



THE GLOBE PROGRAM
A Worldwide Science and Education Program



Biosphere ● Green-Down Protocol
Trees and Shrubs





A. What is
Tree and Shrub
Green-Down?

B. Why Collect
Tree and Shrub
Green-Down
Data?

C. How Your
Measurements
Can Help

D. How to
Collect Your
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E. Entering
Data on GLOBE
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F. Understand
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Overview

This module:

- Describes how to select and define a GLOBE Phenology Protocol Study Site
- Provides a step by step introduction of the protocol method

Learning Objectives

After completing this module, you will be able to:

- Define phenology and what is meant by tree and shrub green-down
- Describe the importance of quality control steps in the the collection of accurate data
- Describe why green-down data is important for understanding our changing Earth system
- Identify a tree and shrub green-down study site and take measurements in the field
- Upload data to GLOBE Data Entry using the mobile app or website
- Visualize data using GLOBE's Visualization Site



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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.

Tree and Shrub Green-Up is one of the GLOBE **phenology** protocols.

You can find more information in:

[Biosphere Introduction](#)





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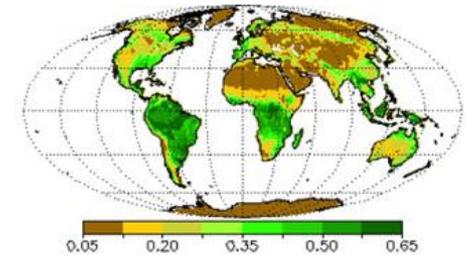
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What is Phenology, and how is it related to Green-Down?

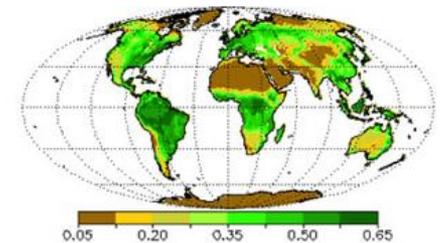
Phenology is the study of living organisms' response to seasonal and climatic changes in the environment in which they live. You can study the phenology of plants and animals.

The plant growing season is the period between green-up and green-down.

Green-down marks the end of the growing season for many plants. A color change is generally associated with green-down of leaves. The color will vary by species.



March
1987



May
1987

Image: NDVI, NASA



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What is Green- Down?

- Plant green-down is also called senescence. It is initiated when environmental conditions change
 - Fewer hours of sunlight and lower temperatures in temperate regions, or drier and warmer temperatures in desert areas.
- Green-down starts dormancy (a state of suspended growth and metabolism)
- For many places around the world, there is one green-up and green-down cycle, e.g., one warm and cold season.
- There are places where multiple wet and dry seasons can occur in a single year, resulting in multiple green-up and green-down cycles.



Most are familiar with green-down of trees, but color change also marks dormancy of grasses. Photo of Green-down, Budapest, Hungary.



Why Collect Green-Down Data?

Scientists are very interested in when leaves appear in spring and how quickly they expand. The timing and rate of fall leaf changes, such as color changes and leaf drop, are also important. These plant phenological events are directly related to **global carbon fixation** and the amount of **carbon dioxide in the atmosphere**. Also they affect and are affected by air temperature and humidity and soil moisture.



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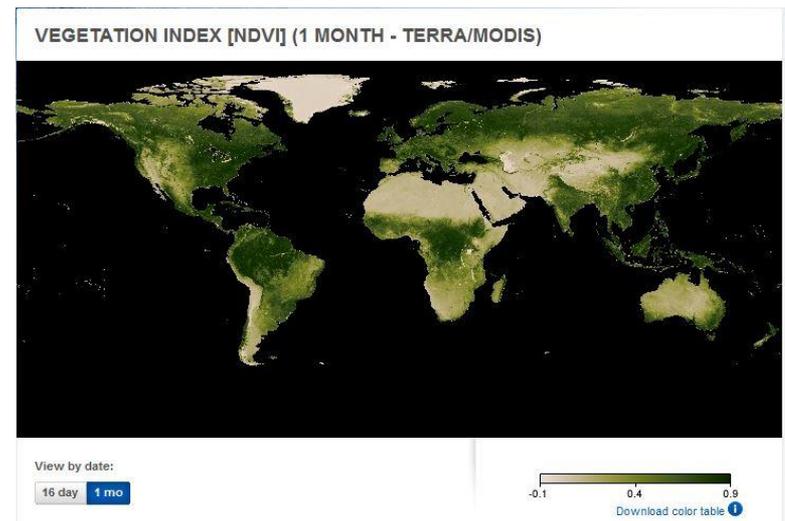
Green-Down from Space?

