Biometry Protocol

Purpose

To quantify and record the land cover in order to determine the specific characteristics of a Quantitative Land Cover Sample Site

To provide GLOBE scientists and others with necessary land cover data

Overview

Students lay out a 30 m x 30 m area within a Quantitative Land Cover Sample Site. At these sites, students observe and record ground cover and canopy cover, identify dominant and co-dominant vegetation species, measure either tree height and circumference or the biomass of the herbaceous ground cover. They designate one of these sites as their Biology Study Site, where they will perform this protocol once or twice each year.

Time

One-half to one full day for each visit

Level

All

Frequency

One to two times per year for your Biology Study Site

One time only for all other Quantitative Land Cover Sample Sites

Key Concepts

- Relation of the pixel size of an image to a site on the ground
- Canopy Cover
- Ground Cover
- Tree Height and Circumference
- *Biomass* of herbaceous vegetation
- Dominant and *Co-Dominant* Species
- Land Cover Classification

Skills

- *Using* a clinometer and densiometer.
- *Using* compass directions
- *Making* ground measurements
- *Identifying* vegetation types and tree species
- *Using* a dichotomous key
- *Measuring* pace

Materials and Tools

- Color printed copies of your local 512 x 512 pixel Landsat Thematic Mapper scene in visible (3, 2, 1) and NIR (4, 3, 2)
- Local road or topographic maps (optional)
- Compass
- 50 m Tape measure
- Marking stakes, flags, or other permanent site markers
- GPS Unit
- Still Camera
- Tubular densiometer (4 cm diameter by 7.5 cm long tube, string, metal nut or washer, tape)
- Dichotomous keys and/or other local species guides
- Clinometer (Clinometer Sheet, cardboard, drinking straw, metal nut or washer)
- Table of Tangents
- Flexible tape measure
- Small bean bag
- Grass clippers or strong scissors
- Small brown paper bags
- Drying oven
- Balance or scale, accurate to 0.1 g
- Land Cover/Biology Investigation Field Data Work Sheet

Preparation

Select site(s)

Practice measurement techniques

Prerequisites

Site Seeing Learning Activity

Introduction

The *Quantitative Land Cover Sample Site Protocol* shows you how to establish Quantitative Land Cover Sample Sites and outlines the steps for collecting data on them. This protocol details the procedures for performing *biometry* measurements at all quantitative sites. This protocol can only be performed on sites with MUC level 1 class 0 (Closed Forest), 1 (Woodland), or 4 (Herbaceous Vegetation). You establish one of these quantitative sites as your Biology Study Site.

How to Lay-out a 30 m by 30 m Area for Biometry Measurements

Special Considerations for Biology Study Sites

Note: If you have already followed an earlier version of this protocol and have established a Biology Study Site, continue to use your current site for repetitive measurement following the later sections of this protocol.

The only difference between your Biology Study Site and the central 30 m x 30 m areas of other Quantitative Land Cover Sample Sites is that biometry measurements are repeated periodically at the study site while at sample sites observations are made just once. After identifying the dominant and co-dominant vegetation types, you will perform a series of biometry measurements over time.

Since your Biology Study Site is permanent, you need to mark the 30 m x 30 m center area where you perform all your measurements with permanent stakes, flags, or other markers. To mark this 30 m x 30 m area:

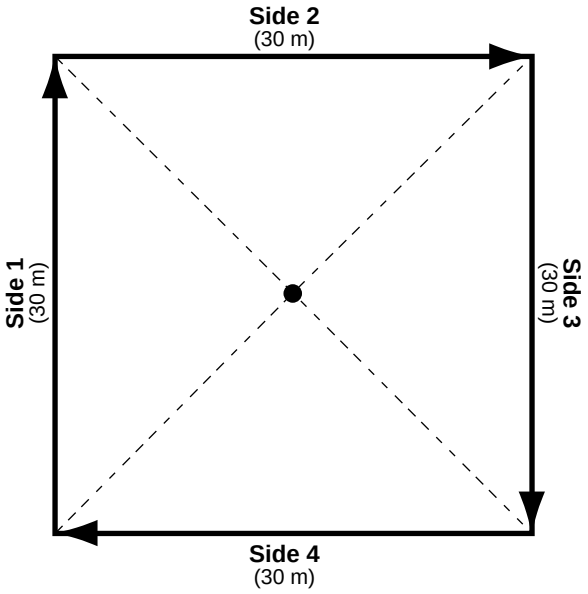
Step 1: Establish Your Biology Study Site

- ❑ Follow Steps 1 through 4 of the Quantitative Land Cover Sample Site Protocol. Make sure this site is a MUC level 1 class 0, 1, or 4 area.

