Non-Standard Site Carbon Cycle Protocols

Photo: E. Burakowski

Read the module content and take the test that follows to earn the GLOBE Biosphere: Non-Standard Carbon Cycle certificate.

Overview

This module…

- Reviews why carbon is an important element in ecosystems and how it cycles through ecosystems
- Shows how to determine if you have a *standard* or *non-standard* site.
- Demonstrates how to set up a standard sample site
- Provides step-by-step instructions for protocols
- Describes how to enter data on the GLOBE website
- Helps you understand your data

Learning Objectives

After completing this module, you will be able to:

- Describe the major pools and fluxes of the carbon cycle
- Perform field measurements to assess carbon storage and plant growth at a local field site and upload data to the GLOBE database
- Understand resources available to help you analyze and interpret your data

Estimated time to complete module: 2 hours

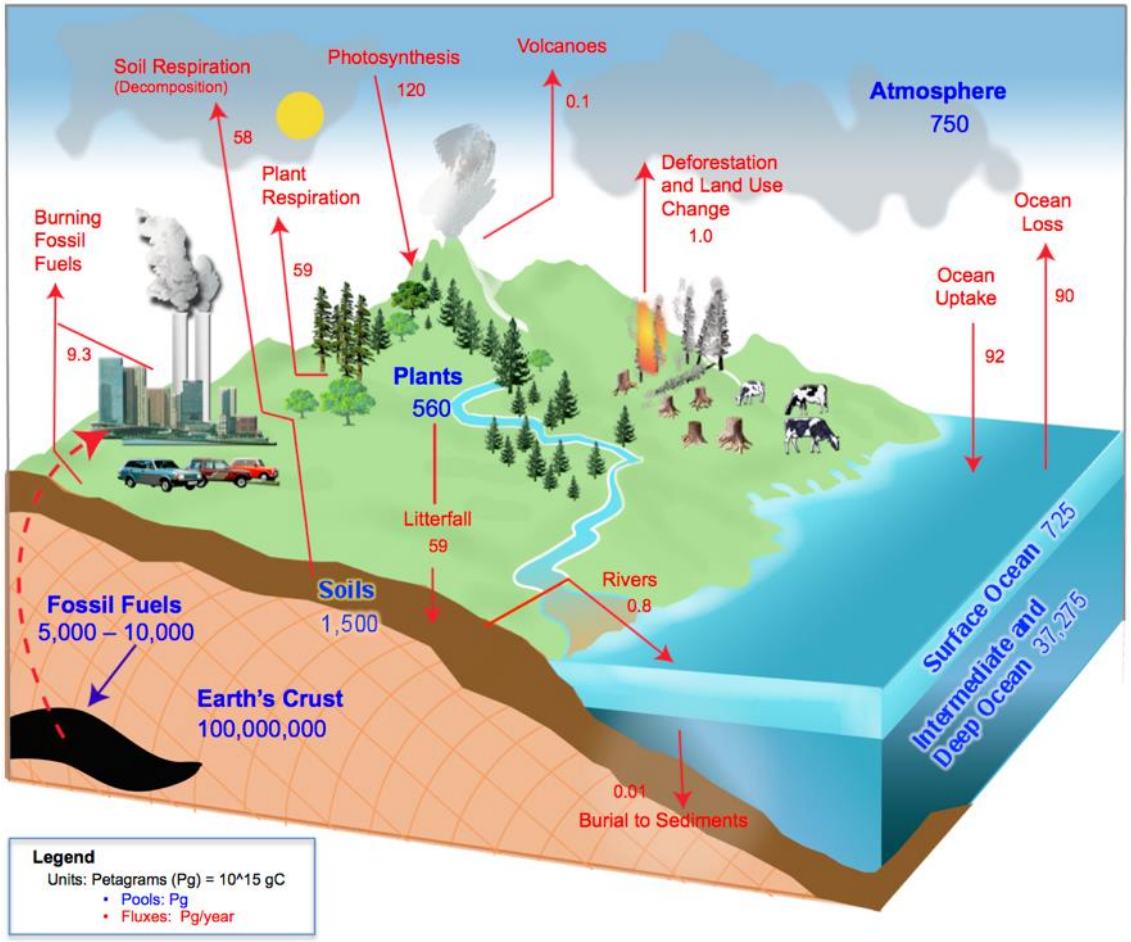
Review: What is the Carbon Cycle?

Carbon is the most abundant element in living things. It is also present in the Earth's atmosphere, soil, oceans, and crust. The **Global Carbon Cycle** is the movement of carbon between the atmosphere, land, and oceans.

The global carbon cycle is a key regulator of Earth's climate system and is central to ecosystem function. Rising CO2 is the dominant contributor to climate change. Understanding how ecosystems cycle and store carbon is key to understanding solutions to climate change.



Review: The Carbon Cycle



Carbon Pools:

A place where carbon resides, measured in Petagrams (Pg)

Carbon Fluxes:

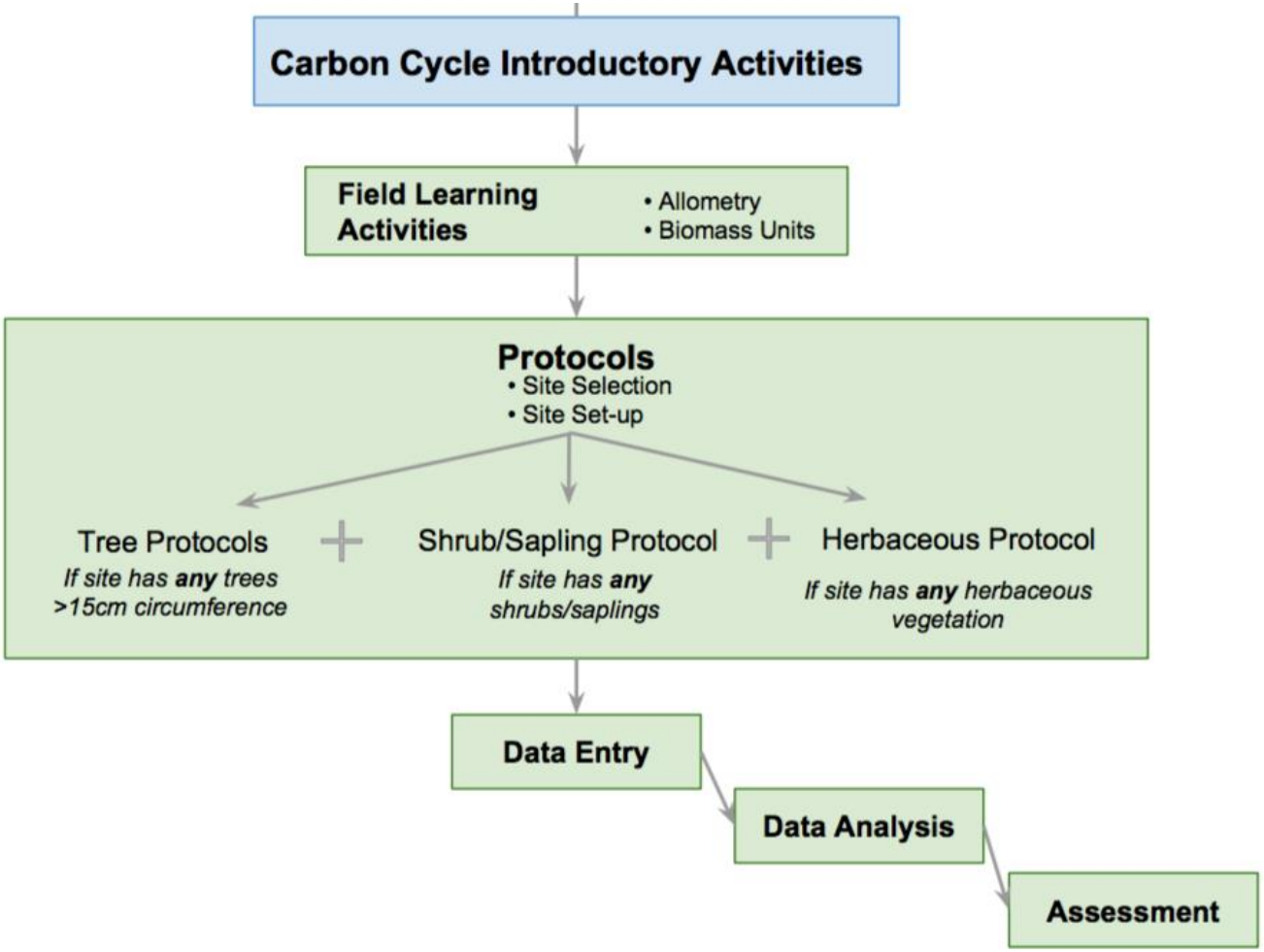
Movement of carbon between pools, measured in Petagrams/year (Pg/year)

Review: Why Collect Carbon Data?

Scientists collect carbon cycle data to understand how terrestrial ecosystems will respond to warmer temperatures and higher CO_2.

Carbon cycle data collected with GLOBE will contribute to a better understanding of the relationship between carbon storage in plants and surface climate.

Field Protocols Flowchart

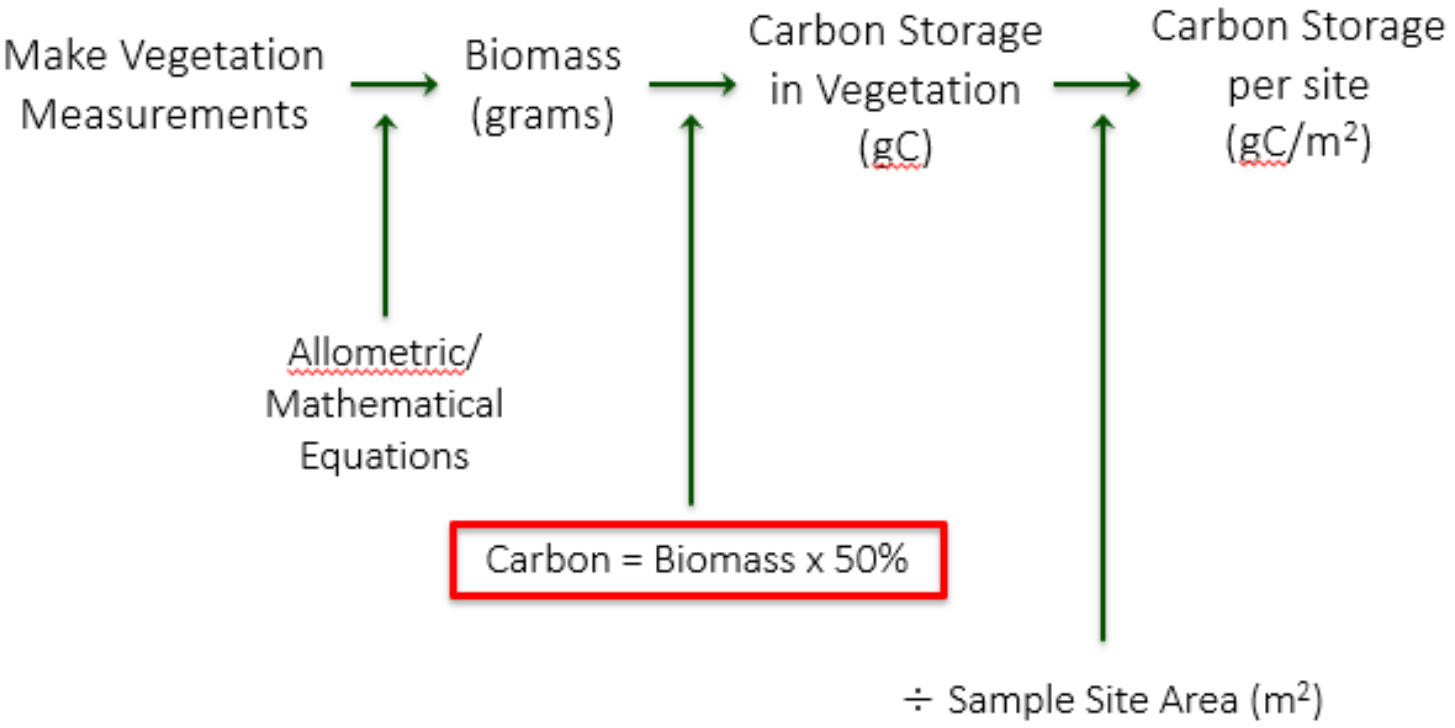


Example Research Questions

There are many research questions that can be explored through carbon field measurements. Below are some examples:

- How much carbon is stored in the vegetation near my school?
- Do different vegetation types store different amounts of carbon?
- How does the uptake of carbon by schoolyard vegetation compare to the emissions of carbon by the school (carbon footprint)?
- Is there more carbon stored in the global human population or trees in [MY STATE]?
- What is the pattern in which biomass and carbon storage change over time in my sample site? *Multiple years of data needed*

How Will You Calculate Carbon?



Non-Standard Site Carbon Field Protocols

For All Sites Complete:

1. Field Learning Activities
2. Site Selection
   - Choose your field site location
3. Site Set-up
   - Set up your site
   - Determine which vegetation you will measure based on tree size and % cover estimates

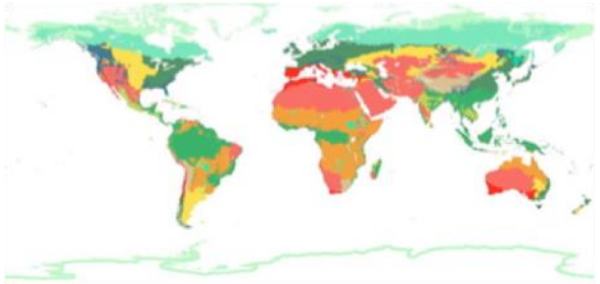
Complete some or all of the following, depending on vegetation present:

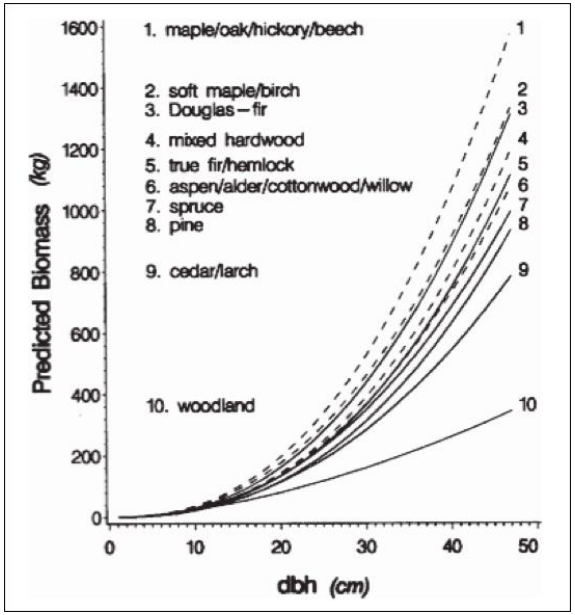
1. How to Measure Trees Supporting Protocol
2. Tree Protocols
3. Shrub/Sapling Protocol
4. Herbaceous Protocol

Field Learning Activities

These activities teach important concepts and skills for understanding and conducting Carbon Protocols.

