In partnership with Garfield Weston Foundation

EXPLORE: URBAN NATURE

Measuring Carbon in Trees

THE URBAN NATURE PROJECT

NATURAL HISTORY MUSEUM

MEASURING CARBON IN TREES

OBJECTIVE

Students measure trees near their school and calculate the amount of carbon stored in individual trees. Students describe how forests help mitigate climate change.

OVERVIEW

Trees play an important role in the carbon cycle by removing carbon from the atmosphere through photosynthesis. They also release carbon through respiration.

On average, one broad leaf tree will absorb one tonne of carbon dioxide during its full lifetime (approximately 100 years). A lot of this carbon is then locked away out of the atmosphere for a long time, by being turned into wood, or taken through the roots and into the soil.

London's urban forest contains an estimated eight million trees and covers around 21 per cent of the city's land area. London's trees store 2.4 million tonnes of carbon and they sequester carbon dioxide from the atmosphere to reduce the impact of climate change. This is equivalent to the carbon produced from 26 billion vehicle miles. Planting more trees and allowing areas to reforest will be critical for reaching net-zero carbon emissions.

As a vital part of the global carbon cycle, forests are an important consideration in climate change, because scientists have linked increases in atmospheric carbon with increases in the global average temperature. Estimating the amount of carbon that trees absorb, store and release is key to understanding climate change and exploring how forests might help to address it.

TIME NEEDED

1 hour

PARTICIPANTS

Small groups

RESOURCES NEEDED

- measuring tape
- calculator

LEARNING OUTCOMES

- appreciate that trees help mitigate the harmful effects of climate change
- apply fieldwork techniques to measure trees
- use simple equations and carry out calculations to measure carbon in trees

INSTRUCTIONS

You will measure the circumference and height of at least one tree near your school. You will then use the data to calculate the amount of carbon in the tree.

Measuring tree diameter

1. Wrap your measuring tape around the tree to measure its circumference, approximately 1.4 meters above the ground.

   Record the circumference in Table 1.

2. Use the equation $d = c \div \pi$ to calculate the diameter of the tree and record it in Table 1

   d = diameter
   c = circumference
   $\pi = 3.14$

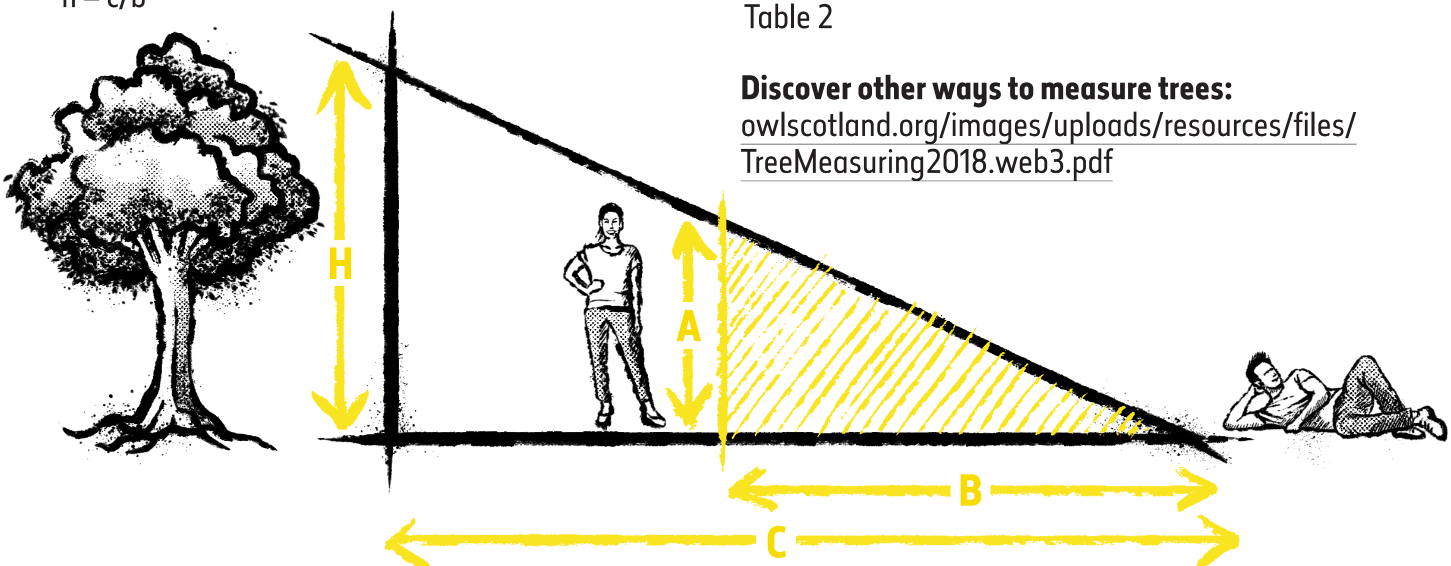
Measuring tree height (option 1)

You can use similar triangles to solve measurement problems, in this case measuring the height of a tree when you can't reach the top.

