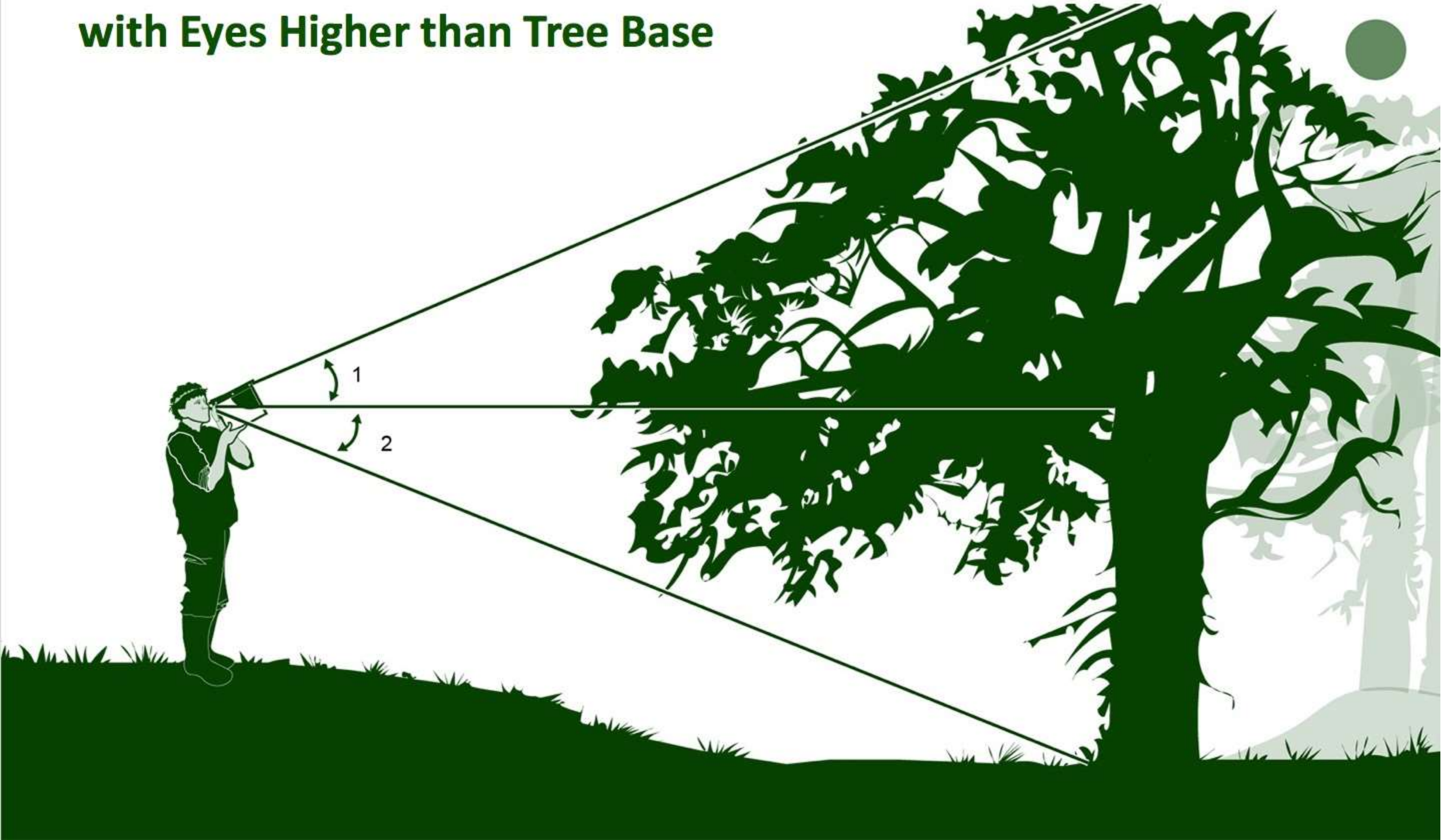
Measuring Tree Height: Two Triangles with Eyes Higher than Tree Base



A. What Is Graminoid, Tree and Shrub Height?
B. Why Collect Graminoid, Tree and Shrub Height Data?
C. How Your Measurements Can Help
D. How to Collect Your Data
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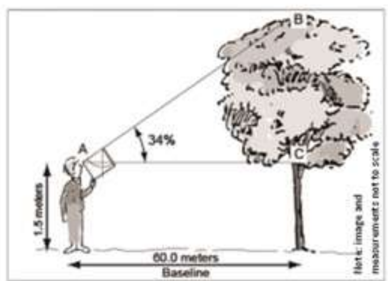
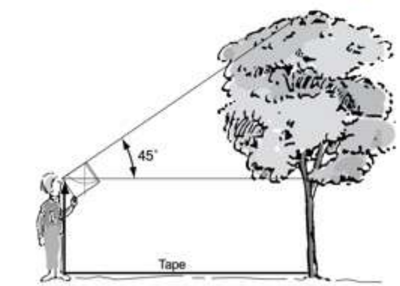
Notes about this slide stack

GLOBE uses 5 different techniques to measure tree and shrub height. There is a slide stack for each of the techniques: select the one that best suits your situation, and use that slide stack to learn how to do the measurement.

1. If your feet are level with the tree base, use one of these two protocols

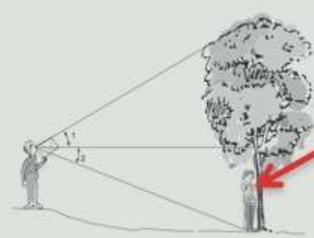


I. Standard Clinometer Technique



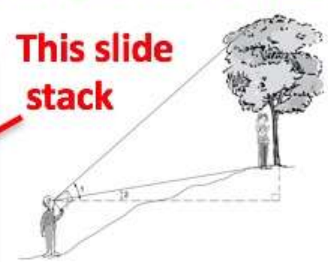
II. Simplified Clinometer Technique

2. If you are measuring tree height on a slope, choose one of these options

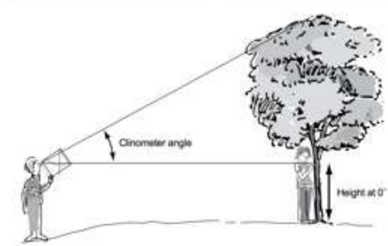


III. Two Triangles with Eyes Higher Than Tree Base

This slide stack



IV. Two Triangles with Eyes Lower than Tree Base



V. Stand by Tree Technique

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Overview

This module:

- **Describes how to build a clinometer, the scientific instrument used to obtain tree and shrub height**
- **Provides a step by step introduction of how to measure the height of grass-like plants**
- **Provides a step by step introduction of a protocol method that can be used when measuring tree or shrub height when measuring tree height on sloping ground when eyes are higher than the base of the tree**

Learning Objectives

After completing this module, you will be able to:

- **Define graminoid tree and shrub height**
- **Describe the importance of quality control steps in the the collection of accurate data**
- **Explain the difference between accuracy and precision**
- **Conduct graminoid tree and shrub height measurements in the field**
- **Upload data to the GLOBE portal**
- **Visualize data using GLOBE's Visualization Site**

Estimated time to complete the module: 1.5 hours

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The Biosphere

The Biosphere is Earth's zone of life. Every organism on Earth belongs to the biosphere. GLOBE has several ways to explore and measure components of the Biosphere through investigations in **land cover** and **phenology**. As well, the Hydrosphere investigations include the macroinvertebrates and mosquito larvae protocols.

Like all parts of the Earth system, the **Biosphere** is subject to change. We can quantify these changes by taking measurements over time, and compare what we saw in the past to what we see in the present.

Graminoid, Tree and Shrub Height measurements are part of GLOBE's Biosphere protocols. Graminoid is another word for grass-like plants.

Photo Credit: Shelley E. Olds

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What is Biometry?

Biometry is the measuring of living things. A scientist is interested not only in the characteristics of vegetation at a study site, but also how it is distributed. How dense is the forest? Does sunlight penetrate to the forest floor? Is the landscape dominated by grasses? Has there been a recent disturbance, such as a forest fire or flood? These are questions that are answered by taking biometric measurements.

In this protocol, you will be measuring the height of trees, shrubs, and grass-like plants using the Measuring **Tree Height on a Slope: Two-Triangles with Eyes Higher than Tree Base Technique.** These measurements will assist you in determining the **MUC classification** of your study site.

