Biometry Protocol

Purpose

To measure and classify the plant life present at a Land Cover Sample Site to help determine the MUC classification.

Overview

Students walk the half-diagonals of their Land Cover Sample Site and take one or more biometry measurements. These may include canopy cover and ground cover, identifying dominant and co-dominant vegetation species, and measuring tree circumference, GPS coordinates and height, and/or graminoid biomass.

Student Outcomes

Students will learn how to use biological sampling techniques to quantify and describe a Land Cover Sample Site.

Science Concepts

Physical Science

- Objects have observable properties that can be measured using tools.

Life Science

- Earth has many different environments that support many different kinds of organisms.
- Organisms change the environment in which they live.
- All populations living together and the physical factors with which they interact constitute an ecosystem.

Geography

- The physical characteristics of place
- The characteristics and spatial distribution of ecosystems

Scientific Inquiry Abilities

- Identify biometry measurements needed for MUC.
- Use vegetation field guides to identify vegetation and species.
- Interpret data to propose MUC classification.
- Identify answerable questions.
- Design and conduct scientific investigations.
- Use appropriate mathematics to analyze data.
- Develop descriptions and predictions using evidence.
- Recognize and analyze alternative explanations.
- Communicate procedures, descriptions, and predictions.

Level

All

Time

Variable, depending on type and number of measurements taken

Frequency

As necessary to determine MUC at most sites, or, frequently as an enrichment study

Materials and Tools

- 50 m tape measure
- Compass
- Species ID keys and/or other local species guides
- *MUC Field Guide* or *MUC System Table* and *MUC Glossary of Terms*
- *GPS protocol*
- *GPS receiver*
- *Stopwatch*
- *GPS data sheet*
- Permanent tree markers (optional)
- Pen or pencil
- Calculator (optional)
- Appropriate *Biometry Data Sheets*
- Tubular densiometer (See *Investigation Instruments* section)
- Clinometer (See *Investigation Instruments* section)
- Flexible tape measure
- Blindfold
- Clipboard
- Small bean bag
- Grass clippers or strong scissors
- Small brown paper bags
- Drying oven

Balance or scale, accurate to 0.1 g

Preparation

Make copies of the appropriate *Work Sheets*.

Familiarize students with the MUC System.

Gather materials for clinometer and densiometer.

Have students practice taking field measurements, pacing and using a compass.

Prerequisites

Students make necessary field instruments.

Site-Seeing Learning Activity Beginning or Intermediate (Suggested)

Biometry Protocol – Introduction

Biometry is the measuring of living things. Why do scientists need measurements of living things? What do they tell us about our environment? The biometry measurements include tree height and circumference, canopy cover, ground cover, and *graminoid* biomass. Graminoids are grass and grass-like plants. These all measure the size or amount of trees and plants.

What do trees and plants store? What are they made of? Can *different* types of land cover have different size trees, shrubs or grasses? Can they have different amounts of trees, shrubs or grasses? Think about a desert. What is the most common tree or shrub there? Is that a sign of what kind of area it is? Compare that to the most common tree in a forest.

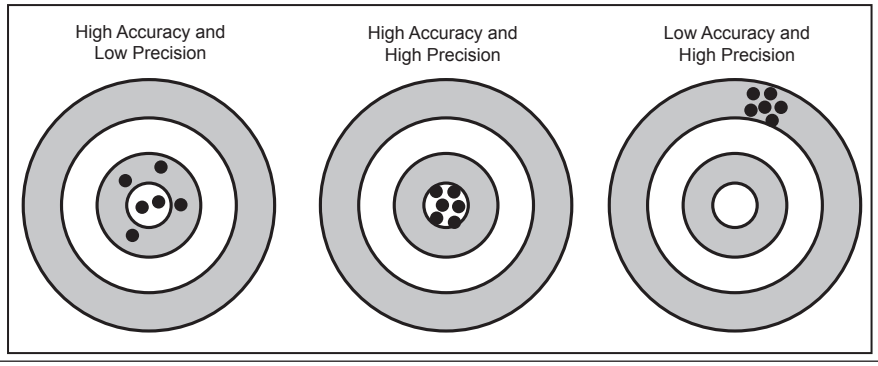
Can the *same* types of land cover have different size trees, shrubs or grasses? Can there be different amounts of trees, shrubs or grasses? Think about two wetlands. Are the trees, shrubs or grasses the same type and size in both areas?

Measurements of living things are important to scientists. They can show the amount of nutrients and gases living things store. They also show the amount of carbon and usable water stored in trees and plants.

Choosing the right MUC class can be hard. How do you know that you have a “deciduous forest” and not an “evergreen forest”? How do you know you are in a “shrubland” and not “woodland”? How do you know a site is “tall graminoid” and not “short graminoid”? Biometry measurements answer these questions.

Biometry measurements help you choose the right MUC class. What kinds of measurements will you need to decide between an evergreen and deciduous forest? What measurements will you need to decide if something is a shrub or a tree? What do you need to know to decide between a tall and short graminoid site?

Biometry measurements make your data more reliable. When scientists use your Land Cover Sample Site data, biometry measurements assure them that the data are of high quality. There are two tests of good measurement technique. Biometry measurements will help assess how close to the bull’s-eye (the right answer) your data are. This is called *accuracy*. Your data are *precise* when you repeat measurements and



get the same results throughout a site. The goal of GLOBE students should be to have their measurements look like the bull's eye in the center (see below), highly accurate and precise! Biometry measurements can help you do that.

Teacher Support

The Measurement

The *Biometry Protocol* is divided into four different measurements: 1) canopy and ground cover; 2) tree, shrub and/or graminoid height; 3) tree circumference; and 4) graminoid biomass. You may choose to take biometry measurements only once in a site during peak growth, or you can return to the same site year after year and repeat the biometry measurements to track changes in the site biomass over time. You may also take biometry measurements twice a year in a single site year after year, once during peak foliage or growth and once during a time of low growth (i.e. winter or drought). You should always use the following two guidelines to determine what measurements you should take:

First, take ANY measurements necessary to determine the correct MUC class. Whenever a decision must be made between MUC classes, take the appropriate biometry measurement (i.e. canopy and ground cover or height) to make that decision. If the decision can be made without biometry measurements, it is not necessary to take any, but you may choose to do so to ensure accuracy.

