THE **GLOBE** PROGRAM

A Worldwide Science and Education Program

Biosphere • Grass Green-Down Protocol

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 grass 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 grass green-down study site and conduct measurements in the field
- Upload data to the GLOBE portal
- Visualize data using GLOBE's Visualization Site

Estimated time to complete module; 1.5 hours

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.

Grass Green-Down is one of the GLOBE **phenology** protocols.

You can found more information in:

Biosphere Introduction

Photo Credit: Shelley E. Olds

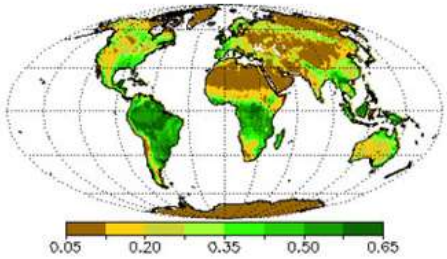
What is Phenology, and how is it related to Green-Down?

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 both plants and animals.

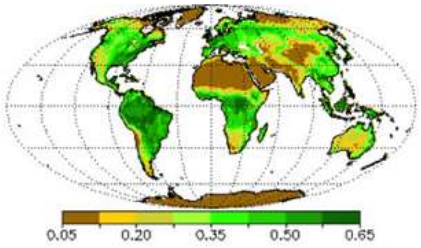
The plant growing season is the period between green-up and green-down.

Plant green-up is initiated when dormancy (a state of suspended growth and metabolism) is broken by environmental conditions such as longer hours of sunlight and higher temperatures in temperate regions, or rains and cooler temperatures in desert areas.

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

What is Grass 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

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.

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.

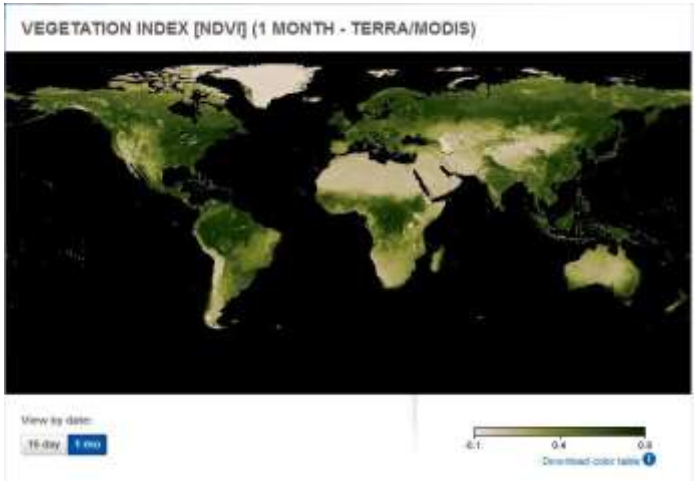
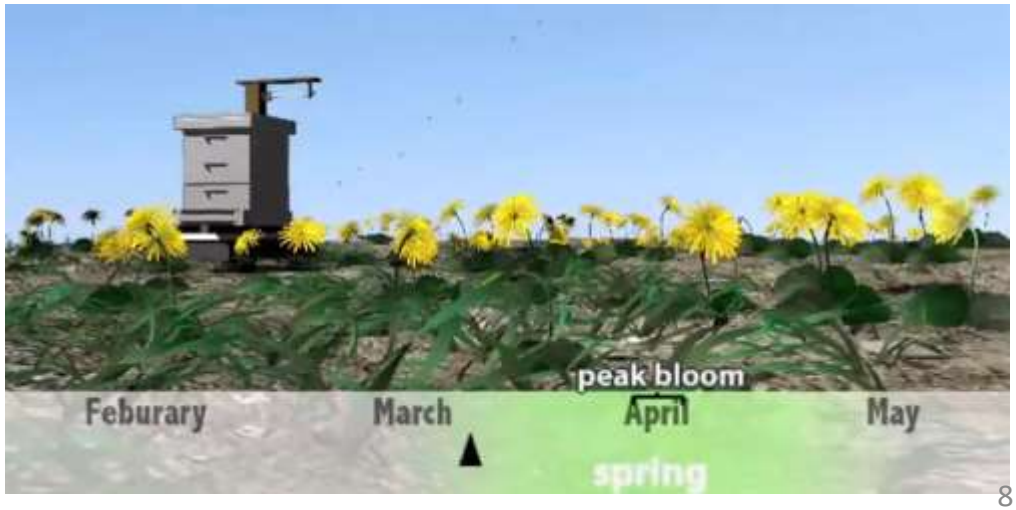


