GLOBEPROGRAM®
A Worldwide Science & 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 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 database
- Visualize data using GLOBE's Visualization System

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, phenology, and carbon storage. Some GLOBE Hydrosphere investigations also include measurements of organisms: the macroinvertebrate and mosquito larvae protocols.

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

More information can be found in the:
Biosphere Introduction
Hydrosphere Introduction

Photo Credit: Shelley E. Olds

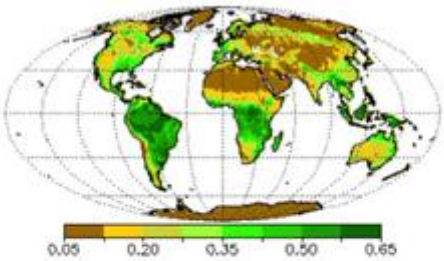
What is Phenology, and how is it related to Green-Down?

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.

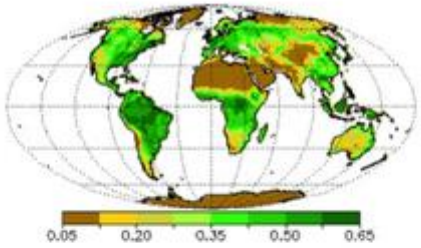
The plant growing season is the period between green-up and green-down.

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.
  - 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

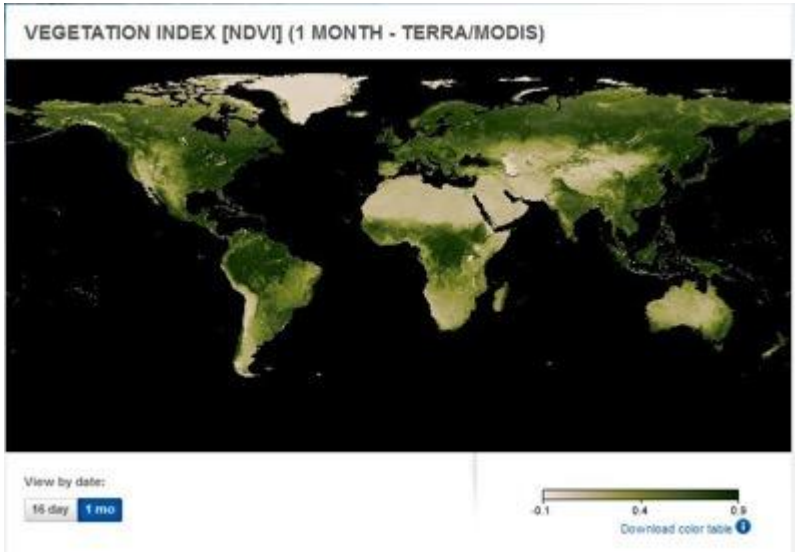
Why Collect Green-Down Data?

Scientists are very interested in knowing 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, as well as soil moisture.

Satellite Measurements of Phenology

Many scientists use data from a NASA sensor, the Moderate Resolution Imaging Spectrometer (MODIS), to monitor the seasonal dynamics of vegetation.

Scientists also use a metric called the Normalized Difference Vegetation Index (or NDVI) to quantify the Earth's greenness. NDVI is calculated from satellite data of red and near-infrared light, and can help monitor vegetation health, ecosystem disturbances, and changes in vegetation density over time. Learn more about NDVI in this My NASA Data Mini-lesson.



Watch an animation of NDVI from the NASA Visualization Studio to see changes in greenness over time!

Why Collect Green-Down Data?

- Your observations are valuable contributions to the scientific community and may be used by educators, students, researchers, and the general public to increase environmental awareness and STEM literacy, as well as advance Earth system science.
- 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.

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** ☺

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) help interpret satellite observations of greenness, such as imagery of the Normalized Difference Vegetation Index (NDVI)

b) 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) help interpret satellite observations of greenness, such as imagery of the Normalized Difference Vegetation Index (NDVI)

b) 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 your site at least two times a week.
Prerequisites	None
Primary Instrument	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

