- FIELDWORK GUIDE -

Fieldwork will concentrate on measuring rate of flux on the fast cycle and looking at the amount of organic carbon stored in trees or soils as part of the medium cycle.

Estimating the amount of carbon stored in trees

Aim: To investigate how carbon is cycled and stored through different ecosystems and in relation to changing temperatures.

As forests and woodlands can act as a store of carbon it is useful to know how much they can hold, and how much would potentially be released through chopping down trees and/or burning. This can be done by estimating the amount of carbon in individual trees then scaling it up to the size of the overall woodland.

METHODOLOGY

Tree Hugging

Use a random numbers table and pace to a point using these numbers. This method removes bias in selecting a specific tree. Measure the tree closest to you to take your measurements. Two measurements are required for each tree: circumference at breast height and height. Measure a total of twelve trees and at the end measure the size of the area the twelve trees were in (this can be done by pacing or using measuring tapes).

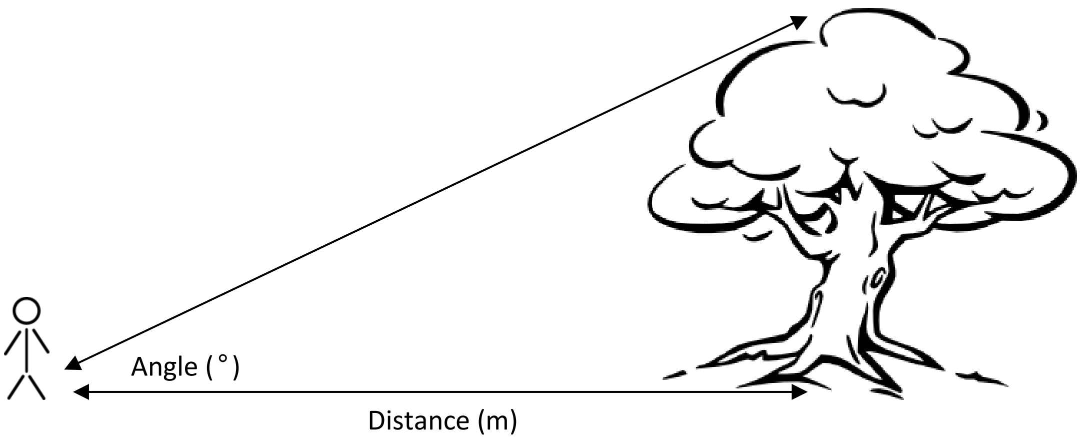
Circumference at Breast Height

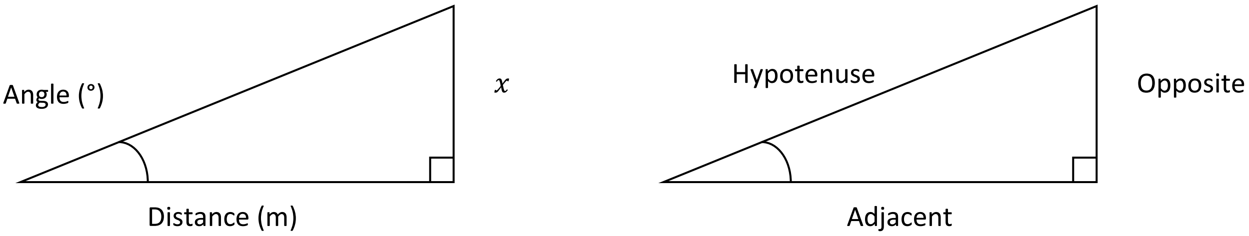
Measure the circumference of the tree at breast height with a tape measure. For bifurcated trees this could be either round one branch or the whole tree as one – either is acceptable, but it is important that you are consistent for all the trees you measure.

Height

There are two different methods for measuring this:

a) Estimate the height visually. One member of the group stands at the base of a tree with a metre ruler and the others stand back and try to determine how many rulers make up the whole tree. This is the quick method and although it is highly subjective is often preferred as it is simpler. Groups can work out different ways to reduce this subjectivity: the same person judges the height or take a group average of heights.
b) Use a clinometer to measure the angle to the top of the tree and distance to the base. The height can then be calculated using trigonometry (see below). This method is more accurate, though be aware the ordinary carbon follow up already contains a lot of mathematics.