Step 2: Establish and Mark Your 30 m x 30 m Biology Study Area

- ❑ Place a marker where you want one corner of your 30 m x 30 m square to be.
- ❑ Use your compass and measuring tape to move 30 meters in a *cardinal* direction (North, South, East, or West). Place a second marker at the end of this transect. This forms side one.
- ❑ From the second marker, move 30 meters perpendicular to side one. Place a third marker at the end of this transect. This forms side two.
- ❑ From the third marker, move 30 meters perpendicular to side two and parallel to side one. Place a fourth marker at the end of this transect. This forms side three.
- ❑ From the fourth marker, move 30 meters toward your original marker. If this transect ends within 2 to 3 meters of the original marker, you are successful. If you are farther off the mark, check your compass headings for each side, check the length of each side, and try again.
- ❑ Establish the center of your square by pacing the diagonal transects of the square and placing a marker where the two paths intersect. You may use string to make these diagonals.

Figure LAND-P-9: Biology Study Site Set-up



Making Biometry Measurements

Depending on the types of vegetation at your site, you and your students will make biometry measurements on canopy cover, ground cover, tree height and circumference, and/or grass biomass.

When to Make Biometry Measurements

At your Biology Study Site: make biometry measurements twice each year—once during peak growing season and once during the least active season. If you have no temperature or rainfall-dependent seasonality in your region, take measurements only once a year.

At all other Quantitative Land Cover Sample Sites: perform biometry measurements just once, as close to the peak of the growing season as possible.

How to Make Canopy Cover and Ground Cover Measurements

Step 1: Make a Densiometer

- ❑ Take a tube approximately 4 cm in diameter and 7.5 cm long. Attach two strings at perpendicular angles across the diameter of one end to form a crosshair.

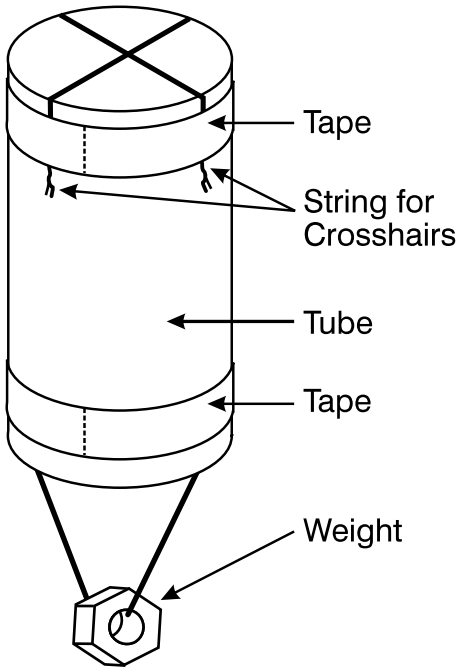


Figure LAND-P-10: Homemade Densiometer

- ❑ Attach an 18 cm piece of string with a metal nut or washer hanging loosely from it across the diameter of the other end of the tube. You have made a densiometer.

Step 2: Tally Canopy Cover and Ground Cover

- ❑ One or more pairs of students pace the two diagonals of the 30 m x 30 m square.
- ❑ After every pace, one student looks up at the canopy through the densiometer, making sure the metal nut/washer is directly below the intersection of the crosshairs at the top of the tube.
  Note: If it takes smaller students more than forty paces to complete a diagonal, they may take measurements at every other pace.
- ❑ If the student sees vegetation, twigs, or branches touching the crosshair intersection, the other student records a " + " in the proper space on the Dominant/ Co-Dominant Vegetation Field Data Work Sheet. If no vegetation, twigs, or branches touch the crosshair intersection (i.e. the student sees the sky above the intersection of the crosshairs), the student records a " - ". The students should end up with a series of +'s and -'s.
- ❑ Now, the student looks down.
- ❑ If vegetation is underfoot or touches the foot or leg below the knee, the other student records a "G" if the vegetation is green, a "B" if the vegetation is brown, or if no vegetation touches the student underfoot or below the knee (i.e. the ground is bare), the other student records a " – ".
  For more accurate readings, other pairs of students should repeat these measurements.