Second, scientists will be using an aerial view when using the MUC and biometry data and you should too. Therefore, measurements of the dominant (covering the greatest area) land cover of the **highest** canopy are the most important. Canopy cover refers to layers of vegetation. There can be several layers of each type (tree and/or shrub). Multiple layers are present when canopy heights are at different levels. When these layers are not present, the ground cover forms the dominant vegetation type. See Figure BIO-BI-1. the Landsat satellite records the amount and wavelength of light reflected be ALL vegetation that it can "see." ICESat-2 provides large-scale vegetation biomass estimates through the measurement of vegetation canopy height. In closed forest sites, where the trees cover the shrubs and ground, the trees will reflect the highest percentage of light. See Figure BIO-BI-2. In woodland sites, where there is space between trees, there will be a greater contribution of reflectance values from the shrubs and ground below the tree canopy, but again, the trees will reflect the greatest percentage of light. See Figure BIO-BI-3. In shrubland sites, where shrubs dominate, the reflectance values will mostly represent the shrubs and not the scattered trees or ground cover that may also be present at the site. See Figure BIO-BI-4. Keeping this in mind should help you determine what biometry measurements to take. For instance, in a closed forest site with tall trees covering the entire site, shrubs scattered throughout the site below the trees and some tall grasses on the forest floor, the biometry measurements that would be most important would be tree canopy, ground cover, and tree height. You may choose to measure shrub height or graminoid biomass but since the tree canopy would dominate the reflectance values, the shrub and graminoid data would be less important. Another example would be in herbaceous vegetation sites. See Figure BIO-BI-5. If a site was primarily graminoid with two trees and several shrubs, the most useful biometry measurement would be graminoid biomass. You can also measure the height of the shrubs and trees, but since they are not the dominant land cover, the graminoids would reflect the highest percentage of light in that area. However, it would still be useful to note that the site contained the trees and shrubs. Any type of information of this sort is important metadata since sites that are purely herbaceous vegetation may reflect light slightly differently than sites that have a few trees or shrubs. (Note: If you use any canopy and ground cover measurements to determine the MUC class, report that measurement also.)

Student Preparation

Students should be able to define and identify a homogeneous land cover site.

Students should understand and know how to classify a site using the MUC System.

Figure BIO-BI-1: Multiple Layers of Vegetation: Tree Canopy, Shrub Canopy and Ground Cover