Use the trigonometry rule SOHCAHTOA. As we have a value for distance (equivalent to the adjacent) and are looking height (x equivalent the opposite) we use the rule:

$$\tan\theta = \frac{opposite}{adjacent}$$

Rearrange the formula to make opposite the subject:

$$opposite = \tan\theta \times adjacent$$

$$height = \tan(angle\ measured) \times distance$$

FOLLOW-UP

Use the table provided on the field sheet (available from Lochranza Centre website Study Resources section on Carbon: www.lochranzacentre.co.uk/study-resources) to find an estimate for the amount of carbon stored in each tree individually e.g. a tree with a CBH of 2.0m and a height of 20m would contain 688kg of carbon. Once this is calculated for each tree individually, total up the carbon content for all twelve trees. This number represents an estimate for the amount of carbon stored in trees in our sampling area and is worked out based on average mass and density of trees (this varies depending on the type of tree/wood, so our using an average is a limitation to our study).

The next step is to work out the area of the whole woodland so we can scale up the amount of carbon in our sample area to the amount in the whole woodland. Maps and grid squares can be used to determine the size of this woodland in kilometres squared. Alternatively Google Maps or Memory Map can give a more precise area (approximately 0.1 km^2 or 100,000m^2, in our case).

The last step is to scale up the carbon content to equal the whole woodland. Make sure you keep the units consistent. Work out the amount of carbon (kg) in $1m^2$ then multiply up by the size of the woodland.

$$Carbon\ in\ 1m^2 = \frac{carbon\ content\ in\ 12\ trees}{sampling\ area}$$

$$Carbon\ in\ woodland\ area\ (kg) = \frac{carbon\ content\ in\ 12\ trees}{sampling\ area} \times woodland\ area$$

e.g. carbon in sample area = 8,000, sampling area = $850m^2$, woodland area = $100{,}000m^2$

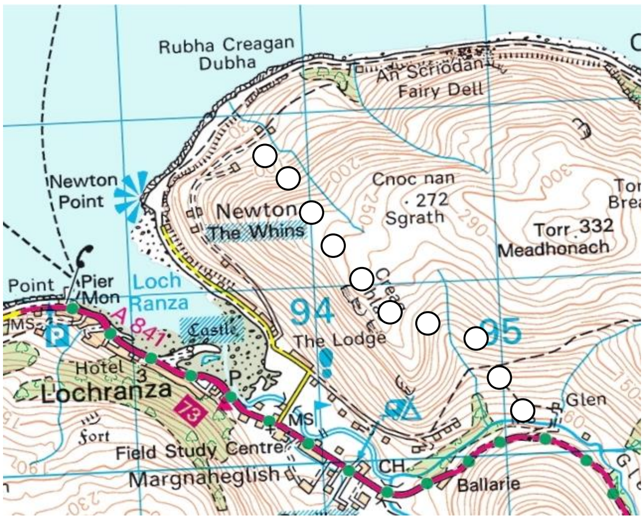
$$Carbon\ in\ woodland\ area\ (kg) = \frac{8000}{850} \times 100000 \qquad = 941176.47\ kg$$

Carbon Flux

Aim: To investigate the amount of carbon that is cycled by plants, through photosynthesis and respiration, as global temperatures rise.

Key questions: Will an increase in temperatures increase the rate of respiration? Will an increase in temperatures increase the rate of photosynthesis? Which of these processes will be affected by increasing temperatures the most?

Location



As global warming is occurring on both large temporal and spatial scales this makes it difficult to study in a day. Here it will be investigated on a small ‘local’ scale i.e. as a proxy study that can be used to simulate what is happening on a larger scale. Note that local changes have global consequences. As a range and change in temperatures are needed, the investigation will take place up the side of Torr Meadhonach with the assumption that temperatures will decrease with increasing altitude according to the environmental lapse rate. However this might not be the case in results (increasing solar radiation through the day).