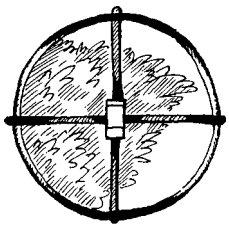
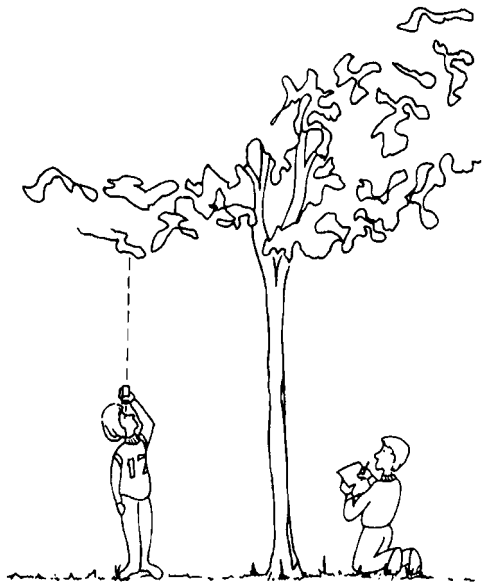


Figure LAND-P-11: Example using a homemade densiometer



Step 3: Report Findings for Canopy Cover and Ground Cover

- ❑ Report the number of +'s and -'s for canopy cover and the number of G's, B's, and -'s for ground cover to the GLOBE Student Data Server along with other biometry data.

  Note: If observations were repeated by different teams of students, choose only one team's set of data to report to GLOBE.

Step 4: Calculate Percentages of Canopy Cover and Ground Cover

- ❑ Calculate canopy cover percentage: Add up all +'s and divide by the sum of the +'s plus -'s. Multiply by 100 to convert this fraction to a percentage.
- ❑ Calculate green ground cover percentage: add up the G's and divide by the sum of the G's, B's, and -'s. Multiply by 100 to convert this fraction to a percentage.
- ❑ Calculate brown ground cover percentage: add up the B's and divide by the sum of the G's, B's, and -'s. Multiply by 100.
- ❑ Add the green ground cover and brown ground cover percentages together to obtain a total ground cover percentage.

How To Identify Dominant and Co-Dominant Vegetation

Having established your site(s), you have a general idea of what types of vegetation grow there. You and your students will now identify the most common (dominant) and second most common (co-dominant) vegetation types on your Biology Study Site or other Quantitative Land Cover Sample Sites. You may need this information to help you identify the MUC classification of your site using the *MUC Classification Protocol*. GLOBE scientists also need this information to study the growth of different kinds of vegetation. For Closed Forest and Woodland sites (MUC level 1 classes 0 and 1) we ask you to identify the scientific names (genus and species) of the two types of trees that have the most canopy coverage. For herbaceous sites (MUC level 1 class 4), identify the plant(s) that cover the most ground as *graminoid* (grass), or *forb* (broad-leaved). Please see the MUC Glossary in the *Appendix* for definitions of these terms.

Step 1: Identify Vegetation Types

- ❑ Repeat the canopy cover and ground cover measurements given above but this time the student identifies each tree species that touches the crosshair. The student also looks at the ground and identifies any vegetation type underfoot or touching her foot or leg. The other student records the types on the Dominant/Co-Dominant Vegetation Field Data Work Sheet.

Note: If you cannot identify the genus and species of a tree in the field, record the common tree name, if known. If the common name is not known, invent names and describe the tree well so that you can accurately identify it later.