Scientists use data from a NASA sensor, the **Moderate Resolution Imaging Spectrometer (MODIS)**, to monitor the seasonal dynamics of vegetation. Green-up/green-down data gathered by GLOBE students, using consistent methods all over the world, are one of the best tools with which to verify the accuracy of these satellite products.

The Normalized Difference Vegetation Index is the analysis of the greenness of Earth viewed from space through the examination of two different spectral wavelengths of light (near infrared and red). Scientist can use this data to track major changes in the density of Earth's vegetation and study changes in plant growth as a result of climate and environmental changes as well as human activity.

See where green-down begins in your area [here](#). Page through the monthly changes in net primary production to see where green gives way to brown and identify the time frame you will want to begin your observations.

*Image: NASA
Earth Observatory*





How Your Measurements Can Help

- Estimates of changes in the growing season are often done using satellite data.
- Ground observations are critical to improve the interpretation of satellite data.
- Monitoring the length of the growing season is important for society so that it can better adapt to variations in the length of the growing season and to other impacts of climate change, which may affect food production, economic growth, and human health.



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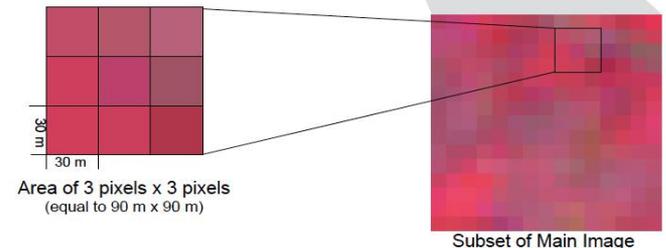
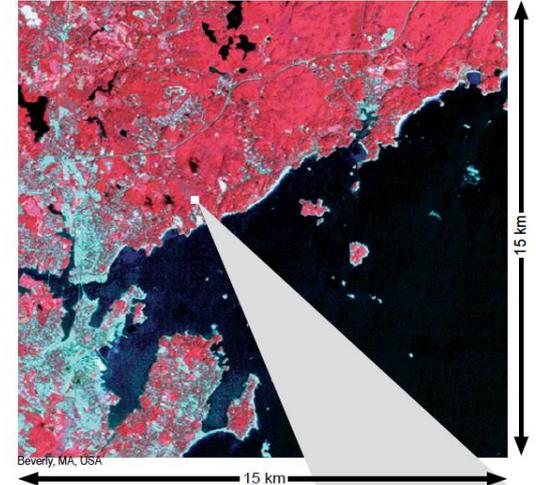


Scientific Importance of Green-Up and Green-Down

Remote sensing from space has the great advantage 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.

Scientists need the data collected at sample sites on the ground to interpret remotely sensed data about an area. It is not possible to effectively visit every place on Earth to map the land cover. Instead, we rely on samples – actual ground visits – and relate these samples to what we can see using various remote sensing systems.

Satellite Image of Beverly, MA in False-Color



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

1. What part of the Earth system is known as the zone of life?

- A. Atmosphere
- B. Biosphere
- C. Lithosphere
- D. Hydrosphere

Do you know the answer?

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Let's do a quick review before moving onto data collection! Answer to question 1.

1. What part of the Earth system is known as the zone of life?

A. Atmosphere

B. Biosphere- correct 😊

C. Lithosphere

D. Hydrosphere

Were you correct?

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Let's do a quick review before moving onto data collection! Question 2

True or False: In every part of the world, there is one green-up and green-down cycle.

Do you know the answer?



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Let's do a quick review before moving onto data collection! Answer to question 2

True or False: In every part of the world, there is one green-up and green-down cycle. **False is correct** 😊

Were you correct?



