Standard Site Carbon Cycle Protocols

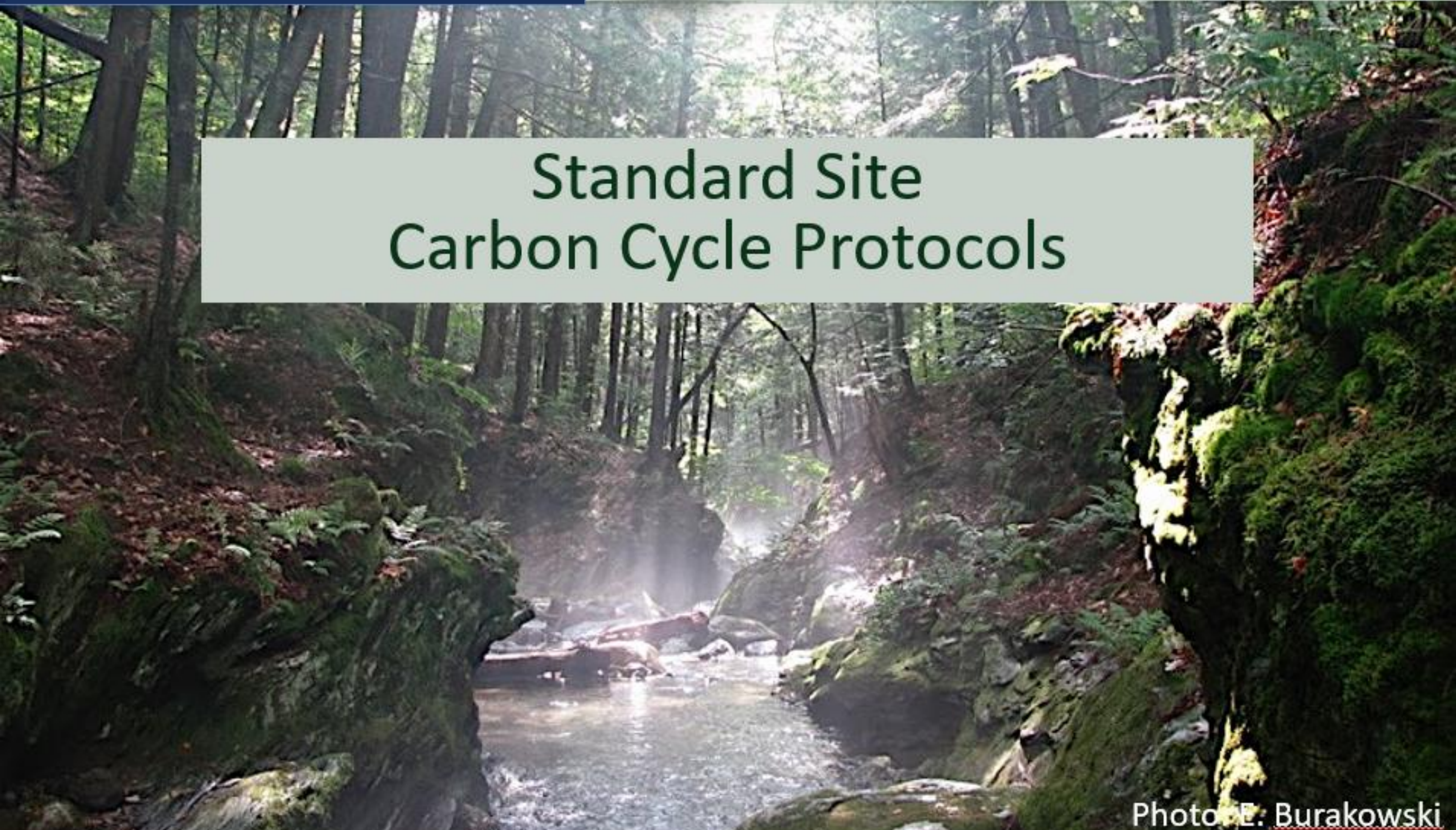

Photo: E. Burakowski

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

Part 1 : Introduction to Carbon Cycle

Overview

This section…

- teaches why carbon is an important element in ecosystems and how it cycles through ecosystems.
- demonstrates how carbon is stored in and transferred between the biosphere, geosphere, atmosphere, and hydrosphere.
- explains how humans have disrupted the natural carbon cycle, including rates of transfer between spheres.
- explains how increases in atmospheric CO_2 impact climate.
- highlights four introductory Learning Activities.

Learning Objectives

After completing this section, you will be able to:

- Provide examples of the role of humans in the global carbon cycle.
- Explain how carbon is stored in and passed between living & non-living things in terrestrial ecosystems.
- Describe two ways in which environmental conditions impact carbon flows through ecosystems.

Estimated time to complete module: 2 hours

The Biosphere

The Biosphere is comprised of all living things on Earth. GLOBE has several ways to explore and measure components of the biosphere through investigations about one of the most fundamental elements for life on Earth – carbon. Carbon also plays a critical role in regulating the Earth's climate system.