First Visit

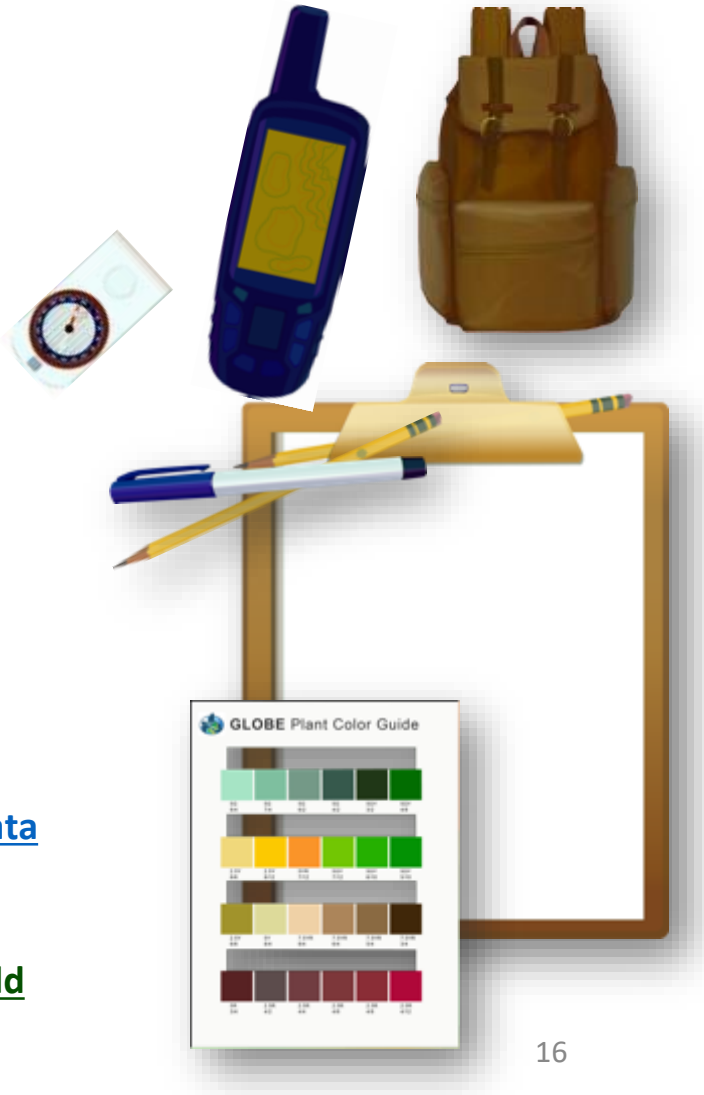
- Pencil or pen
- Camera
- Compass
- Fine-Tip Permanent Marker
- GLOBE Plant Color Guide

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

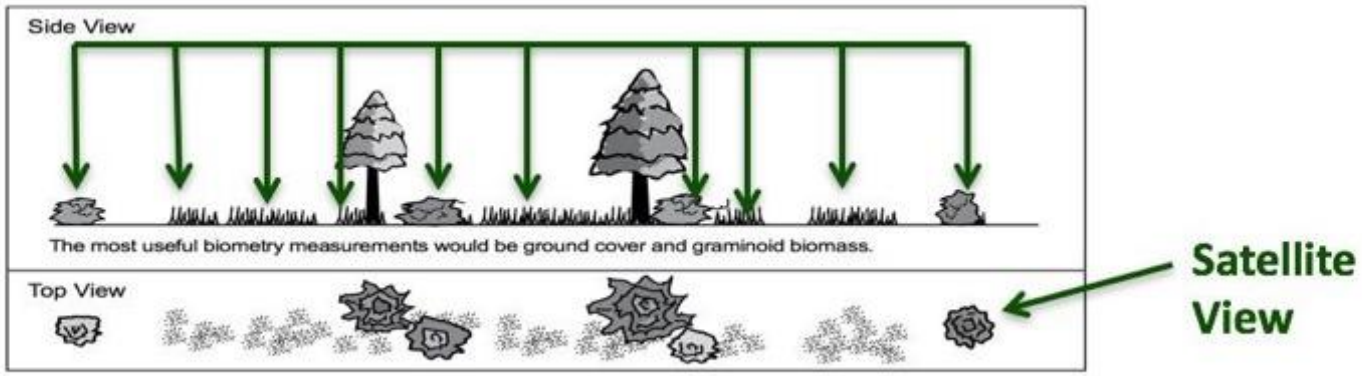
Site selection is important. Chose a site that contains plants indicative of the surrounding climate. You will need to make your observations in a one-meter square that is dominated by grass plants.

- Native species
- Not watered or fertilized
- Away from buildings
- Choose a site that is accessible and can be visited repeatedly.

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

Select one or more species that is common in your area. Think from the perspective of a satellite – what is the satellite "seeing"?

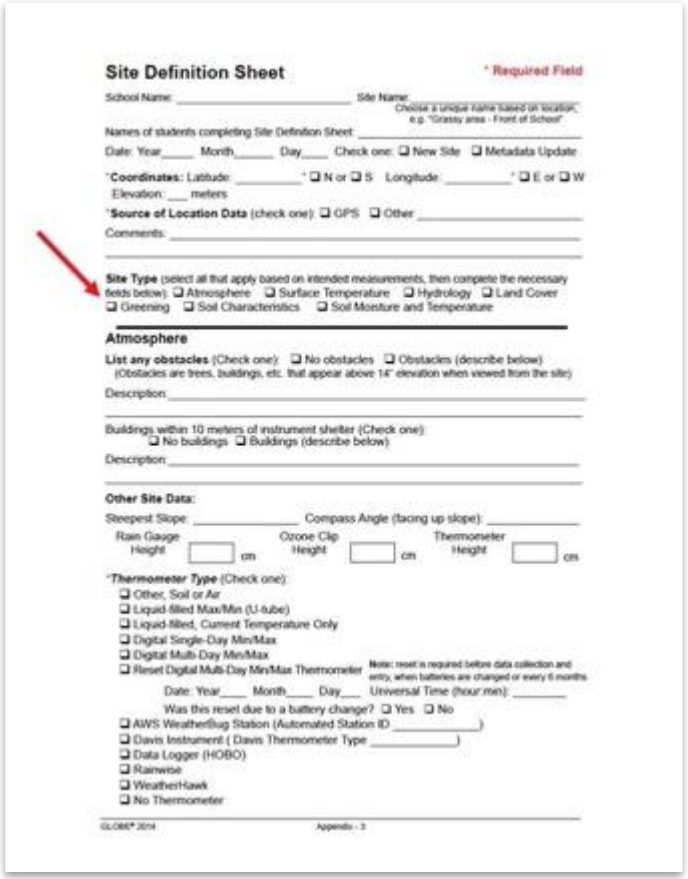


If you are also doing atmospheric or soil moisture protocols, select a site **less than 2 km** from your atmosphere or soil moisture site, and **an elevation difference less than 100 meters**. This is important because local topography affects weather significantly.