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

Why are scientists interested in green-up data? The data can be used to:

- a) to help interpret satellite observations of greenness, such as imagery of the Normalized Difference Vegetation Index (NDVI)
- b) to determine how environmental conditions affect plant growth
- c) calculate changes in growing season length and onset over years
- d) monitor the nature and extent of climate change and its effects on plants and animals
- e) All of the above
- f) Only A and B

Do you know the answer?

A. What is Tree and Shrub Green-Down?

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Let's do a quick review before moving onto data collection! Answer to question 3

Why are scientists interested in green-up data? The data can be used to:

- a) to help interpret satellite observations of greenness, such as imagery of the Normalized Difference Vegetation Index (NDVI)
- b) to determine how environmental conditions affect plant growth
- c) calculate changes in growing season length and onset over years
- d) monitor the nature and extent of climate change and its effects on plants and animals
- e) **All of the above –correct 😊**
- f) Only A and B

Were you correct? Let's now look at data collection.

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Overview of the Tree and Shrub Green-Down Protocol

When	At least twice a week beginning two weeks prior to the anticipated start of green down, continuing until plant color change has ended or leaves have dropped off.
Where	Tree and Shrub Green-Down site
Time Needed	10-15 minutes per measurement. Frequency of observations: Ideally, visit plant at least two times a week to check for the start of green-down and continue observing until color change has ended, or leaves have dropped off
Prerequisites	None
Primary Instrument	Metric ruler, GLOBE Plant Color Guide
Skill level	All
References	Tree, Shrub, and Grass Green-Down Data Sheet Tree and Shrub Green-Down Protocol Field Guide Site Definition Sheet



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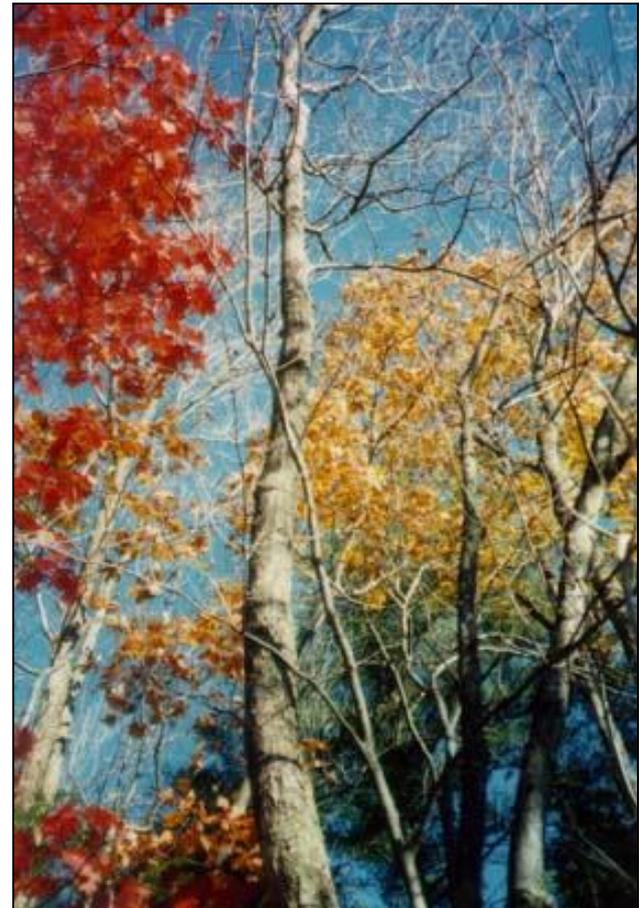
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Multiple Growing Seasons?

Because of the possibility of multiple growing seasons in a year, we are asking you to report which cycle you are observing. If there is only one cycle, then you report green-down cycle 1. The onset of the first green-down after 1 January is considered green-down cycle 1, regardless where you are located on the globe.