Through the burning of fossil fuels and land use change, humans have disrupted the carbon cycle and are now the dominant cause of global climate change.

The GLOBE Carbon Cycle Project consists of four major categories:

(1) Introductory Learning Activities
(2) Classroom experiments (Plant-A-Plant)
(3) Field Measurements (Protocols)
(4) Modeling

A. Overview
B. Learning Objectives
C. What is the Biosphere?
D. What is the Carbon Cycle?
E. Why Collect Carbon Cycle Data?
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G. Quiz Yourself

Carbon: A building block of life

- The most abundant element in living things
- Accounts for 45-50% of the total mass of the biosphere
- Also present in the Earth's atmosphere, soil, oceans, and crust



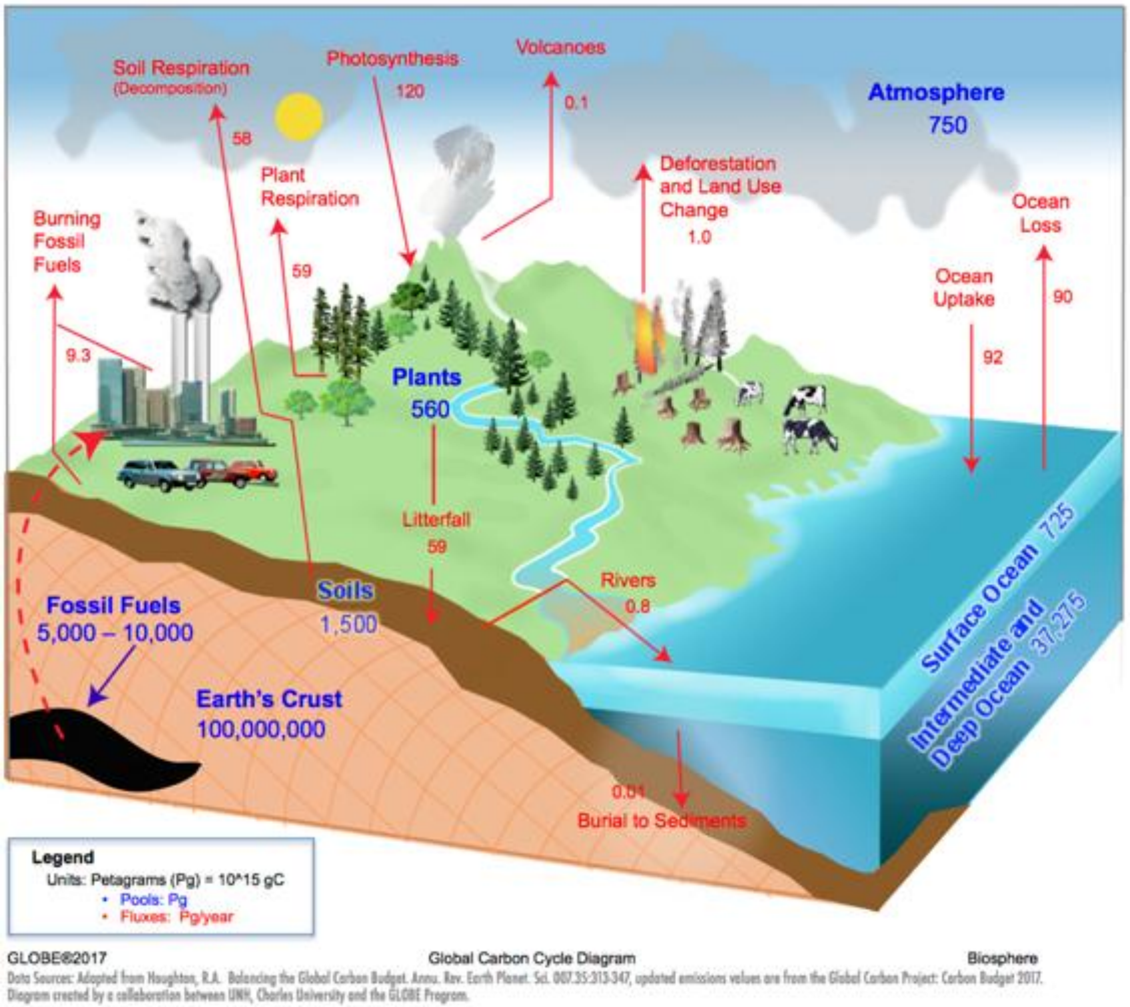



Review: What is the Carbon Cycle?

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 CO_2 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)

How does the biosphere affect atmospheric carbon dioxide (CO_2) concentrations?