METHODOLOGY

This will take at least 20 minutes at each site to allow the chambers to equilibrate to their new surroundings. Whilst waiting 20 minutes for the boxes, collect data on the amount of organic carbon stored in the soils (thickness of the layer) at each site and on the other factors that may be influencing the carbon flux and amount of organic carbon in the soil: vegetation cover, topography, other soil characteristics, climate measurements and land exposure measurements.

These measurements will take a long time at the first few sites but less time once you get used to each of the methods. Do not be tempted to rush the carbon flux readings as 20 minutes is the time required to ensure good results.

Carbon Boxes (set these up first)

Choose a flat site with predominantly grass to place the carbon boxes. Place air temperature and humidity measurers underneath each chamber and record the readings for Time at 0 (T_0).

Draw air sample into 60ml syringe, and slowly (take about 20 seconds) inject into CO_2 meter. This is your T=0 CO_2 reading.

Leave chambers for 20 minutes, after which draw in a 60ml air sample from each chamber’s sampling port. Air should be drawn in, flushed back into the chamber and drawn in again to mix the air within the chamber. Slowly inject the air into the CO_2 meter (again over 20 seconds). This is your T=20 reading.

Record the air temperature and humidity values after 20 minutes.

Vegetation Measurements

Percentage cover vegetation: Using metre rulers as a quadrat, estimate the percentage cover of each type of plant listed. This can be greater than 100% as there are different canopies of vegetation. This is done three times, each time using a random numbers table to pace out to a different location for each quadrat.

Maximum plant height (cm): For each quadrat measure the tallest plant within it. Measure it as it naturally stands, without straightening it.

Soil Measurements

Organic soil depth: In the centre of one of the vegetation quadrats, use the soil auger to draw out a soil sample. Identify the top soil horizon – the organic (O) layer – by its darker colour and the presence of organic material. Measure the thickness of this layer using a 30cm ruler.

Soil pH: Place a sample of soil in a small container and dissolve in water. Measure the pH with a pH meter. Or use the pH probes, by placing the probe into the ground, ensuring the depth to which it is inserted does not exceed the depth of the organic soil layer.

O horizon colour: Smear a sample of the organic layer onto the field sheet and compare it to the soil colour chart.

O horizon moisture: Place the soil moisture meters into the ground, careful to make sure the depth to which they are inserted does not exceed the depth of the organic soil layer.

O horizon soil temperature (°): Place the soil temperature into the ground, careful to make sure the depth inserted to does not exceed the depth of the organic soil layer.

Topography Measurements

Grid reference: Locate yourself with a six figure grid reference using the map provided. This can be checked with a GPS.

Elevation (m): Work this out using the contour lines on the maps. This can then be checked with a GPS.

Aspect: Use a compass to determine which direction the slope is facing. Face downhill and take a bearing. Record the nearest cardinal point.

Slope Angle (°): Measure change in slope angle over a 5 metre distance using a clinometer.

Topex Exposure: As explained on field sheet (available from www.lochranzacentre.co.uk/study-resources). Measure the angle to the horizon every 45° then total up.

Climate Measurements

Wind speed: Hold an anemometer up to the wind. Record the highest number shown. Note this is gusting wind speed and not the background.

Cloud cover (oktas): Measured out of 8. Hold transparent grid sheet up to the sky and record the number of boxes covered by clouds.

Reflected light (lx): Point the lux meter at the ground and record the amount of reflected sunlight.

FOLLOW-UP

Average air temperature and humidity: Both averages are the mean, hoping to account for the temperature change generated by placing the boxes on the ground.

Carbon Flux is measured in grams of CO_2 per metre squared in an hour and is calculated using:

$$CarbonFlux(gCO_2 / m^2 / h) = \frac{\delta CO_2 * \frac{1}{a} * \frac{60}{t}}{1000}$$

Where:
$\delta CO_2 = CO_2\ T_{20} - CO_2\ T_0$
a = surface area of chamber (m^2) = 0.15 m^2
t = time of incubation (minutes) = 20 minutes

Therefore the equation simplifies to:

$$CarbonFlux(gCO_2 / m^2 / h) = \frac{\delta CO_2 * 20}{1000}$$

A positive Carbon Flux value indicates increasing concentrations of CO_2 whilst a negative carbon flux value indicates decreasing amounts of CO_2. The larger the number the more carbon has been transferred.