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Needed Equipment and Documents

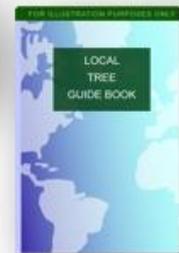
• What You Need the first visit

- Pencil or pen
- Camera
- Compass
- Permanent Marker
- GLOBE Plant Color Guide



• Every Visit

- GLOBE Plant Color Guide
- Pencil or pen



• Documents to Bring to the Field

- [Site Definition Sheet](#)
- [Tree and Shrub Green-Up and Green-Down Site Selection](#)
- [Tree, Shrub and Grass Green-Down Data Sheet](#)
- [Tree and Shrub Green-Down Protocol Field Guide](#)



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Site Selection

- Site selection is important. Chose a site that contains plants indicative of the surrounding climate. You will need to make your observations in a one-meter square that is dominated by grass plants.
 - Native species
 - Not watered or fertilized
 - Away from buildings.

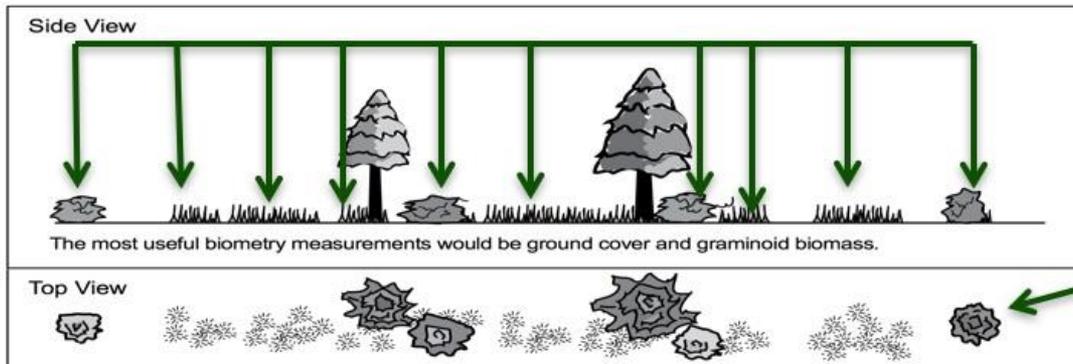


NOTE:. To determine if the plant is too close to a building, stand at the plant and sight the top of the building through your clinometer. If the angle is greater than 45° , the building is too close. You do not want the plant to be closer to the building than it is tall.



Other Site Selection Considerations

Deciduous trees or shrubs, or grasses. Select one or more species that is common in your area. Think from the perspective of a satellite – what is the satellite “seeing”?



Select a site close to an atmosphere or soil moisture site, if possible. Ideally, it should be **less than 2 km** from your atmosphere or soil moisture site, and have **an elevation difference less than 100 meters**. Why is this important?

- Local topography affects weather significantly
- Accessibility. Choose a site that can be easily visited repeatedly
- Consistency. If possible choose the same plant/s each year.

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Site preparation: Trees and Shrubs

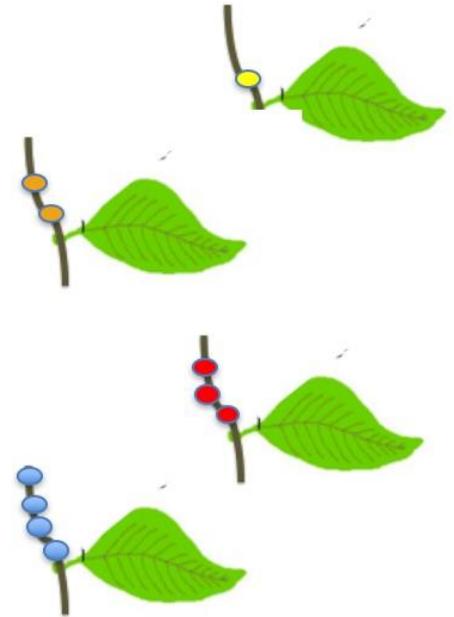
- Before collecting data, set up site, using the [Tree and Shrub Green- Up and Green-Down Site Selection Field Guide](#)
 1. Complete sections of [Site Definition Sheet](#)
 2. Select shrub or tree - It should be a dominant native species, deciduous and easily accessible
 3. Select large and healthy branch. If a lower branch is chosen, it should be on the edge of the stand of trees or shrubs since branches inside a stand may experience a different microclimate due to shading on the north side of plant if living in Southern Hemisphere, south side of plant if living in Northern Hemisphere
 4. Identify genus and species
 5. Mark selected tree and branch with flagging tapeLocate coordinates using the [GPS Protocol](#)
- **Site preparation is done only once. Can be done before or during first green-down visit. You are done with this step!**