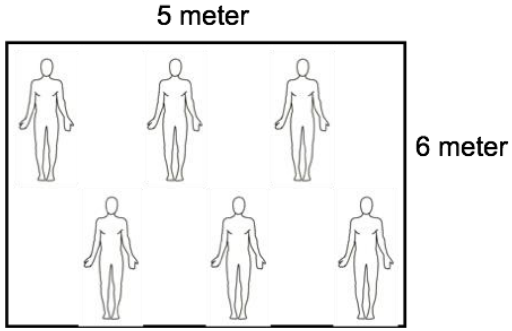
1. Biomass Units
2. Allometry

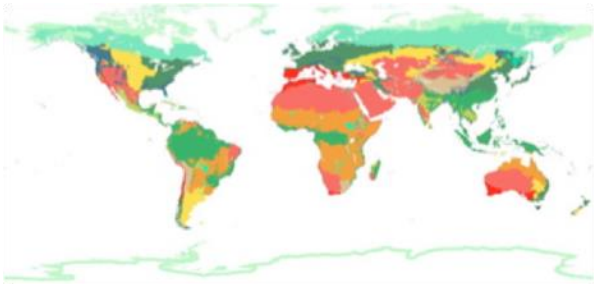




Biomass Units

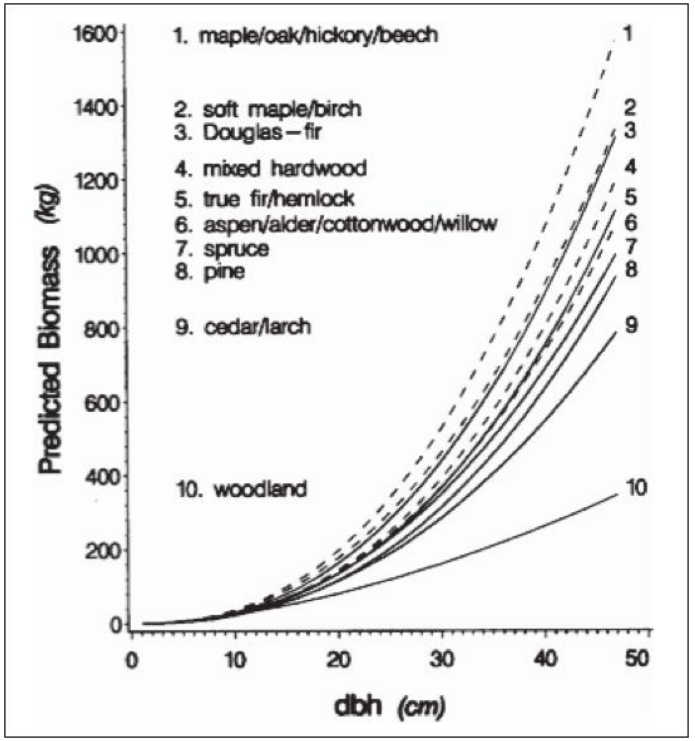
- Students calculate the biomass of the classroom in g/m2.
- Students assess how biomass would change if size or mass of a sample area were different.
- Students rank global biomes from greatest to least biomass and compare their guess to available data.
- Students estimate how much carbon is stored in their in schoolyard (g C/m2) based on their biome classification and what they see.





Allometry

- Students measure their height, arm span, and foot length to show how living organism's parts are related to the whole (allometry).
- Students use this concept to understand how circumference/DBH of trees can be used to estimate biomass.
- Students view allometric relationships of tree species groups.



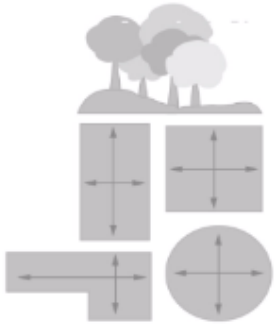
Jenkins et al. 2003

Site Selection

Site selection can be completed with or without student involvement

Determine if your site is a "Standard" or "Non-standard" site:

Standard Site - an accessible area of at least 225 m^2 (15m x 15m) of contiguous vegetation (forest, shrubland, grassland). Aim for 30 m x 30 m (900 m^2). A smaller or different shaped area will work; modify Tree Mapping protocol to suit your site & students.



Please use Standard Site Carbon Cycle Protocols eTraining

Non-standard Site – an accessible area of 225 m^2 (15m x 15m) with some vegetation and some human interference (i.e. a local park, city block, or the school area itself).

Site Selection (Cont'd)

Site selection can be completed with or without student involvement

For a Non-Standard site:

Use aerial maps to make a rough count of the number of trees in the schoolyard, park, or neighborhood of interest.

a) If the number of trees is < 150, your sample site size will be the entire area (i.e. A city block).

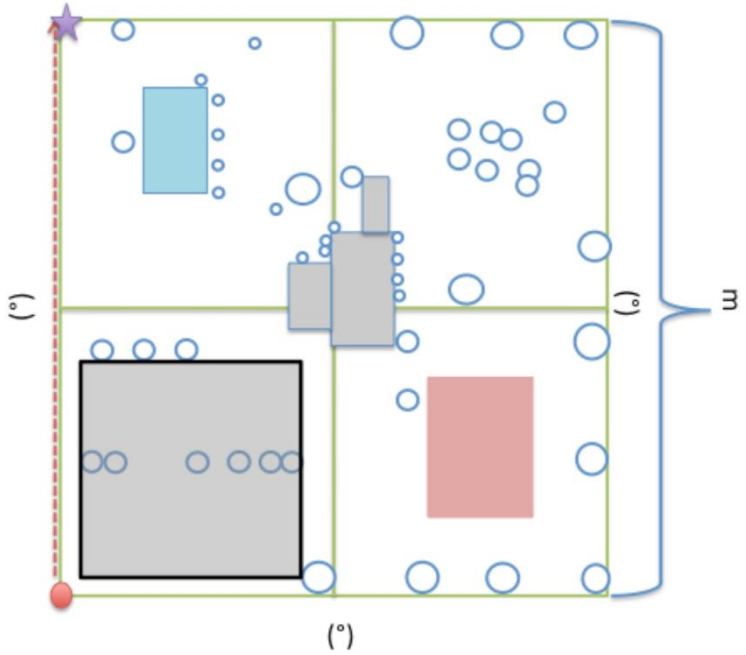
b) If the number of trees is ≥ 150, select 1-2 smaller areas in which to perform all field measurements for carbon.

Non-Standard Site Set-Up

Before going out in the field, students learn necessary skills for Site Set-up: pacing, compass, (and optional GPS).

Students then work in teams to set up a Carbon Cycle sample site:

1. Perimeter Team
2. Photography Team
3. Data recording Team
4. GPS Team if using GPS unit*.

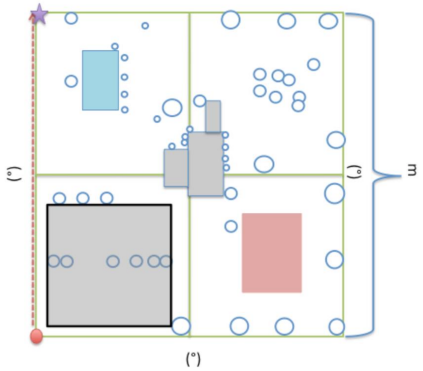


*If using phone for GPS, data recording team collects coordinates

Non-Standard Site Set-up (Cont'd)

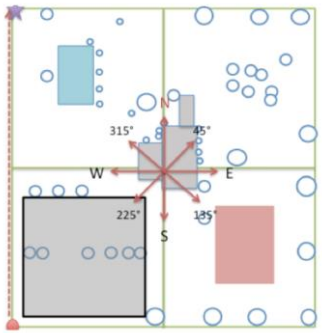
Perimeter Team

Start at one corner of the site and rotate clockwise until facing nearest corner. Record bearing and paces to nearest corner. Repeat for each corner.



Photography Team

Select a spot in middle of site to take photos. Use compass to take one photo in nine directions below and work with data recording team to enter photo numbers or photo time-stamp on site set-up sheet.



Data recording Team

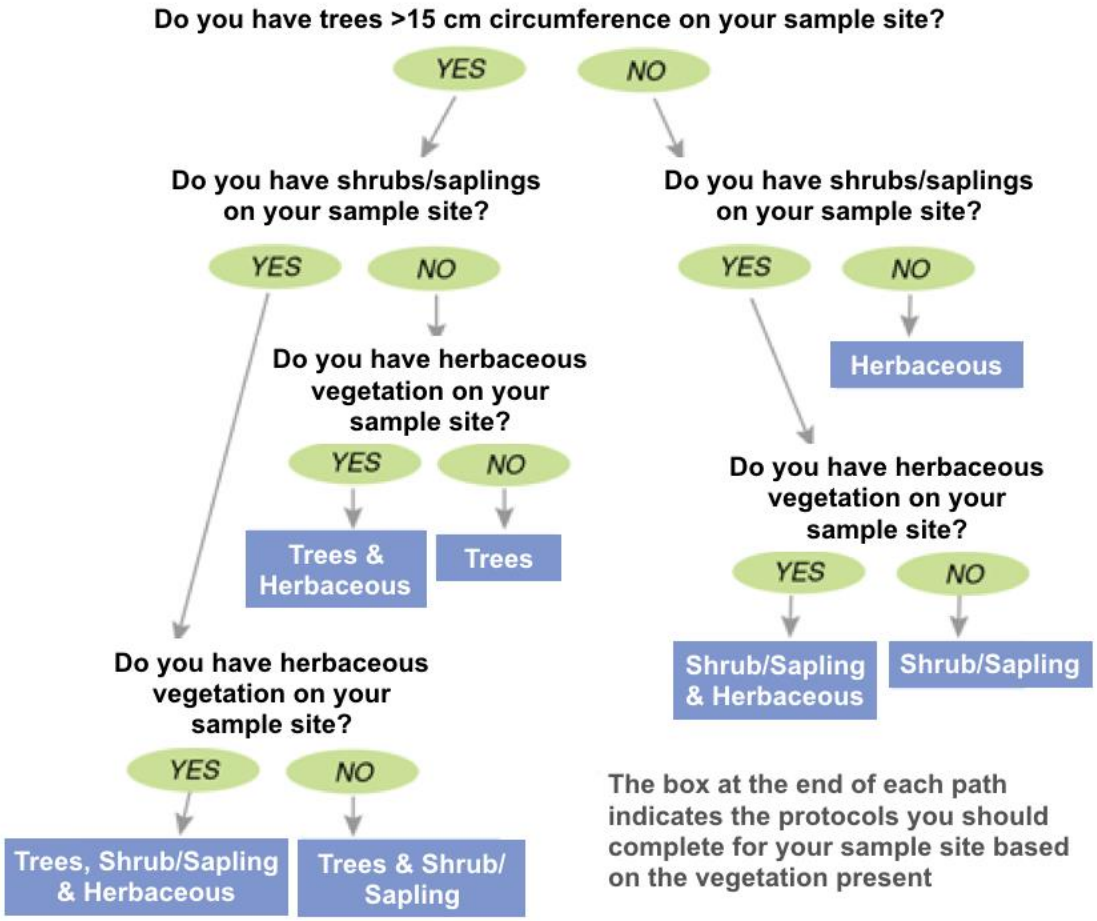
Each team member independently estimates percent cover of shrubs & saplings and herbaceous cover.

Work with photography team to record the photo numbers. Use the time stamp of the photo if using a smart phone.

Provide additional info to metadata section (ie: MUC classification, dominant species, water, etc.)

Protocol Decision Tree

Determine which vegetation you will measure.



*Not sure how big the trees are? See Supporting Protocol 'How To Measure Trees' for instructions on accurate circumference measurements

Trees: Protocol Overview

How to Measure Trees ***(Supporting Protocol)***	Time: 60 minutes Instruments: tree cookies, small flexible measuring tape, calculator Prerequisites: None
Tree Mapping **This can be done simultaneously with tree circumference, shrub/sapling & herbaceous measurements (if applicable).*	Time: 70 minutes (only needs to be completed once per site) Instruments: 50 m flexible measuring tape, local tree ID guide, compass Prerequisites: Site Set-up, How to Measure Trees, Field Learning Activities (Biomass Units, Allometry)
Tree Circumference **This can be done simultaneously with shrub/sapling & herbaceous measurements (if applicable).*	Time: 60 minutes Instruments: Measuring tapes (150-300 cm) Prerequisites: Site Set-up, How to Measure Trees, Tree Mapping, Field Learning Activities (Biomass Units, Allometry)

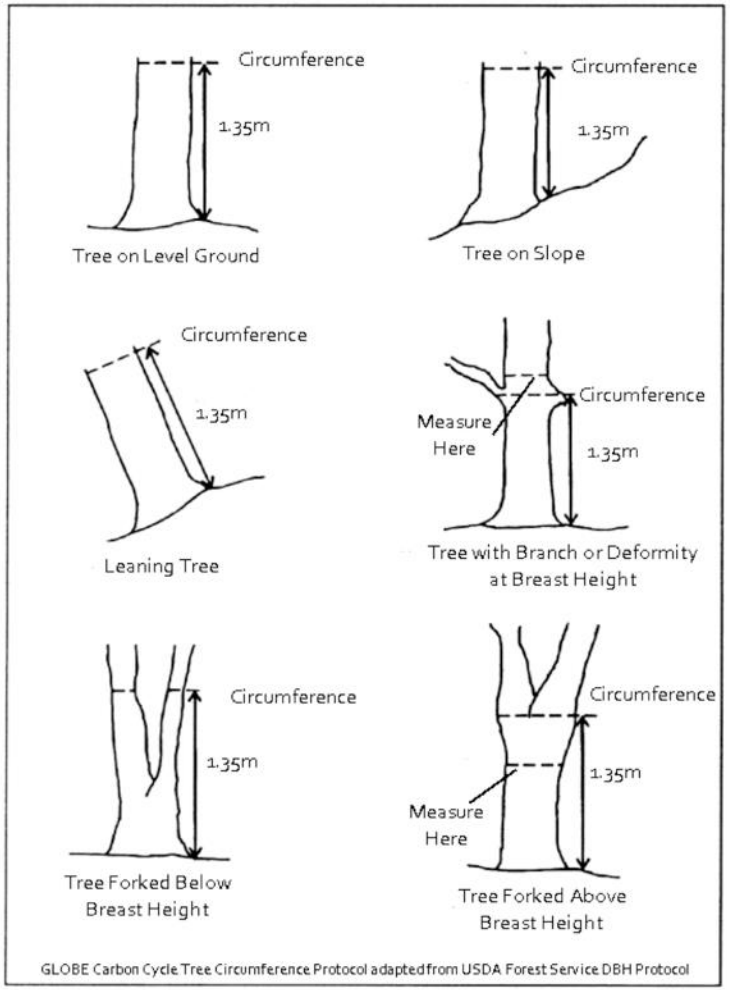
How to Measure Trees

- Students measure tree cookies to understand the relationship between circumference and diameter
- Students learn that **circumference is measured at 1.35 meters from the tree base**
- Students gain understanding of concepts precision and accuracy