Photosynthesis

$$CO_2 + H_2O \rightarrow C_6H_{12}O_6 + O_2$$

Biosphere

Atmosphere

Respiration

$$C_6H_{12}O_6 + O_2 \rightarrow CO_2 + H_2O$$

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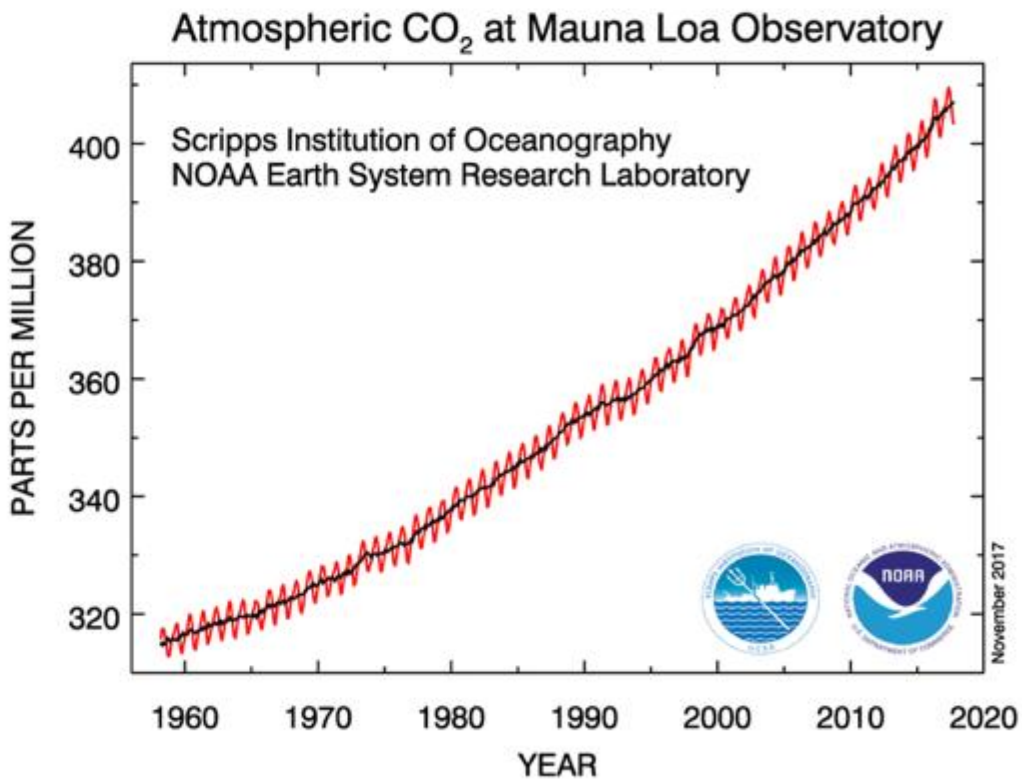
Monthly records of atmospheric CO_2 have been collected at Mauna Loa, Hawaii since 1958.



red – monthly CO_2 showing seasonal cycle

black – long-term trend, adjusted for seasonal cycle

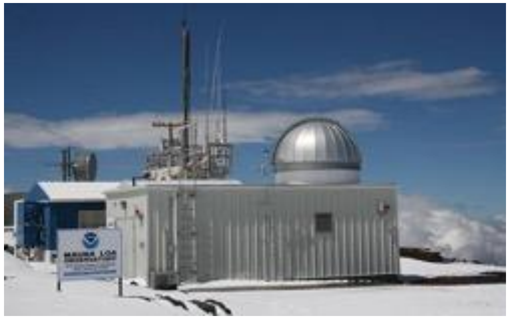


Image: ersl.noaa.gov

A closer look at several years of CO_2 concentrations reveals a zig-zag pattern, a seasonal cycle.

