GLOBE Carbon Cycle

Field Engagement Activities

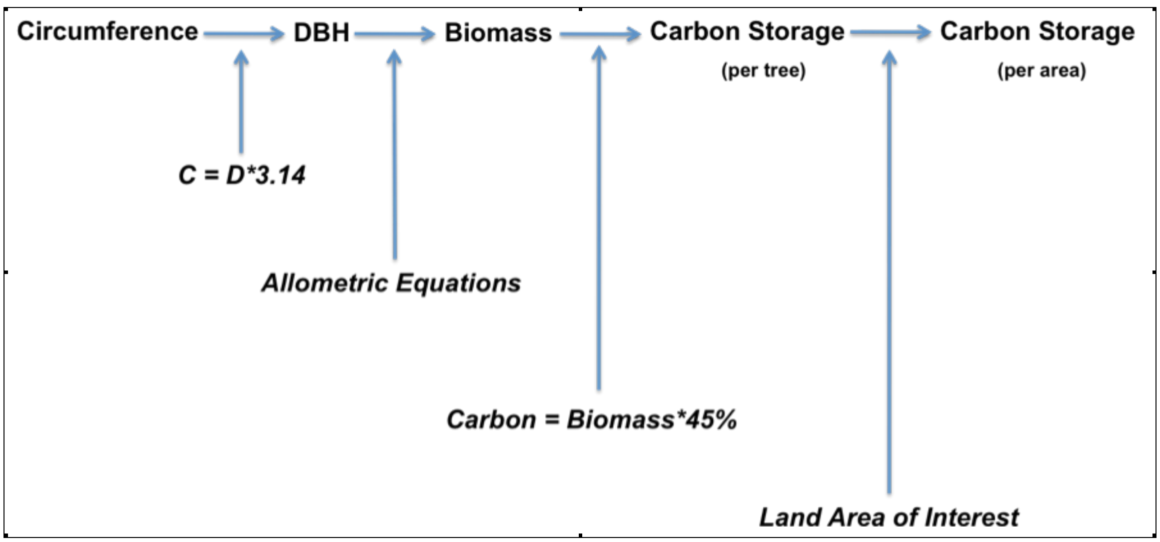
To make field data collection meaningful, it is important to understand why data is being collected and how it will be used later.

Before going outside, consider the essential question -

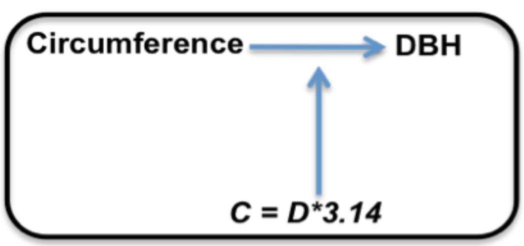
How much carbon is being stored in the forest ecosystem near my school?

To learn how scientists answer this question, perform field engagement activities, which are designed to progress through the basic concepts of tree measurement and carbon storage calculation.

This concept flow chart shows the progression of concepts covered in the engagement activities, *How to Measure Trees, Biomass Units and Not a Llama Tree*.



Each part of concept flow chart can be broken down by section and is covered by a specific engagement activity.

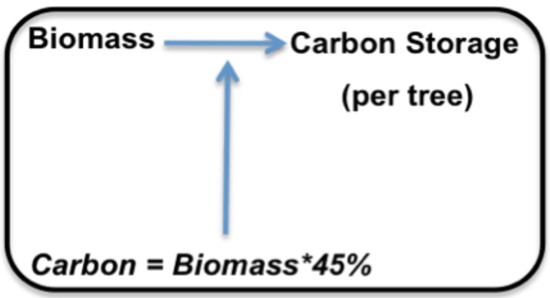


How to Measure Trees

Scientists use a standard method to measure the size of trees, diameter-at-breast height (DBH), to ensure consistency over time, across plots and between data collectors. DBH means the diameter of each tree is measured at "breast height", defined as 1.35m up from the highest point of ground at the tree's base (See the *Tree Circumference Guide* for some pictorial examples). DBH measurements can be used to estimate the volume, biomass, and carbon storage of trees - to learn more about the relationship between DBH and biomass refer to the activity, *Allometry: Not a Llama Tree*. Keep in mind that circumference and DBH are the first two steps in the process of understanding biomass and carbon storage in local ecosystems.

From geometry class, we know that diameter is a line that passes through the center of a circle, with the endpoints of the line located on the edge of the circle. How then can foresters and scientists measure tree diameter without cutting down the tree and measuring its cross section? Scientists measure the circumference of a tree and calculate the diameter using equation 1 shown below. Scientists sometimes use tape measures that are calibrated or adjusted for diameter based on this equation. These tapes are referred to as DBH tapes. During the GLOBE Carbon Cycle field data collection, however, tree circumference is measured rather than diameter (due to tool restrictions); therefore it is important for to know how they are related.