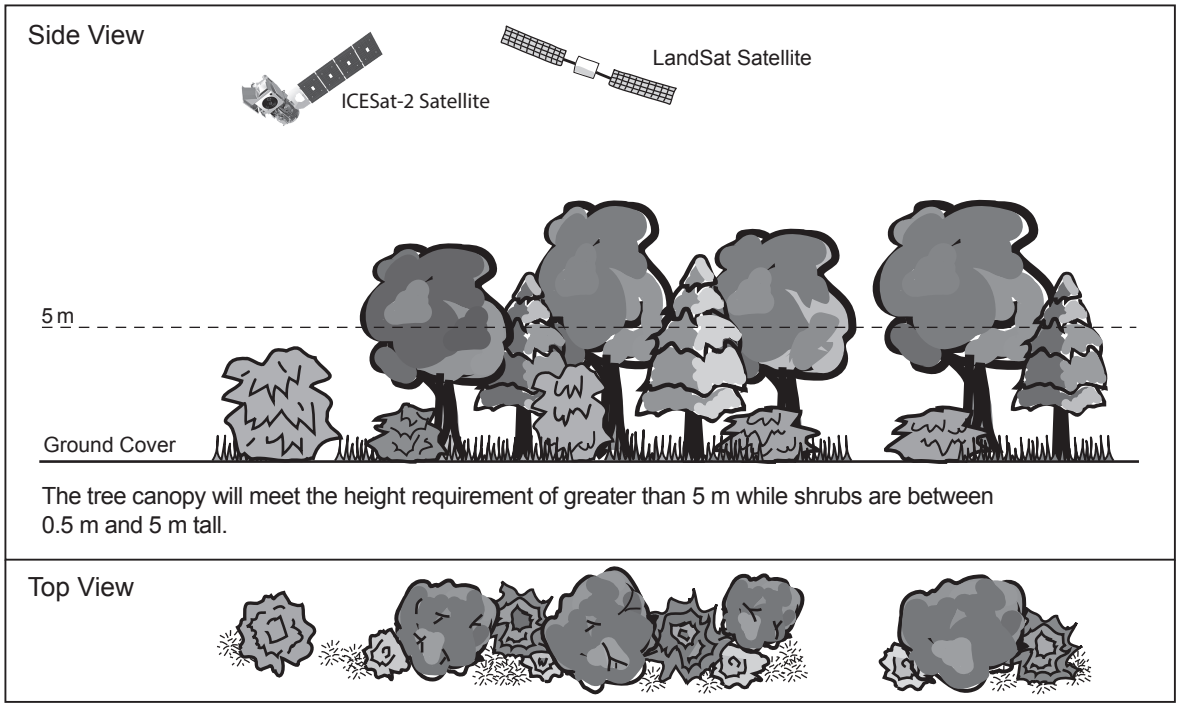


Figure BIO-BI-2: Closed Forest Site

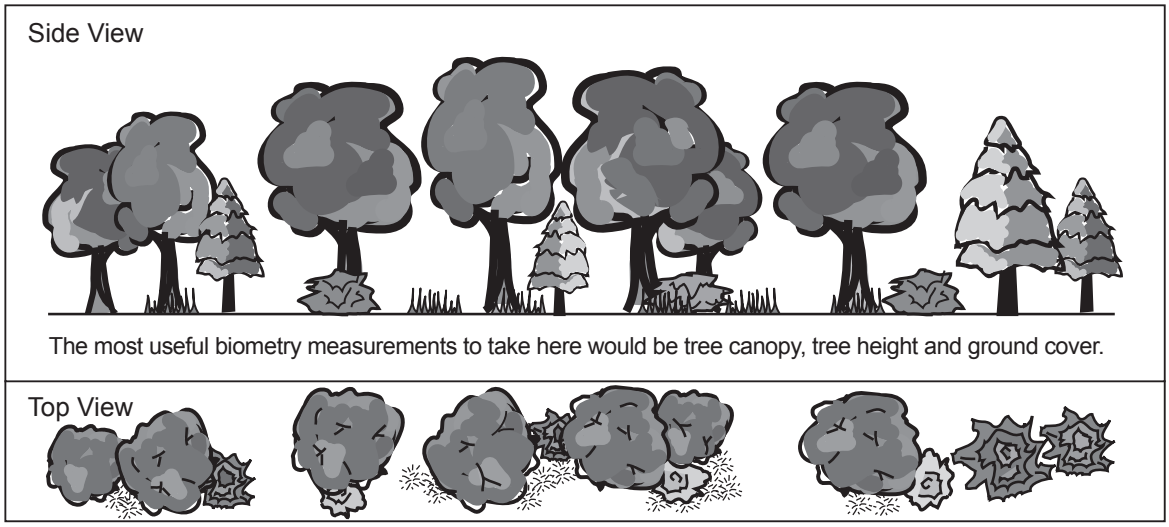


Figure BIO-BI-3: Woodland Site

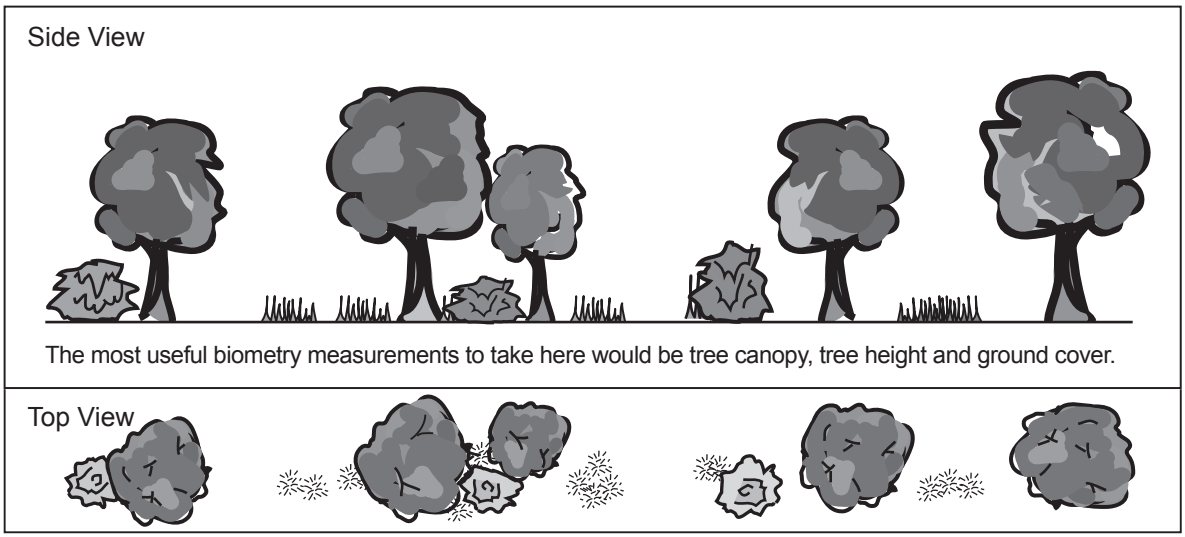


Figure BIO-BI-4: Shrubland Site

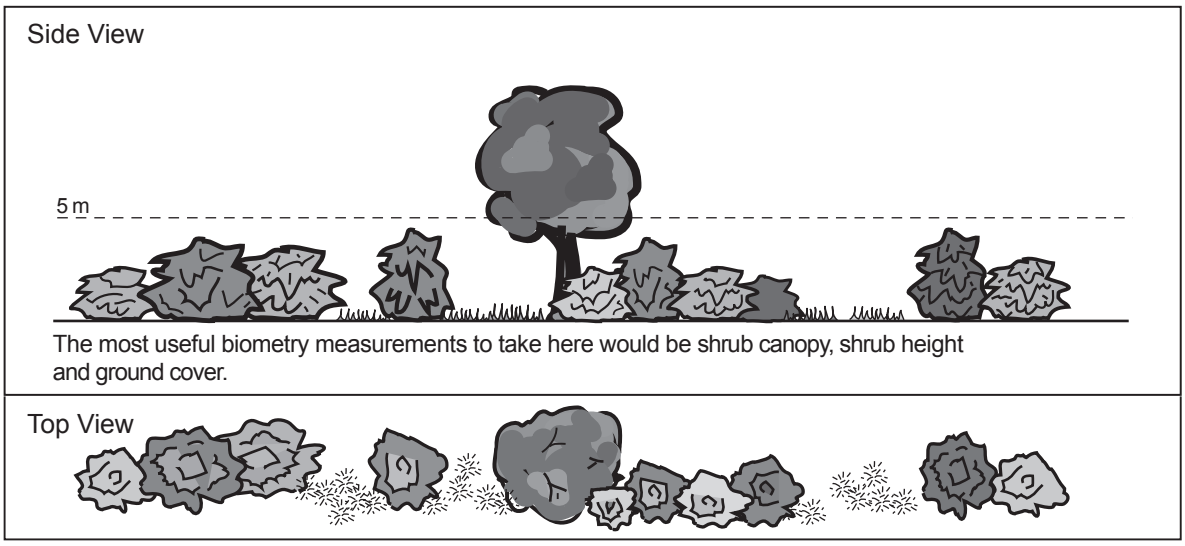
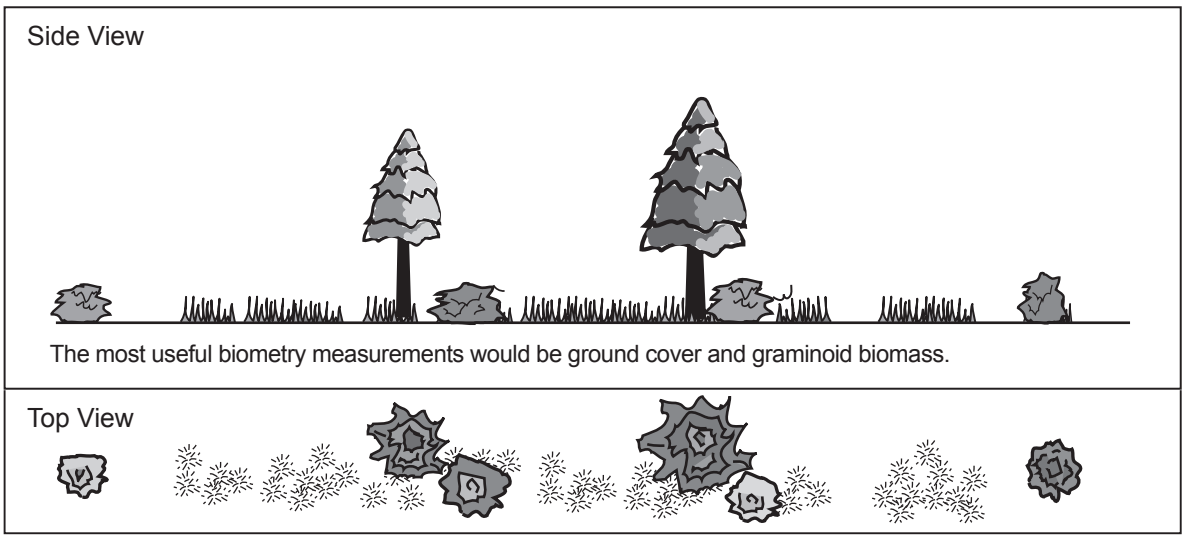


Figure BIO-BI-5: Herbaceous Site



Students should make and know how to use the densiometer and clinometer.