GLOBE Biometry Measurements

- Land Cover Sample Site
- Canopy Cover and Ground Cover
- Graminoid, Tree and Shrub Height
- Tree Height on Level Ground: Simplified Clinometer Technique
- Tree Height on Level Ground: Standard Clinometer Technique
- Tree Height on a Slope: Stand by Tree
- Tree Height on a Slope: Two-Triangle Techniques
- Tree Circumference
- Graminoid Biomass

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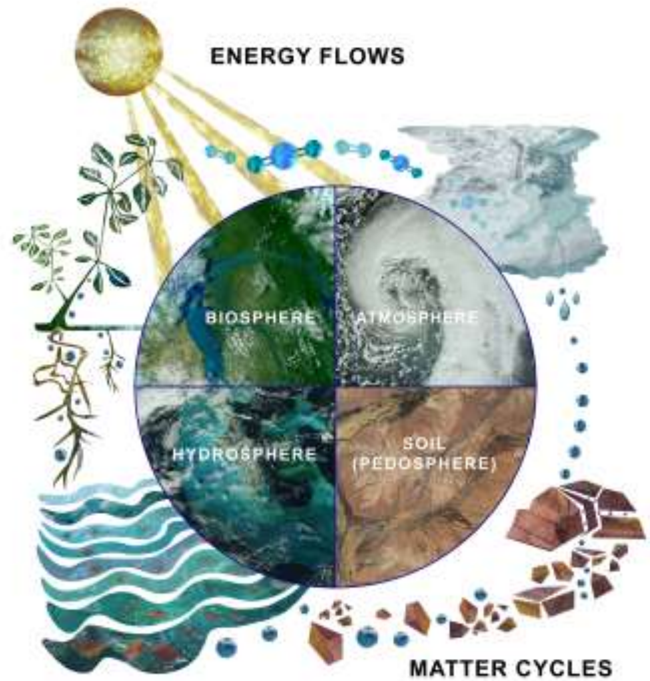
Why Study Land Cover?

Land cover includes both developed and natural areas. All living things depend on their habitat, or land cover, for survival. They find shelter, food, and protection there. Land cover has a direct effect on the kinds of animals that will likely inhabit an area. Therefore, land cover is of great interest to ecologists, who study how plants and animals relate to their environment.

Land cover can influence weather, soil properties, and water chemistry. Different land cover types are all distinct in their effects on the flow of energy, water and various chemicals between the air and surface soil. So, knowing what types of land cover occur is important for a variety of Earth system science investigations.



The Earth System: Energy flows and matter cycles.

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GLOBE Land Cover Investigations

Land cover is a general term used to describe what is on the ground covering the land. Different land cover terms are used to describe the differences we see when we look at the land. Scientists classify land cover based on established criteria. This is done so that there is a consistent use of terms among people. For instance, what one person may call a forest living in the tropical Amazon may be quite different from a person living in northern Canada. Different species of trees live in these places, trees may be of different heights and the amount of ground and canopy cover may be quite different. For this reason, we need a standardized way to describe land cover.

GLOBE uses a land cover classification scheme called Modified UNESCO Classification (MUC). There are many different types of classification schemes used. These are often designed for specific places or regions. MUC can be used around the world and allows people to contribute to a global data base.

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What is Graminoid, Tree and Shrub Height?

To describe your Land Cover Sample Site and identify the MUC code, you may need to measure the average height of the vegetation. For low-lying vegetation, such as grasses, and medium height vegetation, such as shrubs, you will take a random sample of plants, measure them, and calculate the average plant height.

To measure tree height, you will need to use a **Clinometer** to make the measurements. You'will find instructions for building a clinometer in this tutorial.

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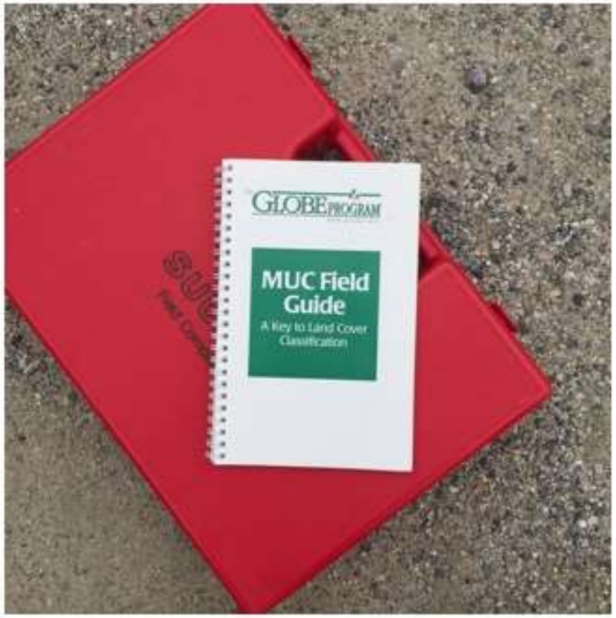
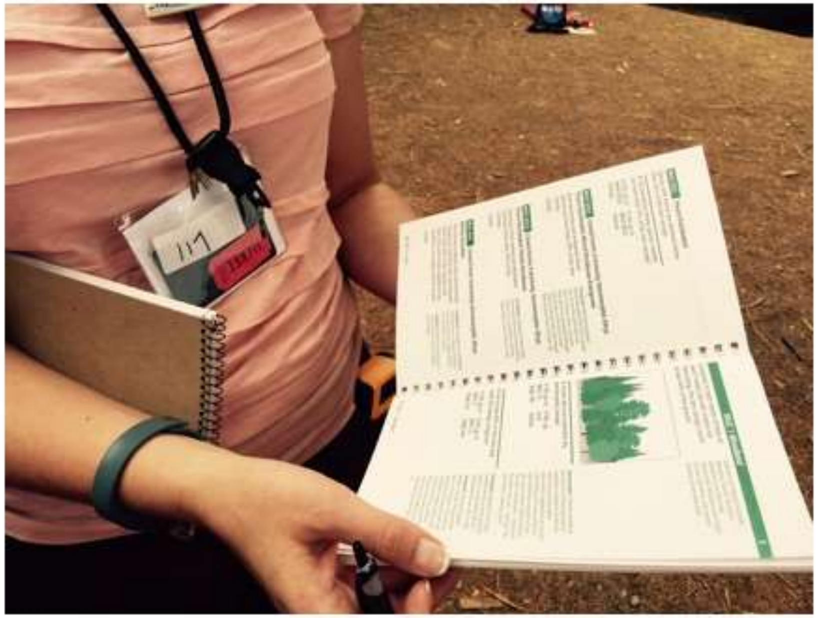
Why Do We Collect Graminoid, Tree and Shrub Height?

You will need to measure the height of graminoid (grasslike) vegetation, shrubs and /or trees to help determine the MUC class of your Land Cover Sample Site. MUC stands for **Modified UNESCO Classification** system, an international standard for describing vegetation. Because the MUC system is widely used, it will allow you to compare your study site to others around the globe.





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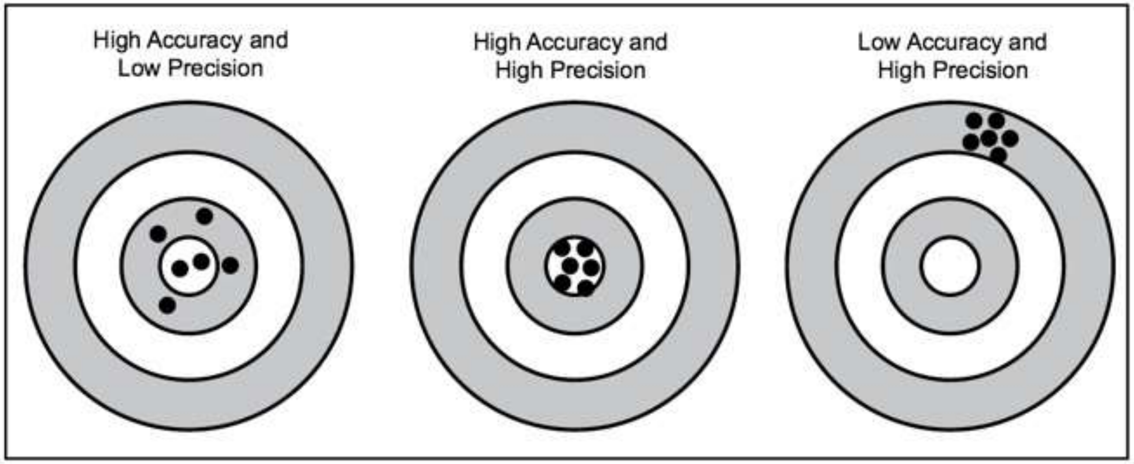
Why Collect Biometry Data?

Biometry measurements are useful for scientists who want to use your Land Cover Sample Site data. It helps to make sure that the MUC class you select is correct. Biometry measurements can help them assess how accurate and precise a land cover data set is. **Accuracy** is a measure of how well the data describe a phenomenon. **Precision** is demonstrated when repeated measurements yield the same outcome. In most GLOBE protocols, you are asked to take a measurement 3 times – allowing for you – as well as other scientists – to determine the precision of your data.



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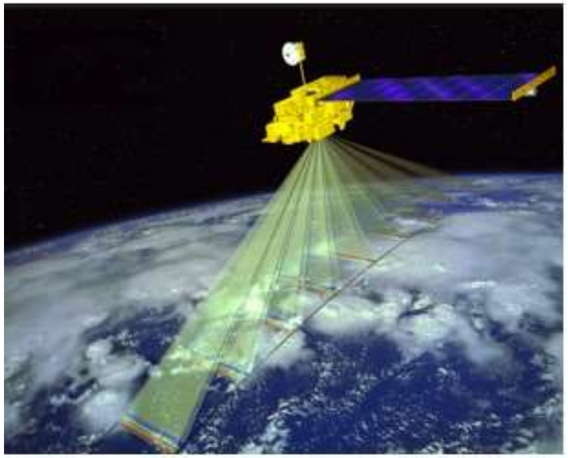
Mapping

An important objective of the land cover investigation to assess the accuracy of maps created by satellite images and aerial photographs.