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: _____
Choose a unique name based on location, e.g. "Grassy area - Front of School"

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: _____

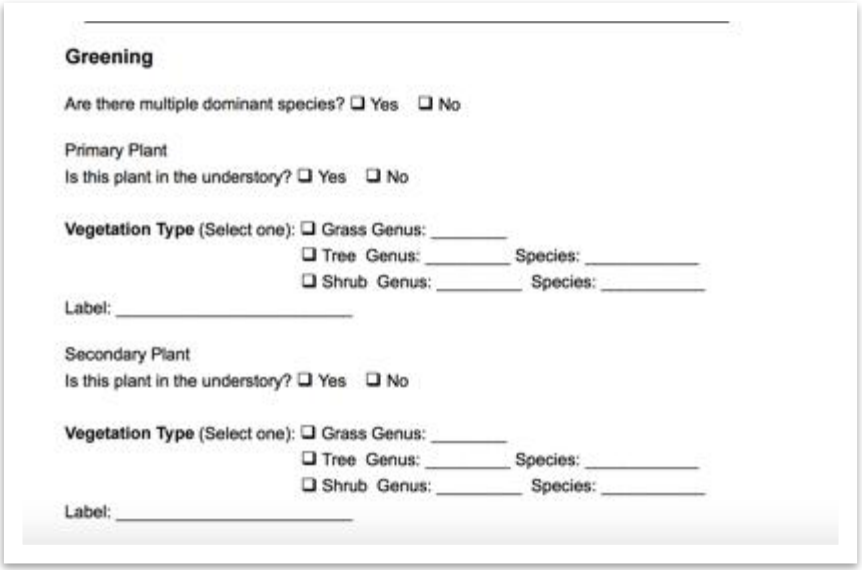
Other Site Data:

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

Rain Gauge Height ____ cm Ozone 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 entry, 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

GLOBE® 2014 Appendix - 3



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 your phone or the **GPS Protocol.**

First Visit: Green-Down Grasses

First visit only/getting started

1. Fill in the top of your *Data Sheet*.

1. Determine whether there are more than one green down cycles; if yes, during which cycle are you currently collecting data (1, 2, or 3)?

1. Look for the four longest green grass shoots.

1. 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

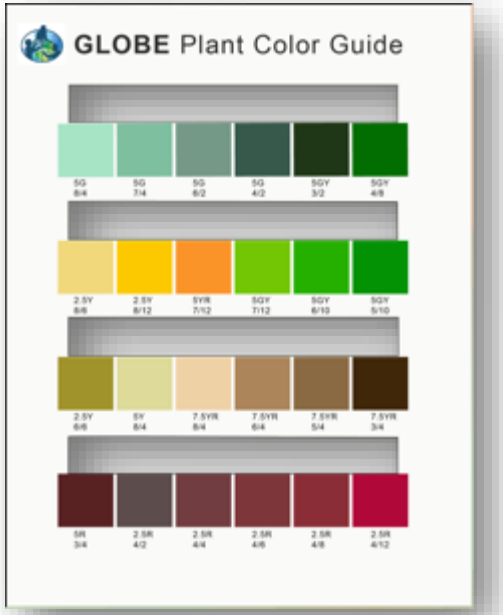
First visit only/getting started

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

Fill in the top portion of the data sheet.

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

Green-down

Tree, Shrub, and Grass Green-Down Data Sheet

School Name: _____ Study Site: _____

Observer Names: _____

Plant Scientific Name: Genus_____ Species: _____

Plant Common Name: _____

Green-Up Cycle:____ Year:____

Tree, Shrub and Grass Green-down					
Date (day & month)	Leaf 1 (Color, fallen, or snow covered)	Leaf 2 (Color, fallen, or snow covered)	Leaf 3 (Color, fallen, or snow covered)	Leaf 4 (Color, fallen, or snow covered)	Data entry ✓

Check the last column in the green-up table to keep track of data submitted.

Comments (date each comment): _____

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 that 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 that 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