Circumference = π*diameter (where π = 3.14) or Diameter = Circumference/ π [equation 1]



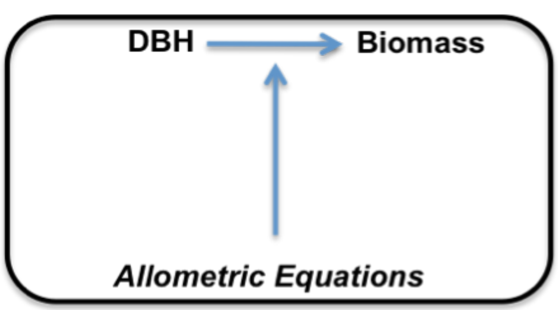
Biomass Units

Biomass is the total mass of living material measured over a particular area. Because all living things contain water (fresh weight) and the percentage of water can vary widely from species to species, biomass is calculated as a dry weight. Dry weight is the mass of life that is left after all the water is removed, much like squeezing out a sponge. For plants, scientists use an oven to remove all the water from the plant material before weighing it to determine its biomass. **Total biomass** is found by summing the dry weight biomass of all individuals in a given land area and then reported by naming the area of concern, e.g. biomass per plot, ecosystem, biome, classroom. To be able to compare biomass in different locations, scientists standardize biomass per unit of area. Typical units of biomass are grams per meter squared (g/m^2), although you will also see kg/m^2, lb/ft^2, etc.

[Biomass = dry weight/area]

While knowing an ecosystem's biomass is useful for many applications such as farming, logging, and wildlife management, another helpful unit of measure in an ecosystem is how much carbon is stored.

Understanding how terrestrial ecosystems store and transfer carbon to and from the atmosphere is essential to understanding climate change, so biomass is often converted to carbon storage (For more information on the role of carbon in climate, see the *Carbon Cycle Introduction Activities*- think photosynthesis, the global carbon cycle and the greenhouse effect). But how do scientists know how much carbon is being stored? All life (biomass) is composed of carbon molecules, and as it turns out plant matter is actually 45% carbon by dry weight. This means once biomass has been calculated, it can be multiplied by 0.45 to achieve approximate carbon content.

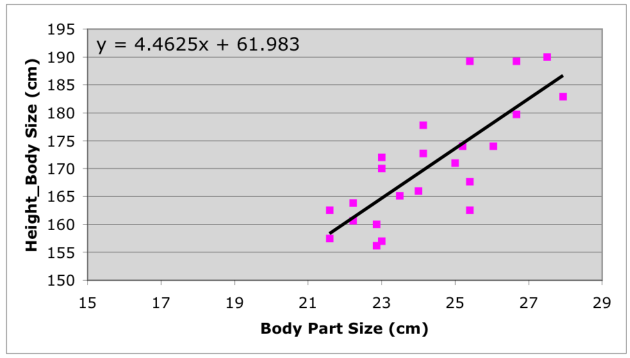


Allometry: Not a Llama Tree

If biomass is a key unit of measurement for understanding ecosystems, it is essential that we have a way to measure it. Logically, it makes no sense to measure the mass of trees by cutting down and weighing them on a scale every time. This would ultimately mean destroying the ecosystem we are trying to understand. Because this is the case, over time, scientists have cut down many trees of different sizes and species to look for relationships between parts of the tree that can be measured easily, such as DBH or height and the whole tree's biomass. The study of this kind of relationship is known as **allometry**.

Allometry is the study of an organism's growth, as is used to describe the relationship between an organism's size and the size of any of its parts.

Allometric relationships can be studied during the growth of a particular organism, as a comparison between organisms of the same species or between organisms of different species. Allometric relationships are best shown on a graph where body size is depicted on the y-axis and body part size is depicted on the x-axis. As individual measurements are added to the graph, a scatter is produced. The average through that scatter (a regression line) determines the allometric equation.



Allometric equations often take the form of:

y = mx + b (line equation)

where y = body size, x = body part size, m = slope, and b = y-intercept value of a straight line.

Not all allometric relationships are linear, such as the relationship between tree DBH and tree biomass. When this is the case, a nonlinear equation, such as log or natural log might be used. Log equations and their transformations can be confusing. For clarification see the Log Calculations Example in the appendix and/or talk to a math teacher.

$\ln(y) = a + b[\ln(x)]$

where y = body size, a and b are coefficients and x = body part size

A log transformation will allow you to solve for y.

$y = e^{(a + b[\ln(x)])}$

The exact form of equations students will see in the Plot Biomass Analysis is:

biomass = Exp(B0 + B1 ln dbh), where ln = log base e (or 2.718282).

If your students participate in the field data collection and analysis, they will need to understand the basics of tree allometry. During *Sample Site Biomass Analysis* students will be able to view their circumference field data in the spreadsheet calculator and a version of the above equation, which is used to calculate biomass. Although a similar equation exists for all trees, they will differ slightly for different tree species groups. These equation differences between species groups largely exist due to differences in tree wood density (see Extensions). For additional information you can read the National-Scale Biomass Estimators for United States Tree Species (Jenkins et al. 2003) paper. Figure 1 (Predicted Biomass Graph) and Appendix A (Species Groups List) are of particular interest.

The Allometry activity addresses the connection between the two previous concept activities, DBH and biomass. By the end of the activity students should understand why they are collecting tree circumference data and how real data are used to create valuable equations.