



**THE GLOBE PROGRAM**

A Worldwide Science and Education Program



**Biosphere**



**Tree and Shrub**

**Green-Up Protocol**





A. What is  
Tree and Shrub  
Green-Up?

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

C. How Your  
Measurements  
Can Help

D. How to  
Collect Your  
Data

E. Entering  
Data on GLOBE  
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F. Understand  
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G. Quiz  
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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-up
- Describe the importance of quality control steps in the the collection of accurate data
- Describe why green-up data is important for understanding our changing Earth system
- Identify a tree and shrub green-up study site and conduct measurements in the field
- Upload data to the GLOBE portal
- Visualize data using GLOBE's Visualization Site

*Estimated time of completion of module: 1.5 hours*





## A. What is Tree and Shrub Green-Up?

## B. Why Collect Tree and Shrub Green-Up Data?

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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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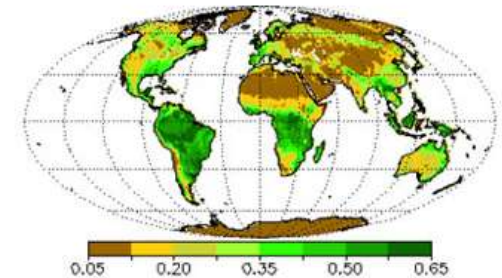
## F. Understand the Data

## G. Quiz Yourself

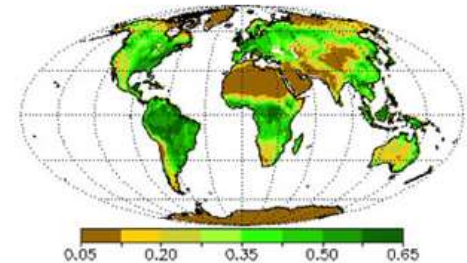
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# What is Green- Up?

- Phenology is the study of living organisms' response to seasonal and climatic changes in the environment in which they live.
- 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.



March  
1987



May  
1987

Image: NDVI, NASA



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## When is Green-Up?

- 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.







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## Why Collect Green-Up 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-up data are used by scientists to:

- To calculate growing season length and monitor interannual changes in growing season duration
- To determine how environmental conditions such as air and soil temperature, precipitation, soil moisture, and day length affect plant growth
- To monitor the nature and extent of climate change and its effects on plants and animals
- To help interpret satellite observations of greenness
- use in climate and ecological models, and predicting forested or grassland area susceptibility to fire.





## How Your Measurements Can Help

- 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.



- Here is a [link](#) to a scientific visualization that shows changes in early spring frost-free regions, comparing average values in the early 1950s with the late 2000s:



1950-1952 average



2009-2011 average

Image Credit: NASA SVS

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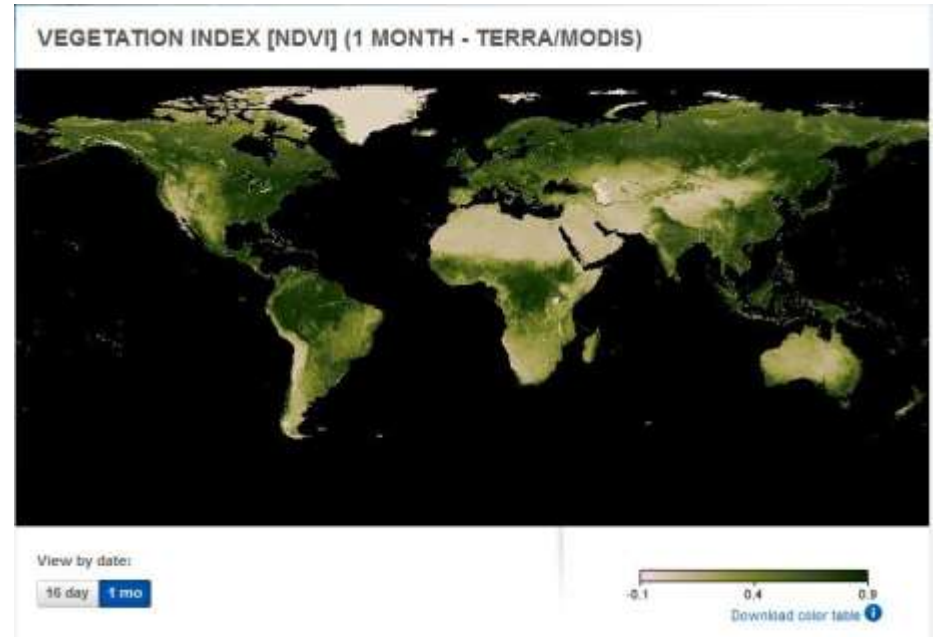
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## Green-Up data help scientists to interpret satellite images