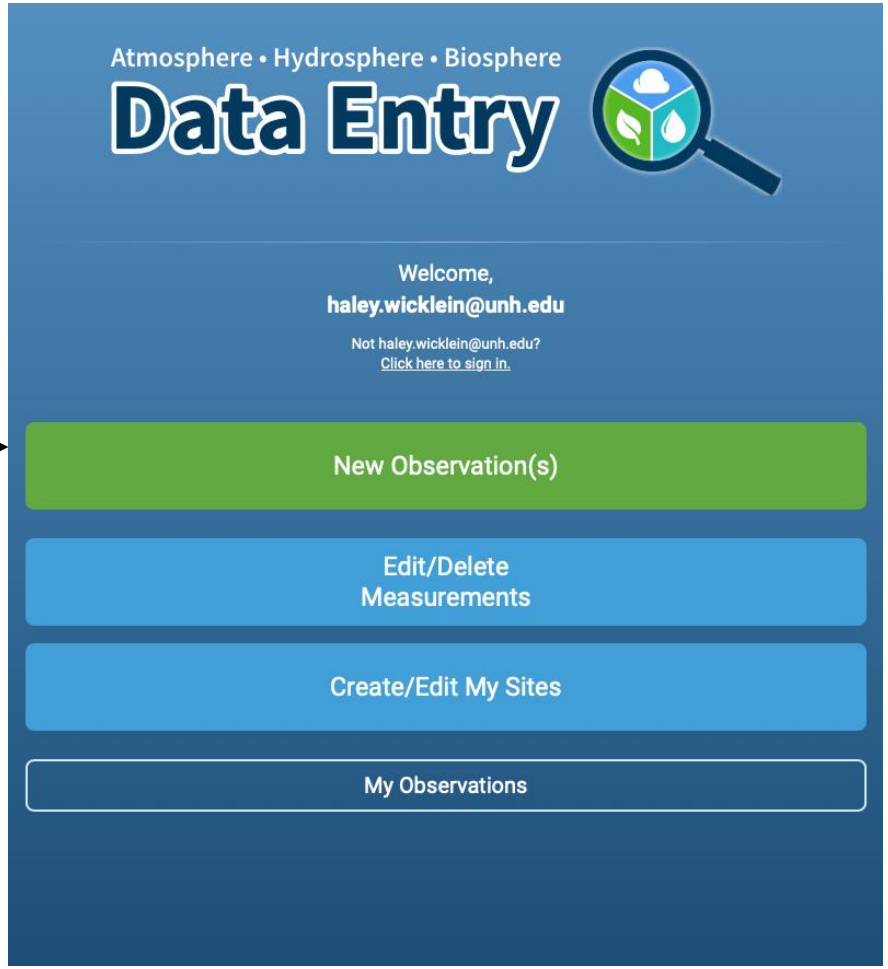
1.Desktop Data Entry: Log environmental data directly on the GLOBE website.

1.Email Data Entry: If connectivity is an issue, data can also be entered via email.

1.GLOBE Observer App: The app allows users to enter data directly from an iOS or Android device for any GLOBE protocol.

Entering your data via the GLOBE website or GLOBE Observer App

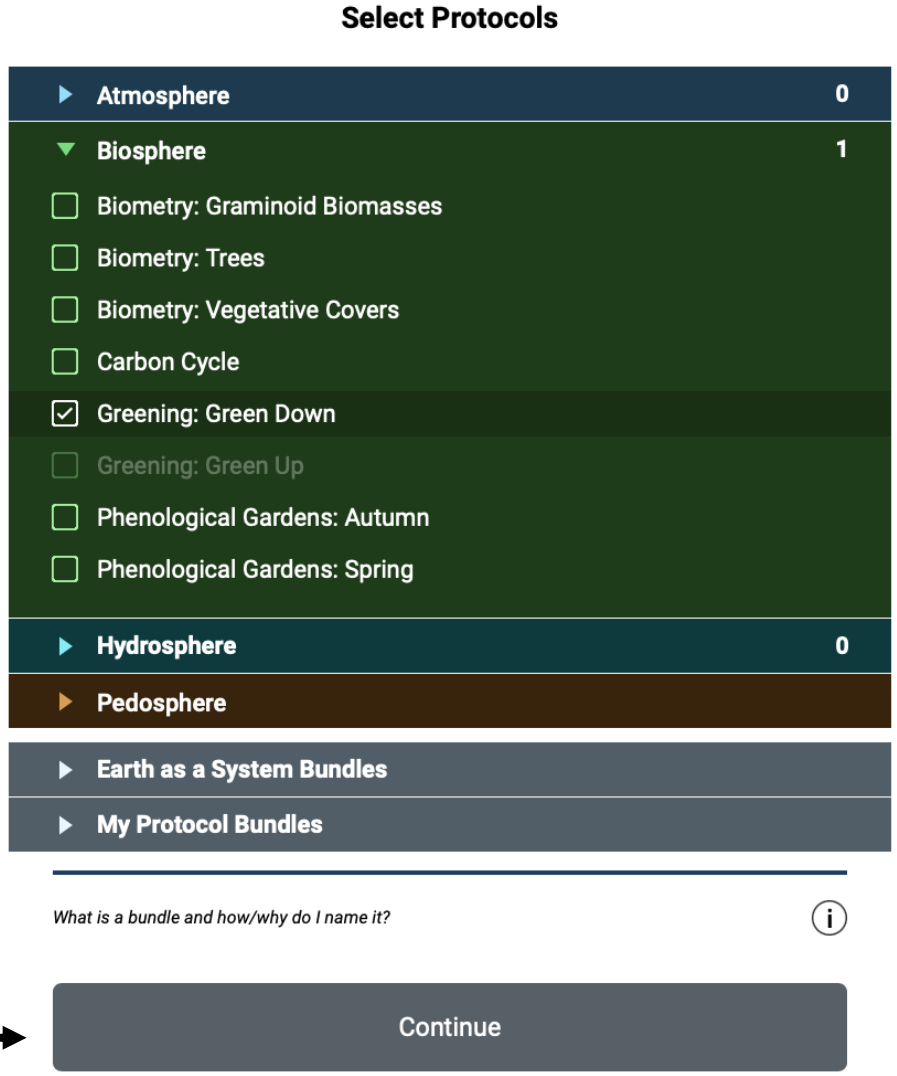
Click "New Observation(s)"