Step 2: Calculate Which Vegetation Types Are Dominant and Which Are Co-Dominant

- ❑ Tabulate your results.
- ❑ If tree canopy cover is 40% or greater and the canopy is above 5 m in height, then your site is Forest or Woodland (MUC level 1 classes 0 or 1). The *dominant* vegetation is the tree species seen the most times through the densiometer. The *co-dominant* vegetation is the tree species

seen the second-most times. If your site is forest or woodland, identify the tree species using dichotomous keys or by consulting local experts. See Helpful Hint: How to Use Dichotomous Keys. Then, proceed to How to Measure Tree Height and Circumference.

- ❑ If tree canopy cover is less than 40%, and your ground cover is more than 60%, then your site is dominated by Herbaceous Vegetation (MUC level 1, class 4). The *dominant* vegetation is the plant seen the most times as part of the ground cover. The *co-dominant* vegetation is the plant seen the second-most times either on the ground or in the canopy. If your site is herbaceous vegetation, identify whether the land covers are *graminoid* (grasses) or *forb* (broad-leafed) using the definitions in the *Appendix*. If the herbaceous land cover is graminoid, proceed to How to Measure Grass Biomass. If the vegetation is broad-leaved, do not perform any further measurements or observations.

Step 3: Record Your Findings

- ❑ If your site is Forest or Woodland, enter the first four letters of the genus and species for both the dominant and co-dominant tree species in the proper space on your Dominant/Co-Dominant Vegetation Field Data Work Sheet.
- ❑ If your site is Herbaceous Vegetation, enter either "GRAM," for grass (graminoid), or "FORB" for other, broad-leaved vegetation, in the proper space on your Data Work Sheet.

Note: If the vegetation on your site is diverse, it may be difficult to identify the dominant and co-dominant vegetation. If two types are not clearly dominant and co-dominant, describe the vegetation types well in the Notes section of your Dominant/Co-Dominant Vegetation Field Data Work Sheet. Enter "mixed" on the *Dominant/Co-Dominant* line.

Examples

To give you a better sense of how this activity works, here are two examples of what might happen:

Example 1: You perform your canopy cover and ground cover measurements, recording the number of times you saw vegetation through your densiometer and the number of times you saw sky. Each time you see canopy vegetation through your densiometer, you also record and tally the tree species. You then calculate a canopy cover of 70% and note that the crowns of trees are touching each other. This means you classify your site as a *forest* (MUC level 1 class 0). The dominant tree species is the species with the most tallies. The co-dominant species is the species with the second most tallies.

Example 2: After you perform your canopy and ground cover measurements, you calculate that the canopy cover is 20% and composed of a single species of pine tree. Your ground cover is 90%, and is composed of 80% grass and 10% forb. This means you classify your site as *herbaceous vegetation* (MUC level 1 class 4). The dominant vegetation is grass ("GRAM" on the Data Work Sheet). Since 20% of the site is pine tree and only 10% of the site is forb, your co-dominant vegetation is the pine tree species.

Helpful Hints: How to Use Dichotomous Keys

The word *dichotomous* comes from the Greek words *dikha*, "in two," and *temnein*, "to cut." Thus, it's meaning: "division into two contradictory parts." A *key* is a table glossary, or cipher, for decoding or interpreting. A *dichotomous key* is a branching decoder, which forks into two approximately equal and contradictory divisions that lead to only one correct outcome. It is like a mouse maze. For the mouse to escape, it must make successive choices between two directions, one correct and one incorrect. The mouse will get out only after making all the correct choices.

To use a dichotomous key we, too, must choose correctly between two options in a series of contradictory options. We use our five senses (sight, hearing, touch, taste, and smell) to determine the correct choices. Here is a simple example of how we might choose what type of shoe we are wearing.

Assume you are wearing a pair of canvas running shoes. The first choice in the key asks if the shoes are made of leather or canvas. Since they are made of canvas, not leather, you follow the "path" to "CANVAS." Here you are asked if your shoes have lightweight soles and are low-cut or if they have heavy soles and are high-cut. Yours are lightweight and low-cut, so you have identified them as canvas running shoes.