First Visit: Green-Down Observations: Trees and Shrubs

First visit only/getting started

1. Complete the upper portion of your data sheet.
2. Determine whether there are more than one green down cycles; if yes, during which cycle are you currently collecting data (1, 2, or 3)?
3. Locate the leaf at the end of the branch. Label this leaf by marking one dot on the branch next to the leaf stem or petiole. Do this with a permanent felt tip marker. Locate the three other leaves on this branch closest to this terminal leaf.
4. Label these leaves by marking two, three, or four dots next to their stems on the branch.



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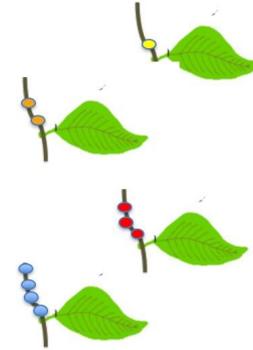
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First Visit: Green-Down Grasses- Site Documentation

First visit only/getting started

5. Take a photograph from the center of the site looking in the north, south, east, and west directions.





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Every Visit: Green-Down Grasses

1. Examine each of your four leaves. For each leaf, use the GLOBE Plant Color Guide to estimate the dominant color of each leaf. For example, if leaf 1 appears colored at 60 percent 5G 7/12 and 40 percent 2.5 Y8/10, record the leaf color as 5G 7/12 for that observation date.
2. Record your observations on the *Tree, Shrub, and Grass Green-Down Data Sheet*.



You are done!



Common Problems If leaf is snow covered, report “snow covered”, If leaf has fallen, report “fallen” and stop reporting after that, Otherwise, continue to report the color until the color stops changing.



Example of Completed Data Sheet

Example of Completed Green-Down Data Sheet

Tree, Shrub, and Grass Green-Down

Date YYYY-MM-DD (year-month-day)	Growing season cycle (1, 2 or 3)	Leaf 1 (Color, fallen, snow covered)	Leaf 2 (Color, fallen, snow covered)	Leaf 3 (Color, fallen, snow covered)	Leaf 4 (Color, fallen, snow covered)	Data submitted to GLOBE
2013-09-30	1	5 G 7/4	5 G 7/4	5 G 7/4	5 G 7/4	<input type="checkbox"/>
2013-10-03	1	5 G 7/4	5 G 7/4	5 G 7/4	2.5 Y 8/6	<input type="checkbox"/>
2013-10-07	1	5 G 7/4	2.5 Y 8/6	5 G 7/4	2.5 Y 8/6	<input type="checkbox"/>
2013-10-11	1	5 G 7/4	2.5 Y 8/6	2.5 Y 8/6	2.5 Y 8/6	<input type="checkbox"/>
2013-10-14	1	5 G 7/4	2.5 Y 8/6	2.5 Y 8/6	2.5 Y 8/6	<input type="checkbox"/>
2013-10-16	1	2.5 Y 8/6	2.5 Y 8/6	2.5 Y 8/6	2.5 Y 8/6	<input type="checkbox"/>
2013-10-20	1	2.5 Y 8/6	2.5 Y 8/6	2.5 Y 8/6	7.5 YR 6/4	<input type="checkbox"/>
2013-10-23	1	2.5 Y 8/6	2.5 Y 8/6	2.5 Y 8/6	7.5 YR 6/4	<input type="checkbox"/>
2013-10-27	1	2.5 Y 8/6	2.5 Y 8/6	2.5 Y 8/6	7.5 YR 6/4	<input type="checkbox"/>
2013-10-30	1	2.5 Y 8/6	2.5 Y 8/6	7.5 YR 6/4	7.5 YR 6/4	<input type="checkbox"/>
2013-11-04	1	2.5 Y 8/6	7.5 YR 6/4	7.5 YR 6/4	fallen	<input type="checkbox"/>
2013-11-06	1	2.5 Y 8/6	7.5 YR 6/4	7.5 YR 6/4		<input type="checkbox"/>
2013-11-11	1	7.5 YR 6/4	7.5 YR 6/4	7.5 YR 6/4		<input type="checkbox"/>
2013-11-14	1	7.5 YR 6/4	7.5 YR 6/4	7.5 YR 6/4		<input type="checkbox"/>
2013-11-17	1	7.5 YR 6/4	fallen	7.5 YR 6/4		<input type="checkbox"/>
2013-11-22	1	7.5 YR 6/4		fallen		<input type="checkbox"/>
2013-11-29	1	7.5 YR 6/4				<input type="checkbox"/>
2013-12-02	1	snow covered				<input type="checkbox"/>
						<input type="checkbox"/>
						<input type="checkbox"/>