Many 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.

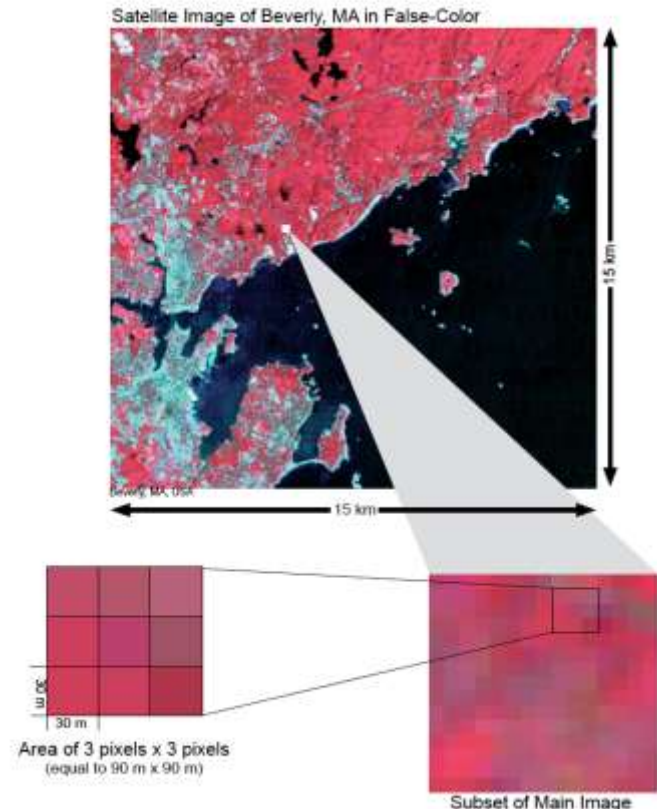




## Scientific Importance of Green-Up and Green-Down

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).*

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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**

**Were you correct?**

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## 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?**

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

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

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- 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-Up Protocol

When	At least twice a week beginning two weeks prior to the anticipated start of green up, until leaf growth plateaus*
Where	Tree and Shrub Green-Up and Green-Down Site
Time Needed	10-15 minutes per measurement
Prerequisites	None
Primary Instrument	Metric ruler
Skill level	All
References	Tree and Shrub Green-Up Protocol Field Guide Tree and Shrub Green-Up Data Sheet Tree and Shrub Green-Up and Green-Down Site Selection Field Guide and 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 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.



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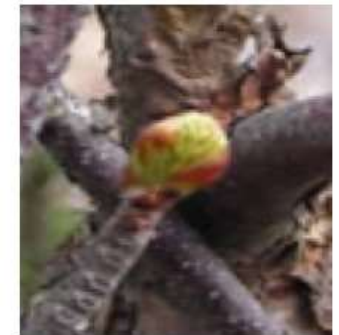
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## Important Definitions for Green-Up

- **Dormancy** is a state of suspended growth and metabolism.
- **Swelling** is seen when the bud is getting bigger.
- **Budburst** is the emergence of new leaves (photosynthetically active foliage) on plants, which signals the beginning of a new growing season cycle.