Remote sensing simply means learning about something without making direct contact with it. We use remote sensing every day by hearing, smelling, and seeing.

With satellites and aircraft, we use machines to be our "eyes" in the sky or in orbit. Remote sensing in space has the great advantages of being able to cover very large areas quickly and to revisit the same area frequently. However, some of the detail that can be seen at ground level may not be detected by a remote sensing system. Therefore, it is beneficial to collect data at sample sites on the ground to accompany remotely sensed data about an area. GLOBE land cover data can contribute to making better, more accurate maps.



Terra's Terra's five instruments provide measurements of plant (vegetation) composition, structure, extent, and change. Image: NASA.

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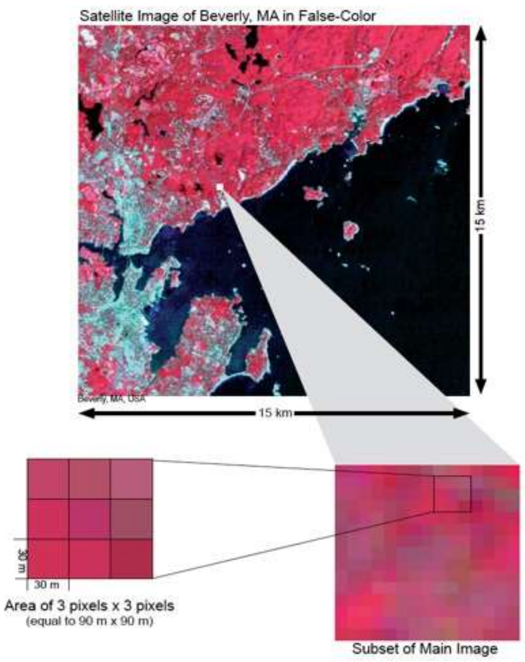
How Your Measurements Can Help: Scientific Importance of Canopy Cover and Ground Cover Data

GLOBE land cover data can contribute to making better, more accurate maps.

Your land cover measurements are used to verify satellite analysis of land cover.

As you zoom in on a 15 km x 15 km satellite image, the pixels (which are 30 m x 30 m in size) become visible. You will be taking field measurements at sites that are 90 m x 90 m (equal to 3 pixels x 3 pixels).



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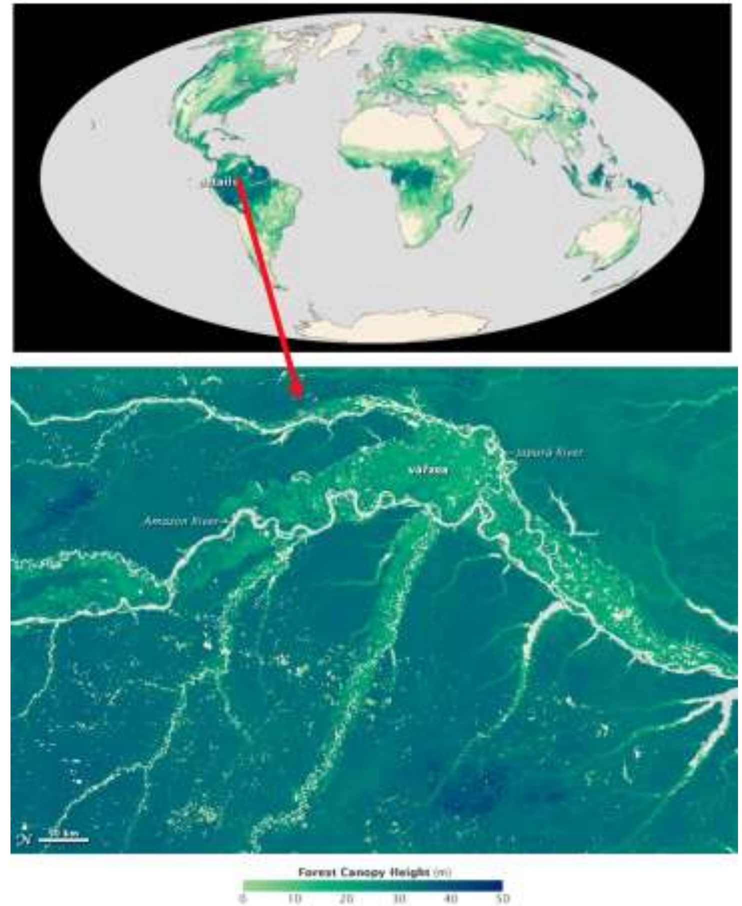
Example: Canopy Height Map Created Using Satellite Data

Here are maps of canopy height derived from satellite data. Overall, the maps show that forest canopy heights are highest near the equator and decrease the closer forests are to the poles. The tallest forests, shown in dark green in the map above, tower higher than 40 meters and are found in a band in the tropics that includes the rainforests of the Amazon, central Africa, and Indonesia.

Both maps are based on data from the Geoscience Laser Altimeter System (GLAS) from the ICESAT satellite and the Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Terra and Aqua satellites, but the close-up incorporates additional elevation data from the Shuttle Radar Topography Mission (STRM) and climatology information from both the Tropical Rainfall Measuring Mission (TRMM) and the Worldclim database.

Ground validation of tree height by GLOBE participants can support a range of analyses, including those developed using satellite data.



Source: NASA Earth Observatory. Research team led by Marc Semard, JPL.

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Let's do a quick review before moving onto data collection! Question 1

1. Scientists use biometry to:

A. Document the characteristics of vegetation of a study site

B. Describe the distribution patterns in the vegetation

C. A and B

D. None of the above

What is the answer?

A. What is Canopy Cover and Ground Cover?
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Let's do a quick review before moving onto data collection!
Answer to Question 1

1. Scientists use biometry to:

A. Document the characteristics of vegetation of a study site

B. Describe the distribution patterns in the vegetation

C. A and B ☺ correct!

Were you correct?

A. What is Canopy Cover and Ground Cover?
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Let's do a quick review before moving onto data collection!
Question 2

2. Which of the following can be impacted by land cover?

A. Weather

B. Water chemistry

C. Soil properties

D. A and B only

E. All of the above

What is the answer?

A. What is Canopy Cover and Ground Cover?
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Let's do a quick review before moving onto data collection! Answer to Question 2

2. Which of the following can be impacted by land cover?

A. Weather

B. Water chemistry

C. Soil properties

D. A and B only

E. All of the above ☺ correct!

Were you correct?

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Let's do a quick review before moving onto data collection! Question 3

3. Why does GLOBE use the Modified UNESCO Classification System?

A. Because it is an international standard

B. Because your study site can then be compared with other study sites around the world

C. A and B

D. None of the above

What is the Answer?

A. What is Canopy Cover and Ground Cover?
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Let's do a quick review before moving onto data collection! Answer to Question 3

3. Why does GLOBE use the Modified UNESCO Classification System?

A. Because it is an international standard

B. Because your study site can then be compared with other study sites around the world

C. A and B ☺ correct!

D. None of the above

Were you correct?

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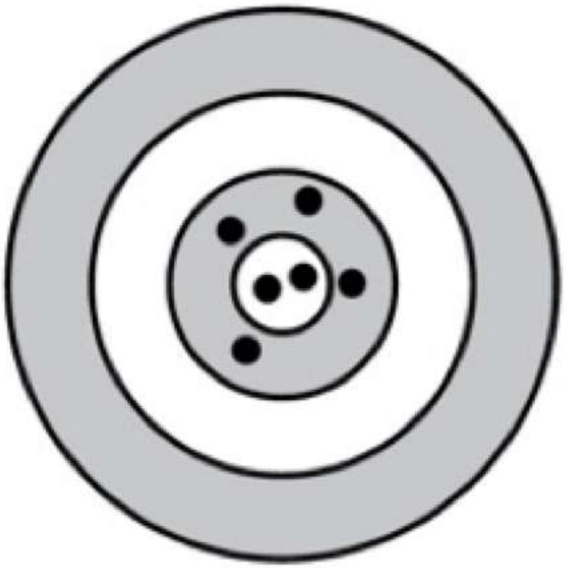
Let's do a quick review before moving onto data collection! Question 4

4. The image below uses a dart board to demonstrate the concept:

A. High accuracy and low precision

B. High accuracy and high precision

C. Low accuracy and High Precision



What is the answer?