Image: NASA Earth Observatory

How Your Measurements Can Help

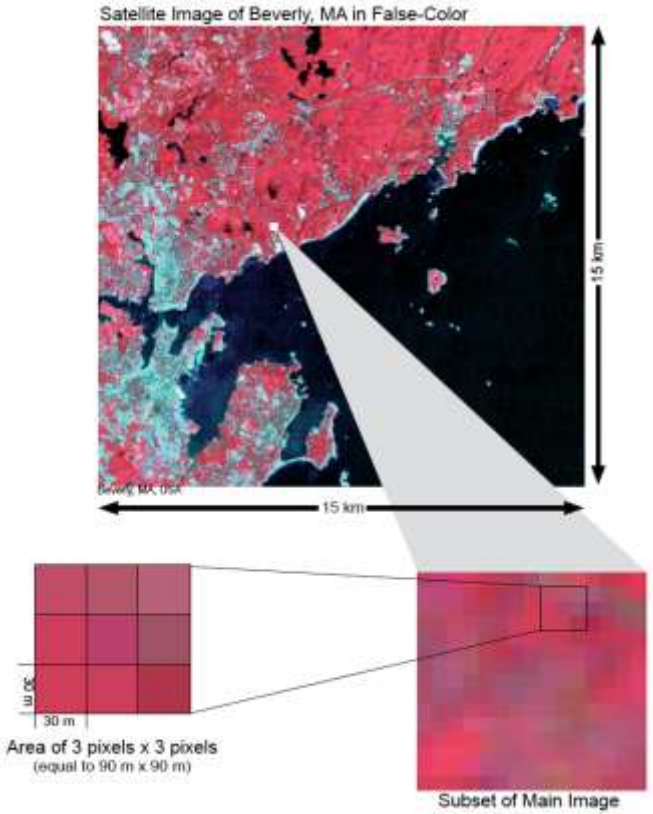
- Estimates of changes in the growing season are often done using satellite data.
- Ground observations are critical to improve the interpretation of satellite data.
- Monitoring the length of the growing season is important for society so that it can better adapt to variations in the length of the growing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



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.



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).

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?

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?

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?

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?

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.

Overview of the Grass 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	Grass Green-Up, Green-Down site: ideally, your observations in a one-meter square that is dominated by grass plants.
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-up and continue observing until leaf growth plateaus.
Prerequisites	None
Primary Instrument	Metric ruler, GLOBE Plant Color Guide
Skill level	All
References	Tree, Shrub, and Grass Green-Down Data Sheet Grass Green-Up and Green-Down Site Selection Field Guide Site Definition Sheet

Needed Equipment and Documents

- **What You Need the first visit**
- Pencil or pen
- Camera
- Compass
- Fine-Tip Permanent Marker
- GLOBE Plant Color Guide

- **Every Visit**
- GLOBE Plant Color Guide
- Pencil or pen

- **Documents Needed Each Visit**
- Grass Green-Down Protocol Field Guide
- Green Down Tree, Shrub and Grass Green-Down Data Sheet
- Site Definition Sheet
- Grass Green-Up and Green-Down Site Selection Field Guide

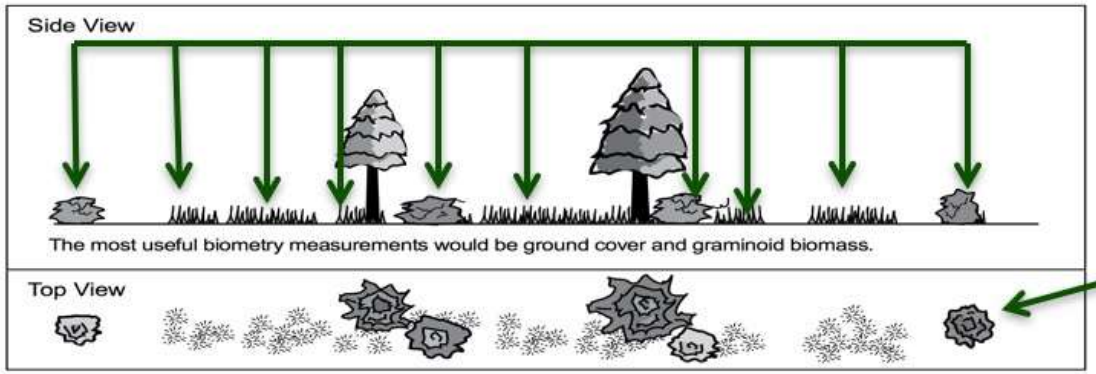
Site Selection

- 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"?