How to Measure Trees (Cont'd)

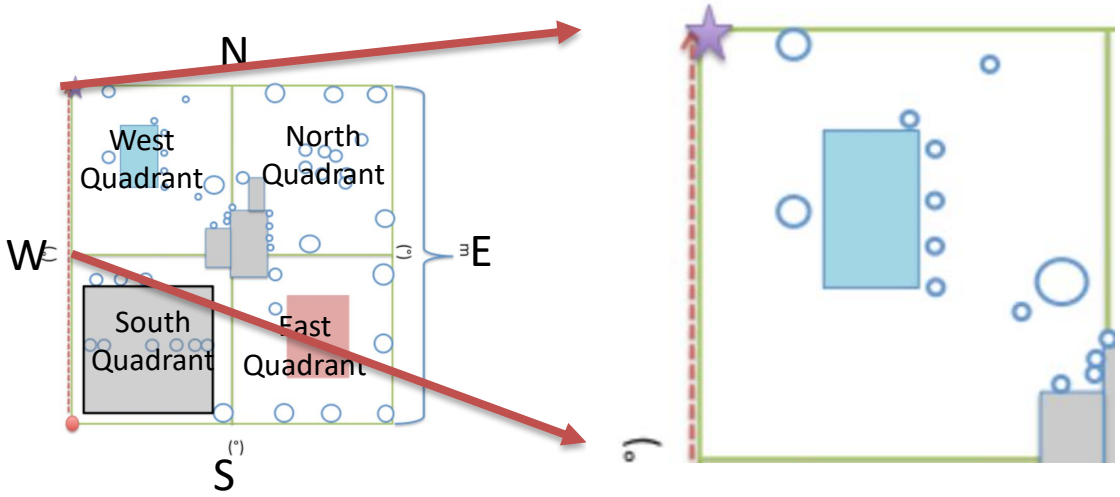
Use the '*Badly Behaving Trees Guide*' at right to accurately measure trees in the field plot:

- Measure up 1.35m from the highest point around the base of the tree - this is "breast height".
- Measure around the tree at the given height in cm to find tree circumference at breast height.
- This can later be converted to diameter at breast height (DBH).



Tree Mapping

1. Aerial image mapping – students draw circles around trees and shrubs visible on a Google Earth aerial image. Devise a naming/numbering system for your trees.
2. Divide class into four quadrant teams. Sub-divide quadrant team into Data Recorder, Tree Verification, and Species ID teams.



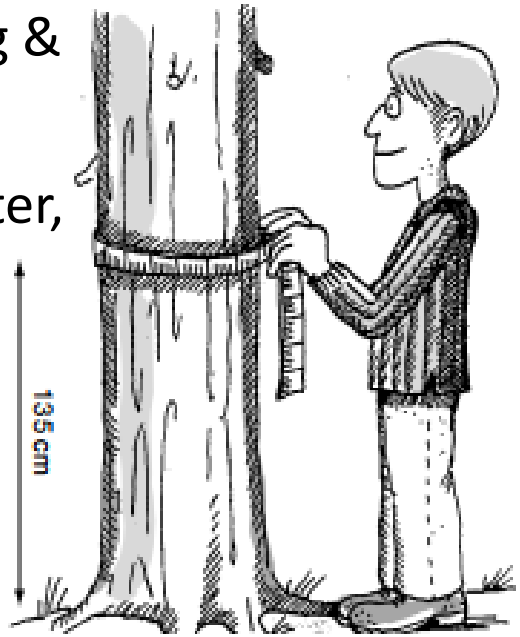
Tree Mapping (Cont'd)

3. Verify trees from aerial image and identify the genus and species.
4. If completing in conjunction with the Tree Circumference protocol, you will also measure circumference at this time.

Tree #s:				Collection Year #: 1
			Date:	2011
Tree #	Notes	Specific Scientific Name	Species Group	CBH (cm)
NE 1	Red Maple	Acer rubrum	Maple Oak	60

Tree Circumference

- Measure circumference at breast height (CBH, 1.35m) for all mapped trees, currently living & greater than 15cm CBH on your site.
- Measure CBH to the nearest tenth centimeter, e.g. 16.6cm.
- In the 'notes' section of the data sheet, include:
  - If the tree has died since the previous year
  - The common name of the tree
  - If circumference was not measured at breast height (due to tree branching or bulging- *See the 'Badly Behaving Tree Guide' for more information*)



Shrubs/Saplings: Protocol Overview

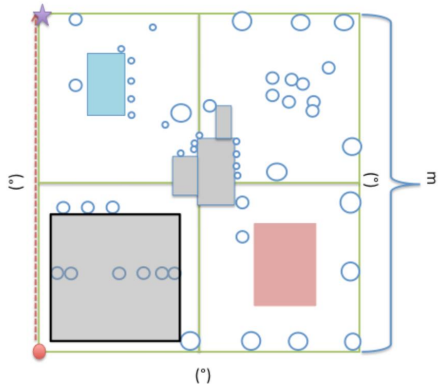
Shrub/Sapling Protocol ***This can be done simultaneously with tree & herbaceous measurements (if applicable).*** ***Complete each year***	**Time: 40 minutes** **Instruments: Compass, 2-3 m stick marked in centimeters** **Prerequisites: Site Set-up**

Shrub/Sapling Protocol

For each plot corner:

- Start at one edge of the site. Measure each shrub on the entire site.
- Mark ‘E’ if the species is evergreen and measure the height of the shrub or sapling
- Mark ‘D’ if the species is deciduous and measure the height of the shrub or sapling.
- Record the length in meters of the longest and shortest sides of the shrub. Also measure the height of the shrub if < 2-3 m tall. If > 2-3 m tall, use a clinometer or estimate height of shrub.
- Repeat for all shrubs and saplings on your site.

Non-Standard Shrub/Sapling Measurements - Student Field Guide



GLOBE Carbon Cycle - Non-Standard Shrub/Sapling Data Sheet

School:			Date:		
Site Name:					
Recorded By:					
Sample #	Type (E = evergreen, D= deciduous)	Length of Longest Side (m)	Length of Shortest Side (m)	Estimated Representative Height (m)	Notes
1					
2					
3					
4					
5					

Datasheet

Herbaceous Vegetation: Protocol Overview

Herbaceous Vegetation Protocol **This can be done simultaneously with tree & shrub/sapling measurements (if applicable).* **Complete each year*	**Time: 40 minutes** **Instruments: OUTSIDE: beanbag, blindfold, measuring tape, clippers, small brown paper bags, INSIDE: balance, drying oven (optional)** **Prerequisites: Site Set-up**

Herbaceous Protocol

Herbaceous Measurements - Student Field Guide

Collect samples of herbaceous vegetation from the site.

1. Blindfold a member of the team and have him/her/them throw a beanbag somewhere in the sample site.
2. Mark a one-meter square around the bean bag to take a random sample.
3. Using grass clippers, clip all the vegetation close to the ground within the square. Do NOT collect any leaves or litter that are already dead or unattached from the ground.
4. Place clippings into brown paper bags and label with the site name, date, and sample number (e.g., Field Site Name, Herb Sample #1, bag 1 of 2).
5. Repeat steps 1-5 two more times.

Herbaceous Protocol (Cont'd)

Dry the herbaceous samples by either:

(a) **Drying oven:** Set oven temp to 50-70°F, put labeled bags in drying oven. Weigh the bag once per day after day one until sample weights the same two days in a row. Record the mass (g) of the sample + bag and the mass of the empty bag.

(b) **Air drying:** Select a dry, secluded area large enough for all sample bags. Open the tops of the bags for maximum airflow. Weigh once per day after day five, until sample weighs the same two days in a row. Record the mass (g) of the sample + bag, and the mass of the empty bag.

Herbaceous Measurements - Student Field Guide

Image: censam.mit.edu

Image: iowalearningfarms

Data Entry at Globe.gov (1/3)

After students have returned from the field with their paper data sheets, data can be shared with the GLOBE and scientific community by entering it into the GLOBE online science database (https://data.globe.gov).

When you submit your data through GLOBE, the calculations to convert your raw data to biomass and carbon storage values will be completed for you.

***Before you enter data,** review it as a class, checking for data quality including precision and typos. See the Carbon Cycle Data Entry Teachers Guide for notes and suggestions .

As Part of your data review - Compare Data To Previous Years if applicable

1. Did any trees increase in circumference? Is it what you expected? Any possible errors? Compare large trees to small trees.
2. Any decreases in tree circumference? Have trees died? Difficult bark (wavy, bumpy)? Measured at same height?
3. Differences in species?
4. Any new trees? Factors that affected current year (i.e.: ice storms, insects, hurricanes).

Data Entry at Globe.gov (2/3)

Data can be entered to the GLOBE website in three ways:

1. Live Data Entry: These pages are for entering environmental data, collected at defined sites, according to protocols, and using approved instrumentation – for entry into the official GLOBE science database.

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

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

Data Entry at Globe.gov (3/3)

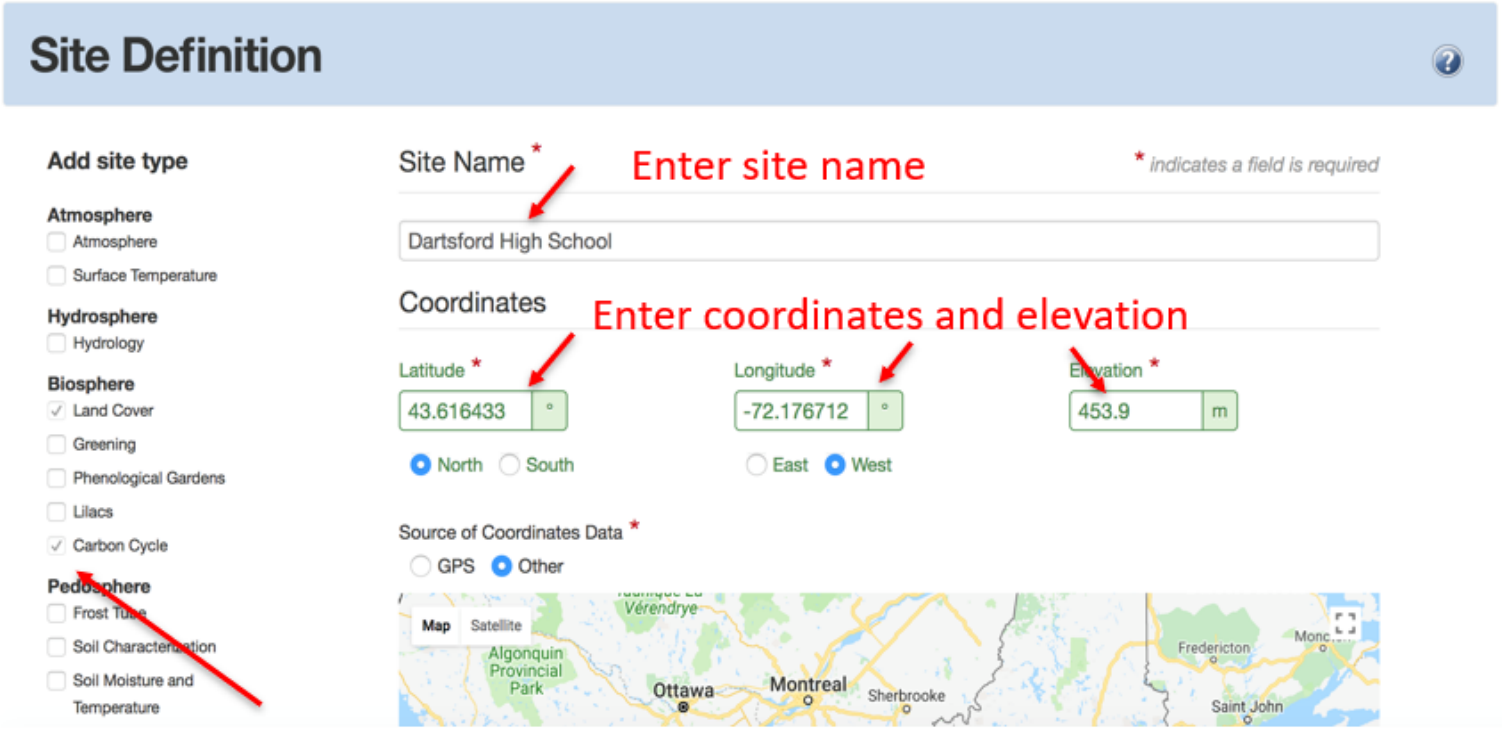
To add your Carbon Cycle data to the GLOBE website, create a new site if you do not already have one.

If you already have a Carbon Cycle site, you can skip ahead to add your Carbon Cycle data.