Enter Data on GLOBE website

Entering your data via the GLOBE website or GLOBE Observer App

Select "Greening: Green Down" →

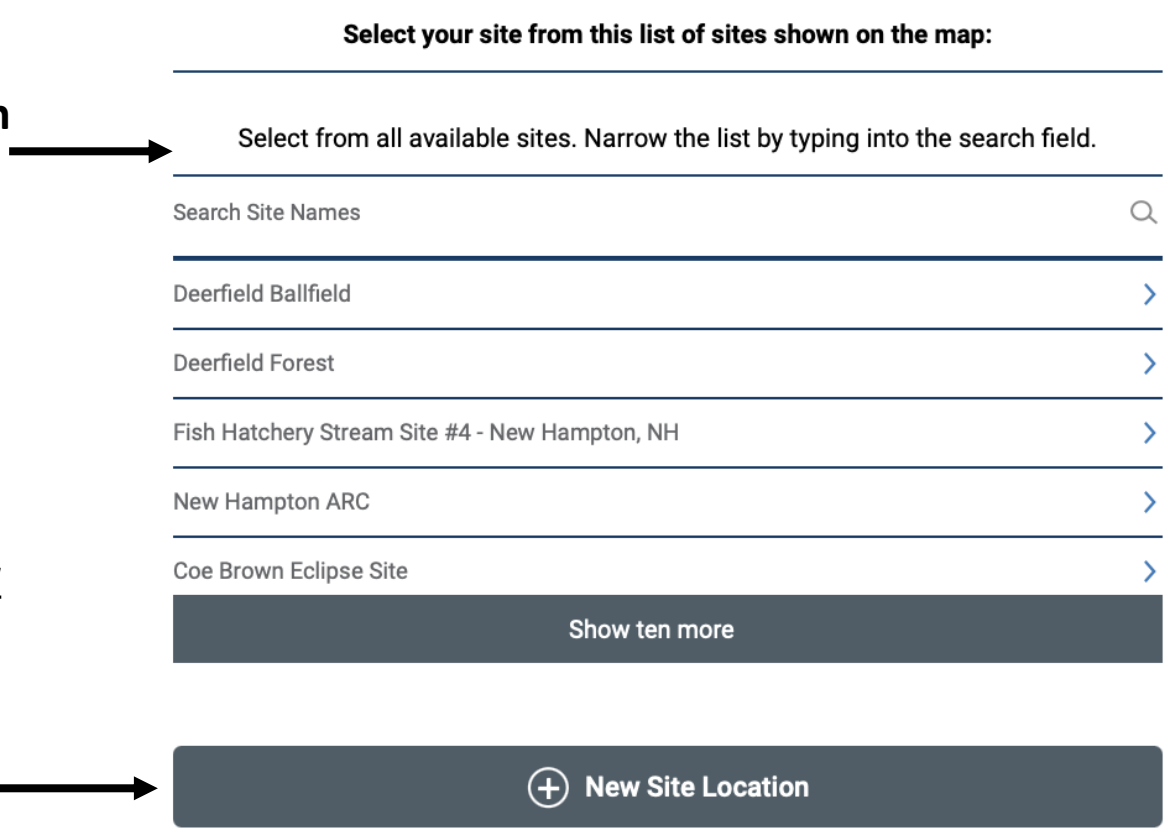


Click Continue →

Entering your data via the GLOBE website or GLOBE Observer App

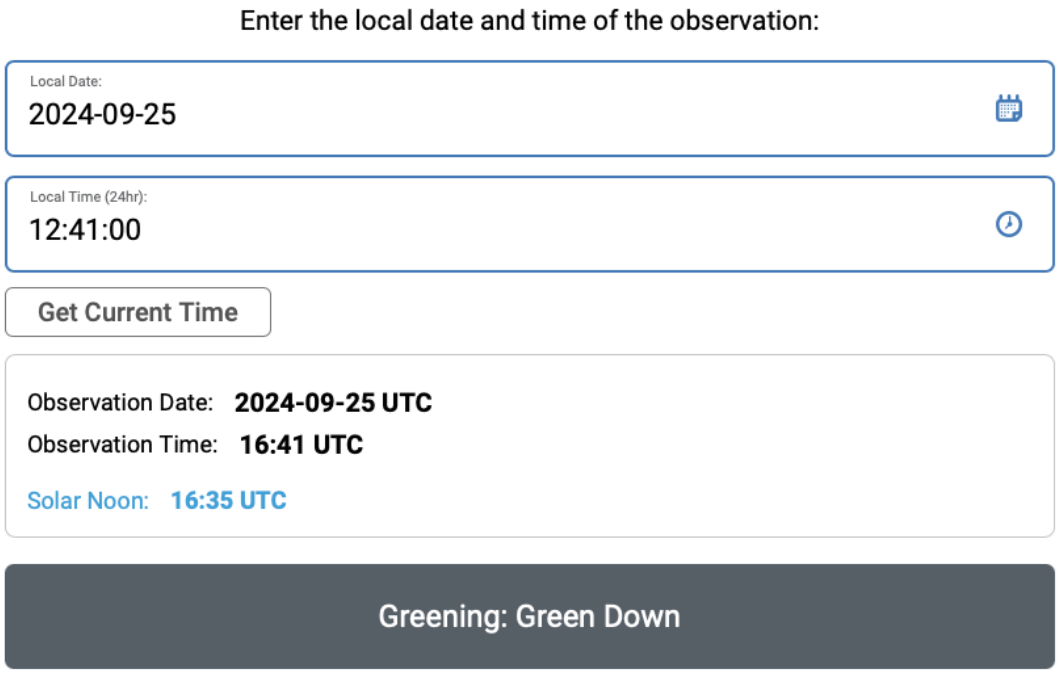
On the location page, scroll down to select your site OR choose "New Site Location" to add a new site.