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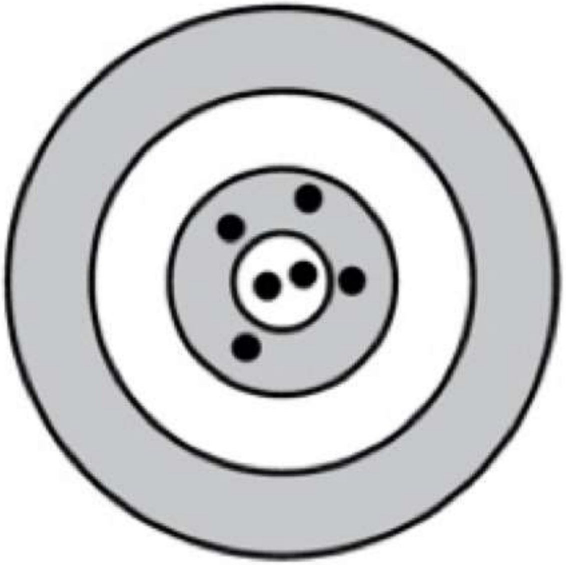
Let's do a quick review before moving onto data collection! Answer to Question 4

4. The image below uses a dart board to demonstrate the concept:

A. High accuracy and low precision☺ correct!

B. High accuracy and high precision

C. Low accuracy and High Precision



Were you correct?

Now, let's explore data collection.

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What do you need to start?

When	**During peak growth period, can be repeated annually as desired**
Where	**A homogeneous GLOBE Land Cover Sample Site**
Time Needed	**2-3 hours to take measurements**
Prerequisites	**Biometry Protocols:** **Canopy Cover and Ground Cover** **Land Cover Sample Site**
Key Instrument	**Clinometer**
References	**Graminoid, Tree and Shrub Height Field Guide** **Graminoid, Tree and Shrub Height Field Guide** **Measure Tree Height on a Slope: Two-Triangle with Eyes Higher than Tree Base Technique**

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How to Collect your Data: Timing and Frequency of Data Collection

The frequency of the measurements you decide to take will depend on your research goals:

- You can take biometry measurements only once in a site during peak growth. This will help with the MUC classification. This baseline data is also useful for scientists.
- You can take measurements twice a year, during peak growth and dormancy periods (winter or drought), to measure seasonal change
- You can return to the same study site year after year and repeat the biometry measurements to track changes in site biomass over time

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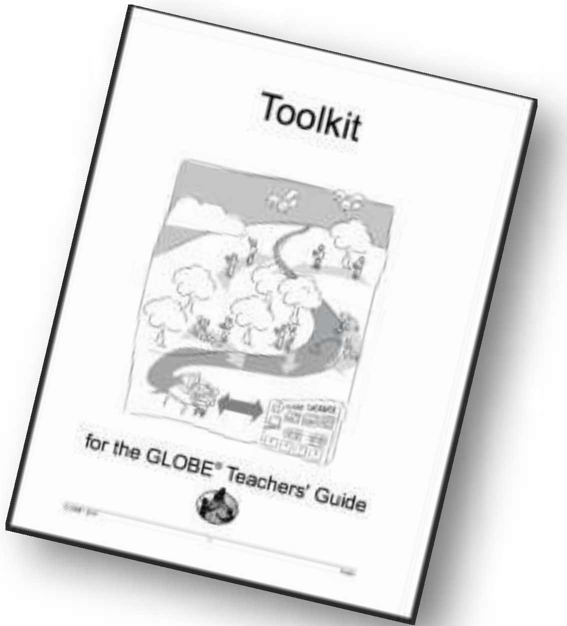
Sources for Equipment You Need

Instructions for making a **homemade clinometer** follow in this tutorial.



For Other Equipment:

The following resources summarize the measurements associated with each protocol, associated skill level, scientific specifications for the instruments, and how to access the equipment you need (purchase, build, or download).

[Where to find specifications for instruments used in GLOBE investigations]

[Where to find scientific instruments used in GLOBE investigations]

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To Measure Graminoid, Tree and Shrub Height, You Will Need the Following Equipment:

- Flexible measuring tape
- 50 m measuring tape
- Pen or pencil
- Clinometer
- Permanent tree markers or flagging (optional, if you plan to return to the site)
- Blindfold
- Small bean bag

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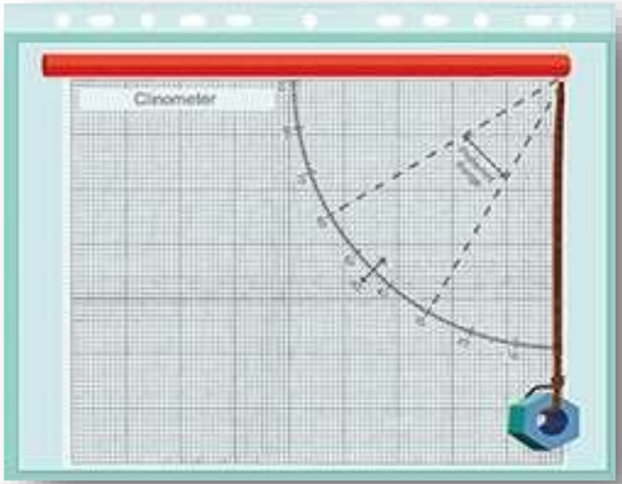
Instructions to Build a Clinometer

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.

Required Material:

- Clinometer Sheet and Table of Tangents (located in Biosphere Appendix)
- Pieces of stiff cardboard at least the size of the sheets referenced above
- Drinking straw
- Metal nut or washer
- 15 cm of thread or dental floss
- Glue
- Scissors
- Something to punch one small hole
- Tape



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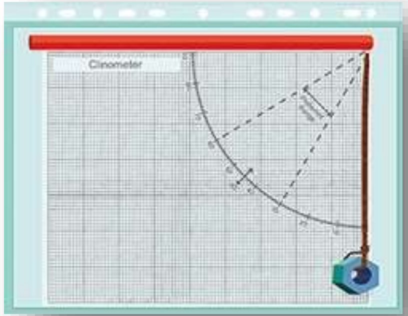
Instructions to Build a Clinometer: Steps

1. Gather the materials.
2. Glue a copy of the Clinometer Sheet onto one side of a piece of cardboard of the same size.
3. Glue a copy of the Table of Tangents to the other side of the cardboard.
4. Punch a hole through the marked circle on the Clinometer Sheet.
5. Push one end of the thread or dental floss through the hole and tie or tape it on the Table of Tangents side of the cardboard. Colored thread or floss will allow it to be seen more easily.
6. Tie a metal nut or washer to the other end of the thread so that it hags in front of the Clinometer Sheet.
7. Tape a drinking straw along the designated line on the Clinometer Sheet, to use as a sighting device.



The cardboard and both the clinometer and table of tangents sheets can be placed in a sheet protector or laminated to ensure longer life. The straw would then be placed on the outside of the plastic and the hole for the thread with the washer would be punched through the entire instrument (plastic cover, cardboard and sheets).

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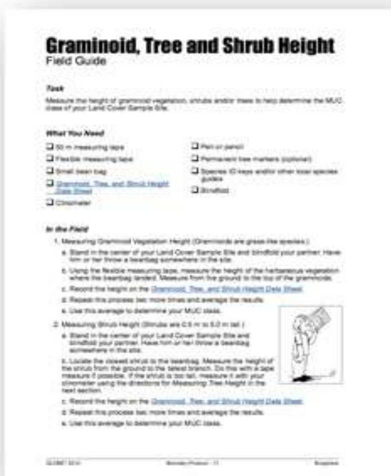
To Measure Graminoid, Tree and Shrub Height, You Will Need the Following Documents:

- **To be prepared, bring the following documents with you in the Field:**
- [Graminoid, Tree and Shrub Height Field Guide]
- [Graminoid, Tree and Shrub Height Data Sheet]
- [Measure Tree Height on a Slope: Two-Triangle with Eyes Higher than Tree Base Technique]


Graminoid, Tree and Shrub Height
Field Guide


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


Land Cover
Tree and/or Shrub Canopy and Ground Cover Data Sheet*

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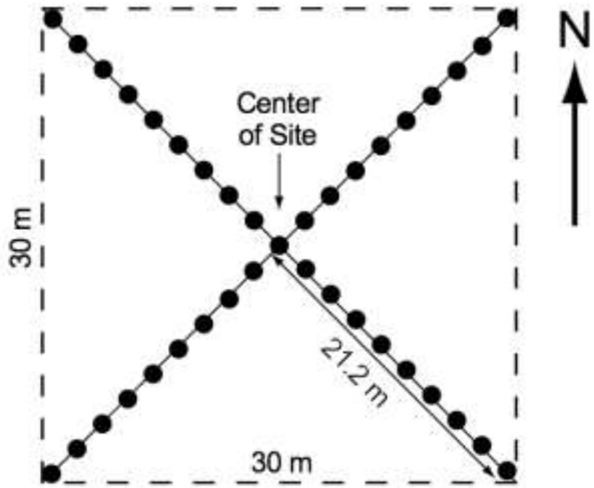
Identifying the Center of the Land Cover Sample Site

•Locate the center of your homogeneous Land Cover Sample Site. This is your starting point.