Add new site at Globe.gov

1. Add new site
2. Add site coordinates by map
3. Describe site, and indicate if standard or non-standard
4. Land Cover type (see Land Cover eTraining)
5. Add MUC description
6. Add site photos
7. Submit

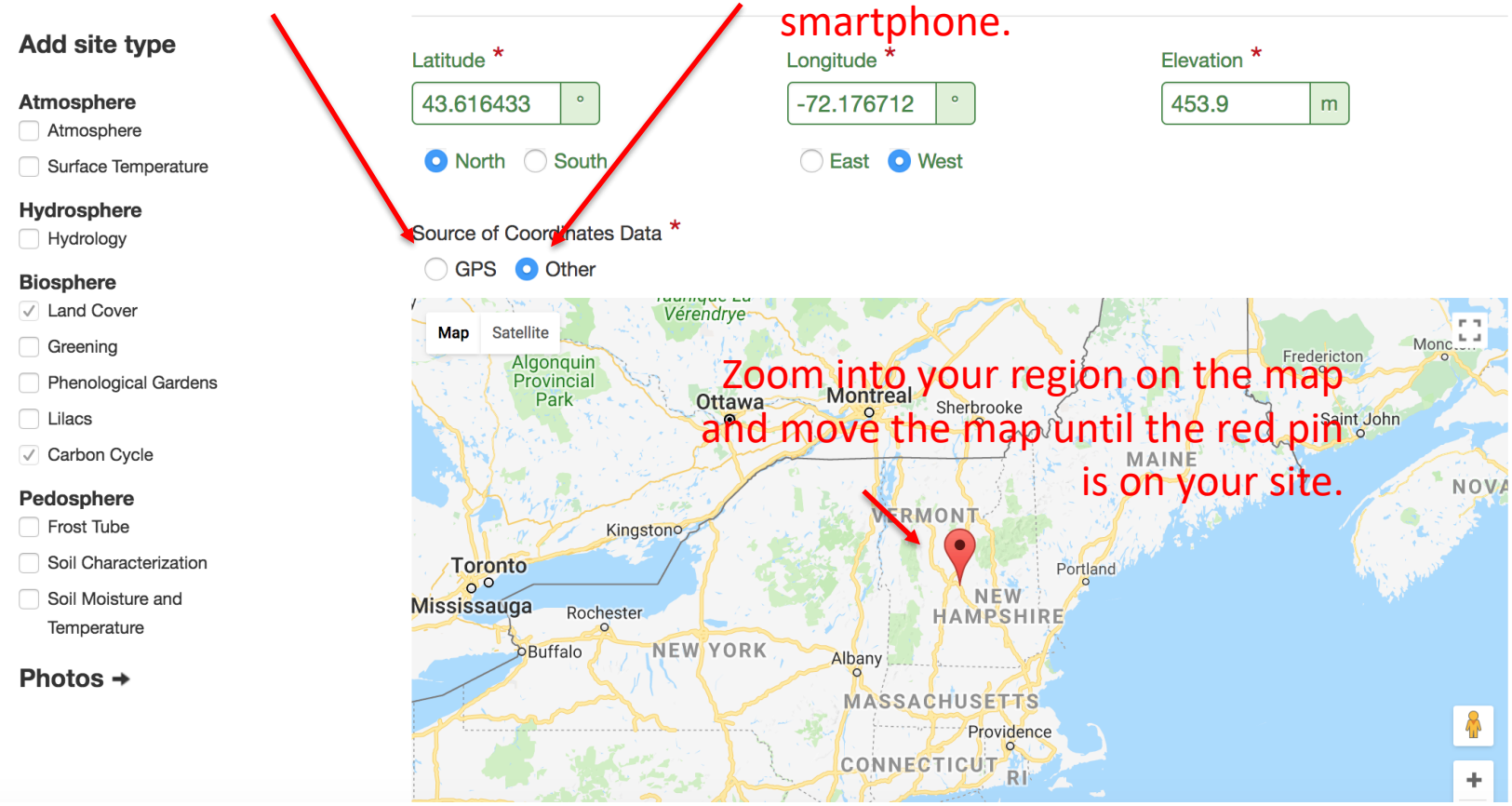
1. Add new site



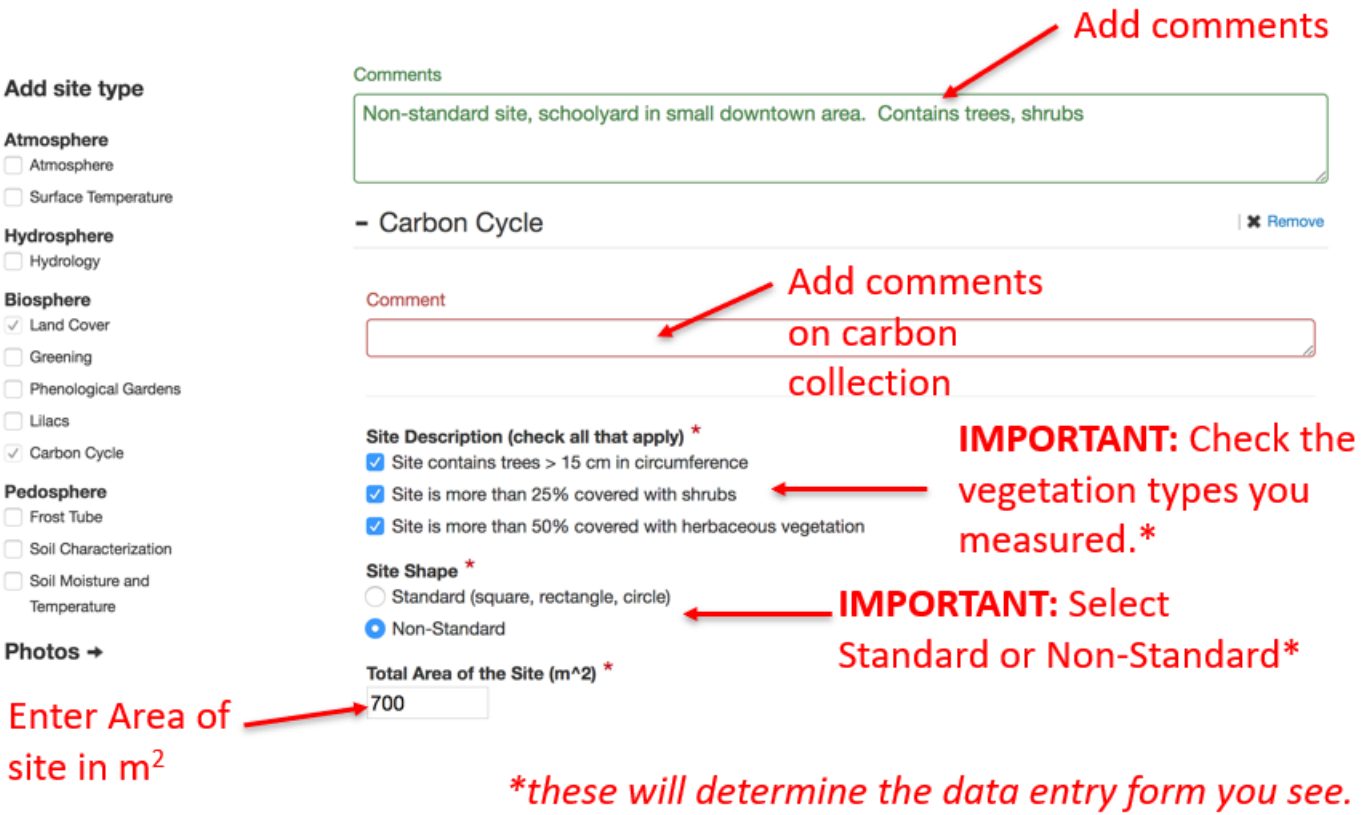
2. Add site coordinates via map

Select 'GPS' if you used a GPS.

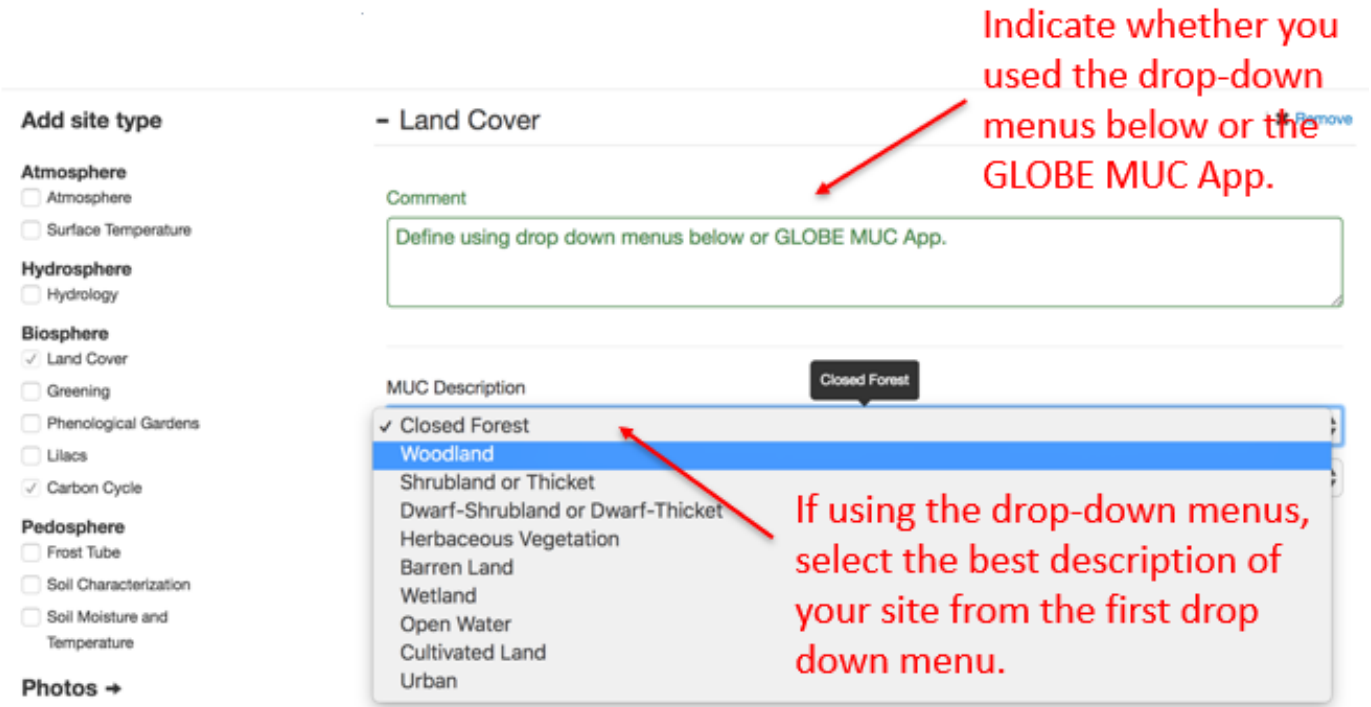
Select 'other' if you use the map below or smartphone.



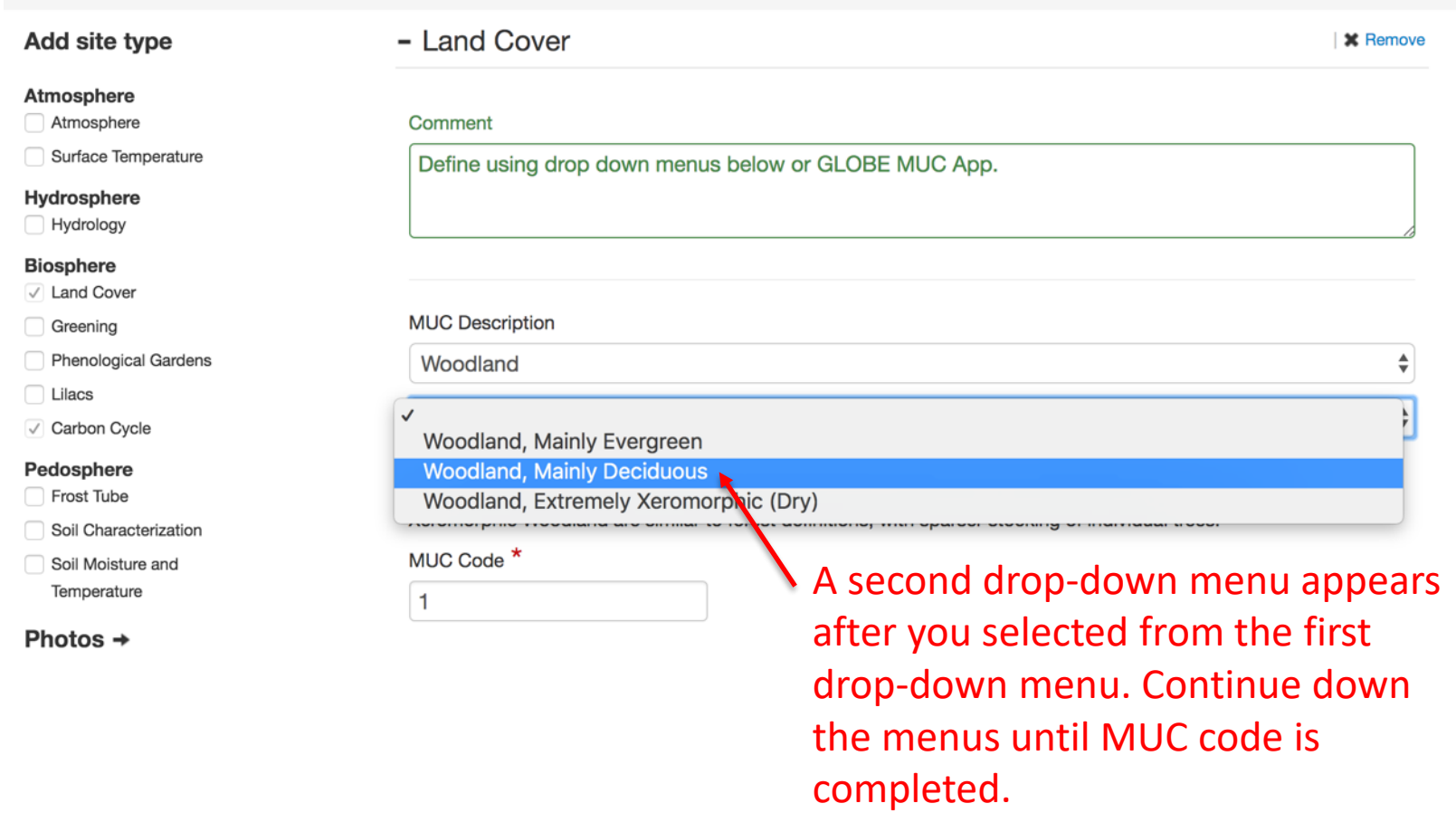
3. Describe site; indicate if standard or non-standard



