3	10.5	16	23.5	49	42	67	87	111	138	168	202	238.5	278.5	321	367	416.5
4	11	18	28	43	62	86	113	145	181	221	266	315	368	425	486	552
5	12	20	33	51.5	75.5	105	139	179	224	274	330	397	457.5	529	605.5	687.5
6	13	22	38	60	89	124	165	213	267	327	394	467	547	633	725	823
8	14	26	48	77	115	162	217	281	353	433	522	620	726	840	963	1,095
10	15	31	57	94	142	200	269	349	439	539	651	773	905	1,048	1,202	1,366
12	16	35	67	111	168	238	321	416	525	645	779	925	1,084	1,256	1,440	1,638
14	17	39	76	128	195	276	373	484	610	751	907	1,078	1,263	1,464	1,679	1,909
16	18	43	86	145	221	315	425	552	696	857	1,035	1,231	1,443	1,672	1,917	2,180
18	19	48	95	162	248	353	477	620	782	963	1,164	1,383	1,622	1,879	2,156	2,452
20	20	52	105	179	274	391	529	688	868	1,069	1,292	1,536	1,801	2,087	2,394	2,723
22	21	56	114	196	301	429	581	756	954	1,175	1,420	1,688	1,980	2,295	2,633	2,994
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
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
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
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

This chart was adapted by Canopy from a Project Learning Tree resource: https://www.plt.org/activity-resources/focus-on-forests-activity-8-climate-change-and-forests/

These estimates are based on the formula: MC (mass of carbon in the tree) = 0.5 x Mw (mass of the wood), where Mw = 0.55 x V (volume of tree) x Dw (density of wood); V = 0.0567 + 0.5074 x (CBH/π)2 x H. It assumes that Dw = 0.6 g/cm^3, and that water makes up 45 percent of the tree's mass.

HOW MUCH CARBON DO PEOPLE USE?

Use the chart on the right to compare the amount of carbon in the tree that you measured to the amount of carbon needed for human activities. Jot down below the number of miles a car could travel, the gallons of gasoline consumed, and the number of times a phone could be charged with the amount of carbon stored in your tree.

MY TREE EQUALS

_____ miles driven by a car

_____ gallons of gasoline

_____ smartphones charged

Kilograms (kg) of carbon	Miles driven by an average passenger	Gallons of gasoline consumed	Number of smartphones charged
5	12	0.5	638
10	24.5	1	1,275
25	61	2.5	3,188
50	122	5	6,376
75	183	7.5	9,563
100	244	10	12,751
200	488	20	25,502
300	732	30	38,253

Source: http://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator

Canopy plants and cares for trees where people need them the most.

3921 East Bayshore Rd. | Palo Alto, CA 94303 | canopy.org | 650-964-6110 | info@canopy.org

WHERE DOES CARBON GO WHEN A TREE DIES?

In the lesson activity below, you will be given two situations that affect the carbon in trees: fire and decomposition. Three friends have given different explanations for each. Choose the description that you think is correct, and explain why you think so in the space provided.

FIRE

Humans burn large amounts of forests every year, usually to clear land for agriculture.

DECOMPOSITION

Fallen branches and the wood of dead trees are broken down by an array of insects, bacteria, and fungi in the process of **decomposition**. This is important because decomposition helps recycle nutrients into the soil, and make them available for plants. When forests are unhealthy, dead plant material can pile up because there are not enough decomposers to break it down.

DONTE

I think that burning wood will release carbon back into the atmosphere as carbon dioxide, and that the decomposition of tree wood by insects, bacteria, and fungi will do the same.

JOLENE

I do not think that burning wood will release the wood's carbon back into the atmosphere as carbon dioxide. I think that the decomposition of wood will only release some carbon, and that the rest will be incorporated into the soil.

MIA

I think that burning wood will release carbon back into the atmosphere as carbon dioxide, and that the decomposition of wood will release some carbon as carbon dioxide, but that most will be incorporated into the soil.

Who do you think is correct? Explain why you agree with him/her.

CARBON & CALIFORNIA'S REDWOODS

BEST IN SHOW

In terms of ability to store carbon, not all trees are made equal. California is fortunate to be home to many coast redwoods, which can grow to over 100 meters tall and can live for over 1,000 years. Coast redwoods are **native** to California, meaning that they have developed here and occur naturally.

Scientists have found that CA's ancient redwood forests store more carbon per acre than any other forest in the world!