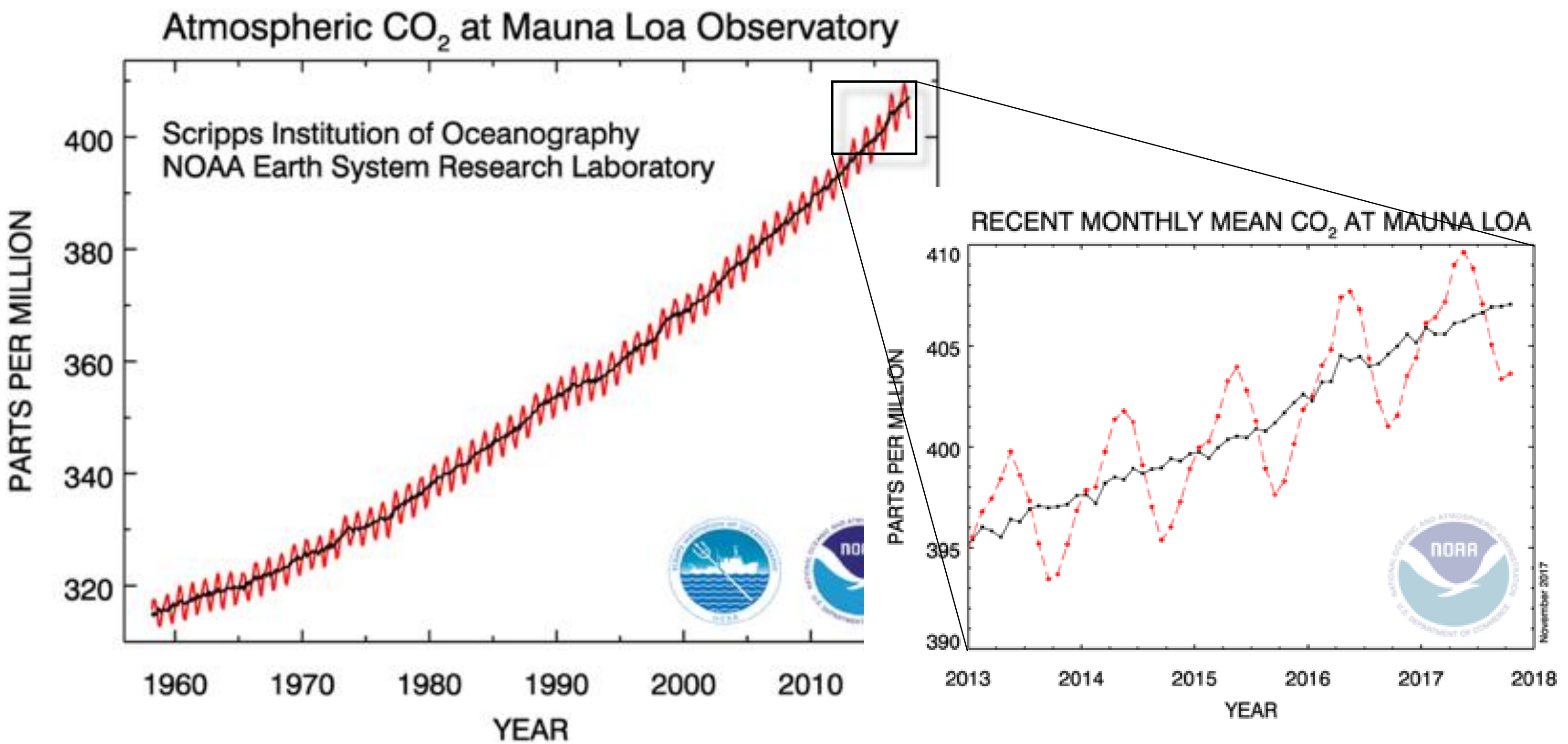


Image: ersl.noaa.gov

The "falling arm" of the zig-zag coincides with periods when *photosynthesis exceeds respiration,* in other words, the biosphere is taking up more CO_2 from the atmosphere than it is releasing.

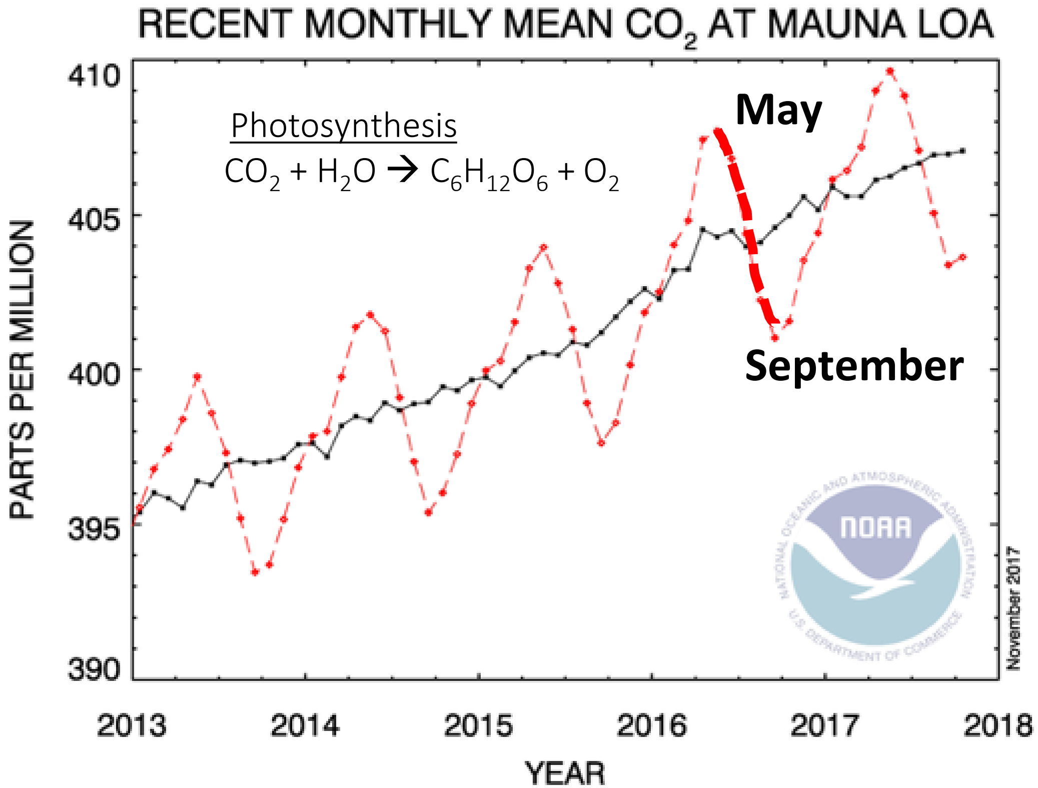


Image: ersl.noaa.gov

The "rising arm" of the zig-zag coincides with periods when *respiration exceeds photosynthesis,* in other words, the biosphere is releasing more CO_2 to the atmosphere than it is absorbing.