Students should know how to use a compass.

Students should practice pacing techniques. They should know their pace and how many paces are in 21.2 meters.

Helpful Hints

- Practice these measurements in a location close to school to get some experience before using them in a Land Cover Sample Site.
- You or your students may want to investigate a potential site with a brief visit to make sure that it is large enough and homogeneous throughout before a longer data collection visit.
- When distinguishing between trees and shrubs, use the definition of a tree given in the *MUC Field Guide* and *MUC Glossary of Terms*: a tree is at least 5 meters tall. You may want to practice estimating this height with the clinometer near your school before entering the field.
- If the shrub canopy is below the observer, treat it as ground cover. Dwarf-shrubs are always considered ground cover.
- There are two *Canopy and Ground Cover Data Sheets*: one to use when the dominant canopy cover is trees and one to use when the dominant canopy cover is shrubs. Your students need to decide which one to use. In a forest or woodland, canopy cover refers to the tree canopy. In a shrubland, canopy refers to the shrub canopy. Always keep in mind that these measurements are helpful to scientists studying land cover from satellite imagery. Therefore, the highest canopy is what you should try to measure.
- If you have difficulty determining if a site is a forest, woodland or shrubland, you may need to walk the half-diagonals twice. Keep in mind the "view from above" and look to the highest canopy with your densiometer for the correct measurement. The first time, use the *Tree Canopy and Ground Cover Data Sheet* recording a (+) where a tree is seen at the densiometer crosshairs. Determine the percentage of trees in the canopy (# of +'s / total number of observations from the *Tree Canopy and Ground Cover Data Sheet*). If the trees are 40% or more of the canopy, this is a forest or woodland and you should use the *Tree Canopy and Ground Cover Data Sheet* for the ground cover data collection on the half-diagonals and report all of these measurements. If trees are less than 40% of the canopy, walk the half-diagonals again using the *Shrub Canopy and Ground Cover Data Sheet*. Record a (+) where a shrub is seen at the densiometer crosshairs. Determine the percentage of shrubs in the canopy (# of +'s / total number of observations from the *Shrub Canopy and Ground Cover Data Sheet*). If the shrubs are greater than 40% of the canopy, this is a shrubland and you should use the *Shrub Canopy and Ground Cover Data Sheet* for the ground cover data collection on the half-diagonals and report all of these measurements.
- If both trees and shrubs are less than 40%, choose the *Data Sheet* corresponding with the highest percentage of canopy cover to take the ground cover measurements. Example: In a site with 15% tree canopy and 35% shrub canopy, use the *Shrub Canopy and Ground Cover Data Sheet* to take your ground cover measurements and report the tree and shrub canopy cover as metadata. Since the tree and shrub canopy make up less than 40% of the canopy, the MUC class will not be a Closed Forest, Woodland or Shrubland. In this case, use the ground cover measurements to determine the correct MUC class.
- It is more efficient to have your students work in pairs or trios for this protocol.
- For more accurate readings, other pairs of students should repeat the measurements. If different teams of students repeat observations, report the average of these values if they generally agree.

- Before going into the field, teach your students how to use your local vegetation field guides.
- It is recommended that you consult local experts (Forest Service, County Extension Agent, etc.) to assist with species identification.
- If your site experiences seasonal variation and you choose to track changes in biomass over time, take biometry measurements once during peak growing season and once during the least active season.

vvWhen measuring the tree height, GPS measurements, using the GPS Protocol, should be measured at the base of each of the trees. Remember, the trees being measured must be at least 3 meter away from each other.

- If it takes smaller students more than forty paces to complete a diagonal, they may take measurements at every other pace.
- For younger students, if the angle on the clinometer is 45 degrees, the distance from the tree will equal the height of the tree above the student's eye level. See the *Alternative Technique to Measure Tree Height on Level Ground: Simplified Clinometer Technique Field Guide*.
- If you are going to revisit a forest or woodland site, mark and number/label the trees you use. Always measure the same trees, and report their heights and circumferences in the same order.
- Examples of forbs include clover, sunflowers, ferns, and milkweeds.
- Do not use a conventional oven to dry the graminoid vegetation. This is dangerous because the oven may have to be left on continuously for several days!
- In warm, dry climates, graminoid biomass samples can be dried in mesh bags outside.
- Make sure to use several small brown drying bags for proper drying of graminoid samples.
- If you are performing the *Canopy Cover* and *Ground Cover* measurements with a class, break the class into groups and have each group pace a different half-diagonal. Each group will need its own copy of the *Field Guide*, a *Data Sheet*, and a densiometer. Ideally, one person should serve as a 'pacer' and one should be the 'recorder.' The 'pacer' walks the distance and makes the measurements. The 'recorder' records the readings onto the *Data Sheet* and makes sure the 'pacer' is walking straight in the assigned direction. The 'pacer' should know how many of his/her paces are in the 21.2 m length of the half-diagonal. Have each student write this number on his/her copy of the *Field Guide*. This is the total number of measurements/paces to take in walking a half-diagonal from the center to the corner of the central 30 m x 30 m area.

Questions for Further Investigation

What are the dominant and co-dominant species in your Land Cover Sample Site? Do these species always occur in sites that have the same MUC class?

Are the dominant and co-dominant species common in your area? Are these species native to your area? Are the trees mature or juvenile?

Is there a relationship between the amount of ground cover and canopy cover?

Are the percentages of the canopy and ground cover consistent with your MUC class?

Which is greater, the amount of brown or green ground cover? Do you think that these amounts will change during the year?

If your MUC 4 site has trees as the co-dominant species: Is the herbaceous vegetation around the trees the same as that in open areas?

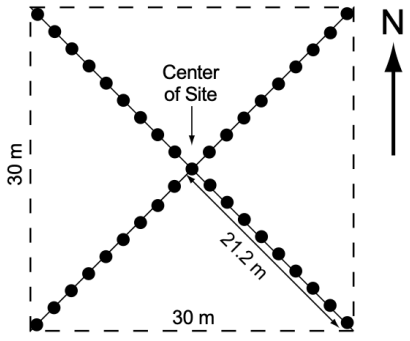
GLOBE Biometry: Vegetative Covers Field Guide

Task:

Take ground and canopy cover measurements while pacing half-diagonals to determine the MUC class of your Land Cover or Biometry Site.

Materials:

- Tubular densiometer
- Compass
- Local species ID guide
- Pencil
- Clipboard
- Vegetative Covers Data Sheet



Land Cover Sample Site with the four 21.2 m half- diagonals (in the NE, SE, SW and NW directions) for sampling.