EL PALO ALTO & LUNA: BELOVED REDWOODS

You might have visited a famous coast redwood in Palo Alto that gave the city its name. The tree, El Palo Alto, means "the tall stick" in Spanish. As of 2020, it is 33.5 meters high and 1,080 years old! The photo to the right shows El Palo Alto in 1875 with twin trunks, before one fell during a storm. Great efforts have been taken to preserve this tree, including installing a water misting system to reach its tall canopy.

Though events like storms and internal decay can fell trees, a bigger threat is **deforestation**: the removal of entire forests of trees by fire or logging. In 1997, a woman named Julie Butterfly Hill was so distraught by the deforestation of the California redwood forests that she climbed into the canopy of a tree called Luna in Humboldt County, north of San Francisco, and refused to leave for *two years* until the lumber company agreed to preserve Luna and some surrounding acreage!

What are two ways in which deforestation contributes to climate change?

Congratulations! You have successfully:

- *Measured the circumference and estimated the height of a tree*
- *Discovered approximately how much carbon it stores*
- *Compared that amount of carbon to what we use in our daily activities*
- *Explained what you think happens to a tree's carbon during fire and decomposition*
- *Identified two reasons why deforestation contributes to climate change*

Challenge: Use your newfound knowledge of the important role that trees play in reducing climate change to seek out opportunities to plant, protect, and advocate for trees. Remember that actions of any size count! You definitely don't need to live in a tree for two years in order to make a positive impact.

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LEAF - Learning About Forests

How to Calculate Tree Value

Calculating the value of a tree involves considering various factors, such as its species, size, location, condition, and ecological benefits. It's important to note that tree valuation is not an exact science, and different methodologies or local market conditions may yield different results. Consulting with tree experts or certified arborists can provide more accurate assessments and specific information relevant to your location.

Additionally, the value of a tree extends beyond its monetary worth. Trees provide ecological benefits, such as shade, air purification, stormwater management, and wildlife habitat. These non-monetary values should also be considered when evaluating the overall worth of a tree.

Instructions

While there are different approaches to tree valuation, one common method is the "Trunk Formula Method." Here's a simple guide on how to calculate tree value using this method:

1. Determine Tree Species: Identify the species of the tree. Different tree species have different values based on their characteristics, rarity, and demand in the local market. Use INaturalist or other free plant identification apps, like PlantNet or PlantSnap, to help you identify tree species.
2. Measure Tree Diameter: Measure the diameter of the tree trunk at 4.5 feet above the ground. Use a measuring tape or calipers to obtain an accurate measurement. Record the diameter in inches. Video: How to calculate tree diameter using simple household tools
3. Calculate approximate tree height: There are different ways you can measure tree height. This is a great way to integrate trigonometry! Here are some helpful tools to calculate tree height:
    - How to calculate tree height using a smartphone
    - How to calculate tree height using the stick trick
    - Helpful videos: How to Measure Tree Height With Just a Stick! and How to Measure a Big Tree
    - How to calculate tree height using a clinometer
    - How to calculate tree height using a tangent height gauge method

LEAF - Learning About Forests

How to Calculate Tree Value

4. Now it's time to plug your data into one of these helpful tree value calculator apps:
   Tree Plantation | 8 Billion Trees | Omni Tree Value Calculator | Tree Value Calculator

Tree Species	Tree Diameter (in.)	Tree Height* (ft.)	Final Estimated Tree Value ($)

Optional: Tree location and condition: Assess the condition of the trees and their location. Factors such as health, structural integrity, aesthetics, and risk potential.

Tree Species	Location	Health	Structural Integrity	Aesthetics	Risk Potential

LEAF - Learning About Forests

How to Calculate Tree Value

Other observations about your tree. What other services does your tree provide?

Tree Species	Location	Does it provide shade to nearby building(s)?	Does it provide stormwater management?	Does it provide habitat for wildlife? What types of wildlife?

Ten Black Scientists that Science Teachers Should Know About | PBS Education

RACHEL CONNOLLY & BROOKE KINNEY : 6-8 minutes

...And Some Free Classroom Resources for Your Instruction

Helping your students see the possibilities of careers in STEM fields means providing them with diverse role models. Black History Month provides teachers with an opportunity to feature the stories and voices of black scientists, engineers and mathematicians in the context of their science instruction. We have made a list of some of the top Black scientists, engineers, inventors and mathematicians, along with media resources to help you bring their work—and stories—into your classroom.

A great place to start is with the The Secret Life of Scientists & Engineers, an Emmy-nominated web-series from the acclaimed PBS series, NOVA. The diversity collection of this series profiles some of today's leading scientists—showing students that science engages men and women of all ages and diverse backgrounds.