Note that *all* dichotomous keys have inherent limitations. In this example, only six types of shoes are included. Even very extensive and technical keys omit some possible choices. This is especially true of exotic vegetation species that have been introduced into an area. Many dichotomous keys only include native species. If the plants you are trying to identify aren't native or your dichotomous key isn't complete enough, you may need to seek expert help.

A second limitation of many dichotomous keys is their use of imprecise terminology (e.g. "low-cut," "lightweight," etc.). Sometimes it is not clear what the authors of the key mean by these terms. The best keys are those that use objective, measurement-based characteristics rather than subjective options.

To help you identify species or find a local dichotomous key, consult foresters, local experts, university research scientists, etc. Your GLOBE Country Coordinator may also have useful information.

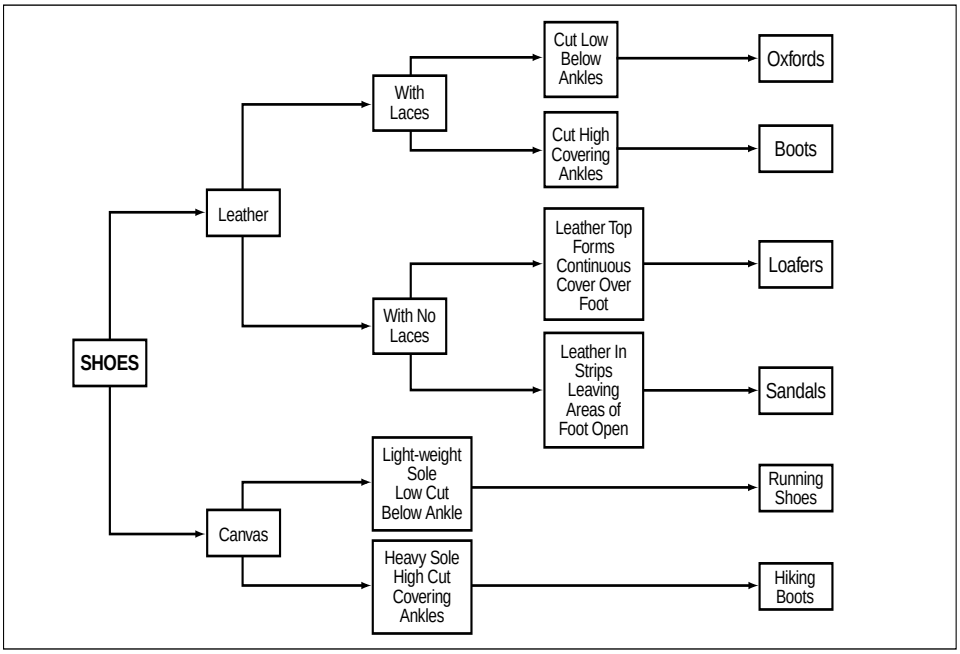


Figure LAND-P-12: Using a Dichotomous Key

How to Measure Tree Height and Circumference

How to Choose Which Trees to Measure

1. If the dominant species on your site is a tree, select five specimens of the tree. Include the largest tree, the smallest tree that still reaches the canopy, and three intermediate trees. Mark the trees for future reference.
2. If you have a co-dominant tree species, repeat the process. If there are fewer than five co-dominant species trees, include other tree species to make a total of five. Mark the trees for future reference.

How To Measure Tree Height Using a Clinometer

A clinometer measures angles to determine the heights of objects without directly measuring them. It is a simplified version of the *quadrant* (a medieval measuring instrument), and the *sextant*, an instrument used to locate the positions of ships. Like these instruments, the clinometer has an arc with graduated degree markings that go from 0 to 90 degrees. See Figure LAND-P-13. When you site an object through the clinometer's drinking straw, you can read the number of degrees of angle BVW by noting where the string touches the arc. Angle BVW is equal to angle BAC, which is the angle of elevation of the clinometer. If you know both the angle of elevation and your distance away from an object, you can calculate the height of that object using a simple equation.