- similar triangles have the same shape but are a different size.
- their corresponding angles are equal
- their corresponding sides are in the same ratio
- you can use the relationships between corresponding parts of similar triangles to solve measurement problems.

  *a = meter stick (or height of a person)

  $a/b = h/c$
  $1/b = h/c$
  $h = c/b$



Tree	c circumference (cm)	d diameter (cm)
1		
2		
3		
4		
5		

Table 1

Measuring tree height (option 2)

1. Working in pairs, choose a tree.
2. Start approximately two meters away from the tree with your back towards it.
3. Bend over and look back at the tree through your legs. Your feet should remain flat on the floor and your legs straight.
4. Move away from the tree until you can see the top.
5. Your partner should measure the distance from your feet to the base of the tree. This is roughly equal to the tree's height. If you can see the top of a tree at a 45-degree angle, then the height of the tree is equivalent to the distance that you are from it.

Tree	Height (m)
1	
2	
3	
4	
5	

Table 2

Discover other ways to measure trees:
owlscotland.org/images/uploads/resources/files/TreeMeasuring2018.web3.pdf

1. Calculating green weight (GW)

The green weight of a tree is an estimate of the mass of the tree when it is alive. This includes all the wood content and any moisture in the tree. Because the moisture in the tree can be hundreds of litres, the green weight can be quite large.

As you can imagine, weighing a live tree is not feasible. For this reason, foresters use a set of formulas to estimate green weight. These equations are based on real data–foresters cut and weighed trees and then analysed the data to develop formulas to fit. Because the percentage of moisture in a tree varies by species, there are specific formulas for different tree species.

The equations used here are an average for Southeastern US mixed forests, a temperate broadleaf and mixed forest biome. These allow you to calculate the above-ground green weight of a tree based on the tree's diameter and height. To find the green weight, insert the values you obtained for diameter (centimetres) and height (metres) into the appropriate equation and record your answers in kilograms in Table 3.

Green weight
For trees with diameter < 28 cm: $GW = 0.0577 \times d^2 \times h$
For trees with diameter > 28 cm: $GW = 0.0346 \times d^2 \times h$

The constant in the equation accounts for the unit conversion between centimetres and metres (you do not need to first convert those measurement units to be the same).

2. Calculating dry weight (DW)

Dry weight represents the mass of the wood in the tree when dried in an oven, so the moisture is removed. On average, experiments have shown that a tree's dry weight is about 50 per cent of its green weight. Therefore, to find the dry weight, you just need to divide the green weight by half (or multiply by 0.5). Complete this equation for each tree you measured and record your answers in Table 3.

Dry weight
$DW = GW \times 0.5$

3. Calculating carbon storage (C)

Carbon storage is the amount of carbon in the wood of the tree. This is the total amount of carbon that is captured from the atmosphere during photosynthesis as well as the amount of carbon sequestered by the tree. From experiments, scientists have found that about 50 per cent of a tree's dry weight is carbon. To find carbon storage, divide the dry weight by half (or multiply by 0.5). Complete this equation for each tree you measured and record your answers in Table 3.

Carbon Storage
$C = DW \times 0.5$

Tree	**Green weight (GW, kg)** d < 28cm: $GW = 0.0577 \times d^2 \times h$ d > 28cm: $GW = 0.0346 \times d^2 \times h$	**Dry weight (kg)** $DW = GW \times 0.5$	**Carbon content (kg)** $C = DW \times 0.5$
1			
2			
3			
4			
5			

Table 3
Height, wood density, and whether the tree is evergreen or deciduous.
Tree species and leaf area are often included in more complicated formulas.

EXTENSION ACTIVITY

Group discussion
Discuss the other benefits of trees to the environment, ecosystems and our everyday lives.

How big is your environmental footprint?
Calculate your carbon footprint and work out how many trees would be needed to offset it.
footprint.wwf.org.uk/#/

Reducing your school's footprint
Have students investigate different carbon emissions reduction strategies and carbon sequestration strategies. Then ask students to develop a plan to reduce your school's carbon footprint.

Here are some ideas to get you started:
woodlandtrust.org.uk/support-us/act/your-school/green-tree-schools-award/reduce-co2-emissions/

Plant trees with your school
Grow an outdoor classroom. Create homes for wildlife. Fight climate change. When your pupils plant trees they will make a real difference to everyone.

Get started with the Woodland Trust's free tree packs:
woodlandtrust.org.uk/support-us/act/your-school/plant-trees-with-your-school/

Other values of trees
Learn more about trees across the UK and Ireland with Treezilla. You can help map, measure and monitor trees in your local area and calculate their ecobenefits.
https://treezilla.org

Discover more about the importance of trees in an urban environment in the Valuing London's Urban Forest report:
treeconomics.co.uk/wp-content/uploads/2018/08/London-i-Tree-Report.pdf

Explore: Urban Nature is part of the Urban Nature Project

Lead donors

Made possible with Heritage Fund

Evolution Education Trust

THE CADOGAN CHARITY

Garfield Weston FOUNDATION

Supporting donors

The Wolfson Foundation

CHARLES WILSON AND ROWENA OLEGARIO

Supporting sponsor

workman