1. George Washington Carver

1860s – January 5, 1943
Field: Botanist, Inventor and Teacher
Known for: Born into slavery, George Washington Carver became a foremost botanist, inventor and teacher. He invented over 300 uses for the peanut and developed methods to prevent soil depletion. He was made a member British Royal Society of Arts — a rare honor for an American – and advised prominent leaders like

Mahatma Gandhi and President Teddy Roosevelt on agriculture and nutrition.

Resource: George Washington Carver | Scientist, Inventor, and Teacher | Video for grades 3-7

2. Percy Julian

1899–1975

Field: Civil Rights Activist, Medical Professional, Scientist, Chemist, Academic

Known for: Percy Julian was a research chemist and pioneer in the chemical synthesis of medicinal drugs from plants, such as cortisone, steroids and birth control pills. He was inducted into the National Academy of the Sciences, National Inventors Hall of Fame and the American Chemical Society for his lasting work.

Resource: Barriers for Back Scientists | Lesson plans for middle and high school

3. Mae Carol Jemison

October 17, 1956 --

Field: Engineer, Physician and NASA astronaut

Known for: American engineer, physician and NASA astronaut, Mae Carol Jemison became the first African American woman to travel in space when she went into orbit aboard the Space Shuttle Endeavour on September 12, 1992.

Resource: The Secret Life of Scientists & Engineers | Mae Jemison | Video for grades 6-12

4. Katherine Johnson

August 26, 1918 –

Field: Mathematician

Known for: Katherine Johnson is best known for her major contributions to the United States' aeronautics and space programs with the early application of digital electronic computers. Her work was recently recognized and featured in the movie Hidden Figures.

Resource: Katherine Johnson | NASA Computer | Video for grades 4-12

5. Gladys West

1930 --

Field: Mathematician
Known for: Born and raised in Virginia, Gladys West leveraged her mathematical and programming expertise to invent an accurate model of the Earth which was used as the foundation for the creation of the Global Positioning System (GPS). She was the second black woman ever to be employed by the Naval Surface Warfare Center Dahlgren Division and was inducted into the United States Air Force Hall of Fame—one of the highest honors awarded by the Air Force.

6. Marie M. Daly

1921–2003
Field: Chemist, Researcher and Activist
Known for: Marie Daly was the first African-American woman to receive a Ph.D. in chemistry in the United States. She worked closely with scientist Dr. Quentin B. Deming and their work opened up a new understanding

of how foods and diet can affect the health of the heart and the circulatory system.
Resource: Biography Marie Maynard Daly, from the Science History Institute

7. Edward Bouchet

September 15, 1852 – October 28, 1918
Field: physicist and educator
Known for: The first African-American to earn a Ph.D. from any American university and the sixth person of any race to receive a Ph.D. in physics from an American university. He taught science at the Institute for Colored Youth for 26 years.
Resource: Historical Detective: Edward Alexander Bouchet and the Washington-Du Bois Debate over African-American Education | Lesson plan for high school from the American Institute of Physics

8. Annie Easley

April 23, 1933 – June 25, 2011
Field: computer scientist, mathematician, and rocket scientist
Known for: Annie Easley worked at NASA as a “human computer,” performing complex mathematical calculations. She evolved with the technology -- becoming an adept computer programmer and helped develop and implement code for numerous projects.
Resource: Biography: Annie Easley, Computer Scientist, from NASA

9. Walter Lincoln Hawkins

March 21, 1911 – August 20, 1992
Field: polymer chemists, scientist and inventor
Known for: Walter Hawkins is best known for inventing a plastic coating for telephone wires that made universal service possible. He is a recipient of the National Medal of Technology and an inductee of the National Inventors Hall of Fame.
Resource: Biography: W. Lincoln Hawkins, from Lemelson-MIT Program

10. Alexa Canady

November 7, 1950 –
Field: Surgeon, Educator
Known for: The first female African-American neurosurgeon in the United States, Alexa Canady was also the first female African-American to be certified by the American Board of Neurological Surgery. She specialized in pediatric neurosurgery and became the director of neurosurgery at the Children's Hospital. Under her guidance, the department was soon viewed as one of the best in the country.
Resource: Biography: Alexa Canady, from Changing the Face of Medicine

Rachel Connolly is the Director of STEM Education for WGBH and PBS LearningMedia. After teaching high school physics in NYC, she moved into teacher professional development and educational programming at the American Museum of Natural History. Her work with the Hayden Planetarium sparked a love of data

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