GLOBE Vegetative Covers Field Guide

Procedure

Locate the center of your study site. This is your starting point. Take the measurements described for canopy cover and ground cover by walking the distance of a half-diagonal (21.2 m) in each of the following four directions: NE, SE, SW and NW (using a compass for bearing). Stop after each pace (2 steps) to complete the canopy and ground cover measurements.

Canopy Cover

Look up through your densiometer at the canopy. Make sure the densiometer is vertical and the metal nut/washer is directly below the intersection of the crosshairs at the top of the tube. Look to the highest canopy.

1. If you see vegetation, twigs or branches at the crosshairs record (T) if the vegetation is a tree and (SB) if the vegetation is a shrub.
2. Identify the species name. If you do not know the genus and species but know the common name, record the common name. If you do not know the common name, collect a leaf or describe or sketch it for identification later.
3. Record the canopy type as Evergreen (E) or Deciduous (D).
4. If you do not see any vegetation record (-).

Ground Cover

Standing with your feet shoulder-width apart, look down and observe any vegetation that is touching your foot or leg below the knee. Do not pick up your foot; only use vegetation touching you without moving. Do not measure ground cover by looking down through the densiometer!

1. If the vegetation is green (alive), record a (G). If the vegetation is brown but still attached, record a (B). If there is no vegetation, record a (-).
2. If the vegetation is green (G), record the vegetation type: graminoid (GD), forb (FB), Shrub (SB), Dwarf Shrub (DS), or other green vegetation (OG).

Summary and Percentages

After you have completed your pacing and measurements, fill out the Summary Sheet on page 3 of the *Vegetative Covers Data Sheet* and calculate the percentages.
Note: If other groups walked other half-diagonals, compare your "% Tree Cover", "% Shrub Cover" and "% Ground Cover" with the other group's diagonal data. Average the percentages from all the groups and use these averaged values to determine the dominant land cover for data entry.

If you have enough information to determine the MUC class of your site at this point, you are done. If tree, shrub or graminoid height cannot be estimated, follow the tree and graminoid data sheets and field guides.

Graminoid, Tree and Shrub Height
Field Guide

Task

Measure the height of graminoid vegetation, shrubs and/or trees to help determine the MUC class of your Land Cover Sample Site.

What You Need

- ❑ 50 m measuring tape
- ❑ Flexible measuring tape
- ❑ Small bean bag
- ❑ *Graminoid, Tree, and Shrub Height Data Sheet*
- ❑ Clinometer
- ❑ Pen or pencil
- ❑ Permanent tree markers (optional)
- ❑ Species ID keys and/or other local species guides
- ❑ Blindfold

In the Field

1. Measuring Graminoid Vegetation Height (Graminoids are grass-like species.)
   a. Stand in the center of your Land Cover Sample Site and blindfold your partner. Have him or her throw a beanbag somewhere in the site.
   b. Using the flexible measuring tape, measure the height of the herbaceous vegetation where the beanbag landed. Measure from the ground to the top of the graminoids.
   c. Record the height on the *Graminoid, Tree, and Shrub Height Data Sheet*.
   d. Repeat this process two more times and average the results.
   e. Use this average to determine your MUC class.
2. Measuring Shrub Height (Shrubs are 0.5 m to 5.0 m tall.)
   a. Stand in the center of your Land Cover Sample Site and blindfold your partner. Have him or her throw a beanbag somewhere in the site.
   b. Locate the closest shrub to the beanbag. Measure the height of the shrub from the ground to the tallest branch. Do this with a tape measure if possible. If the shrub is too tall, measure it with your clinometer using the directions for *Measuring Tree Height* in the next section.

   c. Record the height on the *Graminoid, Tree, and Shrub Height Data Sheet*.
   d. Repeat this process two more times and average the results.
   e. Use this average to determine your MUC class.
3. Measuring Tree Height (Hint: Trees are greater than 5.0 m tall.)

a. Determine your dominant (most common) and co-dominant (second-most common) tree species by counting the number of times each tree species was recorded on the *Canopy and Ground Cover Data Sheet*. Record the names of the species on your *Graminoid, Tree and Shrub Height Data Sheet*.

b. Choose:

- the tallest tree of the dominant species
- the shortest tree of the dominant species that still reaches the canopy
- three trees that have heights in between the tallest and shortest of the dominant species
- there should be a minimum of 3 meters between each tree

c. Permanently mark and number/label the trees if your teacher has instructed you to do so or if you will be returning to this site to take measurements over time.

d. Measure the height of the tree using the clinometer. If you are on ground with a slope, or using the simplified clinometer technique, then use the appropriate *Alternative Technique to Measure Tree Height Field Guide* to substitute for the steps below. Otherwise,

e. Using the GPS Protocol, determine the average latitude and longitude at the base of each of the trees measured.

- Move away from the base of the tree until you can see the top of the tree through the drinking straw of the clinometer.
- For the best results, adjust your distance from the base of the tree so that the clinometer reads as close to 30˚ as possible and you are at least as far from the tree as it is tall.
- Be sure to be on level ground so that your feet are at the same elevation as the base of the tree. Remember, if you are not on the same level with the tree, you need to use an *Alternative Technique to Measure Tree Height Field Guide*.
- Have your partner read and record the number of degrees (˚) of the angle.
- Using the *Table of Tangents*, record the TAN of the angle on the *Data Sheet*.
- Measure the distance between you and the tree. Have your partner help you using the 50 m tape. Record this in the table on your *Data Sheet*.
- Measure the height from the ground to your eye level. (You only need to do this step once!) Record this in the table.
- Calculate the tree height using the following formula:

  Height of Tree = TAN (angle of clinometer) x (distance to tree) + eye height
  and record on your *Data Sheet*.

- Measure the height of each tree three times and calculate the average of the three heights. If they are within one meter, record the average on your *Data Sheet*. If not, repeat the measurements until they are within one meter.

e. Repeat the step above for the other four trees.

f. If your co-dominant species is a tree, repeat steps b-e for the co-dominant tree species. If you do not have five co-dominant species trees on your site, include other tree species to make a total of five. Note that you are using other species in the *Metadata*.

Tree Circumference
Field Guide

Task

Make circumference measurements for your selected dominant and co-dominant trees. Use the same trees you measured for tree height (in the same order).

What You Need

- ❑ Flexible measuring tape
- ❑ *Tree Circumference Data Sheet*
- ❑ Pen or pencil
- ❑ Species ID keys and/or other local species guides

In the Field

1. With the flexible tape measure, measure from the ground at the base of the tree to a height of 1.35 m up on the tree (called Breast Height).
2. Measure the circumference in *centimeters* at Breast Height.
3. Record this on the *Tree Circumference Data Sheet*.
4. Repeat this for each of the trees you measured for height.