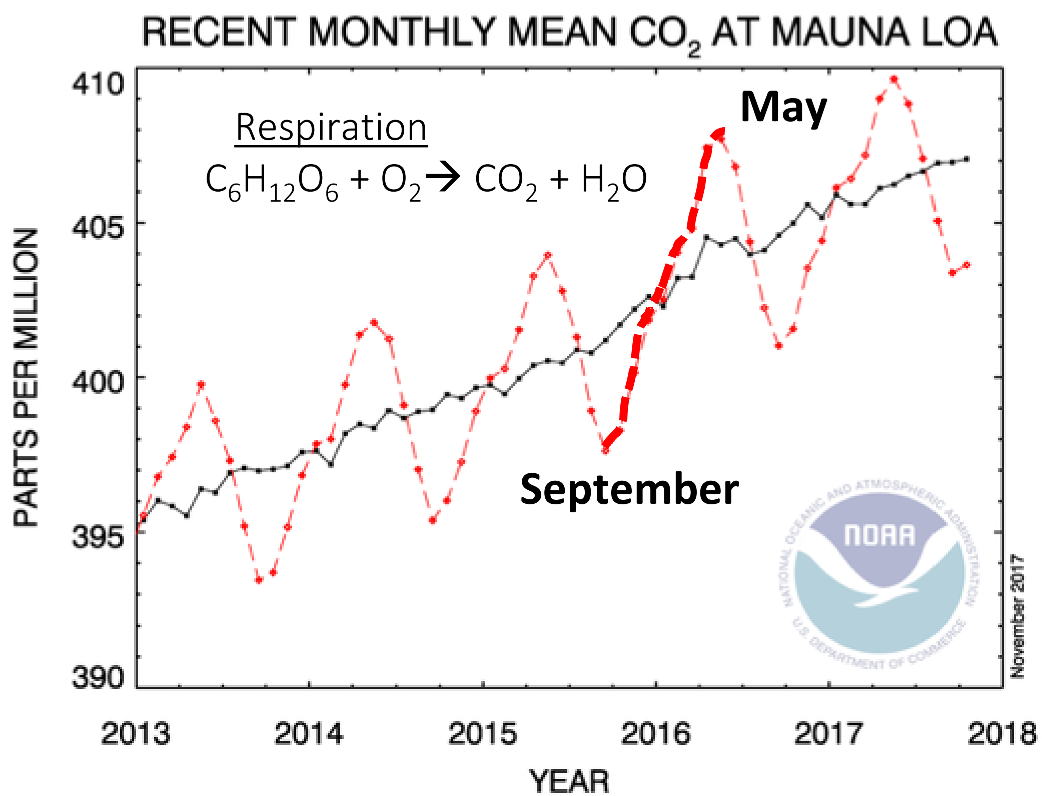
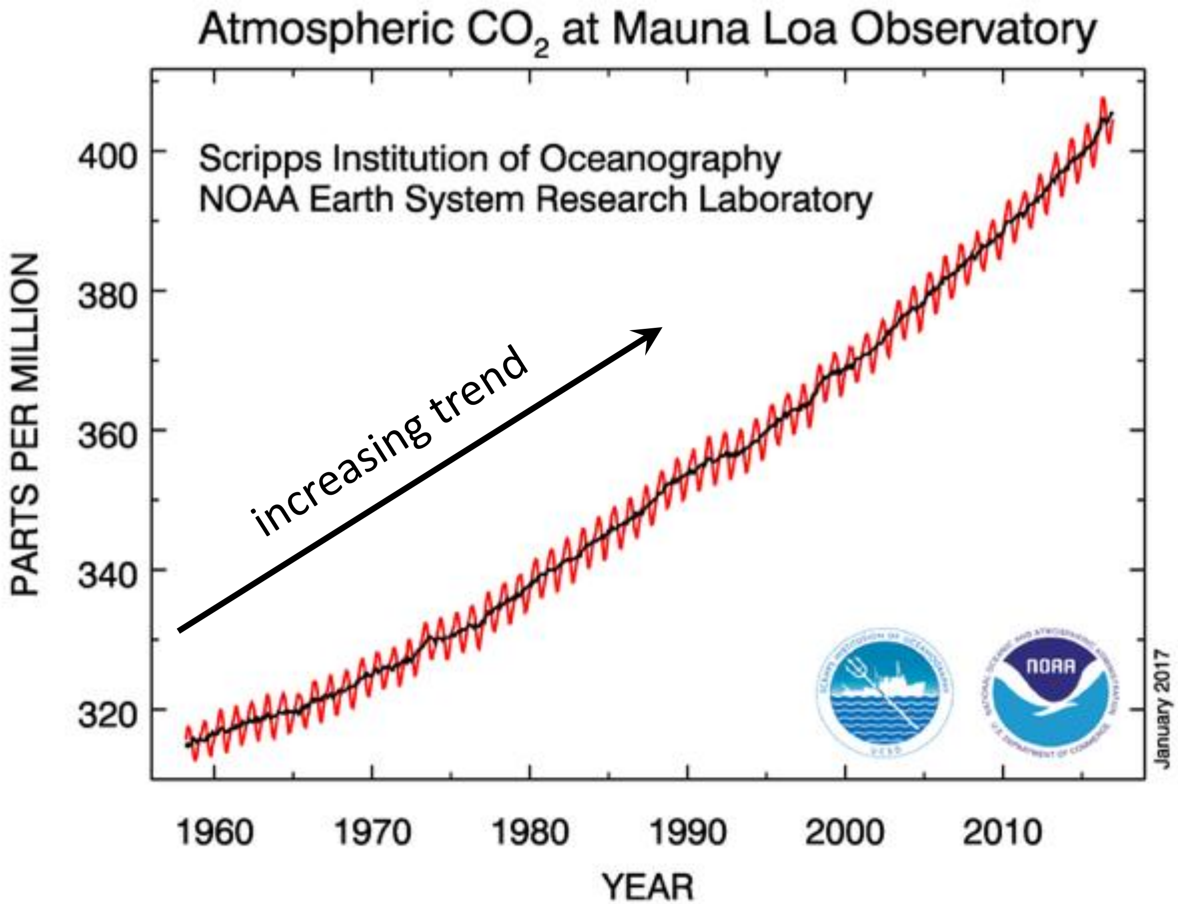