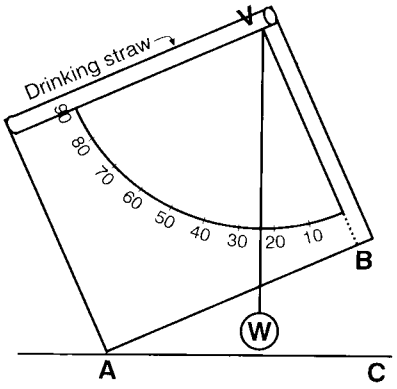


Figure LAND-P-13: Homemade Clinometer

Modified from Bennett, A. and Nelson, L. (1961) Mathematics an Activity Approach. Allyn & Bacon: Boston.

Step 1: Make a Clinometer

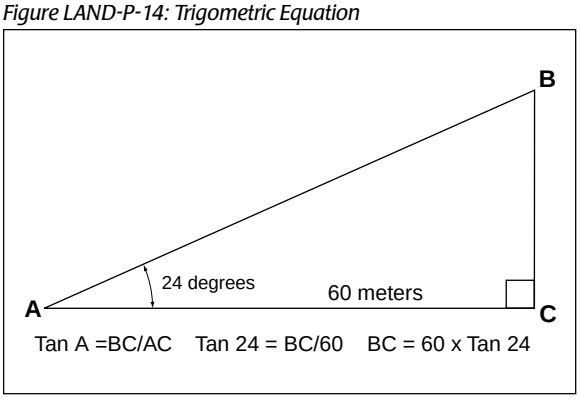
- ❑ Glue a copy of the Clinometer Sheet in the Appendix onto a same-size piece of stiff cardboard.
- ❑ Punch a hole through the marked circle on the sheet and tie one end of a 15 cm piece of string through it.
- ❑ Tie a metal nut or washer to the other end of the string.
- ❑ Tape a drinking straw along the designated line on the sheet, to use as a site.

Step 2: Measure and Record the Distances and Angles Needed to Determine Tree Height

- ❑ At one of your selected trees, move a predetermined distance away from the base of the tree and record the distance. This is your line AC. See Figure LAND-P-14. For the most accurate results you should adjust your distance away from the base of the tree so that Angle BVW is between 30 degrees and 60 degrees.
- ❑ Measure and record the height of your eye above the ground.
- ❑ Site the top of the tree through the drinking straw on the clinometer.
- ❑ Record the number of degrees in angle BVW on the clinometer; this tells you the number of degrees in angle BAC.

In the example (Figure LAND-P-15), a student stands 60m away from the base of a tree sites the top of the tree through his clinometer. His eye is 1.5 meters above ground. He reads an angle of 24 degrees on his clinometer (figures are not drawn to scale).

Figure LAND-P-14: Trigometric Equation



Step 3: Organize Your Data in a Drawing

Refer to Figure LAND-P-14 to draw and label a triangle that represents all the information you have accumulated.

Step 4: Calculate Tree Height

- ❑ Use your Table of Tangents in the Appendix and the following equation to solve for the height of BC:

TAN<A = BC/AC

The above student solved his equation like this:

TAN 24 = BC/60. Therefore,

BC = 60 (TAN 24). Therefore,

BC = 60(.45) = 27m.

- ❑ Add the height of BC to the height of the clinometer from the ground (your eye level) to get the total height of the tree. In the above example, the height of the tree is 27m + 1.5m = 28.5m.

Note: For younger students, if the angle BVW is 45 degrees, the distance from the tree will equal the height of the tree above the student's eye level and this can be illustrated for students by drawing an isosceles right triangle without any additional explanation of the mathematics involved.