Graminoid Biomass
Field and Lab Guide

Task

Measure Graminoid Biomass in Land Cover Sample Sites. **Note:** Graminoid refers to grass-like vegetation only.

What You Need

- ❑ Small bean bag
- ❑ *Graminoid Biomass Data Sheet*
- ❑ Pen or pencil
- ❑ Blindfold
- ❑ Grass clippers or strong scissors
- ❑ Small brown paper bags
- ❑ Species ID keys and/or other local species guides
- ❑ Balance

In the Field

1. Blindfold your partner and have him or her throw a beanbag somewhere in the site.
   a. Mark a one-meter square around the beanbag to take a random sample.
   b. Using the garden clippers, clip all the vegetation close to the ground within the square. Do not collect any unattached leaves or litter.
   c. Sort the clippings into green and brown portions. Any clipping with even a little green is considered green.
   d. Place the green and brown portions into separate brown paper bags. Label the bags as your teacher directs you.
2. Repeat step 1 two more times.

In the Classroom

3. Calculating Graminoid Biomass:
   a. Check the temperature of the drying oven, it should read between 50 and 70 degrees Celsius.
   b. Put the labeled bags in the drying oven.
   c. Use a balance to measure the mass (g) of each bag once a day.
   d. When the mass is the same two days in a row, the samples are completely dry.
   e. Record the mass of each bag and its contents on the *Graminoid Biomass Data Sheet*.
   f. Shake out the contents of one bag and weigh the empty bag. Record this mass. Repeat this step for each bag.
   g. Calculate the mass of the graminoid vegetation (graminoid biomass) using the following formula:

      Graminoid Biomass = Mass of Sample and Bag – Mass of Empty Bag

   h. Record the graminoid biomass of each sample on the *Graminoid Biomass Data Sheet*.

Measure Tree Height on Level Ground: Simplified Clinometer Technique

Field Guide

Task

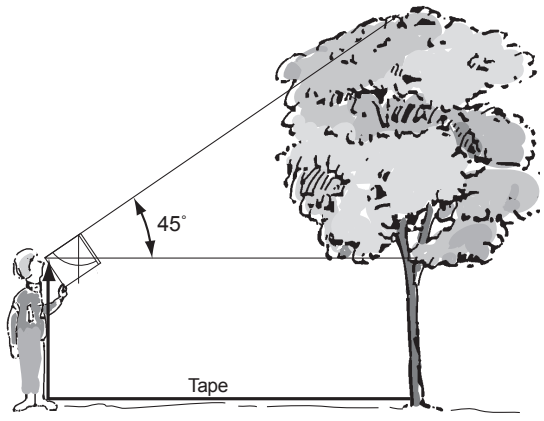
Measure heights of shrubs and/or trees to help determine the MUC class of your Land Cover Sample Sites.

What You Need

- ❑ 50 m measuring tape
- ❑ Flexible measuring tape
- ❑ Small bean bag
- ❑ *Measure Tree Height on Level Ground: Simplified Clinometer Technique Data Sheet*
- ❑ Pen or pencil
- ❑ Permanent tree markers (optional)
- ❑ Clinometer
- ❑ Species ID keys and/or other local species guides
- ❑ Blindfold

In the Field

1. Work in a team of two or three. Move away from the base of the tree until the clinometer reads 45 degrees when you see the top of the tree through the straw.
2. Have your partner stretch the 50 m measuring tape from the base of the tree to your toes. Your partner should then step on the tape at the ground and then run it up to your eye level.
3. This is the height of the tree. Record this on the *Measure Tree Height on Level Ground: Simplified Clinometer Technique Data Sheet*.
4. Repeat steps 1-3 two more times for each tree and report the average value.
5. Using the GPS Protocol, determine the average latitude and longitude at the base of each of the trees measured.



Measure Tree Height on a Slope: Stand by Tree Technique

Field Guide

Task

Measure heights of shrubs and/or trees to help determine the MUC class of your Land Cover Sample Sites.

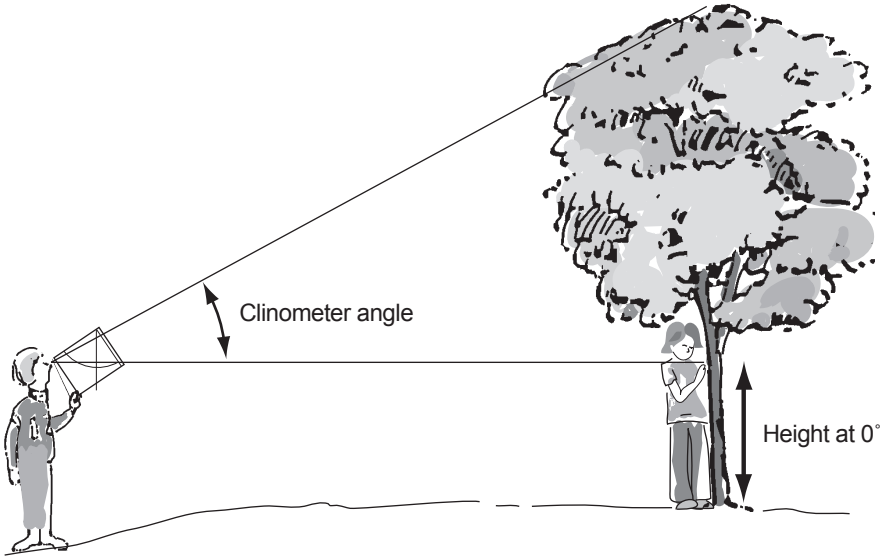
What You Need

- ❑ 50 m measuring tape
- ❑ Flexible measuring tape
- ❑ Small bean bag
- ❑ *Measure Tree Height: Stand by Tree Technique Data Sheet*
- ❑ Pen or pencil
- ❑ Permanent tree markers (optional)
- ❑ Clinometer
- ❑ Species ID keys and/or other local species guides
- ❑ Blindfold

In the Field

1. Work in a team of three. One person stays by the tree. You and another partner move away from the base of the tree until you can see the top of the tree through the drinking straw of the clinometer. **Note:** For the best results, adjust your distance so that the clinometer is as close to 30 degrees as possible and you are further from the tree than it is tall.
2. Site the top of the tree using the clinometer. Have your partner read and record the clinometer angle.
3. Using the *Table of Tangents*, record the TAN of the angle on the *Measure Tree Height: Stand by Tree Technique Data Sheet*.
4. Keeping the clinometer at 0 degrees, look through the straw and have your partner by the tree locate the position on the tree that you see.
5. Measure the height from the base of the tree to the position on the tree that you see when the clinometer reads 0 degrees.
6. Measure the distance between you and the tree. Have your partner help you using the 50 m tape. Record this in the *Measure Tree Height: Stand by Tree Technique Data Sheet*.
7. Calculate the tree height using the following formula:

   [TAN (Angle of the Clinometer) x (Distance to Tree)] + (Height to 0 Degrees on Tree)



8. Record the tree height in the *Measure Tree Height: Stand by Tree Technique Data Sheet*.

9. Repeat steps 1-8 two more times for each tree and report the average value.

10. Using the GPS Protocol, determine the average latitude and longitude at the base of each of the trees measured.

Measure Tree Height on a Slope: Two-Triangle with Eyes Higher than Tree Base Technique

Field Guide

Task

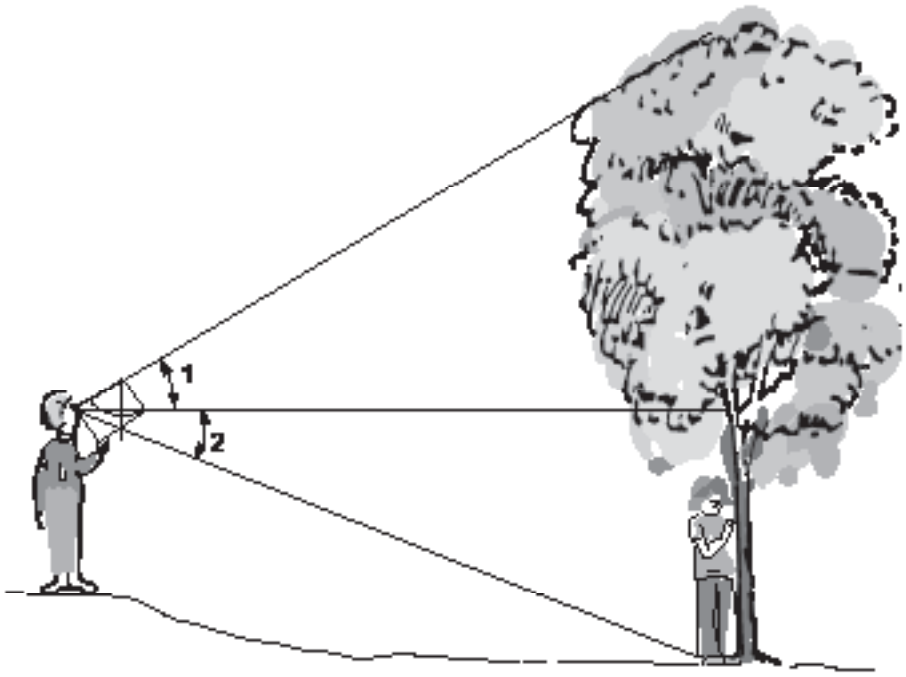
Measure heights of shrubs and/or trees to help determine the MUC class of your Land Cover Sample Sites.

What You Need

- ❑ 50 m measuring tape
- ❑ Flexible measuring tape
- ❑ Small bean bag
- ❑ *Measure Tree Height on a Slope: Two-Triangle with Eyes Higher than Tree Base Technique Data Sheet*
- ❑ *Table of Cosines*
- ❑ Pen or pencil
- ❑ Permanent tree markers (optional)
- ❑ Clinometer
- ❑ Species ID keys and/or other local species guides
- ❑ Blindfold

In the Field

1. Work in a team of two. You and your partner move away from the base of the tree until you can see the top of the tree through the drinking straw of the clinometer. **Note:** For the best results, adjust your distance so that the clinometer is as close to 30 degrees as possible and you are further from the tree than it is tall.
2. Site the top of the tree using the clinometer. Have your partner read and record the clinometer angle. This is the 1st Clinometer Reading.
3. Using the *Table of Tangents*, record the TAN of the angle on the *Measure Tree Height on a Slope: Two-Triangle with Eyes Higher than Tree Base Technique Data Sheet*.
4. Turn the clinometer around and look through the straw through the opposite end. Site the base of the tree. Have your partner read and record this clinometer angle. This is the 2nd Clinometer Reading.
5. Using the *Table of Tangents*, record the TAN of the angle on the *Measure Tree Height on a Slope: Two-Triangle with Eyes Higher than Tree Base Technique Data Sheet*.
6. Using the *Table of Cosines*, record the COS of the 2nd Clinometer Reading on the *Measure Tree Height on a Slope: Two-Triangle with Eyes Higher than Tree Base Technique Data Sheet*.



7. Measure the horizontal distance from your eyes to the base of the tree. Have your partner help you using the 50 m tape. Record this in the *Measure Tree Height on a Slope: Two-Triangle with Eyes Higher than Tree Base Technique Data Sheet*.
8. Calculate the Baseline using the following formula:

   (Distance to the Tree) x COS (2nd Clinometer reading)
9. Calculate the tree height using the following formula:

   TAN (1st Angle of Clinometer) x (Baseline) + TAN (2nd Angle of Clinometer) x (Baseline)
10. Record the tree height in the *Measure Tree Height on a Slope: Two-Triangle with Eyes Higher than Tree Base Technique Data Sheet*.
12. Repeat steps 1-11 two more times for each tree and report the average value.
13. Using the GPS Protocol, determine the average latitude and longitude at the base of each of the trees measured.