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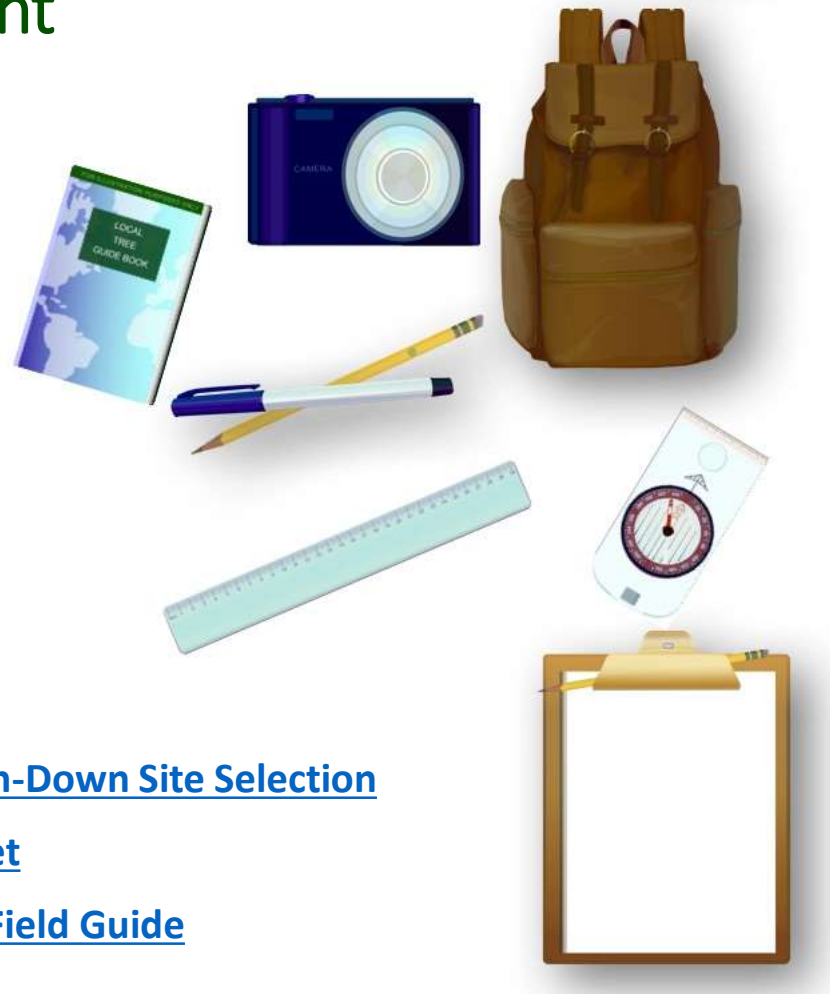
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# Tree and Shrub Green-Up Protocol Assemble Field Equipment

## *What You Need*

- Pencil or pen
- Camera
- Compass
- Fine-Tip Permanent Marker
- Ruler with mm units
- Tree ID Guide



## Documents Needed in the Field

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



## Tree and Shrub Green-Up Protocol (1/8 slides) Overview of Steps

- Define the site
- Take GPS measurement
- Tree and shrub species
- Take pictures of study site
- Tree or shrub data: four buds of the same branch
  - Date
  - bud condition
  - leaf length



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## Site selection (2/8)

- Site selection is important!
- Objective – chose plants that are indicative of the surrounding climate
  - Native species
  - Not watered or fertilized
  - Away from buildings.



***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.***





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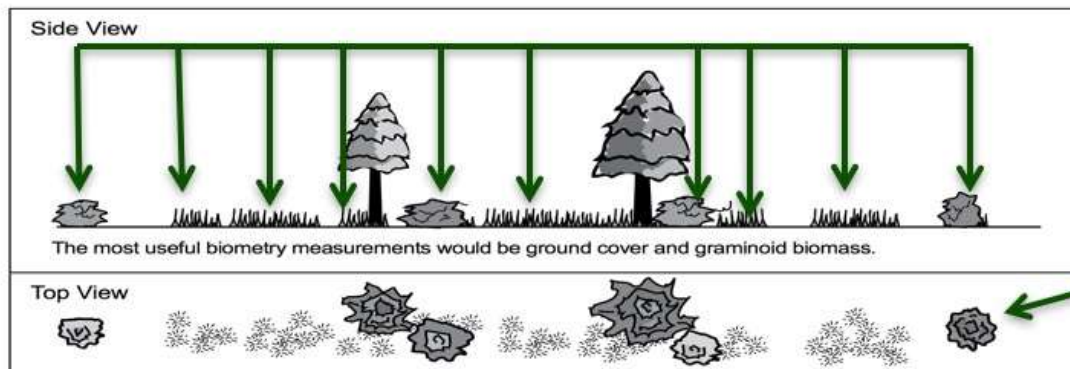
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## Other Site Selection Considerations (3/8)

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”?