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

A. What Is Graminoid, Tree and Shrub Height?
B. Why Collect Graminoid, Tree and Shrub Height Data?
C. How Your Measurements Can Help
D. How to Collect Your Data
E. Entering Data on GLOBE Website
F. Understand the Data
G. Quiz Yourself
H. Additional Information

1 a. Measuring Graminoid Vegetation Height

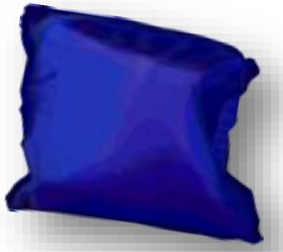
- Stand in the center of your Land Cover Sample Site and blindfold your partner. Have them throw the beanbag somewhere in the site.

- Using a flexible measuring tape, measure the height of the herbaceous vegetation where the beanbag landed. Measure from the ground to the top of the graminoids.

- Record the height on the Graminoid, Tree and Shrub Height Data Sheet.

- Repeat this process **two more times** and average the results.

- You have now completed the Graminoid Height measurement.



A. What Is Graminoid, Tree and Shrub Height?
B. Why Collect Graminoid, Tree and Shrub Height Data?
C. How Your Measurements Can Help
D. How to Collect Your Data
E. Entering Data on GLOBE Website
F. Understand the Data
G. Quiz Yourself
H. Additional Information

1b. Measuring Shrub Vegetation Height (0.5 m-5 m tall)

Stand in the center of your Land Cover Sample Site and blindfold your partner. Have him or her throw a beanbag somewhere on the site.

Locate the shrub closest 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).

Record the height on the Graminoid, Tree and Shrub Height Data Sheet.

Repeat this process **two more times** and average the results

Use this average to determine your MUC class.

You have now completed the steps for Shrub Height

A. What Is Graminoid, Tree and Shrub Height?
B. Why Collect Graminoid, Tree and Shrub Height Data?
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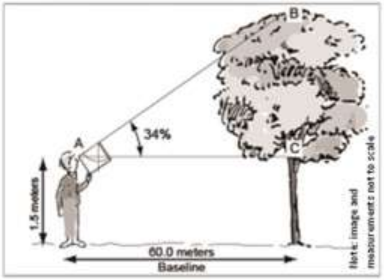
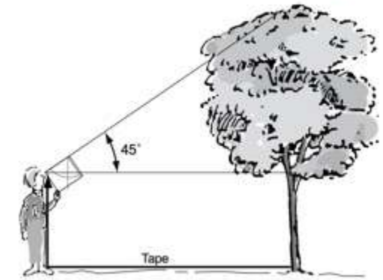
2. Measuring Tree Height Using Standard Clinometer Technique

There are different techniques to measure tree and shrub height. You need to select the one that best suits your situation, and follow that field guide. There is a slide stack for each of the methods below.

1. If your feet are level with the tree base, use one of these two protocols

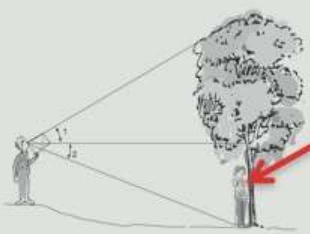


I. Standard Clinometer Technique



II. Simplified Clinometer Technique

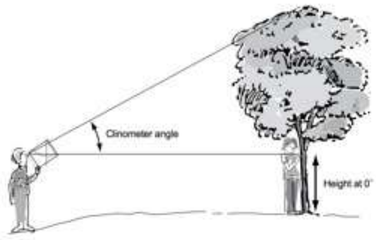
2. If you are measuring tree height on a slope, choose one of these options



III. Two Triangles with Eyes Higher Than Tree Base

This slide stack

IV. Two Triangles with Eyes Lower than Tree Base



V. Stand by Tree Technique

A. What Is Graminoid, Tree and Shrub Height?
B. Why Collect Graminoid, Tree and Shrub Height Data?
C. How Your Measurements Can Help
D. How to Collect Your Data
E. Entering Data on GLOBE Website
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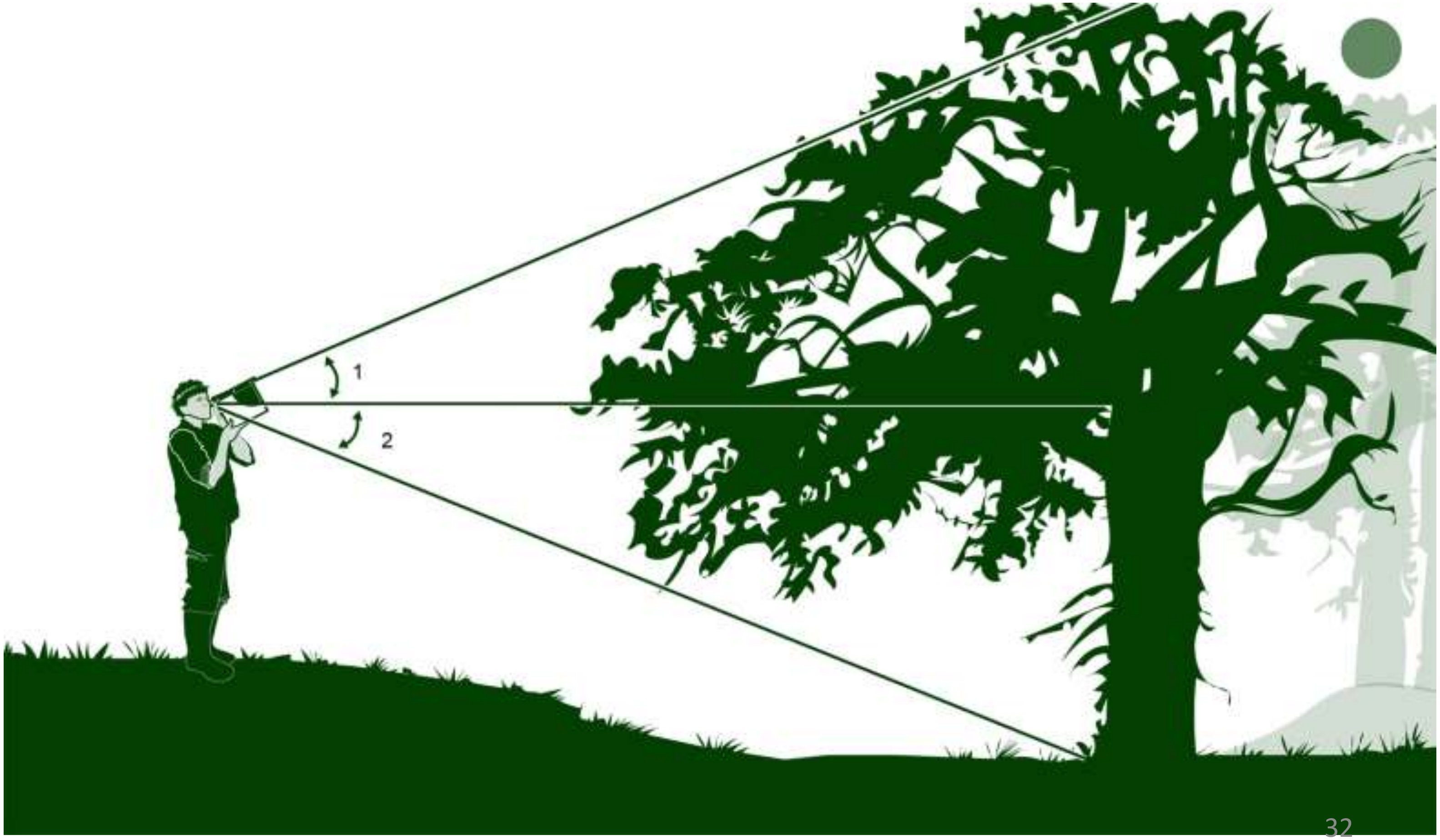
G. Quiz Yourself
H. Additional Information

Measuring Tree Height- Two Triangles with Eyes Higher

The method you use will depend on the topography of your site. This is the Two Triangles with Eyes Higher than Tree Base.



A. What Is Graminoid, Tree and Shrub Height?
B. Why Collect Graminoid, Tree and Shrub Height Data?
C. How Your Measurements Can Help
D. How to Collect Your Data
E. Entering Data on GLOBE Website
F. Understand the Data
G. Quiz Yourself
H. Additional Information

Measuring Tree Height- Determine the dominant species

1. 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 the Graminoid, Tree and Shrub Height Data Sheet.

Dominant tree species in this photo is Ponderosa Pine (Colorado, USA).

Land Cover
Measure Tree Height on Level Ground Data Sheet
Clinometer Data

A. What Is Graminoid, Tree and Shrub Height?
B. Why Collect Graminoid, Tree and Shrub Height Data?
C. How Your Measurements Can Help
D. How to Collect Your Data
E. Entering Data on GLOBE Website
F. Understand the Data
G. Quiz Yourself
H. Additional Information

Measuring Tree Height- Choose your Trees

- 2. **Select 5 trees to sample, including:**
  - 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.