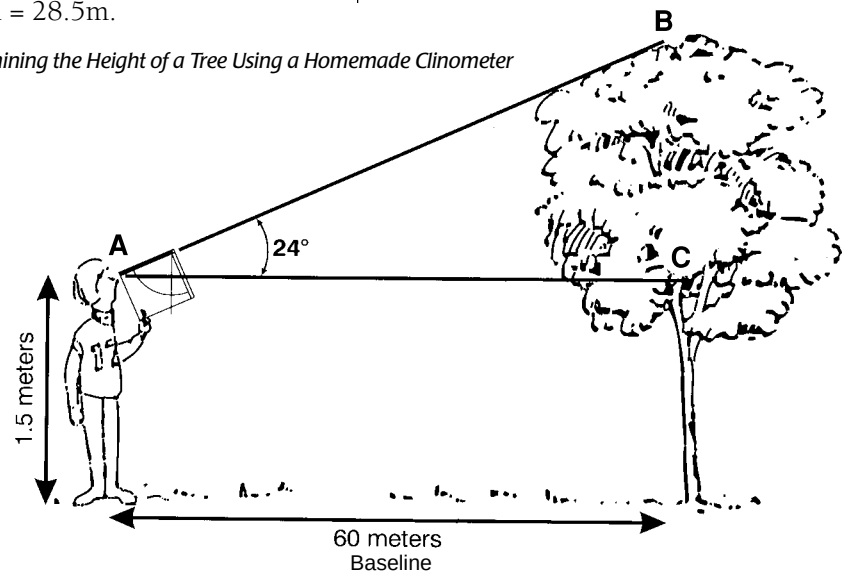
Step 5: Repeat the Above Process for All Selected Trees

Step 6: Calculate and Record Average Tree Height(s)

- ❑ Add the heights (in meters) of the dominant species trees and divide by five to obtain their average height.
- ❑ If you have five co-dominant species trees, repeat the process for them.
- ❑ Record tree height averages on your Data Work Sheet.

Note: If you would like to practice measuring heights before going to your site, find a tall outdoor object for which you know or can directly measure the height (such as a flagpole or the school building). After completing the above process, compare your results with the known height of the object.

Figure LAND-P-15: Determining the Height of a Tree Using a Homemade Clinometer

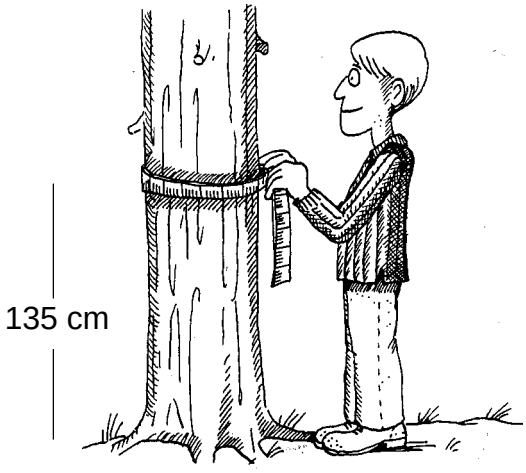


How To Measure Tree Circumference

Step 1: Measure and Record Tree Circumference

- ❑ With a flexible tape measure, measure the tree's circumference at exactly 1.35 m above ground level. Scientists call this measurement *circumference at breast height* (*CBH*).
- ❑ Repeat process for all five dominant species trees and, when applicable, all five co-dominant species trees.
- ❑ Record circumferences in centimeters on your Land Cover/Biology Investigation Field Data Work Sheet.

Figure LAND-P-16: Measuring Tree Circumference



Source: Jan Smolík, 1996, TEREZA, Association for Environmental Education, Czech Republic

How To Measure Grass Biomass

If the dominant and/or co-dominant species at your site is grass, you will measure the *biomass* - the total mass of both live (green) and *senescent* (brown) herbaceous vegetation - per square meter on your site. This data will help others to document land cover and to assess and model water and nutrient cycles. Do not measure the biomass of any vegetation other than grasses, even if they are the dominant or co-dominant species present.

Step 1: Select and Mark Three Random Sampling Locations

- ❑ Blindfold a student and have him or her throw a small bean bag while you spin him or her at the center of your site. The bean bag's landing point will be one random sampling location.
- ❑ Repeat process twice more.
- ❑ At each sampling location, use a tape measure to mark out a one meter square on the ground.

Step 2: Collect and Sort Grass Clipping Samples

- ❑ Use garden clippers to clip all the grass vegetation within the square. When completed, the square should be devoid of any grass vegetation except for short stubs (*Vegetation* means it is still rooted in the ground. Do not collect any unattached leaves or litter).
- ❑ Sort clippings into living and senescent portions. Any clipping with even a little green is considered living. Only entirely brown clippings are senescent.
- ❑ Place the living and senescent portions into separate brown paper (*not* plastic) bags, and label each bag carefully. If your site has very extensive growth, use several small bags instead of two large ones.