Satellite  
View

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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## First Visit: Tree and Shrub Green-Up Protocol (4/8)

### First time only/getting started

1. Complete the upper portion of your **Tree and Shrub Green-Up Data Sheet**.
- 2. For the selected tree or shrub, locate the bud at the end of the branch. Label this bud by marking one dot on the branch next to the bud.
- 3. Locate the three other buds closest to this bud. Label these buds by marking two, three, or four dots next to them.



Photo Credit: Markus Eugster



## First Visit: Tree and Shrub Green-Up Protocol (5/8)

- **First time only:**
- 4. Take a photograph from the center of your site looking in the north, south, east, and west directions.



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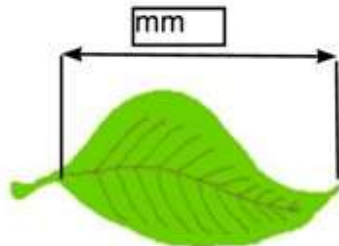
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## Every Visit: Tree and Shrub Green-Up Protocol (6/8)

1. Examine each bud.

- Record “dormant” if the bud is unchanged.
- Record “swelling” if the bud is getting bigger.
- Record “budburst” the first day you see the green tips of leaves.
- Record “lost” if something happens to the bud and you cannot continue observations.

2. After each budburst, use a ruler to measure the length of the leaf or leaves. Do not include leaf stem or petiole in your leaf measurements.



3. Measure the leaves until the leaf length stops increasing. Different leaves may stop growing at different dates





## Every Visit: Tree and Shrub Green-Up Protocol (7/8)

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Tree and Shrub Green-Up					
Date (day & month)	Leaf 1 (dormant, swelling, budburst, leaf length (mm))	Leaf 2 (dormant, swelling, budburst, leaf length (mm))	Leaf 3 (dormant, swelling, budburst, leaf length (mm))	Leaf 4 (dormant, swelling, budburst, leaf length (mm))	Data entry ✓



Measure leaf  
length





## Every Visit: Tree and Shrub Green-Up Protocol (8/8)

### Tree and Shrub Green-Up

Date (day and month)	Leaf 1 (Dormant, Swelling, Budburst, Length (mm), Lost)	Leaf 2 (Dormant, Swelling, Budburst, Length (mm), Lost)	Leaf 3 (Dormant, Swelling, Budburst, Length (mm), Lost)	Leaf 4 (Dormant, Swelling, Budburst, Length (mm), Lost)	Reported to GLOBE Database <input checked="" type="checkbox"/>
3 March	dormant	dormant	dormant	dormant	<input checked="" type="checkbox"/>
6 March	dormant	dormant	dormant	dormant	<input checked="" type="checkbox"/>
11 March	swelling	swelling	swelling	dormant	<input checked="" type="checkbox"/>
14 March	budburst	budburst	swelling	swelling	<input checked="" type="checkbox"/>
18 March	2	4	budburst	budburst	<input checked="" type="checkbox"/>
22 March	6	10	5	6	<input checked="" type="checkbox"/>
25 March	12	15	10	12	<input type="checkbox"/>
29 March	20	22	18	19	<input type="checkbox"/>
2 April	30	32	25	28	<input type="checkbox"/>
5 April	38	lost	36	38	<input type="checkbox"/>
8 April	45		42	44	<input type="checkbox"/>
11 April	45		44	44	<input type="checkbox"/>
14 April	45		44	44	<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 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 many buds do you need to monitor on each branch when applying the Green-up Protocol?