3. Permanently mark number and label the trees if you plan to return to this site to take measurements over time.

Adjust your distance from the tree so that you are at least as far away from the tree as the tree is tall. For the most accurate measurement, adjust your distance so that the angle of the clinometer is as close to 30 degrees as possible.

Be sure to be on level ground so that your feet are at the same elevation as the base of the tree. If you are standing on a slope, you need to use an Alternative technique to measure tree height

A. What Is Graminoid, Tree and Shrub Height?
B. Why Collect Graminoid, Tree and Shrub Height Data?
C. How Your Measurements Can Help
D. How to Collect Your Data
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G. Quiz Yourself
H. Additional Information

III. Measuring Tree Height When Tree is on a Slope: Two-Triangle and Eyes Higher than the Tree Base-1

For this situation, use:

Tree Height on a Slope: Two-Triangle with Eyes Higher than Tree Base Technique Data Sheet.

In the Field

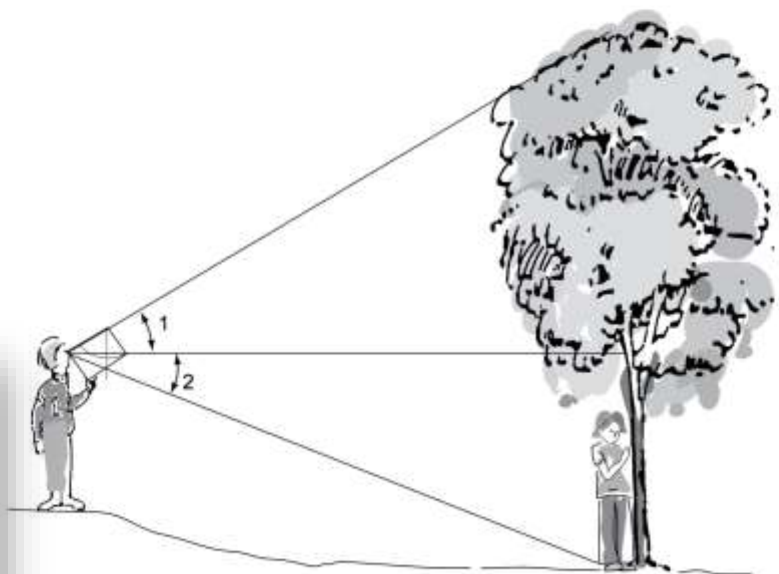
Work in a team of two. You and your partner move away from the base of the tree until you can see the top of the tree through the drinking straw of the clinometer.

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.

A. What Is Graminoid, Tree and Shrub Height?
B. Why Collect Graminoid, Tree and Shrub Height Data?
C. How Your Measurements Can Help
D. How to Collect Your Data
E. Entering Data on GLOBE Website
F. Understand the Data
G. Quiz Yourself
H. Additional Information

III. Measuring Tree Height When Tree is on a Slope: Two-Triangle and Eyes Higher than the Tree Base-2

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.



Land Cover

Measure Tree Height on a Slope: Two-Triangle with Eyes Higher or Lower than Tree Base Technique
Data Sheet *(Page 1 of 2)*

School Name: ____ Site: ____
Measurement Time: Year ____ Month ____ Day ____ Hour (UT) ____
Recorded By: ____

Clinometer Data									
Tree Species 1 Name ____ ☐ Dominant ☐ Co-Dominant	1st Clinometer Reading (°)	TAN of 1st Clinometer Reading	2nd Clinometer Reading (°)	TAN of 2nd Clinometer Reading	COS of 2nd Clinometer Reading	Distance to Tree (m)	Baseline Calculation (m)	Tree Height (m)	Average Tree Height (m)
Specimen 1									
Specimen 2									
Specimen 3									
Specimen 4									
Specimen 5									

Baseline = (Distance to the Tree) x (COS of 2nd Clinometer Reading)

Tree Height (Eyes Higher than Tree Base) = [(TAN of 1st Clinometer Reading) x (Baseline)] + [(TAN of 2nd Clinometer Reading) x (Baseline)]

Tree Height (Eyes Lower than Tree Base) = [(TAN of 1st Clinometer Reading) x (Baseline)] - [(TAN of 2nd Clinometer Reading) x (Baseline)]

Note: Measure each tree three times and average the three height values. If all three values are within 1 meter of the average, report the values. If not, repeat the measurements until they are within 1 meter of their average, and then report those values.

A. What Is Graminoid, Tree and Shrub Height?
B. Why Collect Graminoid, Tree and Shrub Height Data?
C. How Your Measurements Can Help
D. How to Collect Your Data
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F. Understand the Data
G. Quiz Yourself
H. Additional Information

III. Measuring Tree Height When Tree is on a Slope: Two-Triangle and Eyes Higher than the Tree Base-3

- 3. Using the **Table of Tangents** record the TAN of the angle on the **data sheet**.

Angle (°)	Tan.	Angle (°)	Tan.	Angle (°)	Tan.	Angle (°)	Tan.	Angle (°)	Tan.
1	.02	17	.31	33	.65	49	1.15	65	2.14
2	.03	18	.32	34	.67	50	1.19	66	2.25
3	.05	19	.34	35	.70	51	1.23	67	2.36
4	.07	20	.36	36	.73	52	1.28	68	2.48
5	.09	21	.38	37	.75	53	1.33	69	2.61
6	.11	22	.40	38	.78	54	1.38	70	2.75
7	.12	23	.42	39	.81	55	1.43	71	2.90
8	.14	24	.45	40	.84	56	1.48	72	3.08
9	.16	25	.47	41	.87	57	1.54	73	3.27
10	.18	26	.49	42	.90	58	1.60	74	3.49
11	.19	27	.51	43	.93	59	1.66	75	3.73
12	.21	28	.53	44	.97	60	1.73	76	4.01
13	.23	29	.55	45	1.00	61	1.80	77	4.33
14	.25	30	.58	46	1.04	62	1.88	78	4.70
15	.27	31	.60	47	1.07	63	1.96	79	5.14
16	.29	32	.62	48	1.11	64	2.05	80	5.67

Example: Assume you have established a baseline distance of 60.0 meters. Assume that you have measured the tree top to an angle of 34°. From the Table, you will see that the tangent of 34° is 0.67. Therefore, the tree height above your eye height is 60.0 m x .67 = 40.2 meters. By adding your eye height above the ground (1.5 m), the total tree height is 41.7 meters.

A. What Is Graminoid, Tree and Shrub Height?
B. Why Collect Graminoid, Tree and Shrub Height Data?
C. How Your Measurements Can Help
D. How to Collect Your Data
E. Entering Data on GLOBE Website
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H. Additional Information

III. Measuring Tree Height When Tree is on a Slope: Two-Triangle and Eyes Higher than the Tree Base- steps 4-6

- 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. For the 2nd clinometer reading, use the **Table of Tangents**, and record the TAN of the angle on the **data sheet**.
- 6. Using the **Table of Cosines**, record the COS of the 2nd Clinometer Reading on the **data sheet**.

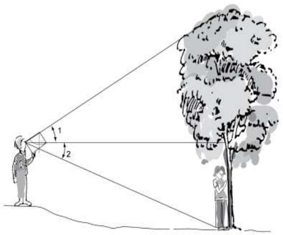
Angle (°)	COS	Angle (°)	COS	Angle (°)	COS	Angle (°)	COS	Angle (°)	COS
1	1.00	17	0.96	33	0.84	49	0.66	65	0.42
2	1.00	18	0.95	34	0.83	50	0.64	66	0.41
3	1.00	19	0.95	35	0.82	51	0.63	67	0.39
4	1.00	20	0.94	36	0.81	52	0.62	68	0.37
5	1.00	21	0.93	37	0.80	53	0.60	69	0.36
6	0.99	22	0.93	38	0.79	54	0.59	70	0.34
7	0.99	23	0.92	39	0.78	55	0.57	71	0.33
8	0.99	24	0.91	40	0.77	56	0.56	72	0.31
9	0.99	25	0.91	41	0.75	57	0.54	73	0.29
10	0.98	26	0.90	42	0.74	58	0.53	74	0.28
11	0.98	27	0.89	43	0.73	59	0.52	75	0.26
12	0.98	28	0.88	44	0.72	60	0.50	76	0.24
13	0.97	29	0.87	45	0.71	61	0.48	77	0.22
14	0.97	30	0.87	46	0.69	62	0.47	78	0.21
15	0.97	31	0.86	47	0.68	63	0.45	79	0.19
16	0.96	32	0.85	48	0.67	64	0.44	80	0.17

* For use with *Two-Triangle Alternative Technique to Measure Tree Height Field Guides*

A. What Is Graminoid, Tree and Shrub Height?
B. Why Collect Graminoid, Tree and Shrub Height Data?
C. How Your Measurements Can Help
D. How to Collect Your Data
E. Entering Data on GLOBE Website
F. Understand the Data
G. Quiz Yourself
H. Additional Information

III. Measuring Tree Height When Tree is on a Slope: Two-Triangle and Eyes Higher than the Tree Base- steps 7-11

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 (2^{nd} Clinometer reading)

9. Calculate the tree height using the following formula:

TAN (1stAngle of Clinometer) x (Baseline) + TAN (2ndAngle of Clinometer) x (Baseline)

10. Record the tree height on the data sheet.

11. Repeat steps 1-11 two more times for each tree (for a total of 5 trees) and report the average value. **You are done!**

A. What is Canopy Cover and Ground Cover?
B. Why collect Canopy Cover and Ground Cover data?
C. How your measurements can help.
D. How to collect your data.
E. Entering data on GLOBE Website.
F. Understand the data.
G. Quiz yourself.
H. Additional information

Let's do a quick review before moving onto data entry! Question 5

5. Which GLOBE protocols should be conducted prior to measuring tree and shrub height?

A. Canopy Cover and Ground Cover

B. Land Cover Sample Site

C. Both A and B

D. None of the above

What is your answer?