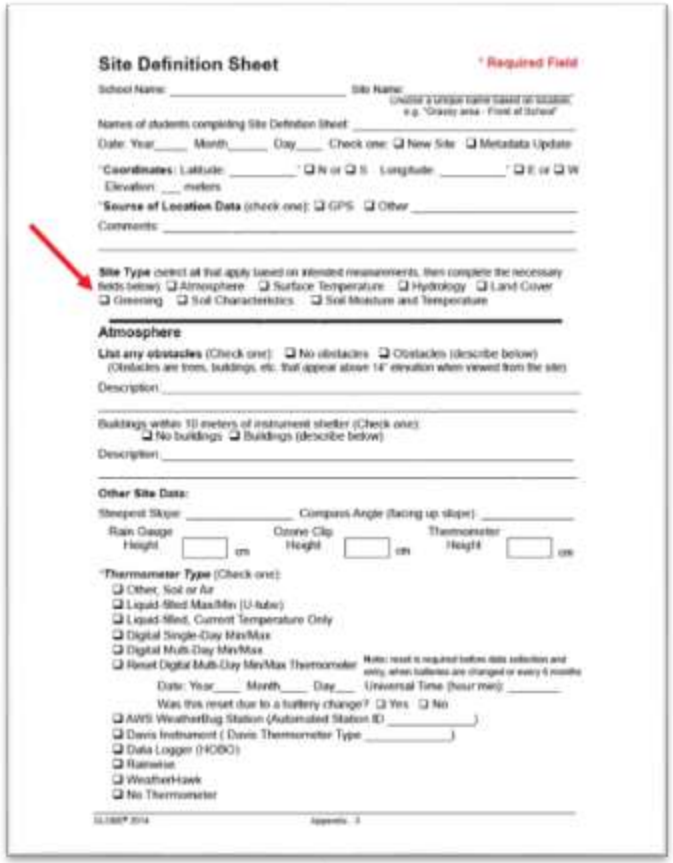
Select a site close to an atmosphere or soil moisture site, if possible. Ideally, it should be **less than 2 km** from your atmosphere or soil moisture site, and have **an elevation difference less than 100 meters**. Why is this important?

- 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.

Grass Green-Down Site Definition-1

1.Complete the Greening portion of the Site Definition Sheet.

2.Identify genus using field guides or help of plant specialists. Record the genus on the Site Definition Sheet.



Site Definition Sheet * Required Field

School Name: _____ Site Name:

Names of students completing Site Definition Sheet: _____

Date: Year____ Month____ Day____ Check one: ❑ New Site ❑ Metadata Update

*Coordinates: Latitude: _____° ❑ N or ❑ S Longitude: _____° ❑ E or ❑ W

Elevation: ___ meters

*Source of Location Data (check one): ❑ GPS ❑ Other _____

Comments: _____

Site Type (select all that apply based on intended measurements, then complete the necessary fields below): ❑ Atmosphere ❑ Surface Temperature ❑ Hydrology ❑ Land Cover ❑ Greening ❑ Soil Characteristics ❑ Soil Moisture and Temperature

Atmosphere

List any obstacles (Check one): ❑ No obstacles ❑ Obstacles (describe below)
(Obstacles are trees, buildings, etc. that appear above 14° elevation when viewed from the site)

Description: _____

Buildings within 10 meters of instrument shelter (Check one):
❑ No buildings ❑ Buildings (describe below)

Description: _____

Other Site Data:

Steepest Slope: _____ Compass Angle (facing up slope): _____

Rain Gauge Height ____ cm Crone Clip Height ____ cm Thermometer Height ____ cm

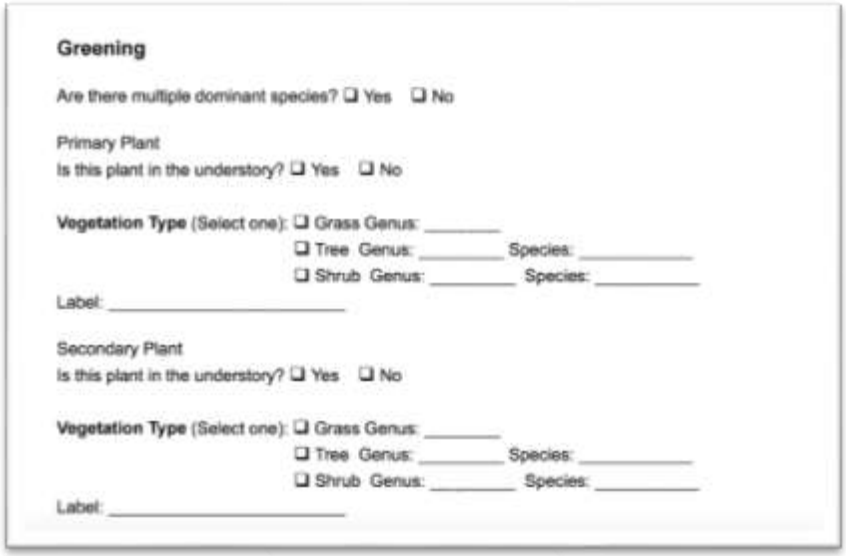
*Thermometer Type (Check one):
❑ Other, Soil or Air
❑ Liquid-filled Max/Min (U-tube)
❑ Liquid-filled, Current Temperature Only
❑ Digital Single-Day Min/Max
❑ Digital Multi-Day Min/Max
❑ Reset Digital Multi-Day Min/Max Thermometer

Note: reset is required before data collection and only when batteries are changed or every 6 months

Date: Year____ Month____ Day____ Universal Time (hour:min): _____

Was this reset due to a battery change? ❑ Yes ❑ No

❑ AWS WeatherBug Station (Automated Station ID: _____)
❑ Davis Instrument (Davis Thermometer Type _____)
❑ Data Logger (HOBO)
❑ Rainwise
❑ WeatherHawk
❑ No Thermometer



Greening

Are there multiple dominant species? ❑ Yes ❑ No

Primary Plant
Is this plant in the understory? ❑ Yes ❑ No

Vegetation Type (Select one): ❑ Grass Genus: _____
❑ Tree Genus: _____ Species: _____
❑ Shrub Genus: _____ Species: _____

Label: _____

Secondary Plant
Is this plant in the understory? ❑ Yes ❑ No

Vegetation Type (Select one): ❑ Grass Genus: _____
❑ Tree Genus: _____ Species: _____
❑ Shrub Genus: _____ Species: _____

Label: _____

Grass Green-Down Site Definition-2

3.Select a one-meter square area dominated by grass plants. Mark your one-meter square plot with nails or stakes or other durable identifiers.

4. Locate coordinates using the **GPS Protocol**

First Visit: Green-Down Grasses

First visit only/getting started

1. Fill in the top 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. Look for the four longest green grass shoots.

4. Mark the base of the longest grass shoot with a single dot, using a permanent felt marker. Mark the second longest shoot with two dots, the third with three dots and the fourth shoot with four dots.

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.

Every Visit: Green-Down Grasses

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

You are done!