- a) All the buds
- b) 10 buds
- c) 4 buds
- d) 1 bud

**What is the answer?**

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## Let's review so far! Answer to Question 5

How many buds do you need to monitor on each branch when applying the Green-up Protocol?

- a) All the buds
- b) 10 buds
- c) **4 buds – correct 😊**
- d) 1 bud

**Were you correct?**

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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](mailto: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:

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## Data Entry Screen- Step 1

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

✕ Add site

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

#### 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](#)





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## Data Entry Screen- Step 2

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

**Add the Tree/Shrub  
you are  
monitoring for  
Green-Up**

**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 scutiflora

Label  
Shrub -Salix (willow)

☒ This plant is in the understory Remove

Vegetation Type Grass Genus BROMUS

Label  
Grass -Brome

Add plant

Photos

Photo Date: [ ]

Update Site Reset

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



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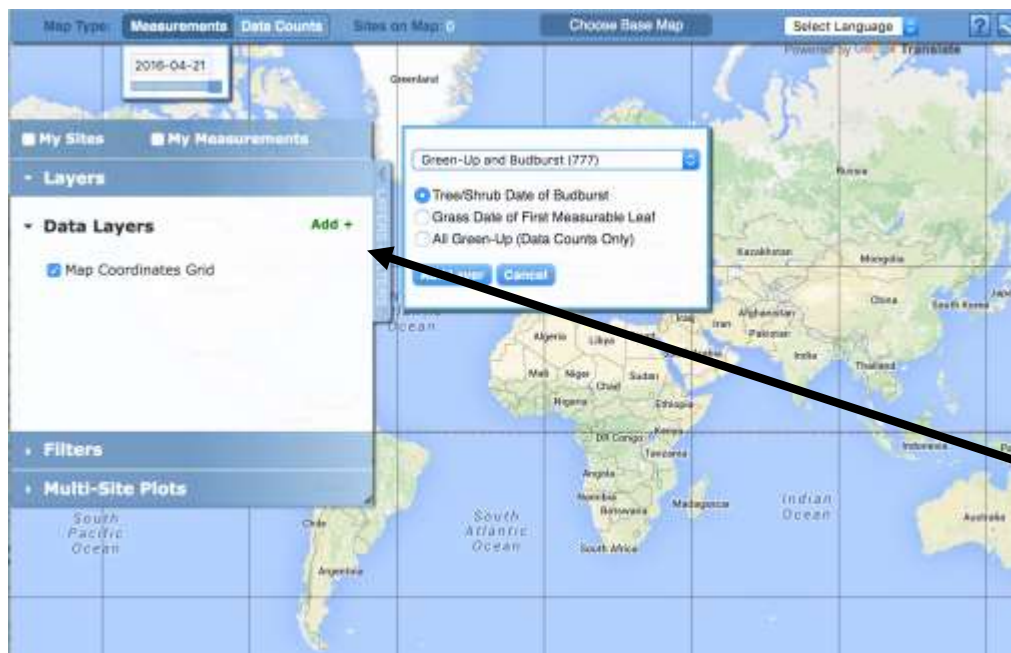
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## Visualize and Retrieve Data- Step 1

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.



Click on “add”  
and select  
Green-Up and  
Budburst from  
the 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](#)