Image: ersl.noaa.gov

The long-term trend shows an increase in CO_2 of 1-3 parts per million per year since 1958.



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Increases in atmospheric CO_2 are primarily from the burning of fossil fuels.

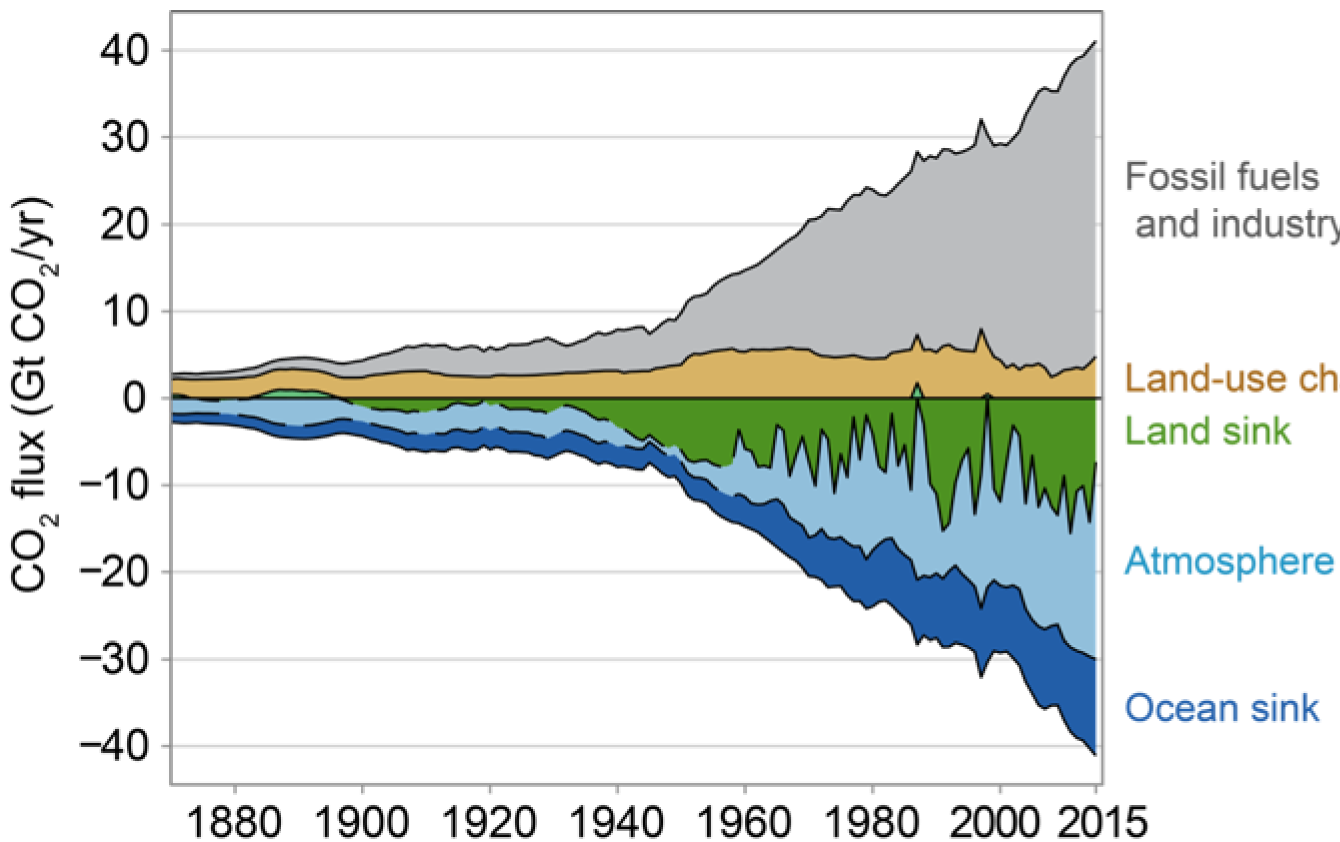


Image: La Quere et al. 2016, Figure 3

Fossil fuels come from organic material that was buried and deposited millions of years ago.