Grass Green-Down Data Sheet

1. Fill in the top portion of the data sheet

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


Green-down
Tree, Shrub, and Grass Green-Down Data Sheet

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	❑
2013-10-03	1	5 G 7/4	5 G 7/4	5 G 7/4	2.5 Y 8/6	❑
2013-10-07	1	5 G 7/4	2.5 Y 8/6	5 G 7/4	2.5 Y 8/6	❑
2013-10-11	1	5 G 7/4	2.5 Y 8/6	2.5 Y 8/6	2.5 Y 8/6	❑
2013-10-14	1	5 G 7/4	2.5 Y 8/6	2.5 Y 8/6	2.5 Y 8/6	❑
2013-10-16	1	2.5 Y 8/6	2.5 Y 8/6	2.5 Y 8/6	2.5 Y 8/6	❑
2013-10-20	1	2.5 Y 8/6	2.5 Y 8/6	2.5 Y 8/6	7.5 YR 6/4	❑
2013-10-23	1	2.5 Y 8/6	2.5 Y 8/6	2.5 Y 8/6	7.5 YR 6/4	❑
2013-10-27	1	2.5 Y 8/6	2.5 Y 8/6	2.5 Y 8/6	7.5 YR 6/4	❑
2013-10-30	1	2.5 Y 8/6	2.5 Y 8/6	7.5 YR 6/4	7.5 YR 6/4	❑
2013-11-04	1	2.5 Y 8/6	7.5 YR 6/4	7.5 YR 6/4	fallen	❑
2013-11-06	1	2.5 Y 8/6	7.5 YR 6/4	7.5 YR 6/4		❑
2013-11-11	1	7.5 YR 6/4	7.5 YR 6/4	7.5 YR 6/4		❑
2013-11-14	1	7.5 YR 6/4	7.5 YR 6/4	7.5 YR 6/4		❑
2013-11-17	1	7.5 YR 6/4	fallen	7.5 YR 6/4		❑
2013-11-22	1	7.5 YR 6/4		fallen		❑
2013-11-29	1	7.5 YR 6/4				❑
2013-12-02	1	snow covered				❑
						❑
						❑

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?

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?

Let's review so far! Question 5

How do you ensure that you look at the same blades of grass as you monitor green-down?

a) Take a GPS reading of the grass blade

b) Mark the blades with small dots, with the longest blade marked with one dot, the second longest with two dots, and so on.

What is the answer?

Let's review so far! Answer to Question 5

How do you ensure that you look at the same blades of grass as you monitor green-down?

a) Take a GPS reading of the grass blade

b) Mark the blades with small dots, with the longest blade marked with one dot, the second longest with two dots, and so on.- correct ☺

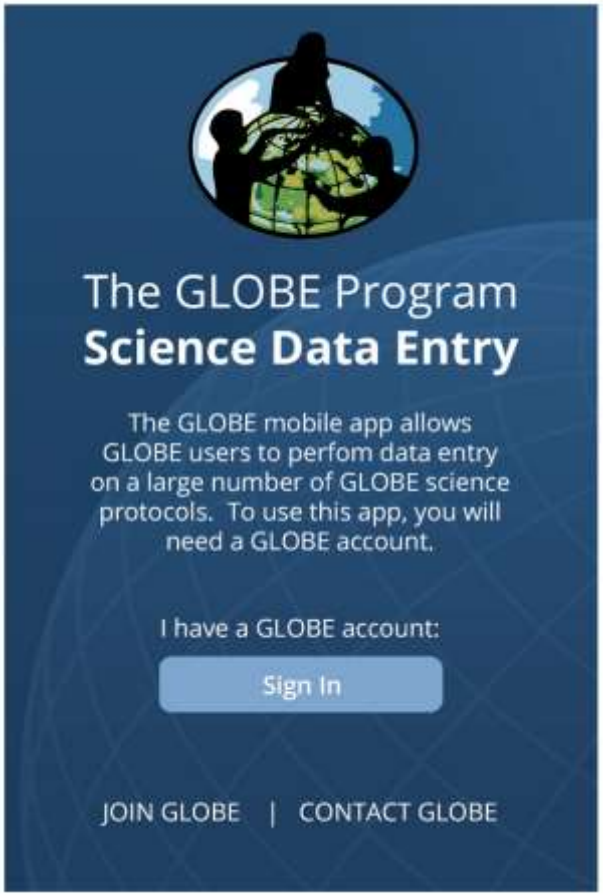
Were you correct? Now let's look at GLOBE Data Entry and Visualization