## Visualize and Retrieve Data- Step 2

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



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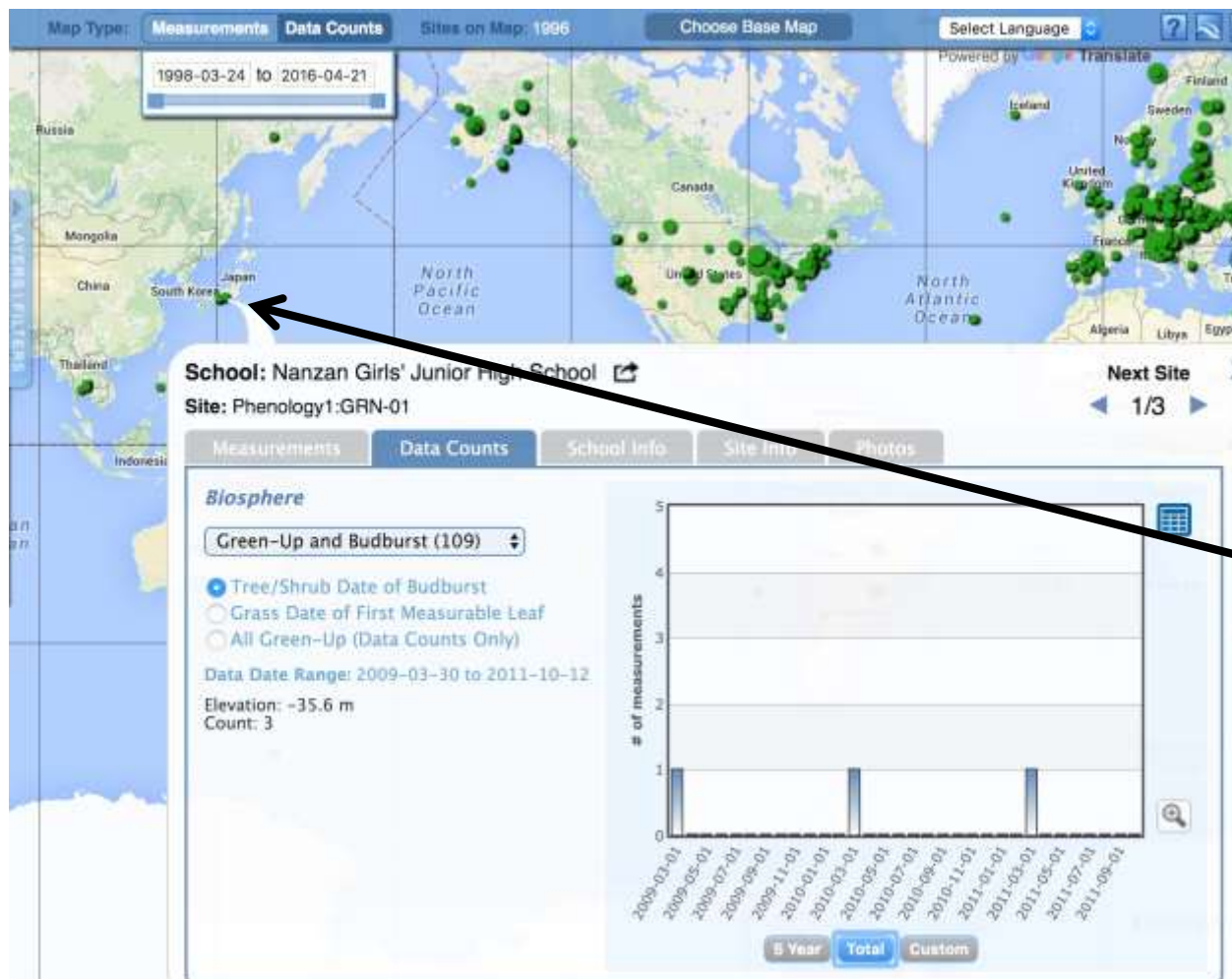
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## Visualize and Retrieve Data- Step 3



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.

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# Review questions to help you prepare to do the Tree and Shrub Green- Up Measurements as part of the GLOBE Phenology Protocols

1. Tree Green-Up 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-Up takes place in a location, year by year?
4. Has Green-Up dates changed in North America over the past 70 years?
5. Define these terms: Dormancy, Swelling and Budburst.
6. Why is it important that your sampling site is not located close to a building?
7. Why do you think it is important to monitor green-up of a dominant native species?
8. Why is it important to identify your tree to genus and species?
9. How do you mark the buds so you know to measure the same buds throughout the green-up season?
10. When you measure the leaf, do you measure from the base of the leaf stem?



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## You are done!

- You have now completed the slide stack. If you are ready to take the quiz, sign on and take the quiz corresponding to **Tree and Shrub Green-Up 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-Up** measurements!
- Welcome to the **Green-Up GLOBE community!**



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## Frequently Asked Questions- FAQ

### **Will the marker hurt the bud?**

Do not mark the bud itself. Mark the woody branch next to it. That way you will not hurt the plant.