Play the Earth Operators Manual Video
https://www.youtube.com/watch?v=_8VqWKZIPrM

Ice cores trap ancient atmosphere in tiny bubbles.

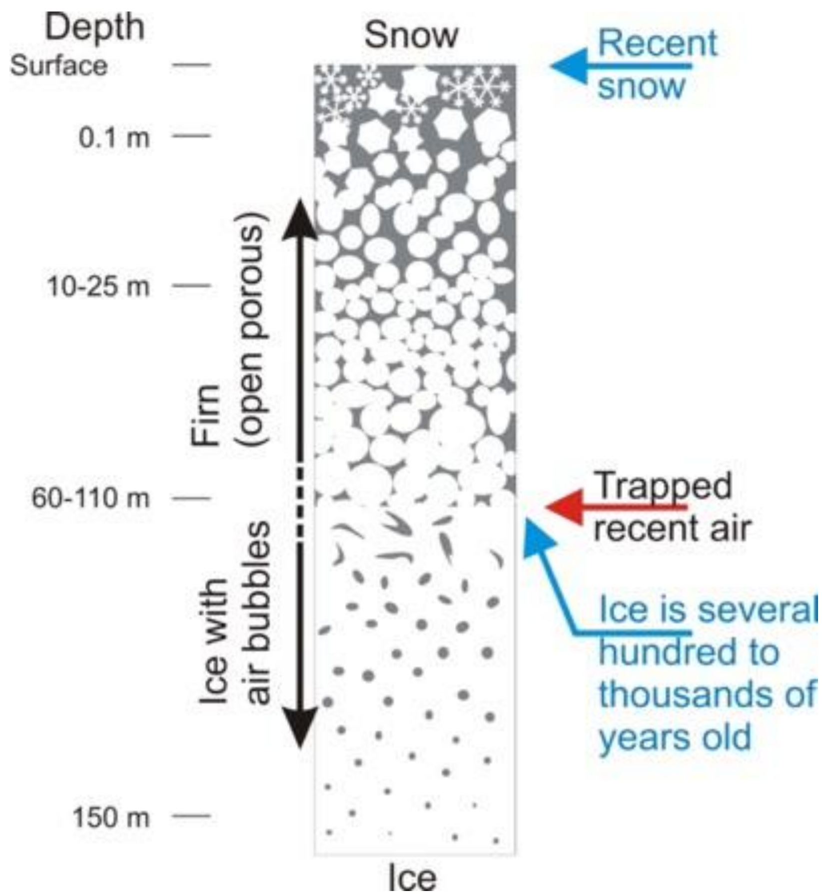


Image: Niels Bohr Institute

Image: Bernhard Bereiter

From ice cores, we know atmospheric CO_2 is higher today than it has been in the past 800,000 years.