Report Your Data to GLOBE

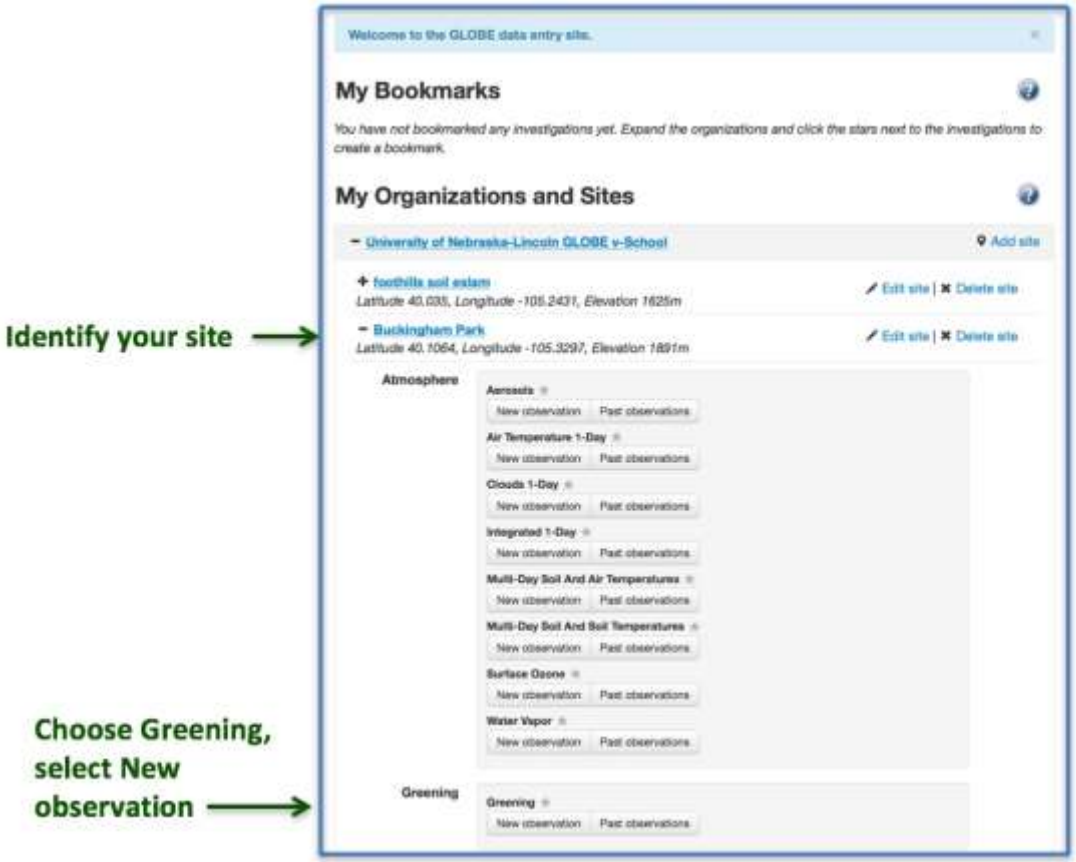
- **Live Data Entry:** Upload your data to the official
- GLOBE science database

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

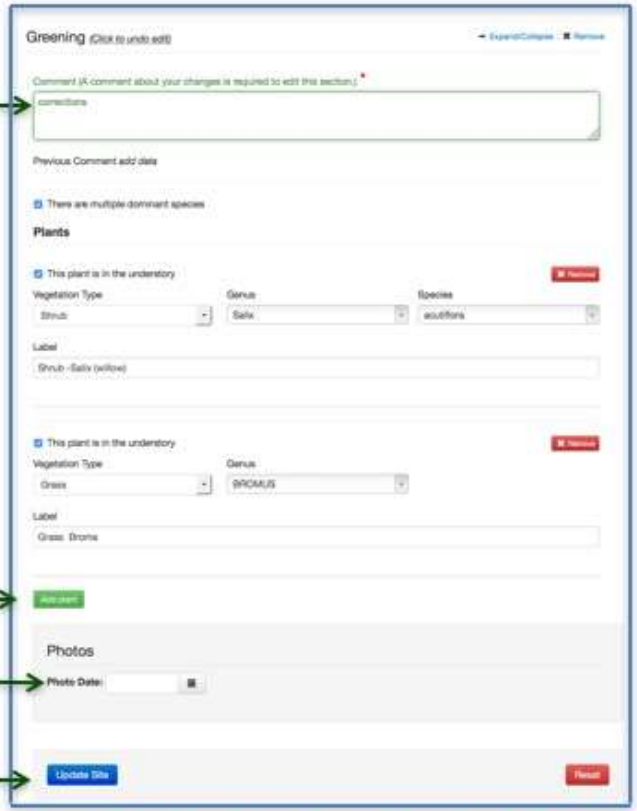
- **Mobile Data App:** Download the GLOBE Science Data Entry app to your mobile device and select the right option.
- **For Android** via **Google Play**
- **For IOS** via the **App Store**