Measure Tree Height on a Slope: Two-Triangle with Eyes Lower than Tree Base

Field Guide

Task

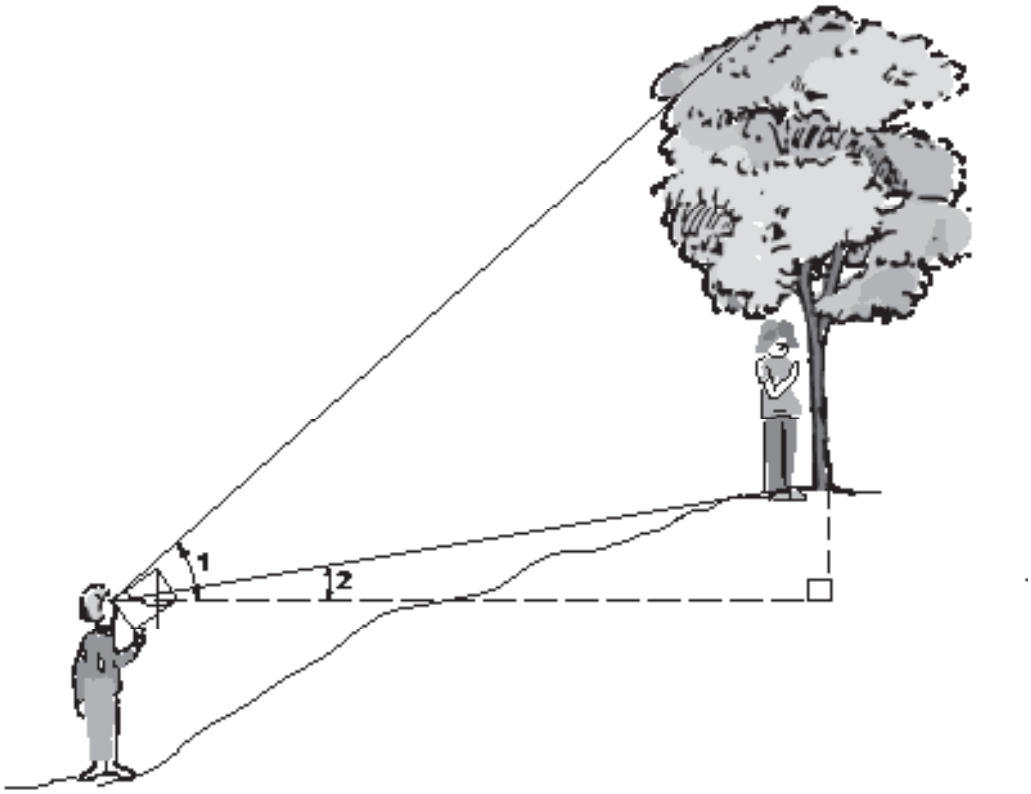
Measure heights of shrubs and/or trees to help determine the MUC class of your Land Cover Sample Sites.

What You Need

- ❑ 50 m measuring tape
- ❑ Flexible measuring tape
- ❑ Small bean bag
- ❑ *Measure Tree Height on a Slope: Two-Triangle with Eyes Lower than Tree Base Data Sheet*
- ❑ *Table of Cosines*
- ❑ Pen or pencil
- ❑ Permanent tree markers (optional)
- ❑ Clinometer
- ❑ Species ID keys and/or other local species guides
- ❑ Blindfold

In the Field

1. Work in a team of two. You and your partner move away from the base of the tree until you can see the top of the tree through the drinking straw of the clinometer. **Note:** For the best results, adjust your distance so that the clinometer is as close to 30 degrees as possible and you are further from the tree than it is tall.
2. Site the top of the tree using the clinometer. Have your partner read and record the clinometer angle. This is the 1st Clinometer Reading.
3. Using the *Table of Tangents*, record the TAN of the angle on the *Measure Tree Height on a Slope: Two-Triangle with Eyes Lower than Tree Base Data Sheet*.
4. Site the base of the tree using the clinometer. Have your partner read and record this clinometer angle. This is the 2nd Clinometer Reading.
5. Using the *Table of Tangents*, record the TAN of the angle on the *Measure Tree Height on a Slope: Two-Triangle with Eyes Lower than Tree Base Data Sheet.*
6. Using the *Table of Cosines*, record the COS of the 2nd Clinometer Reading on the *Measure Tree Height on a Slope: Two-Triangle with Eyes Lower than Tree Base Data Sheet.*



7. Measure the horizontal distance from your eyes to the base of the tree. Have your partner help you using the 50 m tape. Record this in the *Measure Tree Height on a Slope: Two-Triangle with Eyes Lower than Tree Base Data Sheet*.
8. Calculate the Baseline using the following formula:

   (Distance to the Tree) x COS (2nd Clinometer Reading)
9. Calculate the tree height using the following formula:

   TAN (1st Angle of the Clinometer) x (Baseline) – TAN (2nd Angle of the Clinometer) x (Baseline)
10. Record the tree height in the *Measure Tree Height on a Slope: Two-Triangle with Eyes Lower than Tree Base Data Sheet*.
11. Repeat steps 1-11 two more times for each tree and report the average value.
12. Using the GPS Protocol, determine the average latitude and longitude at the base of each of the trees measured.

Frequently Asked Questions

1. We have a MUC 0; however, no particular species is dominant. What should we do?
In your metadata, record that you have a mix of species for the dominant species and what those species are in the metadata. If you take tree height and circumference measurements, use the same criteria for selecting the trees but report the canopy as "mixed."

2. What should we do if there is a multi-storied canopy?
If there is a multi-story canopy, try to identify the highest level of the canopy without changing your position. If the vegetation touches the intersection of the crosshairs, mark a (+).

3. What if the entire circle I see through the densiometer is full of vegetation, but there is no vegetation at the crosshairs?
This is a sampling question. The Land Cover/ Biology Team has chosen the intersection of the crosshairs as the sample. Therefore, this would be a (–).

4. What if we can't get to our site during peak vegetation (full leaf-on) conditions?
If you cannot get to your site during peak growth (leaf-on), measure your site during the leaf-off period and try your best to get the peak growth (leaf-on) data, when you can.

5. What if my students are too young to understand the math used to determine tree height?
Use the *Simplified Technique for Measuring Tree Height on Level Ground*.

6. What if I want to measure the heights of trees on a slope?
There are additional guides for these situations that provide different methods to measure the heights of trees on slopes. The one you choose depends on the topography of your site.

7. What if the tree is leaning?
If the tree is leaning, just measure to the top of the tree as usual. Measure the baseline distance to a point directly below the highest point of the canopy, which may not be where the trunk of the tree meets the ground.

8. What if the canopy cover is thick and I cannot clearly see the top of individual trees?
A very thick canopy often occurs in areas where many of the trees are very close in height. You may have to move around your area to find a good sight-line to the tops of your trees.

9. How accurate is measuring tree heights?
Like any other measurement, accuracy and precision increase with practice and the use of care in the measurement. Three groups measuring the same tree should get results within +/- 1 meter of each other.

10. What do I do if I do not have a single co-dominant tree or shrub species?
If the co-dominant species is mixed at your site, measure the heights and circumferences for 5 trees or shrubs of different species. Note the species you are using in the Metadata.

11. What do I do if there are not 5 trees or shrubs of the dominant species at my site?
Should I measure any heights and circumferences?
If there are less than five, measure all the trees or shrubs at your site and make a note in the Metadata.

12. My school does not have a drying oven. Can we dry the grass another way?
First, check to see if you can use a drying oven at a community college, university, government agency or some other business or organization in your community. In warm, dry climates, graminoid biomass samples can be dried in mesh bags outside. Do not use a conventional oven to dry the graminoid vegetation. This is dangerous!

13. When I am measuring grass biomass, what do I do with mosses or lichens?
Moss and lichens are considered "Other Green" and have their own designation on the *Canopy and Ground Cover Data Sheet*. Do not include mosses or lichens in your dried samples. Record in metadata if these species comprise a large part of your green ground cover.