Plot a scattergraph of the Net CO_2 fluxes against average air temperature for each of the boxes, each in a different colour or symbol with a key to show which is which.

Covered Box

Theoretically the covered box should show an increase in CO_2 levels each time, as light is blocked out, preventing photosynthesis and the take down of CO_2. As the plants are still respiring, CO_2 is still being released back into the atmosphere, therefore the flux should be a positive value. As temperatures increase it is expected that the rate of respiration will increase, as rising temperatures create the optimal conditions for enzyme activity, and therefore a larger CO_2 flux observed. However, a maximum temperature will eventually be reached above which plants struggle to function and slowly start to die, at which point a decrease in CO_2 flux would be observed.

A positive correlation can be observed on the long term data set. However, there is a lot of spread around the data and lots of anomalous results. A few reasons for this are suggested below:

Errors with the box: A poor seal may result in gases from the atmosphere escaping or entering the chamber, leading to a smaller increase than expected. Error is also generated during the transfer from the syringe to the CO_2 meter.

Wet ground: Completely saturated ground leads to anaerobic conditions with a lower concentration of atmospheric oxygen. This therefore inhibits the rate of respiration and a negative flux is often recorded at these sites (think drowning plants).

Vegetation cover: The type and amount of vegetation cover will affect the rate of photosynthesis and respiration. Woody plants such as heather will have lower rates of photosynthesis compared to grass as there is a lower 'green' surface area. A high percentage of moss often results in a high positive flux. Moss undergoes less photosynthesis than most plants and therefore is likely to stop photosynthesising earlier than other plants, giving a longer time period of just respiration, hence the larger increase.

Nutrients: Nutrients in the ground will impact on the amount of photosynthesis occurring e.g. fertilisers in the ground near farms.

Time of day: Later in the evening, when light levels are potentially lower, rates of respiration are much higher, as observed through a large increase in CO_2 levels. This is because plants do not photosynthesise during the night and are winding down in the evenings.

Uncovered Box

As both photosynthesis and respiration are continuing under the clear box the CO_2 levels should remain steady or similar. However, we are investigating whether one process increases faster than the other with increasing temperatures. If a negative flux is observed then photosynthesis increased more (more CO_2 is taken in); if a positive flux is observed then respiration increased more (more CO_2 is released).

In more 'stressful' conditions i.e. lower temperatures, low light levels, low or high moisture levels, it is likely plants will concentrate on respiration, therefore an increased flux would be observed (acting as a source of carbon). But in more optimal conditions i.e. higher temperatures, good light levels and medium moisture levels it is thought the amount of photosynthesis will increase more than respiration. Plants will therefore be able to convert the CO_2 into organic carbon (acting as a store or sink of carbon). However it is not known whether in the longer term this will in turn lead to higher rates of respiration as the plants are now larger.

Statistical Tests

Spearman's Rank can be calculated between air temperature and CO_2 flux.

Located Data

Print the located data graphs onto A3 paper. With located data, each site has its own collection of graphs to be plotted at the corresponding altitude. Make sure you keep the scale of each graph the same across all sites to allow easy and direct comparisons. Plot all the data for one site first so you know how to plot each type of graph.

Maximum plant height bar graph: Take the tallest plant height at each site and plot it as a bar graph. This an be drawn to look like the plant species it was e.g. blade of grass or tree.

Vegetation cover pie chart: Work out the average percentage cover for each type of vegetation across the three quadrats and convert into degrees.

$$^{\circ} = \frac{\%\ cover\ in\ each\ category}{total\ \%\ cover} \times 360$$

Plot each segment onto the pie chart using a protractor and write the percentage in. Fill out the key.

Soil depth: The top of the graph represents the soil surface (0cm). Plot the thicknesses of the organic soil layer downwards and colour in using colours as close to the true colour as possible.

Abiotic factors radar diagram: Work out the range of values across all sites to ensure appropriate scales are devised. Plot the value for each factor on its individual scale then join up the points and shade the contained area.