Key topic areas	Equipment and resources required
• Carbon cycle	Tape measure
• Biodiversity	Clinometer
• Ecosystems	Labels for trees
• Climate change	String (or method of attaching labels)

Context

Understanding photosynthesis is key to understanding carbon sequestration. In the context of trees this means that their leaves take in carbon dioxide and use it to produce carbon in the form of glucose which is then used for growth energy and to build mass in the form of thicker and longer trunks and branches, additional stems and foliage. Therefore the size of a tree can be thought of as a direct measure of the amount of carbon it contains.

Students are likely to already be aware that some vegetation species grow faster and slower than others: for example the typical growth rates of garden bamboo (30cm/day) differs greatly from conifers (15cm/year). Therefore just because a tree is large does not necessarily mean it has lived through a period of high carbon dioxide levels; this is more an indication of how it processes atmospheric carbon. These varying rates of carbon processing have been compared and given a value akin to the trees density. This value is known as the species' specific gravity, found on a scale from 0 to 1 where one is the maximum density, or in this case, the higher the carbon content.

Understanding different patterns of carbon sequestration means that students can appreciate the role that trees play in the management of current and future climate change. In areas where there are plans to remove trees in order to allow for new buildings and infrastructure projects it can be extremely valuable to understand the potential loss of sequestration that could happen as a result of such plans. Equally, where afforestation projects are being considered it can be useful to know which tree species are best planted to plan for a more sustainable climate future.

Classroom set up

Students may already be familiar with the process of photosynthesis in science but it is worth reminding students of the elements of this process that play a pivotal role in the carbon cycle.

$$\text{water} + \text{carbon dioxide} \xrightarrow[\text{chlorophyll}]{\text{sunlight}} \text{glucose} + \text{oxygen}$$

Teachers might ask students to consider what links photosynthesis may have to climate change, opening up a discussion about the value of trees in our future in which the effects of a changing climate will be ever more acutely felt.

Show students two pictures side by side: one of an ancient oak tree in a natural woodland and one of a juvenile spruce tree in a plantation. Ask students to generate as many ideas as they can for reasons why one may have more or less carbon than the other. Students are likely to recognise that age and size will affect carbon content but teachers may need to support students to recognise that species, canopy shape and the growing conditions will also have an impact.

Next introduce students to the concept of specific gravity and how we can use it as a way of helping us to find an estimate of carbon content for specific trees in the school grounds. Teachers may wish to also introduce the equation for calculating carbon content with older students.

It is worth noting that this set of equations are based on calculating the volume of a tree as a cone shape.

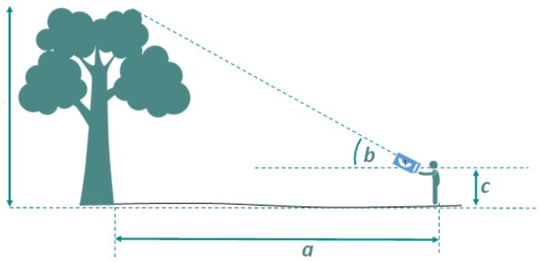
$$radius = \frac{circumference}{2\pi} \rightarrow volume = \pi \, radius^2 \times \left(\frac{height}{3}\right) \rightarrow carbon\ content = \frac{volume \times specific\ gravity}{2}$$

Viewing them from satellite imagery, students can identify areas of the school grounds where there are clusters of trees suitable for measuring. Basing their ideas off two contrasting areas of trees (A and B) such as by site and situation, students can hypothesise which area is likely to have the higher average carbon content per tree.

In the field

Prior to the students going outside, an equal number of trees (around 10) should be numbered in both sites A and B using string to attach labels such as A1, B1… A2, B2 etc. to specific trees. At each tree pairs of students should then measure or note

- the circumference of the trees trunk in metres (at chest height, using a tape measure)
- the distance between the tree and the observer in metres (a)
- the angle between the observer's eye and the top of the tree in degrees (b)
- the height of the observer themselves (to eye level) in metres (c)
- the tree species



Using this data with the equations above and specific gravity values (see *How to calculate tree carbon content*) will give carbon content for each tree in dry tonnes. Students can also use *Tree Carbon Content Calculator* as a maths short cut.

Suggested data presentation

Using hand drawn techniques, or digital methods such as GIS software, the individual trees can be mapped onto a plan of the school grounds. Proportional circles (one for each tree) can be plotted representing the size of the carbon store in dry tonnes. This will allow students to compare the typical size of tree carbon stores in area A with area B.

The proportional circles can either be an exact proportional size to the carbon store of individual trees or more simply plotted according to three circle sizes representing categories.

Key questions for reflection and analysis

- How does carbon store size vary across our school site?
- Which area of trees has most value in our carbon future?
- Which species of tree are best to plant now to reduce future atmospheric carbon?
- Why might increased tree planting ot be a sustainable management strategy for climate change?
- How can we manage trees to ensure they continue to sequester carbon at their current rate?
- What environmental factors may have meant that our two areas were not fairly comparable?
- What assumptions are made within the carbon content equation?
- How might we have improved the accuracy of our recorded data?

Taking it further

Dry tonnes of carbon is likely to represent a fairly meaningless value for many students. Comparing data on carbon footprint in relation to domestic appliances with the size of different trees can contextualise this data. Students might like to work out the school's annual carbon footprint and how many of the largest carbon store trees might need to be planted to off set it.