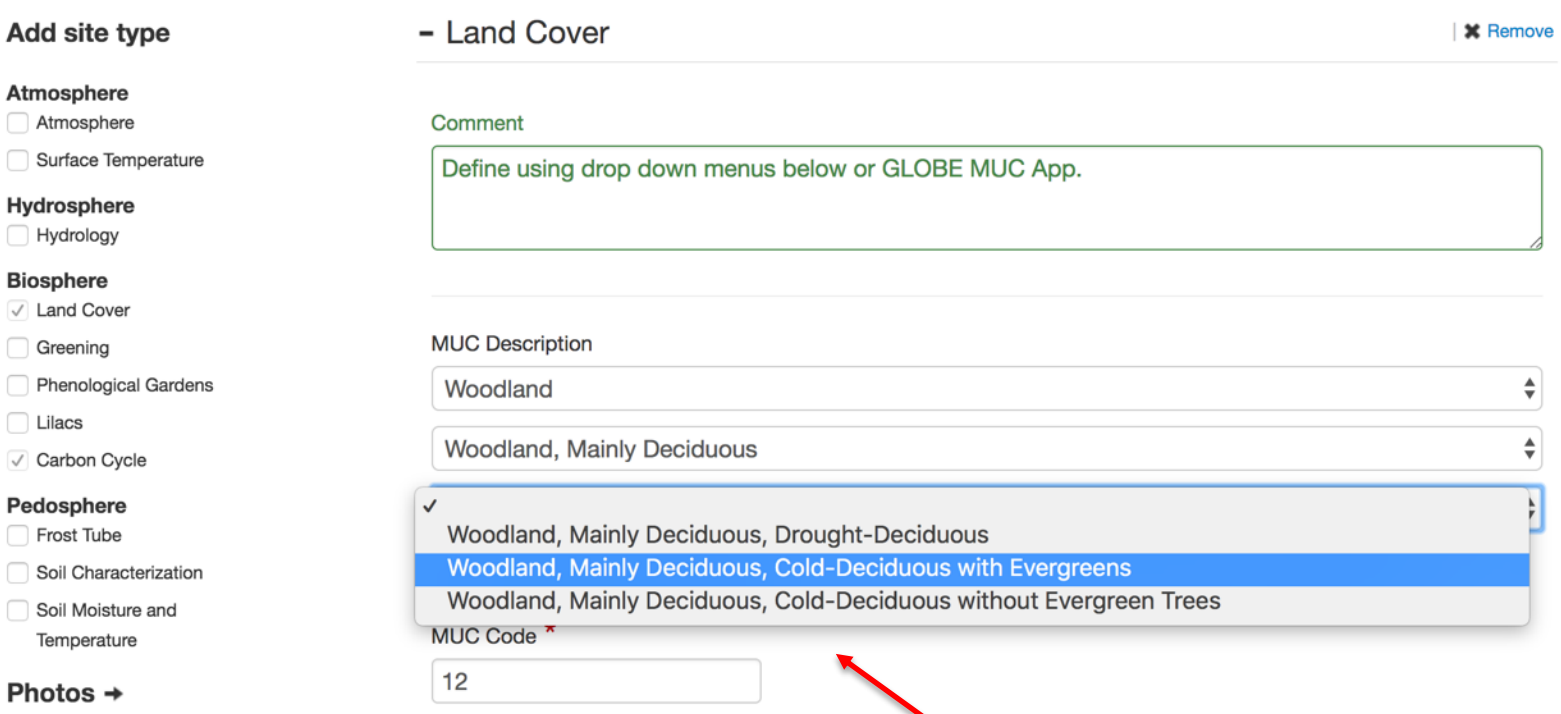
4. Describe Land Cover



5. Add Modified UNESCO Classification (MUC) Land Cover (1/4)



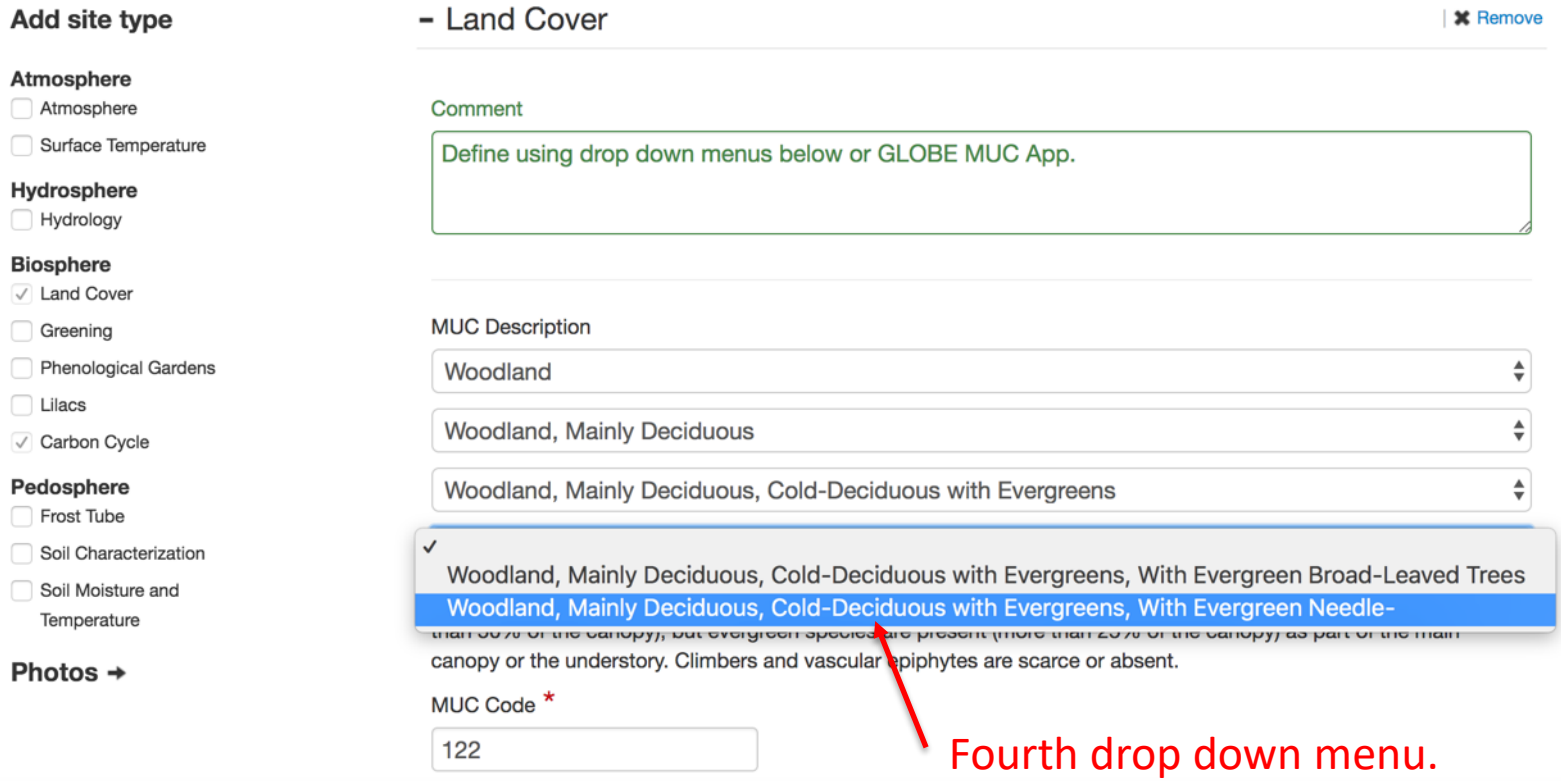
5. Add MUC Land Cover (2/4)



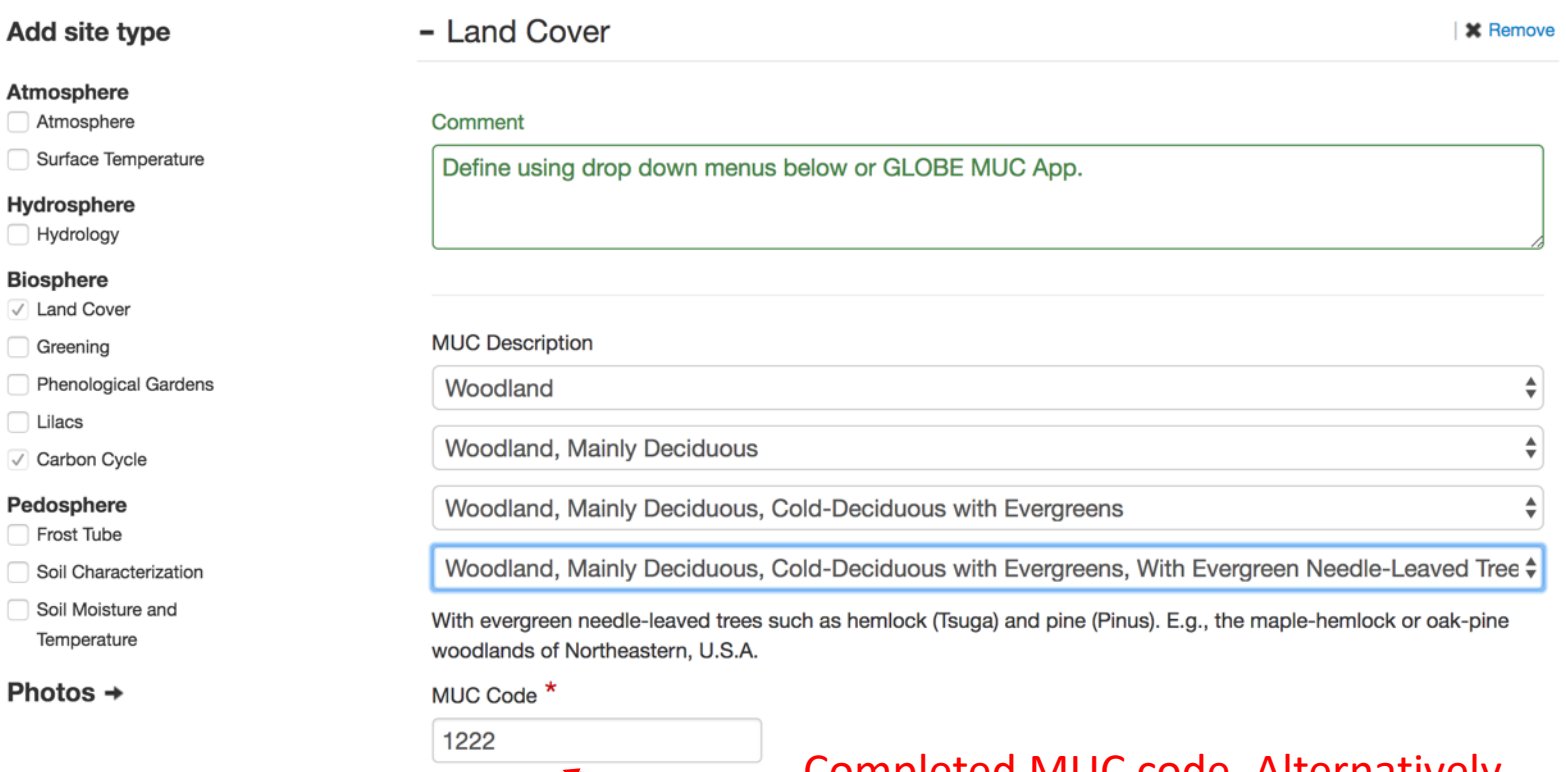
Continue down the menus.

MUC code will update automatically in this box. You do not need to enter numbers here if you are using the menus.

5. Add MUC Land Cover (3/4)

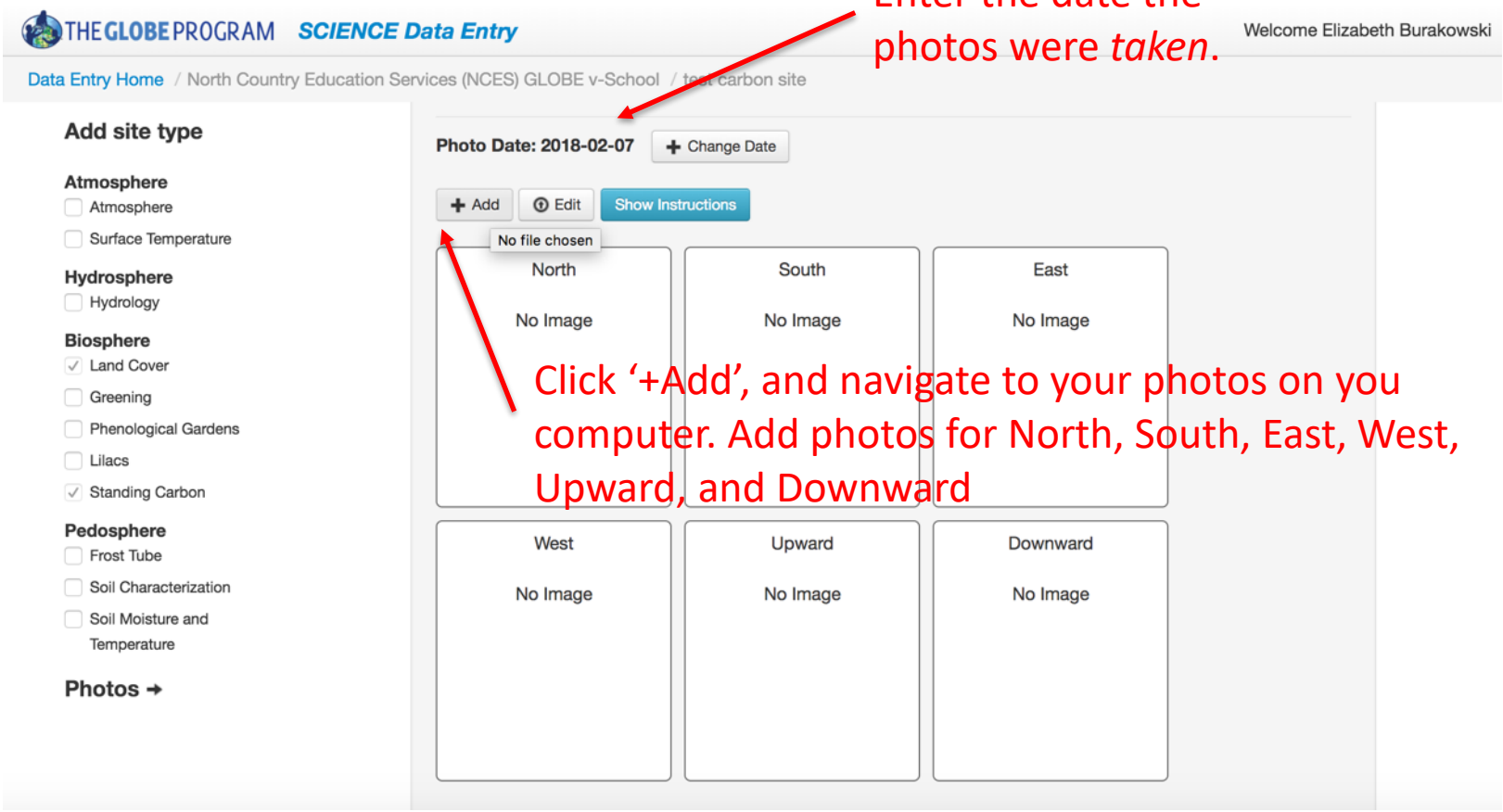


5. Add MUC Land Cover (4/4)

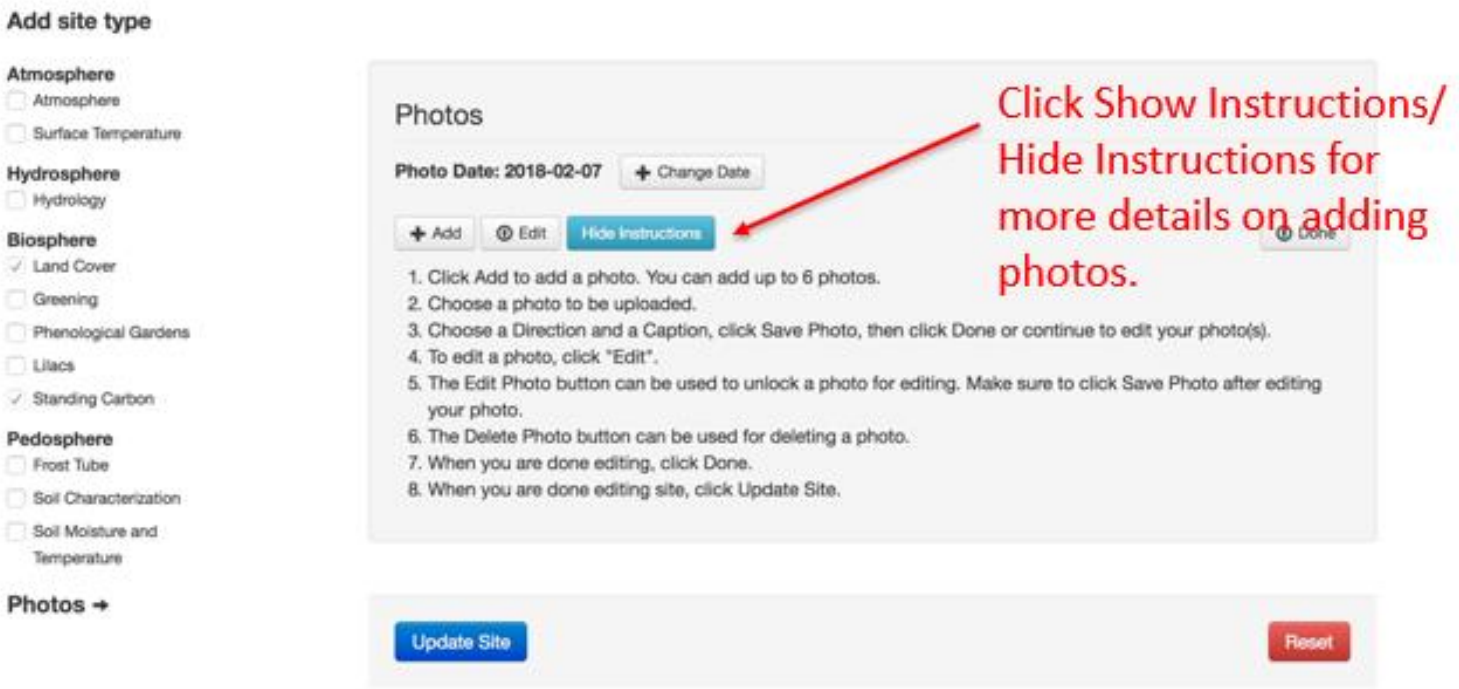


Completed MUC code. Alternatively, you can skip the drop-down menus and enter the 4-digit MUC code directly from the GLOBE MUC App.