A. What is Canopy Cover and Ground Cover?

B. Why collect Canopy Cover and Ground Cover data?

C. How your measurements can help.

D. How to collect your data.

E. Entering data on GLOBE Website.

F. Understand the data.

G. Quiz yourself.

H. Additional information

Let's do a quick review before moving onto data entry! Answer to Question 5!

5. Which GLOBE protocols should be conducted prior to measuring tree and shrub height?

A. Canopy Cover and Ground Cover

B. Land Cover Sample Site

C. Both A and B ☺ **correct!**

Were you correct?

A. What is Canopy Cover and Ground Cover?

B. Why collect Canopy Cover and Ground Cover data?

C. How your measurements can help.

D. How to collect your data.

E. Entering data on GLOBE Website.

F. Understand the data.

G. Quiz yourself.

H. Additional information

Let's do a quick review before moving onto data entry! Question 6

6. When do you use a blindfold in this protocol?

A. When you use the clinometer

B. When you are doing the Canopy cover and groundcover protocol

C. When you are doing random sampling for grass—like vegetation height measurements

D. A and B only

E. None of the above

What is the answer?

A. What is Canopy Cover and Ground Cover?
B. Why collect Canopy Cover and Ground Cover data?
C. How your measurements can help.
D. How to collect your data.
E. Entering data on GLOBE Website.
F. Understand the data.
G. Quiz yourself.
H. Additional information

Let's do a quick review before moving onto data entry! Answer to Question 6

6. When do you use a blindfold in this protocol?

A. When you use the clinometer

B. When you are doing the Canopy cover and groundcover protocol

C. When you are doing random sampling for grass—like vegetation height measurements ☺ correct!

D. A and B only

E. None of the above

Were you correct?

A. What is Canopy Cover and Ground Cover?
B. Why collect Canopy Cover and Ground Cover data?
C. How your measurements can help.
D. How to collect your data.
E. Entering data on GLOBE Website.
F. Understand the data.
G. Quiz yourself.
H. Additional information

Let's do a quick review before moving onto data entry! Question 7

7. Which trees do you sample?

A. The tallest tree of the dominant species

B. The shortest tree of the dominant species that still reaches the canopy

C. Three threes that have heights in between the tallest and the shortest of the dominant species

D. A and B

E. All of the above

What is the answer?

A. What is Canopy Cover and Ground Cover?
B. Why collect Canopy Cover and Ground Cover data?
C. How your measurements can help.
D. How to collect your data.
E. Entering data on GLOBE Website.
F. Understand the data.
G. Quiz yourself.
H. Additional information

Let's do a quick review before moving onto data entry!
Answer to Question 7

7. Which trees do you sample?

A. The tallest tree of the dominant species

B. The shortest tree of the dominant species that still reaches the canopy

C. Three threes that have heights in between the tallest and the shortest of the dominant species

D. A and B

E. All of the above ☺ correct!

Were you correct?

A. What is Canopy Cover and Ground Cover?
B. Why collect Canopy Cover and Ground Cover data?
C. How your measurements can help.
D. How to collect your data.
E. Entering data on GLOBE Website.
F. Understand the data.
G. Quiz yourself.
H. Additional information

Let's do a quick review before moving onto data entry! Question 8

8. What can you do to be sure that your clinometer readings are as accurate as possible?

A. Adjust your distance so that the clinometer reads as close to 30 degrees as possible

B. In distance, stand further away from the tree than the tree is tall

C. Both A and B

D. None of the Above

What is the answer?

A. What is Canopy Cover and Ground Cover?

B. Why collect Canopy Cover and Ground Cover data?

C. How your measurements can help.

D. How to collect your data.

E. Entering data on GLOBE Website.

F. Understand the data.

G. Quiz yourself.

H. Additional information

Let's do a quick review before moving onto data entry! Answer to Question 8!

8. What can you do to be sure that your clinometer readings are as accurate as possible?

A. Adjust your distance so that the clinometer reads as close to 30 degrees as possible

B. In distance, stand further away from the tree than the tree is tall

C. Both A and B ☺ correct!

D. None of the Above

Were you correct?

Now let's look at data entry!

A. What Is Graminoid, Tree and Shrub Height?
B. Why Collect Graminoid, Tree and Shrub Height Data?
C. How Your Measurements Can Help
D. How to Collect Your Data
E. Entering Data on GLOBE Website
F. Understand the Data
G. Quiz Yourself
H. Additional Information

Report your Data to GLOBE

Live Data Entry: Upload your data to the official GLOBE science database

Email Data Entry: Send data in the body of your email (not as an attachment) to DATA@GLOBE.GOV

Mobile Data App: Download the GLOBE Science Data Entry app to your mobile device and select the right option.