Step 3: Prepare and Weigh Grass Clipping Samples

- ❑ Back at school, dry the bags over a period of days in a drying oven at a temperature no higher than 50 to 70 degrees celsius. Weigh each bag once a day. The samples are completely dry when you get the same mass on two consecutive days. (Note: Do *not* use a conventional cooking oven for this process; that would dangerous!)
- ❑ Weigh each bag, one at a time. Then, shake out the contents and weigh the empty bag. Subtract the empty bag weight from the total weight to get the weight of the grass. (Use a scale capable of measuring weights to plus or minus 0.1 g.)

Step 4: Record and Report Findings

- ❑ Record the weight in grams of both the green and brown material from each sample location.
- ❑ Report the weights of green and brown material for each of the three samples to the GLOBE Student Data Server.
- ❑ Calculate the average weight (biomass) of green material by adding the weights of the three samples and dividing by three. Record this weight in the Biometry Summary section of the Land Cover/ Biology Investigation Field Data Work Sheet for future reference and comparison.
- ❑ Calculate the average weight (biomass) of brown material by adding the weights of the three samples and dividing by three. Record this weight in the Biometry Summary section of the Land Cover/ Biology Investigation Field Data Work Sheet for future reference and comparison.

How to Enter Your Observations on the Land Cover/Biology Investigation Field Data Work Sheet

You will find a Land Cover/Biology Investigation Field Data Work Sheet in the *Appendix*, which you can use to record site observations and measurements. Make as many blank copies of this work sheet as you need. Use a separate work sheet each time your students make observations. This work sheet contains spaces to record every possible ground observation and measurement in this protocol. Depending upon what observations or measurements you make, some spaces will be left blank.

Your students should record the following data and information on the Land Cover/Biology Investigation Field Data Work Sheet:

1. Site Identification: Identify your Land Cover Sample Site. Designate the visit as either "training" or "validation" and as either "qualitative" or "quantitative." If it is a quantitative site, record whether it is your Biology Study Site.
2. Site Name: Identify the name you and your students give to your study site.
3. Country/State/City: Identify your locality using these identifiers.
4. GPS Location: Record the latitude and longitude of your site's center point, which has been determined using GPS.
5. Date and Time: Record the date and time of your field observations and measurements.
6. Recorded By: Record the name of the student or other person entering data on the form.
7. MUC Land Cover Classes 2, 3, and 4: Record the name and numerical code of the best match to your site's cover type as determined by the Modified UNESCO Classification System (MUC). If your cover is *urban* or *agricultural*, you may stop. All other observations and measurements are for natural vegetation.

8. Dominant and Co-Dominant Species:
   - If your dominant and/or co-dominant species are trees, enter the first four letters of the genus and species of each (as labeled in a dichotomous key).
   - If your dominant and/or co-dominant species are herbaceous vegetation, enter either "GRAM," for grass (graminoid), or "FORB" for other, broad-leaved vegetation.
   - If the vegetation on your site is diverse and the dominant and co-dominant species are impossible to ascertain, describe the vegetation types well in the Notes, Photographs section (below) and enter "mixed" on these lines.
9. Canopy Cover: Record + and - observations when using the densiometer method.
10. Ground Cover: Record the G, B, and - observations for ground cover.
11. Number, Height, and Circumference of Trees: Record the number of trees and the height and circumference measurements on your five dominant and five (when applicable) co-dominant tree species specimens. (If grasses are the dominant and co-dominant vegetation, leave these fields blank.)
12. Green/Brown Biomass: If your sample is dominated by grasses, record the green and brown biomasses for each of your sample locations after drying your samples at school. (If grass is not the dominant vegetation, leave these fields blank.)
13. Biometry Summary: Record the calculated canopy cover percentages, the green and brown ground cover percentages, the average tree height and circumference, and the average grass biomass obtained from combining the multiple samples.
    Note: Report all items marked by a star on the data form to the GLOBE Student Data Server.
14. Notes, Photographs: Record relevant field observations such as weather conditions, the number and orientation of photographs taken, etc.