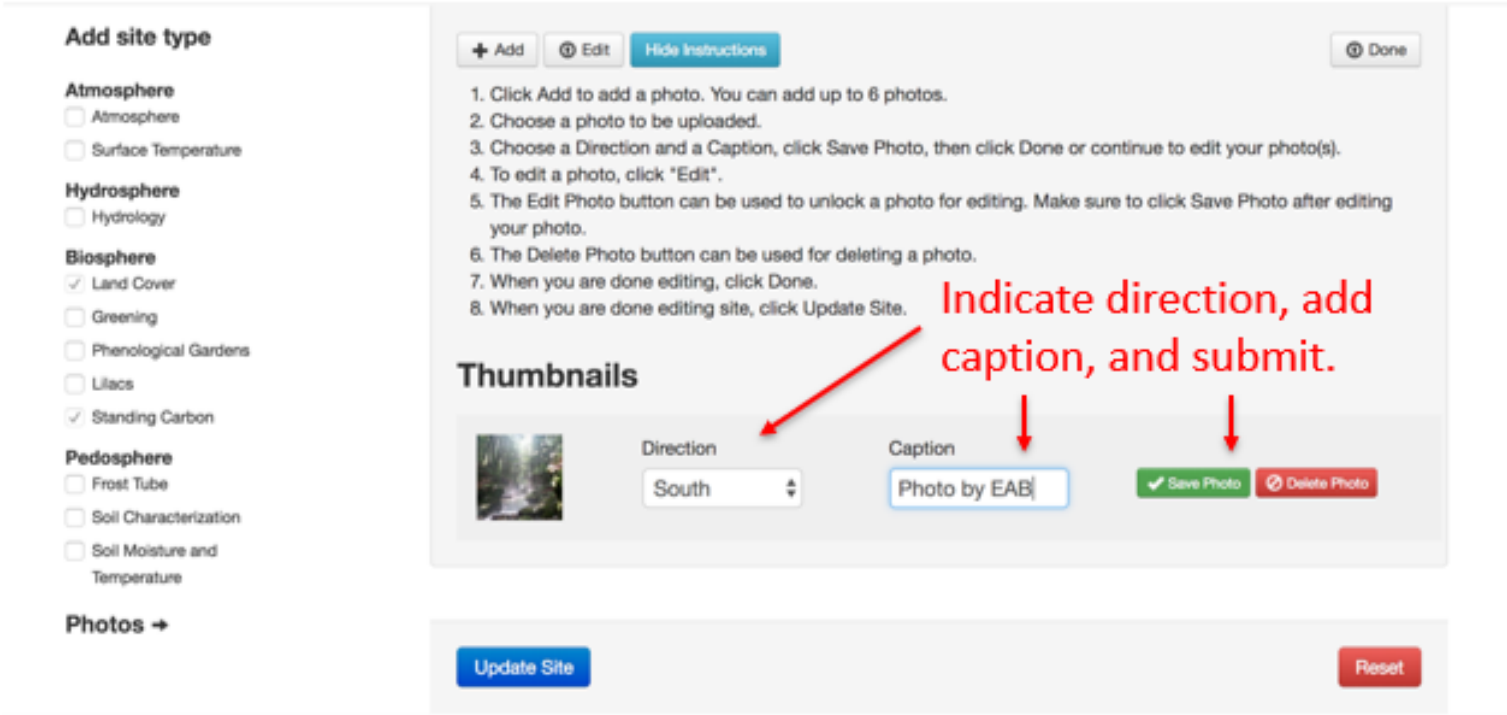
6. Add site photos (1/3)



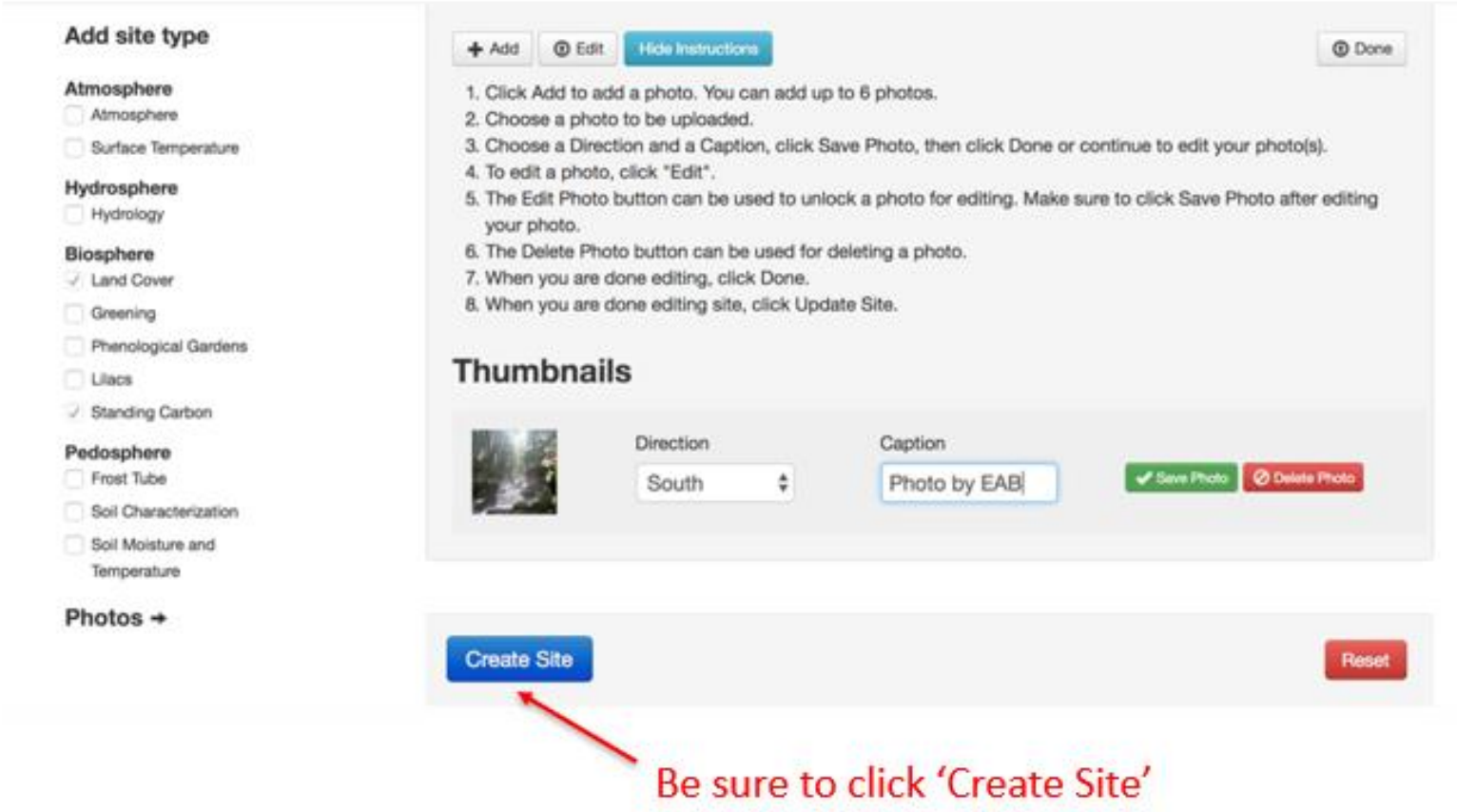
6. Add site photos (2/3)



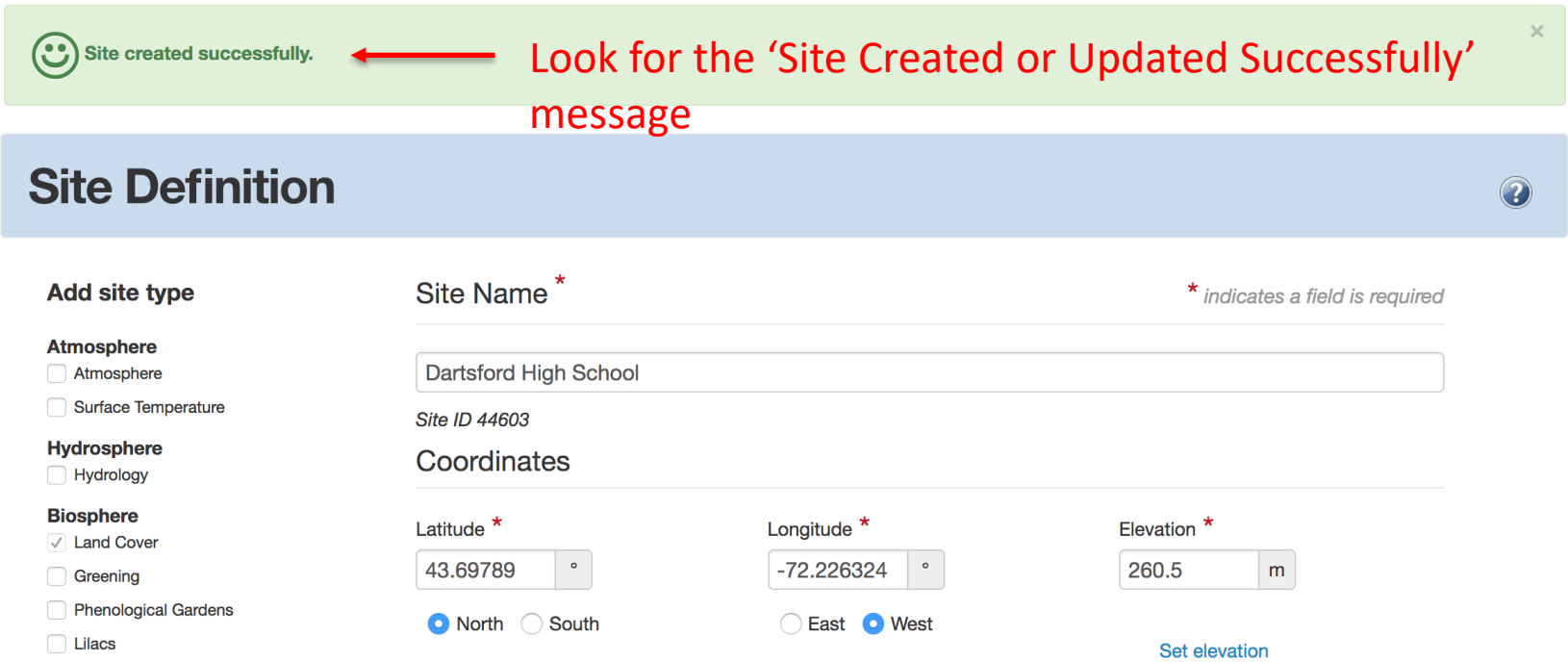
6. Add site photos (3/3)