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



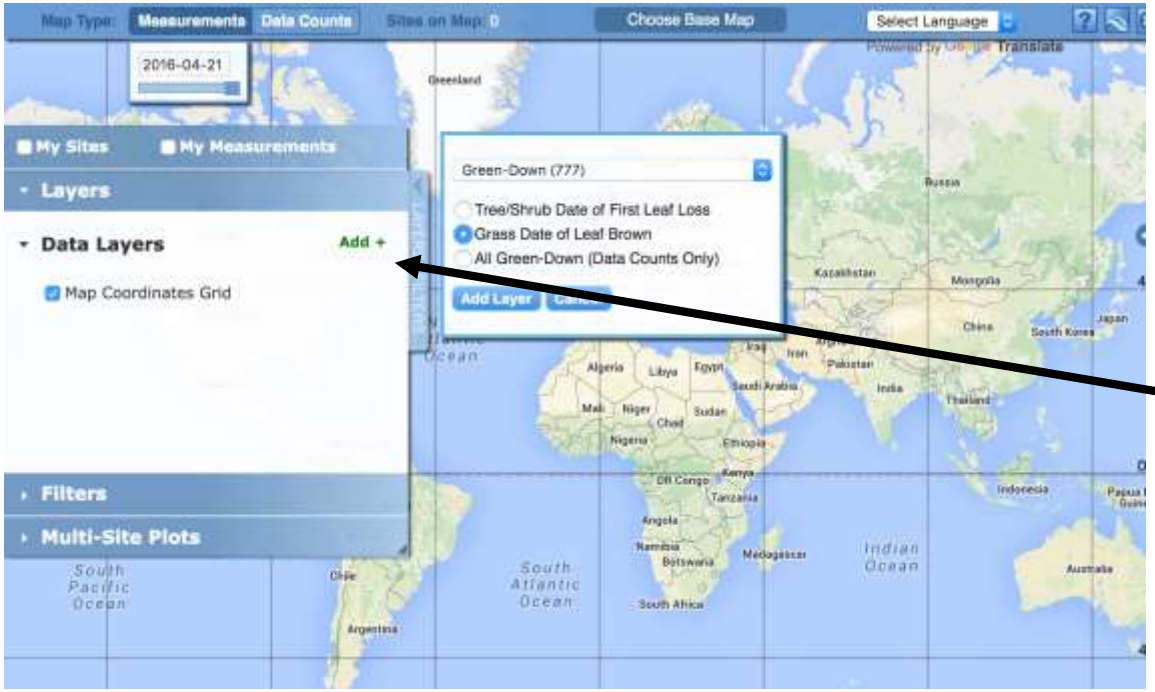
Entering your data via Live Data Entry or Data Entry Mobile App- Screen 2



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

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.