Tutorials are available on how to add a new site.



Entering your data via the GLOBE website or GLOBE Observer App

Add the time and date that you collected your data

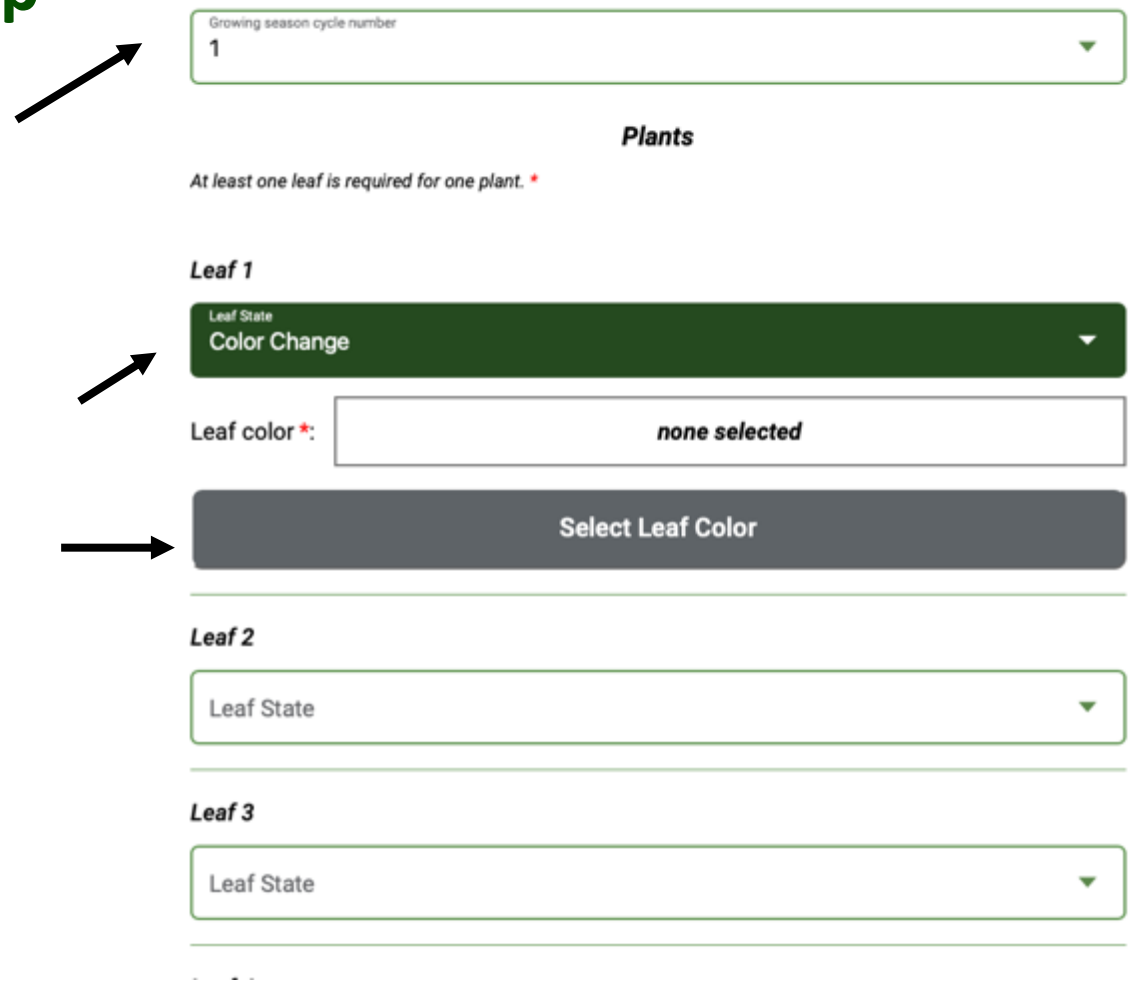


Click Greening: Green Down

Entering your data via the GLOBE website or GLOBE Observer App

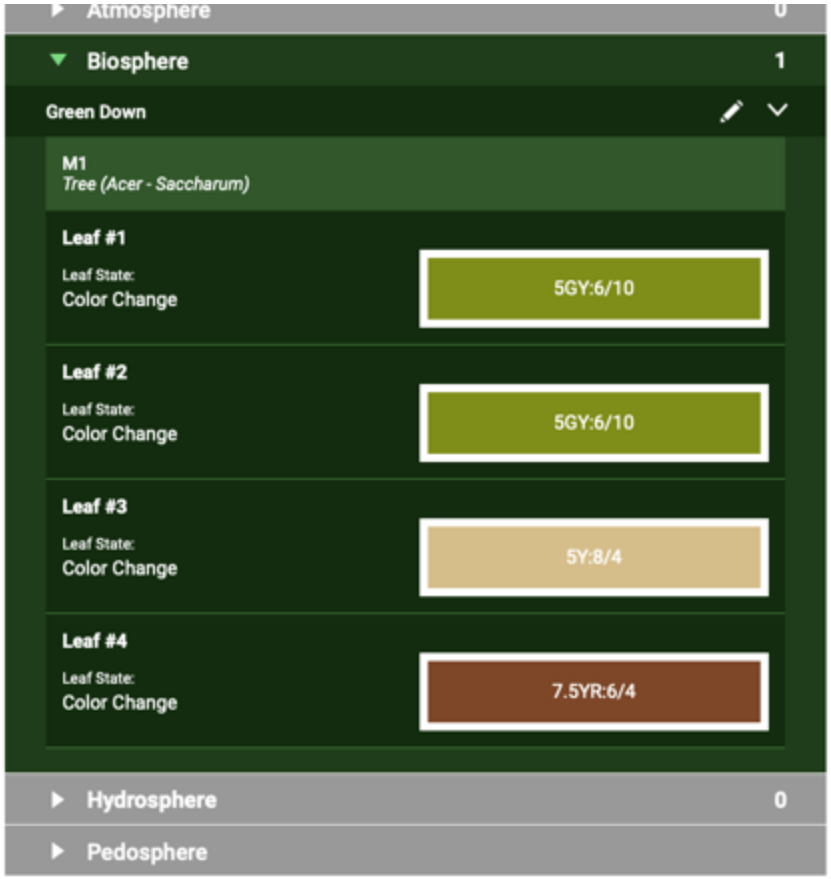