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Let's review so far! Question 4

When selecting a phenology site, you want to be sure it is accessible and easy to visit, and that you collect data that can be examined in the context of other GLOBE data you might collect. GLOBE recommends you place your site as close to your other study sites as possible, and no further than:

- a) 2 km from your Atmosphere or Soil (Pedosphere) investigation sites
- b) 100 m difference in elevation from your Atmosphere or Soil study sites
- c) Both A and B
- d) Neither A nor B: you must collect your data at your Biosphere Land Cover study site.

What is the answer?



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Let's review so far! Answer to question 4

When selecting a phenology site, you want to be sure it is accessible and easy to visit, and that you collect data that can be examined in the context of other GLOBE data you might collect. GLOBE recommends you place your site as close to your other study sites as possible, and no further than:

- a) 2 km from your Atmosphere or Soil (Pedosphere) investigation sites
- b) 100 m difference in elevation from your Atmosphere or Soil study sites
- c) Both A and B- correct 😊**
- d) Neither A nor B: you must collect your data at your Biosphere Land Cover study site.

Were you correct?



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Let's review so far! Question 5

How do you ensure that you look at the same tree leaf as you monitor green-down?

- a) Take a GPS reading of the tree leaf
- b) Mark the twig attached to each of 4 leaves with small dots

What is the answer?



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Let's review so far! Answer to Question 5

How do you ensure that you look at the same tree leaf as you monitor green-down?

- a) Take a GPS reading of the tree leaf
- b) **Mark the twig attached to each of 4 leaves with small dots- correct 😊**

Were you correct? Now let's look at GLOBE Data Entry and Visualization



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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](#)



The GLOBE Program Science Data Entry

The GLOBE mobile app allows GLOBE users to perform data entry on a large number of GLOBE science protocols. To use this app, you will need a GLOBE account.

I have a GLOBE account:

[Sign In](#)

[JOIN GLOBE](#) | [CONTACT GLOBE](#)



Entering your data via Live Data Entry or Data Entry Mobile App- Screen 1

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Identify your site →

Choose Greening, select New observation →

Welcome to the GLOBE data entry site.

My Bookmarks

You have not bookmarked any investigations yet. Expand the organizations and click the stars next to the investigations to create a bookmark.

My Organizations and Sites

- University of Nebraska-Lincoln GLOBE v-School [Add site](#)
- + foothills soil eslam [Edit site](#) | [Delete site](#)
Latitude 40.035, Longitude -105.2431, Elevation 1625m
- Buckingham Park [Edit site](#) | [Delete site](#)
Latitude 40.1064, Longitude -105.3297, Elevation 1891m

Atmosphere

- Aerosols ★
New observation | Past observations
- Air Temperature 1-Day ★
New observation | Past observations
- Clouds 1-Day ★
New observation | Past observations
- Integrated 1-Day ★
New observation | Past observations
- Multi-Day Soil And Air Temperatures ★
New observation | Past observations
- Multi-Day Soil And Soil Temperatures ★
New observation | Past observations
- Surface Ozone ★
New observation | Past observations
- Water Vapor ★
New observation | Past observations

Greening

- Greening ★
New observation | Past observations



Entering your data via Live Data Entry or Data Entry Mobile App- Screen 2

A. What is Tree and Shrub Green-Down?

B. Why Collect Tree and Shrub Green-Down 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

(If you want to add or update a species name later, you can make changes- indicate in this box.)