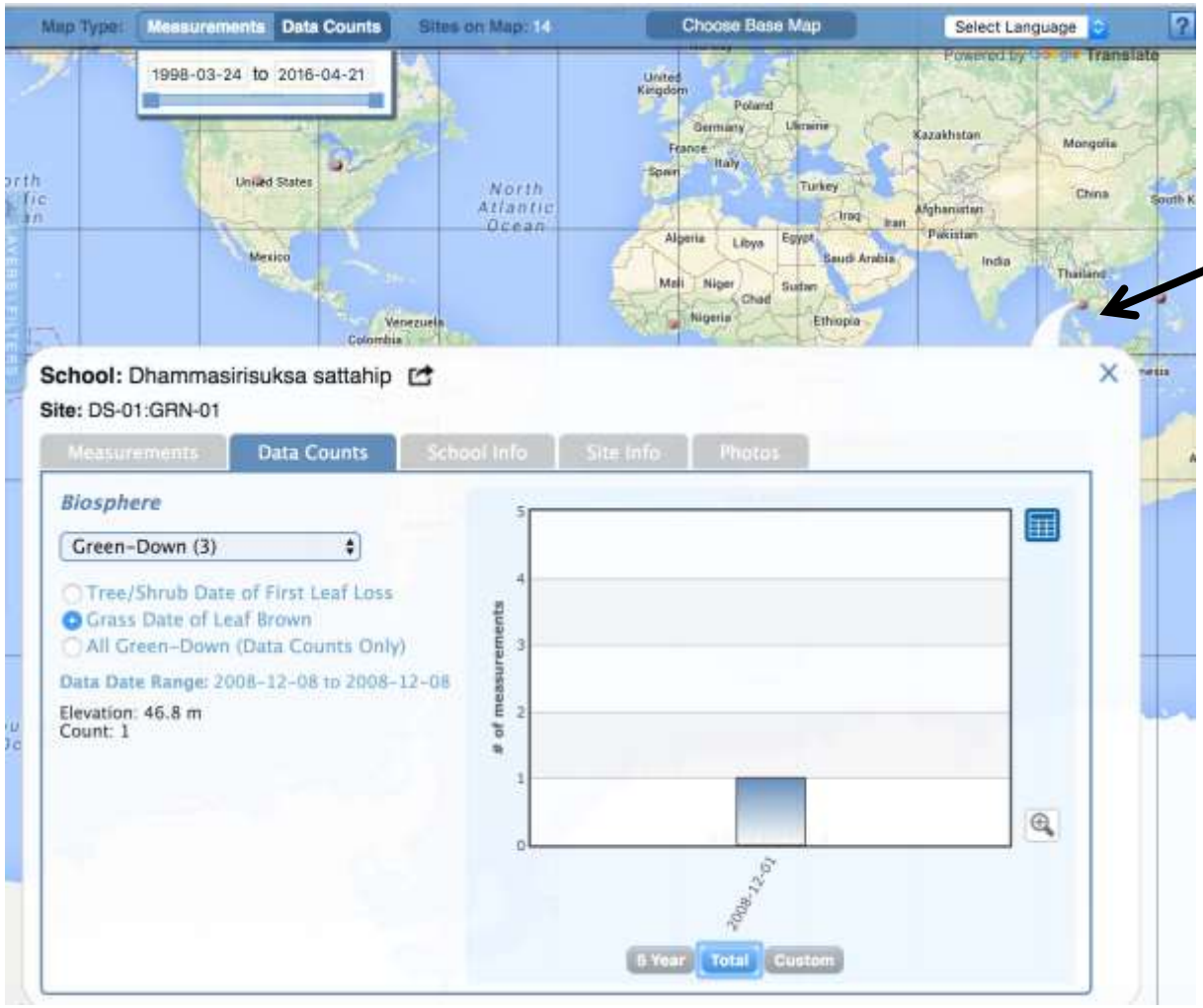
Click "Add" and dropdown menu will appear. Select green-down.

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

Visualize and Retrieve Data- Step 2

- Select the date for which you need Green-Down data, add layer, and you can see locations where data is available.

Visualize and Retrieve Data- Step 3



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.

Review questions to help you prepare to do the Grass Green-Down Measurements associated with the GLOBE Biometry Protocols

1. **Grass 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 grass green-down measurements?**
9. **How do you identify the grass 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 grasses in a natural habitat, rather than in a lawn or a crop field?**

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 Grass 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 Grass Green-Down Protocol measurements! Welcome to the GLOBE phenology community!

Research Questions for Investigation:

- What other animals (butterflies, waterfowl, songbirds) migrate after plants green-down? When? Why?
- Does the timing of green-down occur earlier or later at higher elevations in your region? Why?
- Does the timing of green-down occur earlier or later inland or near the coast in your region? Why?
- How do fallen plant leaves affect soil properties such as soil color, water-holding capacity, and soil nutrients? How could you find out? Why is this important?

FAQ: Frequently Asked Questions

Should I use the same leaves I used for green-up?

If possible, use the same grass plot. If you use other plants try to select plants of the same species. If the plants you use for green-down are at a different location than the ones you used for green-up, then define a new site.

Do you have any tips how to locate the same grass blade and make measurements throughout the observation period?

The best way to locate the grass blades is by providing small dots on the leaves you are monitoring, according to the protocol. Next to the grass blade, mark this area with some flagging tape on a wire or other way so that the area can be located easily throughout the observation period

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

Questions about the content of this module? Contact GLOBE eTraining: rlow@ucar.edu

Credits

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