Choose your growing season cycle number

Add your leaf color codes for each grass leaf by selecting "color change" and clicking "Select Leaf Color"



Review and sent data via the GLOBE website or GLOBE Observer App

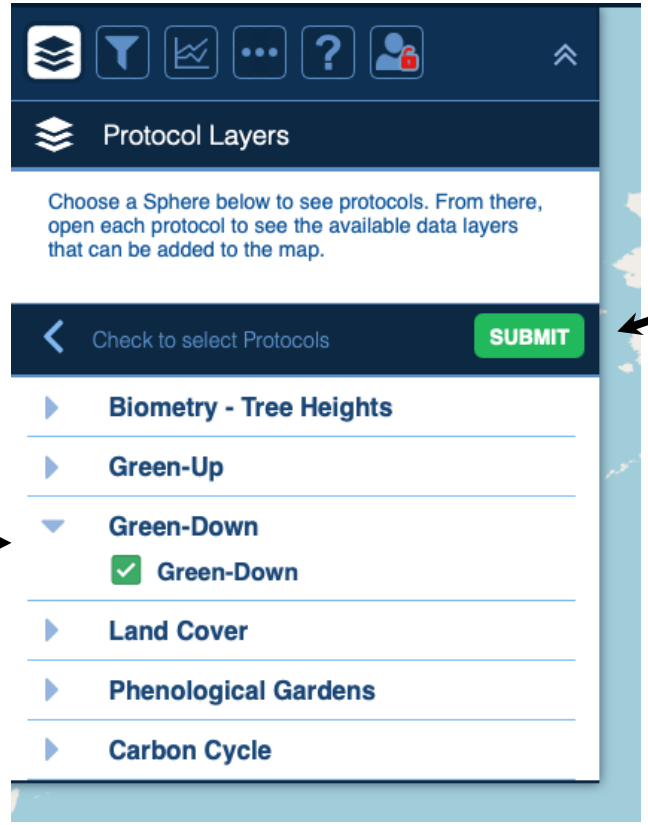
Review the data you entered



Click send observation and wait for the message that your observation was successfully sent!