### **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.

### **Will all the buds start to swell at the same time?**

No. Some of the buds on your branch may not green-up on exactly the same day as the terminal bud.





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## Frequently Asked Questions FAQ- 2

### **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.

### **What if multiple leaves emerge from a single bud after the bud bursts open?**

Choose one of the leaves and mark it with the permanent marker. Take measurements of the marked leaf.

### **Should I look at the same buds from year to year?**

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





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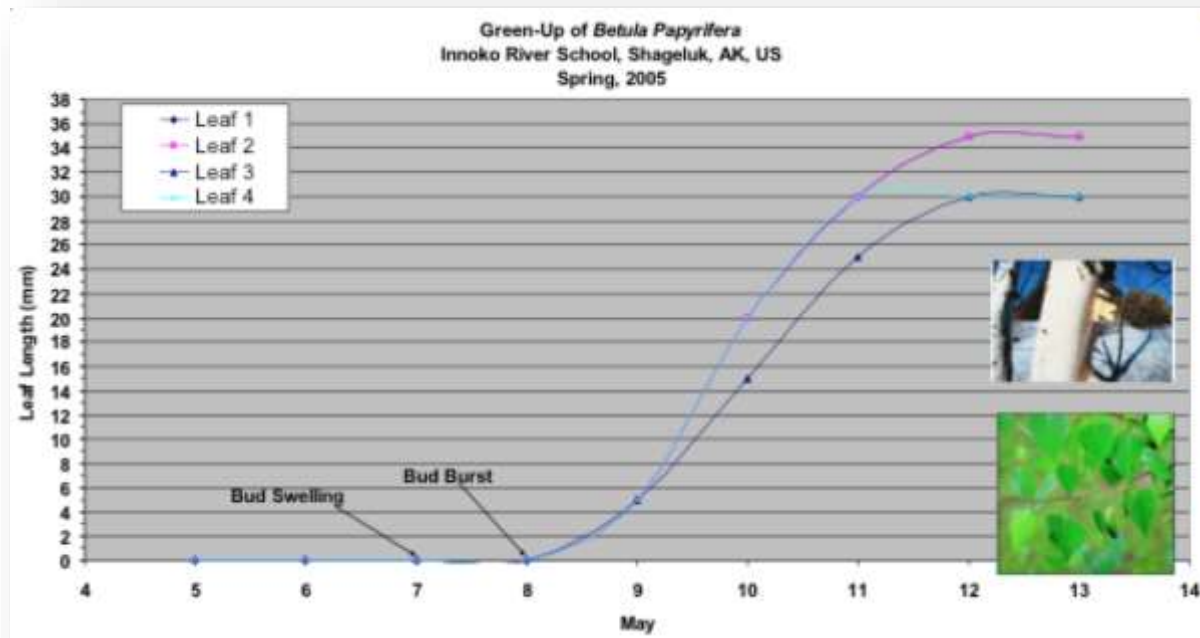
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## Data Analysis Example

- Do leaves grow at the same rate for different species?
- Will leaves of the same species grow at the same rate at different locations?



This graphic shows the green-up data of *Betula papyrifera* (paper birch) collected by the Innoko River School in Shageluk, Alaska in May, 2005. Four different leaves were measured, but two of the leaves have the same green-up trend, so the lines lay on top of each other. You can see that the green-up of these paper birch leaves happened in a span of five days. It appears that the leaves have stopped growing because the curves have plateaued, but we need additional observations to be sure. Source: GLOBE.



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## Research Questions for Further Investigation:

- How long does green-up take for a given species?
- How does green-up differ among different species within a forested study area?
- How does green-up relate to precipitation? To soil moisture?
- Does temperature influence the rate of green-up?
- What other research questions can you think of that can use green-up data?



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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](#)  
Questions about content of this module? Contact GLOBE eTraining: [rlow@ucar.edu](mailto:rlow@ucar.edu).

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