7. Submit site



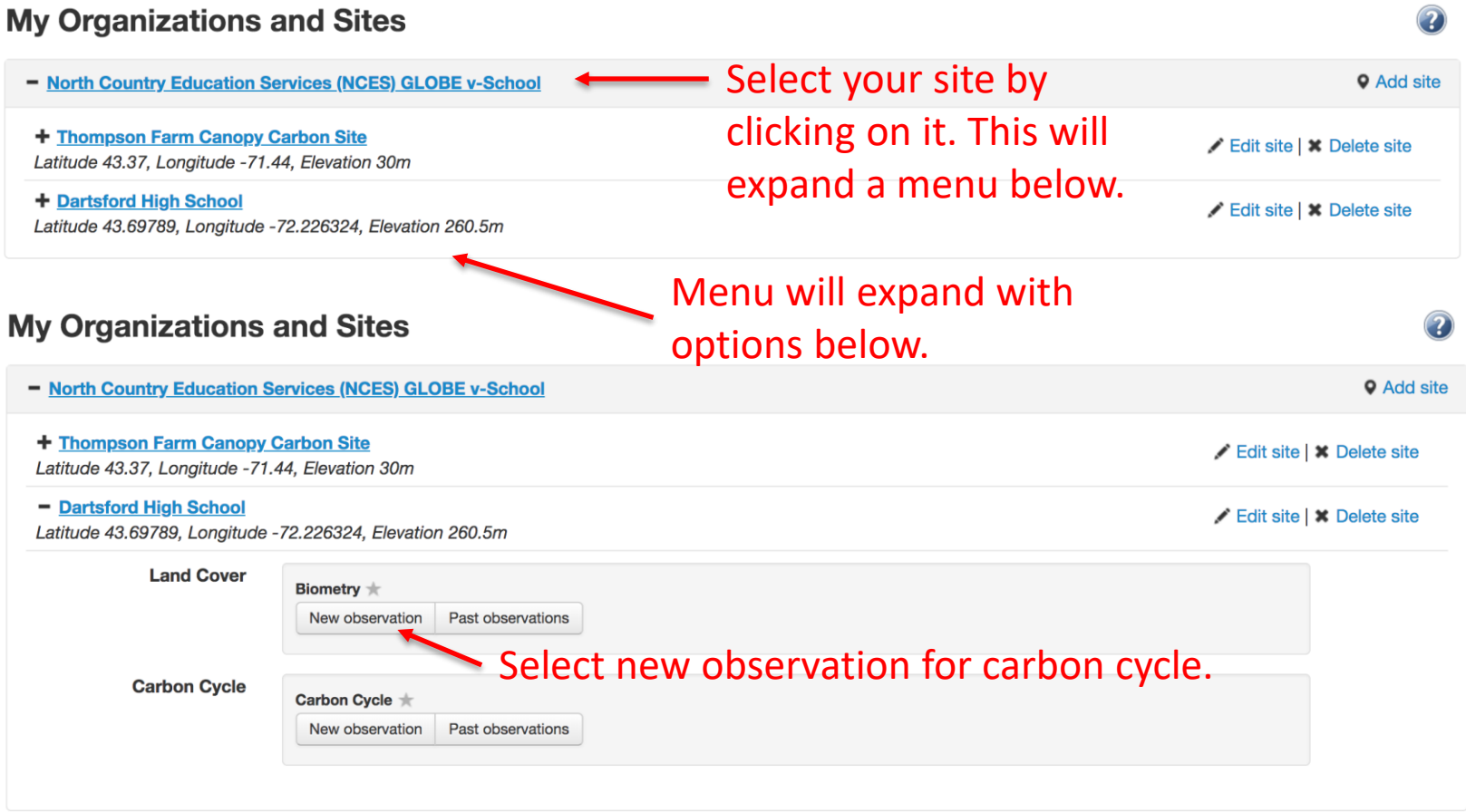
8. Confirm site submission/update



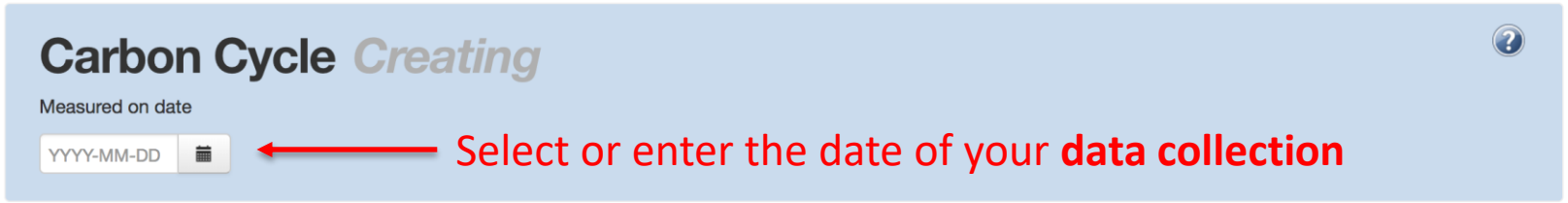
If you don't see "Site Created or Updated successfully, follow the red error messages to complete the form".

Add Carbon Cycle data

Once your site has been established in the database, navigate to data entry home.

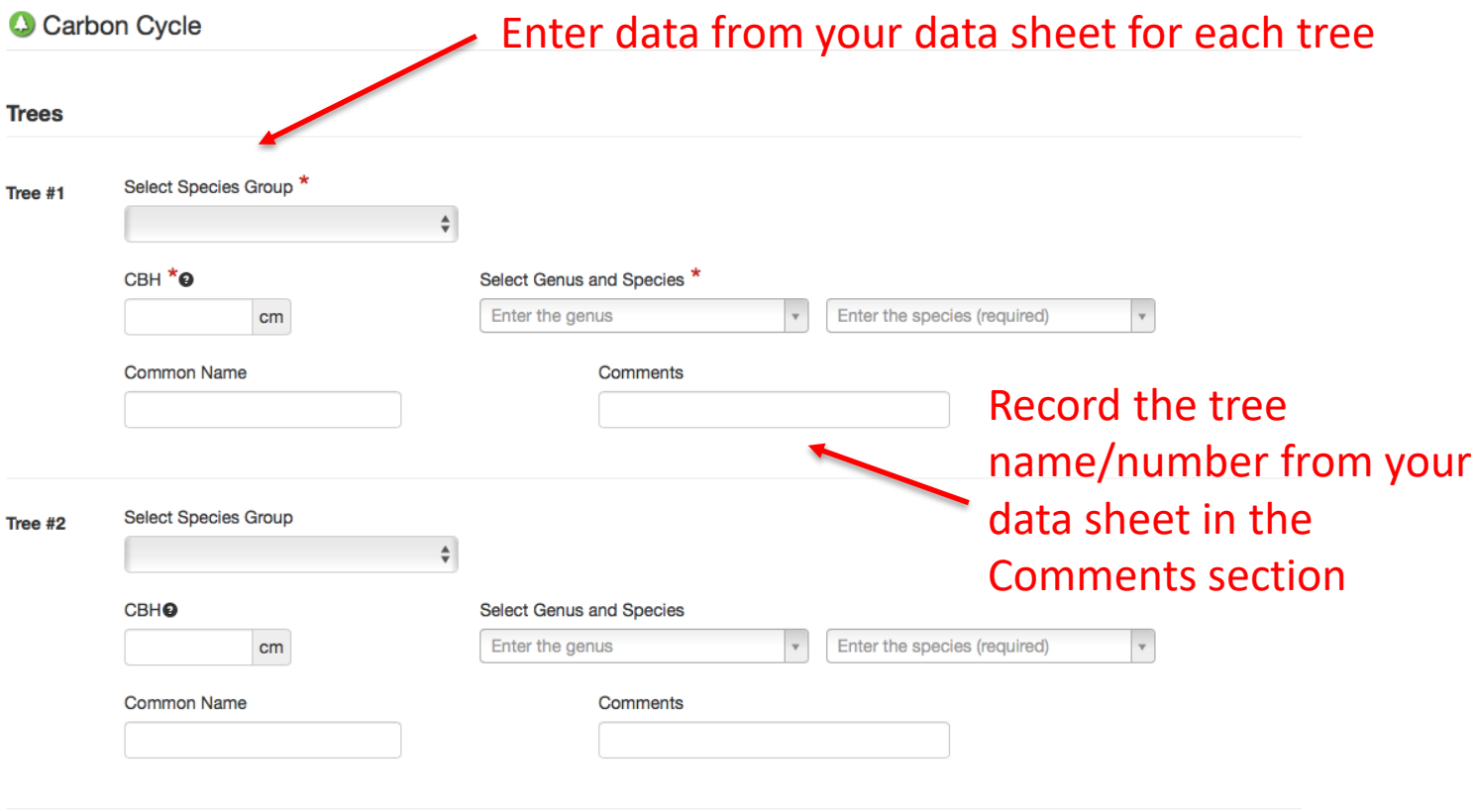


Add carbon data*



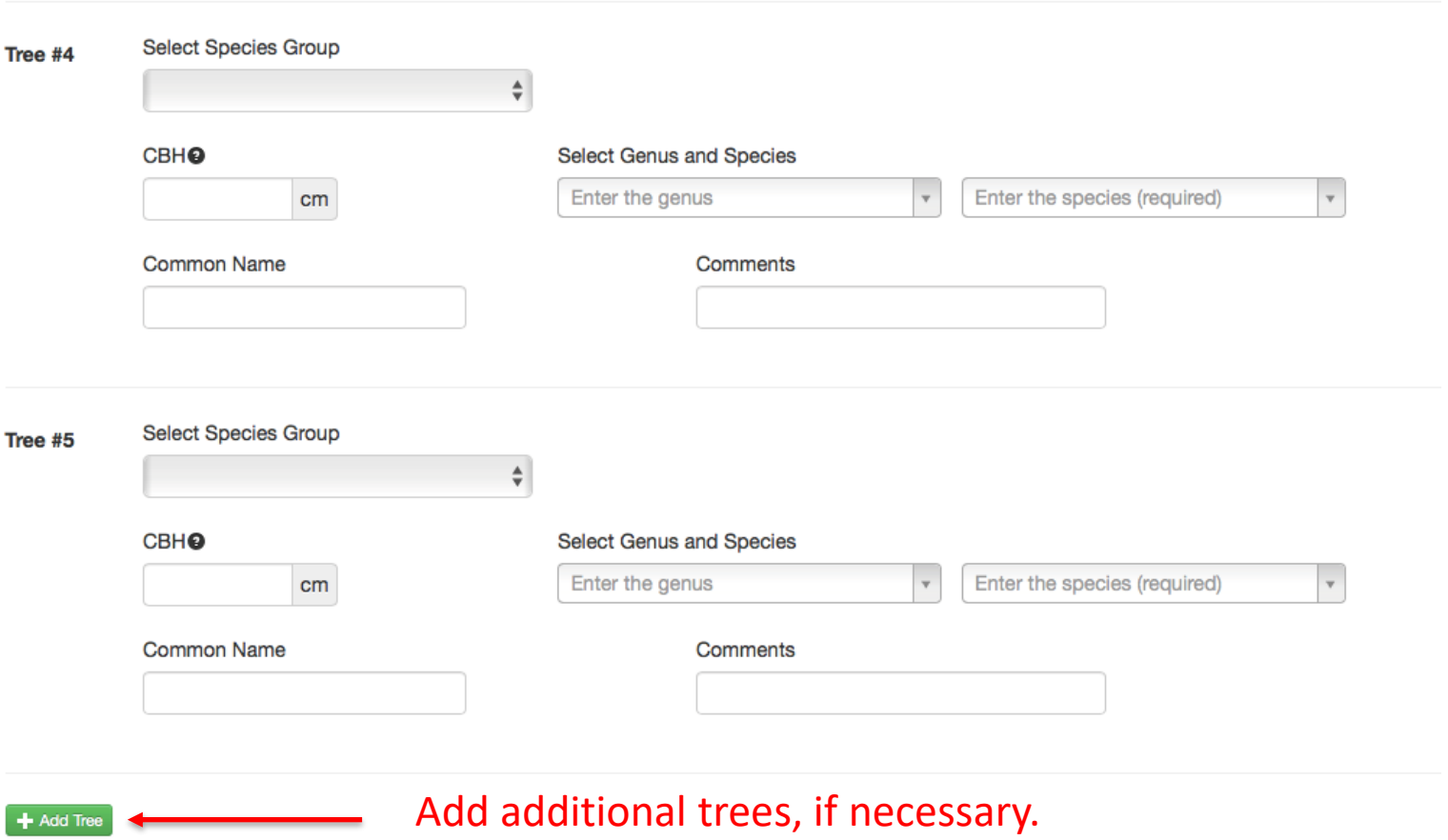
*Data entry on the GLOBE website is very similar to the GLOBE App. Only web data entry is shown here.

Add carbon cycle tree* data



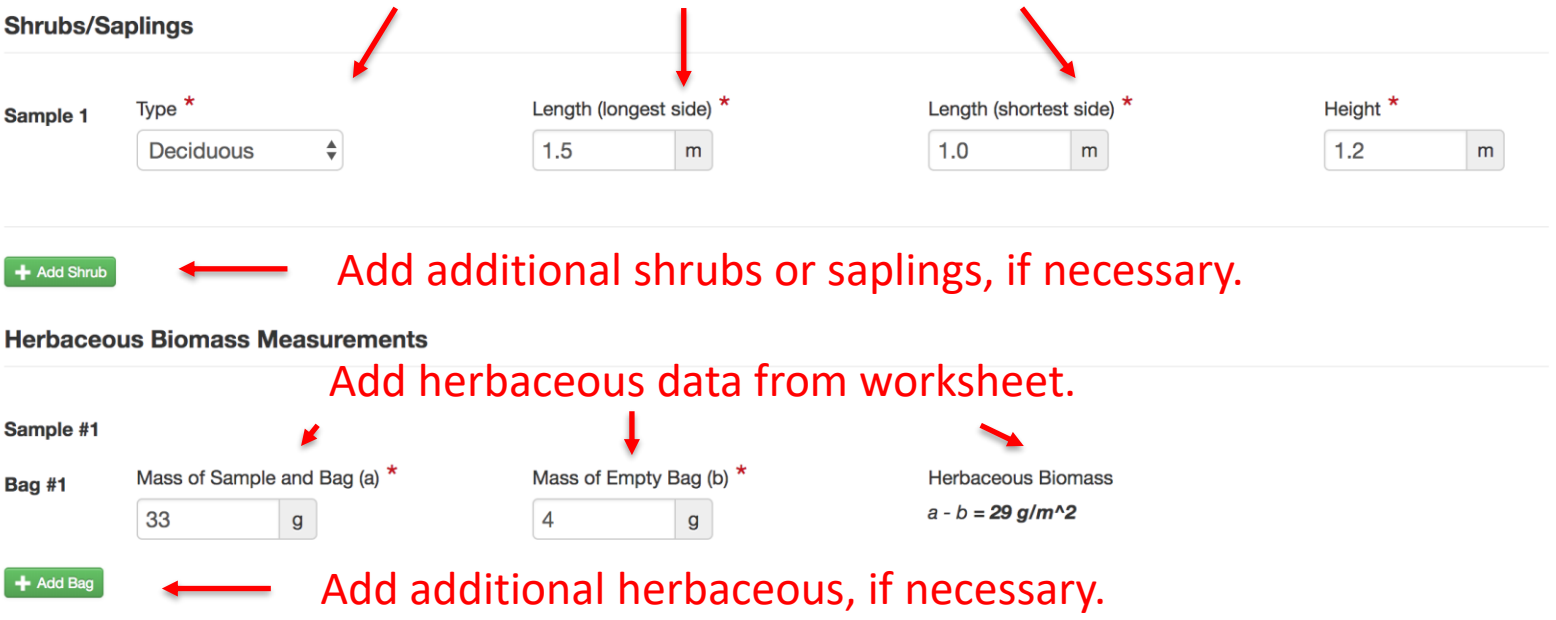
* not all sites will have trees. Skip if not applicable to your site.

Add additional trees if necessary



Enter shrub, sapling* and herbaceous data.

Add shrub, sapling data from worksheet.