Visualize and Retrieve Data

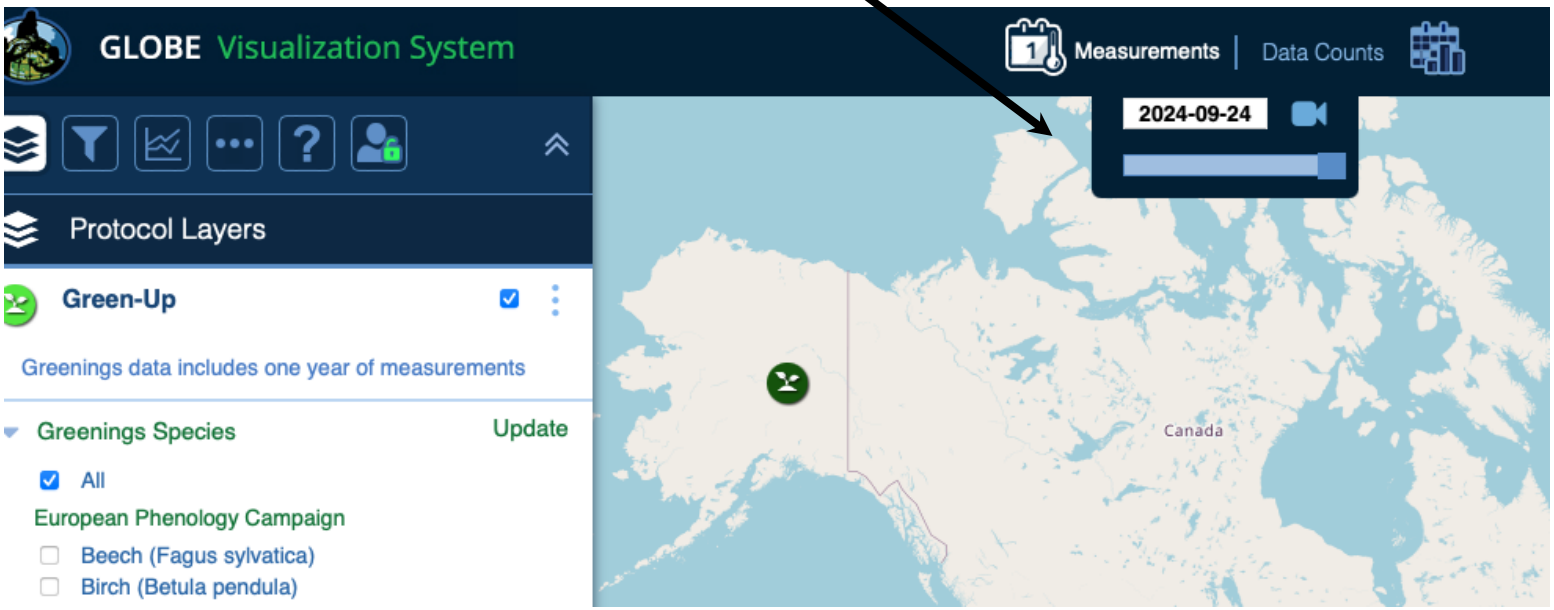
GLOBE provides the ability to view and interact with data measured across the world. Use the **visualization tool** to map, graph, filter and export Green-Down data that have been measured across GLOBE protocols since 1995.



See video tutorials on using the GLOBE Visualization system.

Visualize and Retrieve Data

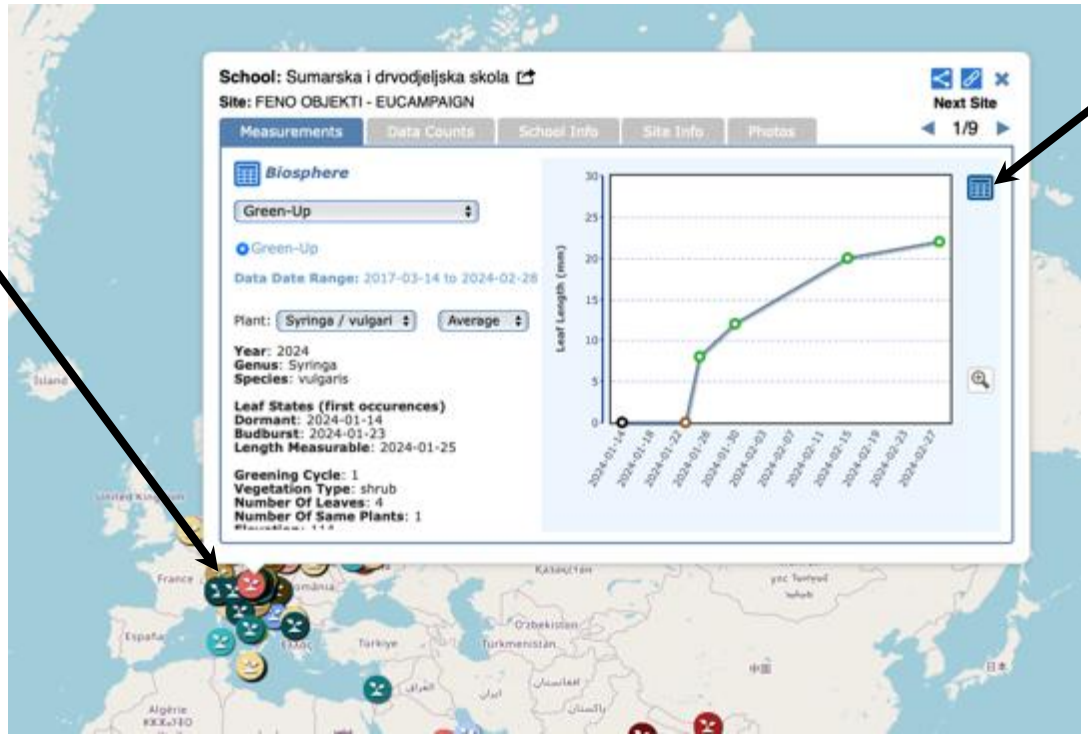
Select the date for which you need Green-Down data.



Visualize and Retrieve Data

Select the sampling site for which you need Green-Down Data, and a box will open with a data summary for that site.

Clicking on a location will open to a map note providing data for that location and time.



Click on the table icon to view the data in a table and download it as a .csv 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. Sign on to the GLOBE website and take the assessment corresponding to Grass Green-Down Protocol.

When you pass the assessment, you are ready to take **Grass Green-Down** measurements!

Welcome to the **Green-Down GLOBE 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.

Questions about the content of this module? Contact GLOBE: training@nasaglobe.org.

Credits

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