Add the species you are monitoring for Tree/Shrub Green-Down

Add other species you are monitoring

Upload photo

submit

Greening (Click to undo edit) Expand/Collapse Remove

Comment (A comment about your changes is required to edit this section.)

corrections

Previous Comment add data

There are multiple dominant species

Plants

This plant is in the understory Remove

Vegetation Type: Shrub Genus: Salix Species: acutiflora

Label: Shrub - Salix (willow)

This plant is in the understory Remove

Vegetation Type: Grass Genus: BROMUS

Label: Grass Broms

Photos

Photo Date:

**You are done!
Want to check who else has submitted Green-Down data using the GLOBE Visualization System?**



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Visualize and Retrieve Data- Step 1

GLOBE provides the ability to view and interact with data measured across the world. Select our [visualization tool](#) to map, graph, filter and export Green-Up data that have been measured across GLOBE protocols since 1995.



Select Green-Down data from drop down menu

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



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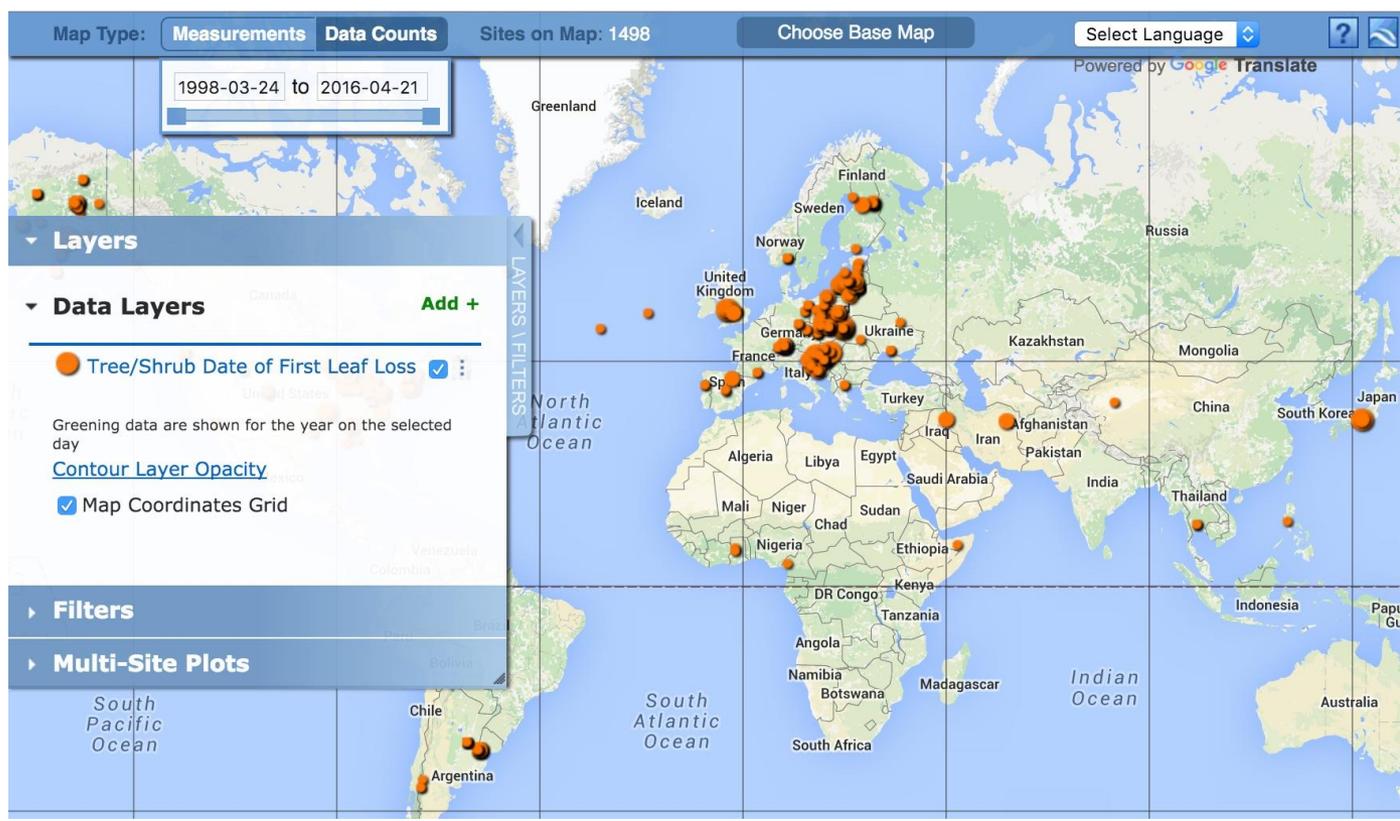
F. Understand the Data