For Android via Google Play

For iOS via the App Store

A. What Is Graminoid, Tree and Shrub Height?

B. Why Collect Graminoid, Tree and Shrub Height Data?

C. How Your Measurements Can Help

D. How to Collect Your Data

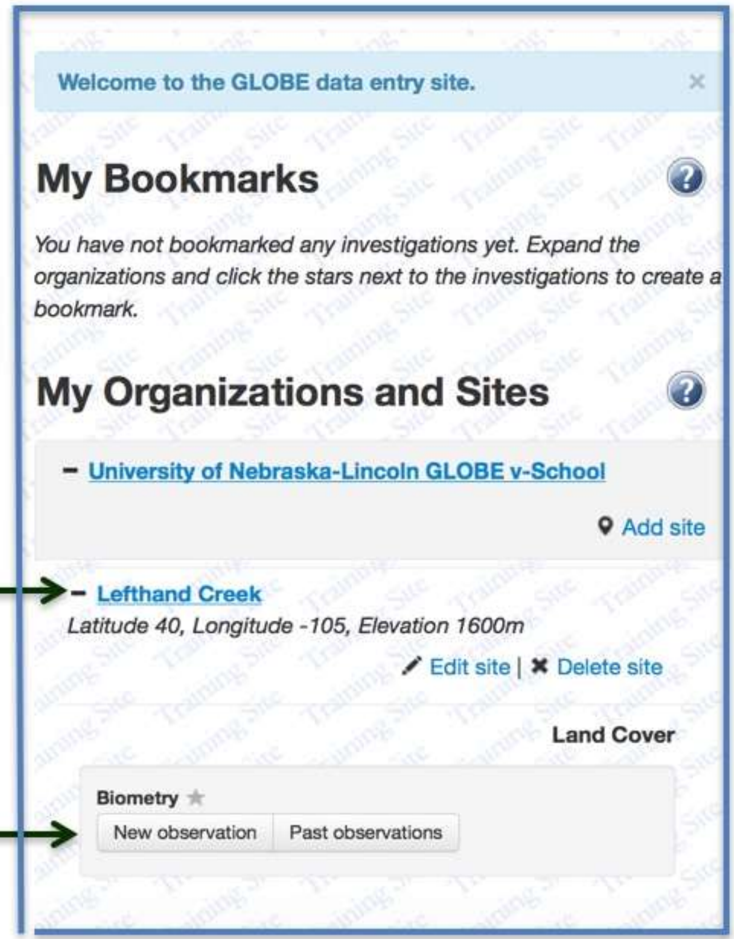
E. Entering Data on GLOBE Website

F. Understand the Data

G. Quiz Yourself

H. Additional Information

Entering your data via Live Data Entry or Data Entry Mobile App



Identify your Sampling site

Under Land Cover, select *"New observation"*

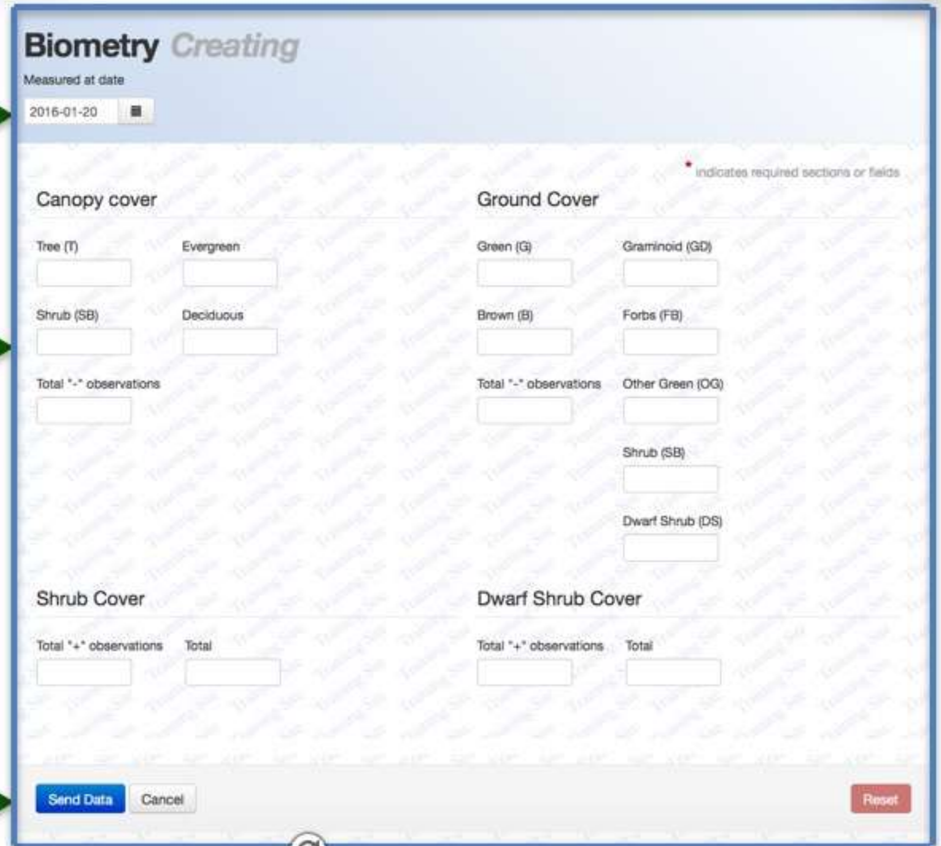
A. What Is Graminoid, Tree and Shrub Height?
B. Why Collect Graminoid, Tree and Shrub Height Data?
C. How Your Measurements Can Help
D. How to Collect Your Data
E. Entering Data on GLOBE Website
F. Understand the Data
G. Quiz Yourself
H. Additional Information

On the Biometry Page, Input the date to access the form

When you input the date, you will see the rest of the form

When inputting cover values, be sure that each reporting category you identified totals 100%

Submit data



You have finished your submission. You can see land cover data submitted by others using the GLOBE Visualization Tool.

A. What Is Graminoid, Tree and Shrub Height?
B. Why Collect Graminoid, Tree and Shrub Height Data?
C. How Your Measurements Can Help
D. How to Collect Your Data
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H. Additional Information

Visualize and Retrieve Data: Select Land Cover

Your Canopy Cover and Ground Cover measurements will allow you to determine the Land Cover Classification of your study site. GLOBE provides the ability to view and interact with data measured across the world. Select our visualization tool to map, graph, filter and export Land Cover Classification data that have been measured across GLOBE protocols since 1995. These screenshots show the steps.

Link to step-by-step tutorials on Using the Visualization System will assist you in finding and analyzing GLOBE data: PDF verson PowerPoint version

A. What Is Graminoid, Tree and Shrub Height?
B. Why Collect Graminoid, Tree and Shrub Height Data?
C. How Your Measurements Can Help
D. How to Collect Your Data
E. Entering Data on GLOBE Website
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H. Additional Information

Visualize and Retrieve Data: Select Range of Dates

Select the date for which you need Land Cover Classification data, add layer and you can see where data is available.

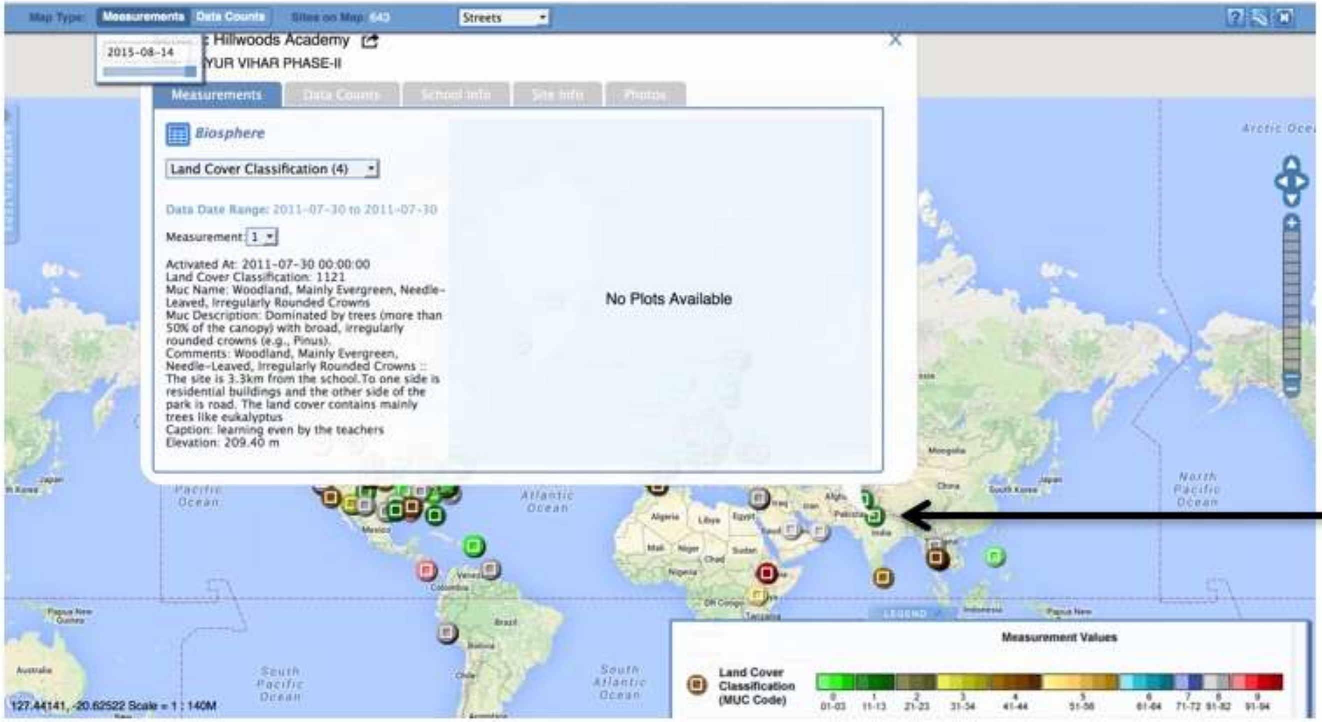
Locations where Land Cover Classification data is available for the week you selected

Link to step-by-step tutorials on Using the Visualization System will assist you in finding and analyzing GLOBE data: [PDF verson] [PowerPoint version]

A. What Is Graminoid, Tree and Shrub Height?
B. Why Collect Graminoid, Tree and Shrub Height Data?
C. How Your Measurements Can Help
D. How to Collect Your Data
E. Entering Data on GLOBE Website
F. Understand the Data
G. Quiz Yourself
H. Additional Information

Visualize and Retrieve Data: Accessing Data

Select the date for which you need Land Cover Classification data, add layer and you can see where data is available.



Link to step-by-step tutorials on Using the Visualization System will assist you in finding and analyzing GLOBE data: [PDF verson] [PowerPoint version]

A. What Is Graminoid, Tree and Shrub Height?
B. Why Collect Graminoid, Tree and Shrub Height Data?
C. How Your Measurements Can Help
D. How to Collect Your Data
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Review questions to help you prepare for the Graminoid, Tree and Shrub Height Quiz:

1. **Graminoid, Tree and Shrub Height are part of what set of GLOBE Biosphere Protocols?? (slide 3)**
2. **What is a graminoid plant? (slide 3)**
3. **What land cover classification scheme does GLOBE use, in order to ensure comparisons between sample sites around the globe? (slide 8)**
4. **What specialized instrument will you use to determine tree and tall shrub height? (slide 7)**
5. **What is the difference between the terms *accuracy* and *precision*? (slide 9)**
6. **What geometric shape will you be identifying to help you calculate tree height using a clinometer? (slide 30-31)**
7. **How many trees do you need to measure for your sample in the Tree and Shrub Height part of the Biometry Protocol? (slide 33)**
8. **In determining which of the 5 different tree height measurement techniques to use, what is the most important environmental characteristic to consider? (slide 30)**
9. **What is the system used by GLOBE to see the geographic distribution of data? (slide 50-52)**
10. **Do you use the Two-Triangle method when the area between the observer is flat, or on a slope? (slides 30-31)**

A. What Is Graminoid, Tree and Shrub Height?
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Frequently Asked Questions-FAQ's

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

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.

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

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.

A. What Is Graminoid, Tree and Shrub Height?
B. Why Collect Graminoid, Tree and Shrub Height Data?
C. How Your Measurements Can Help
D. How to Collect Your Data
E. Entering Data on GLOBE Website
F. Understand the Data
G. Quiz Yourself
H. Additional Information

Frequently Asked Questions-2

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.

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.

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.

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