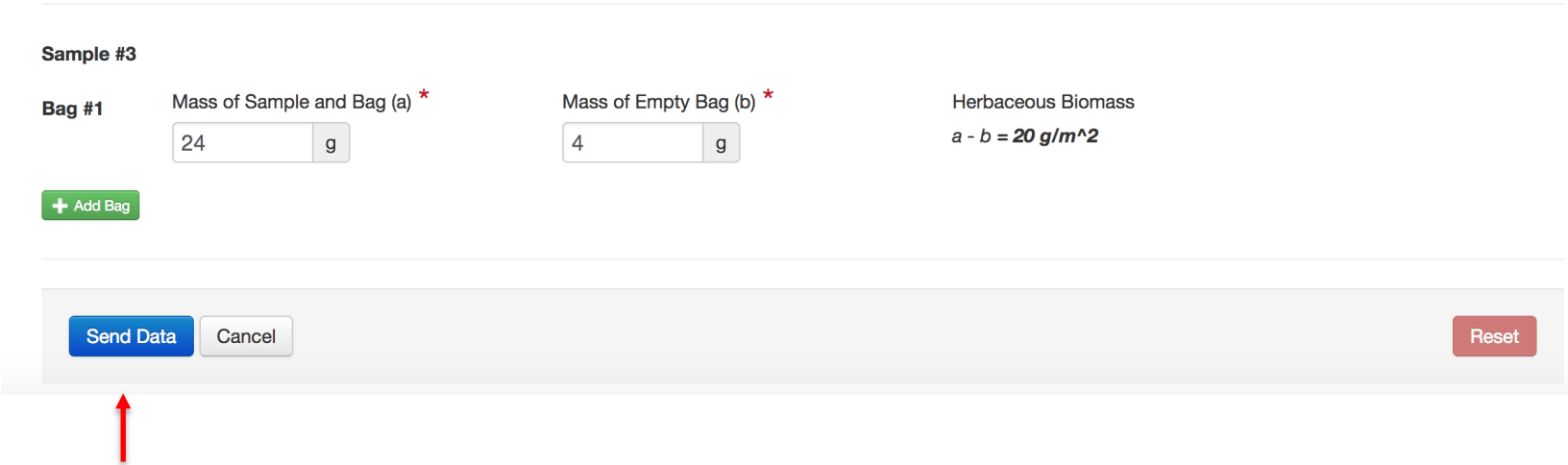
Add additional shrubs or saplings, if necessary.

Add herbaceous data from worksheet.

Add additional herbaceous, if necessary.

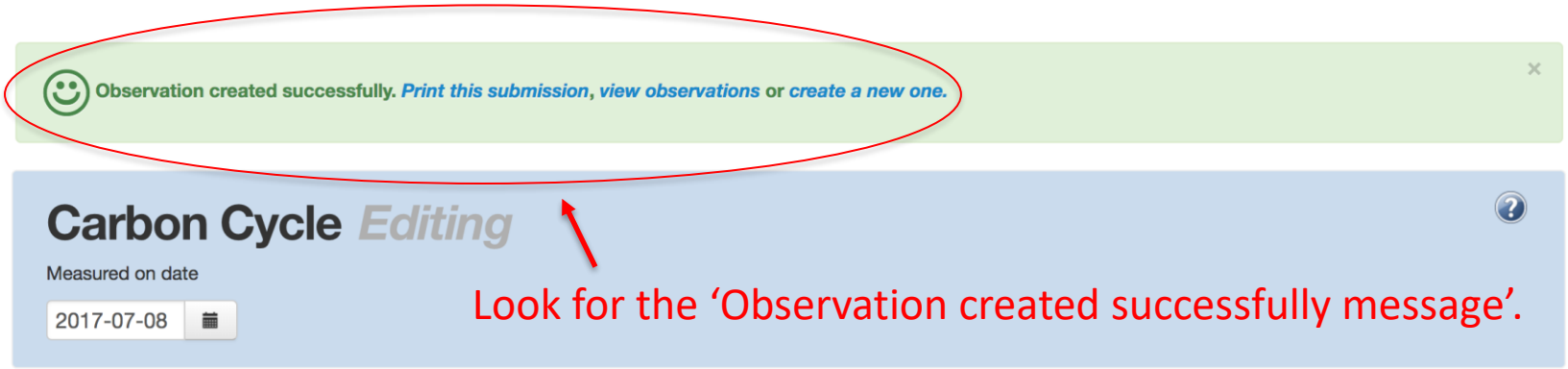
* not all sites will have shrubs/saplings or herbaceous. Skip if not applicable.

Send Data to GLOBE



Click ‘Send Data’ when data entry is complete.

Confirm Data Submission



Understanding Your Data: Data Analysis

Use the *Biomass & Carbon Data Analysis Teacher Guide* (separate documents for *Trees*, *Shrubs/Saplings*, and *Herbaceous vegetation*) to assist students with observing and understanding patterns and trends in their tree field measurement data.

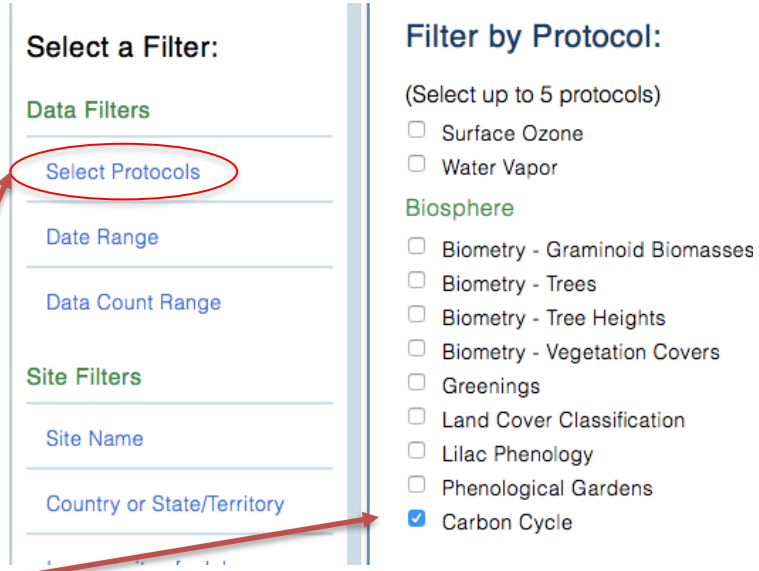
Requires:

- Data spreadsheet downloaded from GLOBE (*see instructions on following page*)
- Microsoft Excel (or similar spreadsheet program)
- *Biomass Analysis Questions*

Download Data from GLOBE (1/3)

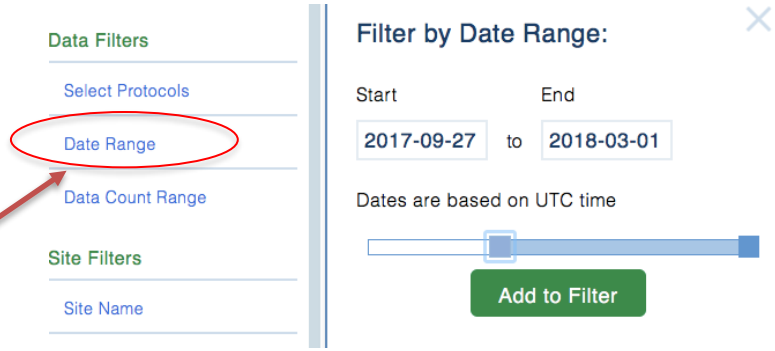
*complete with carbon and biomass estimates

1. Go to GLOBE's Data Access Tool
2. Read through the instructions to familiarize yourself with this tool.
3. Under Data Filters, click 'Select Protocols'
4. Scroll down to find the Biosphere section, click 'Carbon Cycle', and click on Add Protocols.



Add Protocols

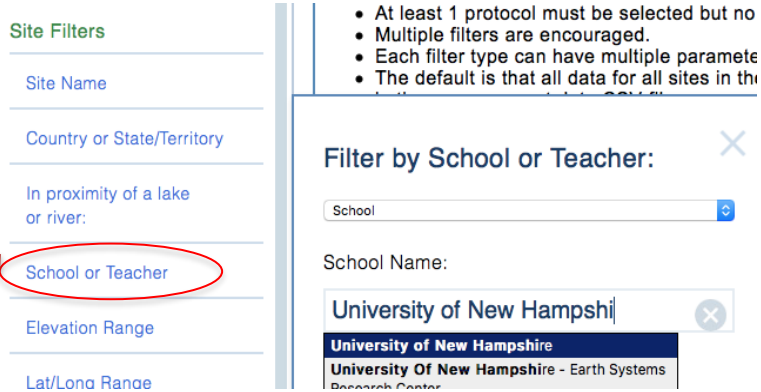
5. Select a data range that includes the date in which you collected data. Click on Add to Filter.



Add to Filter

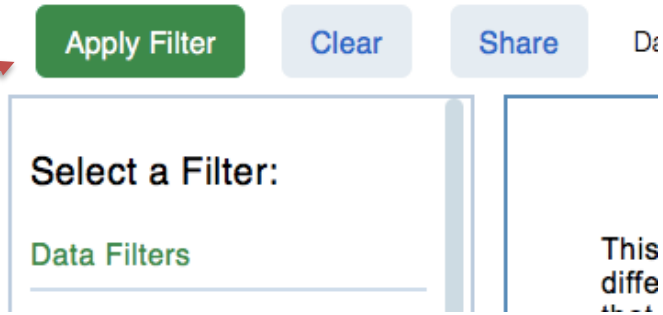
Download Data from GLOBE (2/3)

6. Under Site Filters, click ‘School or Teacher’, and select your school.



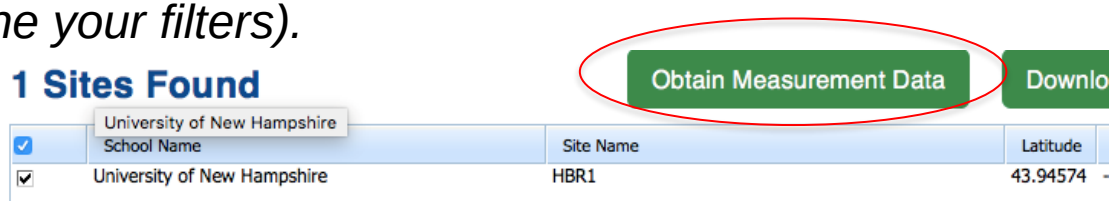
7. If you have multiple Carbon Cycle field sites, select the individual site which you are interested in under ‘Site Name’.

8. Click the green ‘Apply Filter’ button in the top left.



Download Data from GLOBE (3/3)

9. Click 'Obtain Measurement Data' *(Note, data will be downloaded for the whole list you see, if your school is not the only one listed, redefine your filters).*



10. The button will update, and you can click Download Measurement Data (~1) to download a .csv, which can be opened in a spreadsheet tool such as Excel. *(See an example Carbon Cycle spreadsheet on the Data Analysis section of the Carbon Cycle webpage).*

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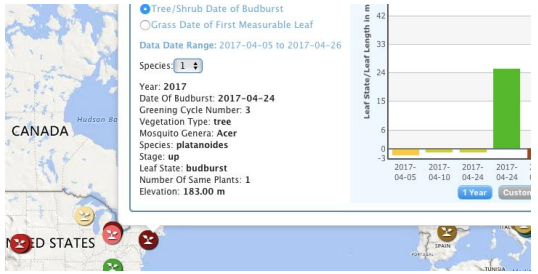
* ***Note**, you can also use the [GLOBE Visualization System](#) to view your and other school's Carbon Cycle data on a map.*



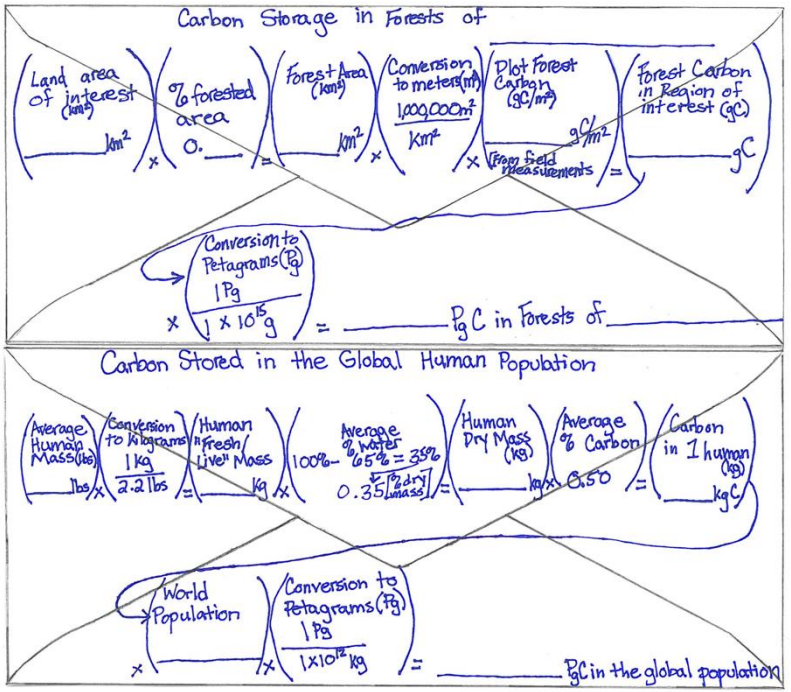
Understanding Your Data: Data Interpretation

1. Human carbon storage vs. tree carbon storage
2. Schoolyard area (scaling)
3. Net Primary Production (NPP)

Human Carbon vs. Tree Carbon

Use a back-of-the-envelope calculation to determine whether more carbon is stored in humans or trees.

Example research question that can be answered through this activity: Is there more carbon stored in the global human population or the trees in [MY STATE]?



** This activity can help students understand why there is not a 'human' pool on the Global Carbon Cycle Diagram.

Schoolyard area scaling

Very helpful activity for Non-Standard Sites!

The *Determining Scale & Calculating Area Teacher Guide* describes how to use an aerial photo/map to scale your sample site carbon measurements to larger areas of similar vegetation.

Example research question that can be answered through this activity: How much carbon is stored in the vegetation near my school?

**Note the teacher will need Google Earth Pro (a free application) to create the map image.*

Calculating Net Primary Productivity

Use the *Calculating Net Primary Productivity Teacher Guide* to understand the change in carbon storage over time.
Needs multiple years of carbon data

Example research question that can be answered through this activity: What is the pattern in which biomass and carbon storage change over time in my sample site?

Net Primary Productivity (NPP), or the production of plant biomass, is equal to all of the carbon taken up by the vegetation through photosynthesis *minus* the carbon that is lost to respiration. NPP can be calculated with this equation:

$$NPP = Carbon\ stored\ for\ Year\ 2\ - Carbon\ Stored\ for\ Year\ 1$$

Quiz Questions

Challenge yourself to answer these questions and check whether you have achieved the learning objectives of this module.

1. Name two carbon cycle field learning activities.
2. What are some research questions you could ask using GLOBE carbon cycle data at your site?
3. What is the minimum area for a Non-Standard site?
4. If your site has trees, what data will you record for each tree?
5. At what height do you measure tree circumference?
6. If a tree is on a steep slope, what guide could you use to accurately measure tree circumference?
7. How are tree measurements converted to biomass?
8. What data will you record if your site has shrubs or saplings?
9. How is biomass converted to carbon storage?
10. How might someone calculate carbon storage of vegetation over the entire town based on your field measurements?

Questions about this module? Contact GLOBE: help@globe.gov

Additional Links:

NASA's A Breathing Planet, Off Balance Article and Video:
https://www.nasa.gov/feature/goddard/carbon-climate

NASA Global Climate Change Website:
https://climate.nasa.gov/

NASA Scientific Visualization Studio
(https://svs.gsfc.nasa.gov)

Global Carbon Project
(http://www.globalcarbonproject.org)

Global Carbon Atlas
(http://www.globalcarbonatlas.org)