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Visualize and Retrieve Data- Step 2

- Select the date or range of dates for which you need Green-Down data, add layer and icons will appear at locations where data is recorded.





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Visualize and Retrieve Data- Step 3

1998-03-24 to 2016-04-21

School: IES Esteban Manuel de Villegas

Site: Soto rio Najerilla:GRN-01

Measurements | Data Counts | School Info | Site Info | Photos

Biosphere

Green-Down (30)

- Tree/Shrub Date of First Leaf Loss
- Grass Date of Leaf Brown
- All Green-Down (Data Counts Only)

Data Date Range: 2002-09-29 to 2014-11-02

Elevation: 369.2 m
Count: 8

Date	# of measurements
2011-04-01	0
2011-07-01	0
2011-10-01	1
2012-01-01	0
2012-04-01	0
2012-07-01	1
2012-10-01	1
2013-01-01	0
2013-04-01	0
2013-07-01	0
2013-10-01	1
2014-01-01	1
2014-04-01	0
2014-07-01	0
2014-10-01	1
2015-01-01	0
2015-04-01	0
2015-07-01	0
2015-10-01	0
2016-01-01	0
2016-04-01	0

5 Year | Total | Custom

Clicking on a location will open to a map note providing Green-Down data for that location and time. Follow instructions in the tutorial to download data as a .csv file for analysis.



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Review questions to help you prepare to do the Tree and Shrub Green-Down Measurements associated with the GLOBE Biometry Protocol

1. Tree and Shrub Green-Down measurements are part of what GLOBE Protocol area or Earth system sphere?
2. What is phenology?
3. Why is it important for scientists to know when green-down takes place in a location, year by year?
4. With respect to Green-Up and Green-Down, when is the plant growing season?
5. Green-down is a metabolic response to what changes in a plant's environment?
6. Why is green-down data useful for scientists and what does it tell us about changes in the Earth system?
7. Why do we use the GLOBE plant color guide when monitoring Green-Down?
8. When do you start and stop your Tree and Shrub green-down measurements?
9. How do you identify the leaves you are monitoring, so you can return to the same leaves throughout the green-down phase of the plant growth cycle?
10. Why is it important to measure green-down of trees in a natural habitat, away from buildings and other built structures?



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Congratulations!

You have now completed the slide stack. If you are ready to take the quiz, sign on and take the quiz corresponding to the **Tree and Shrub Green-Down Protocol**.

You can also review the slide stack, post questions on the discussion board, or look at the FAQs on the next page.

When you pass the quiz, you are ready to take **Tree and Shrub Green-Down Protocol** Measurements. Welcome to the GLOBE phenology community!



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Frequently Asked Questions

What do you mean by a relatively large branch?

Use your judgment. Each branch should be healthy and large relative to the other branches on the tree or shrub. You want the branch to still be there next year. Be careful not to damage the branch during the labeling and measurements.

What if a branch breaks during the study?

Continue your observations by teaming up with other students and observing their branch.

Should I look at the same branch from year to year?

You should observe the same branch, which will typically have new terminal buds each year.

What if needle-leaved trees are the abundant vegetation?

Usually there are understory deciduous shrubs that can be used instead. For example, Snowberry in Douglas Fir, Gamel Oak in Ponderosa Pine. Typically these deciduous plants are what the satellites are detecting as Green-up. The Green-up of conifers is a subtle process and not easily observed.



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Please provide us with feedback about this module. This is a community project and *we need and welcome* your comments, suggestions and edits! Comment here: [eTraining Feedback](#)

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