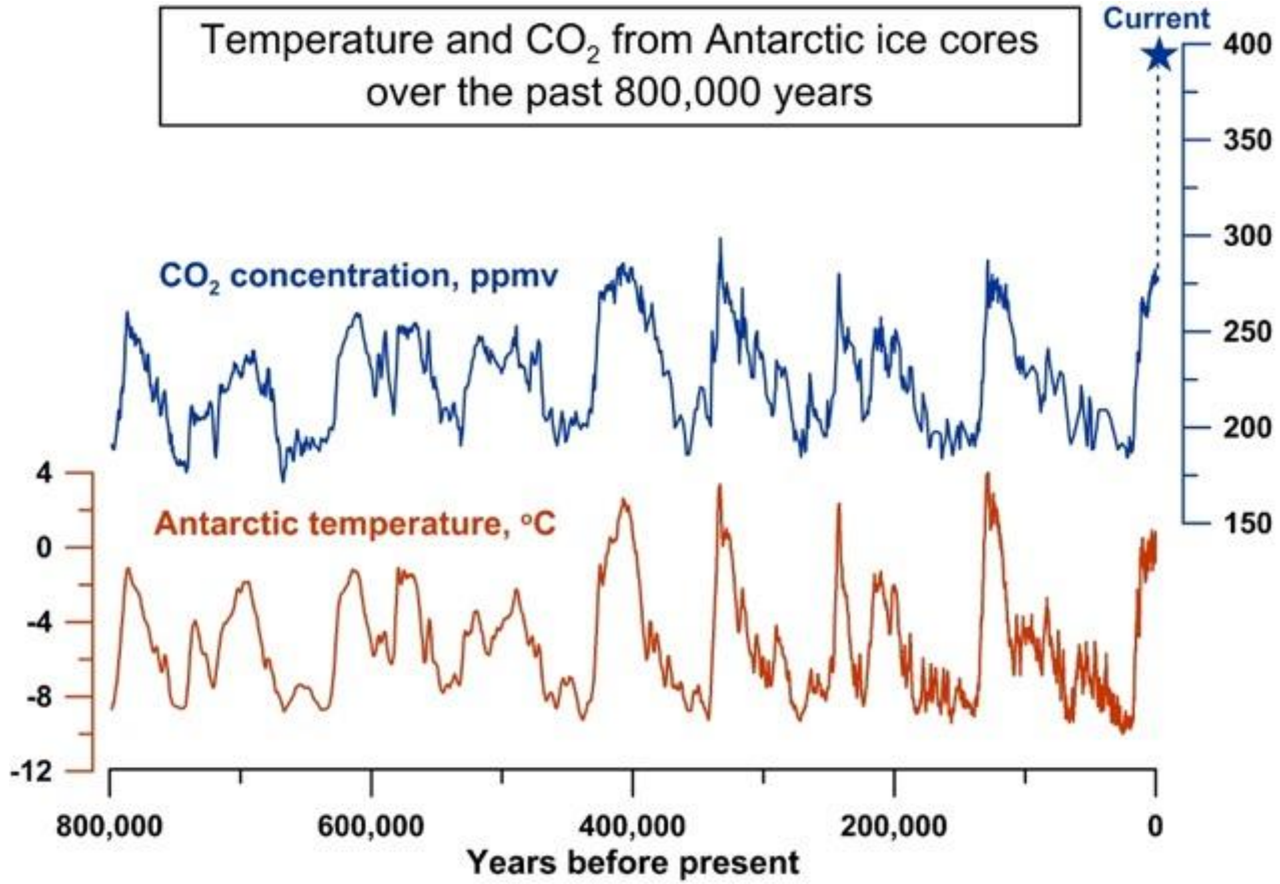


Image: Jeremy Shakun/Harvard University

Carbon dioxide is a greenhouse gas. It traps heat in the atmosphere and warms the Earth.

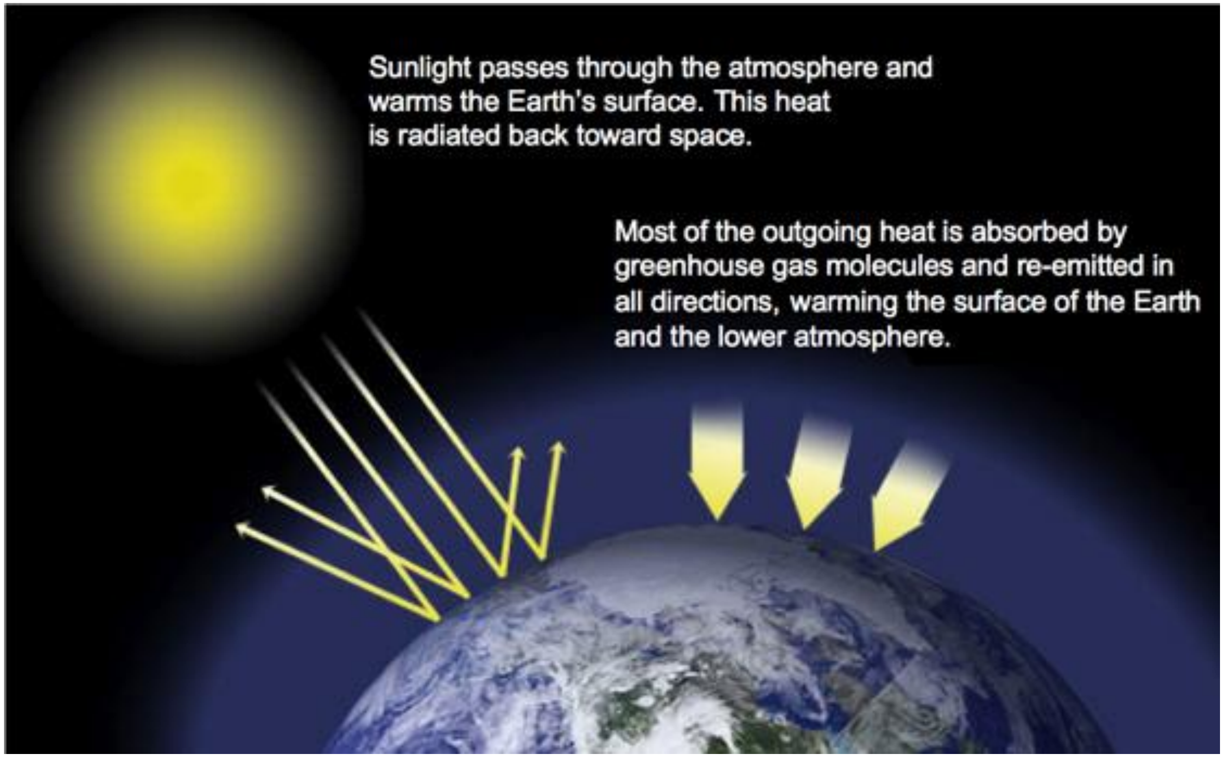
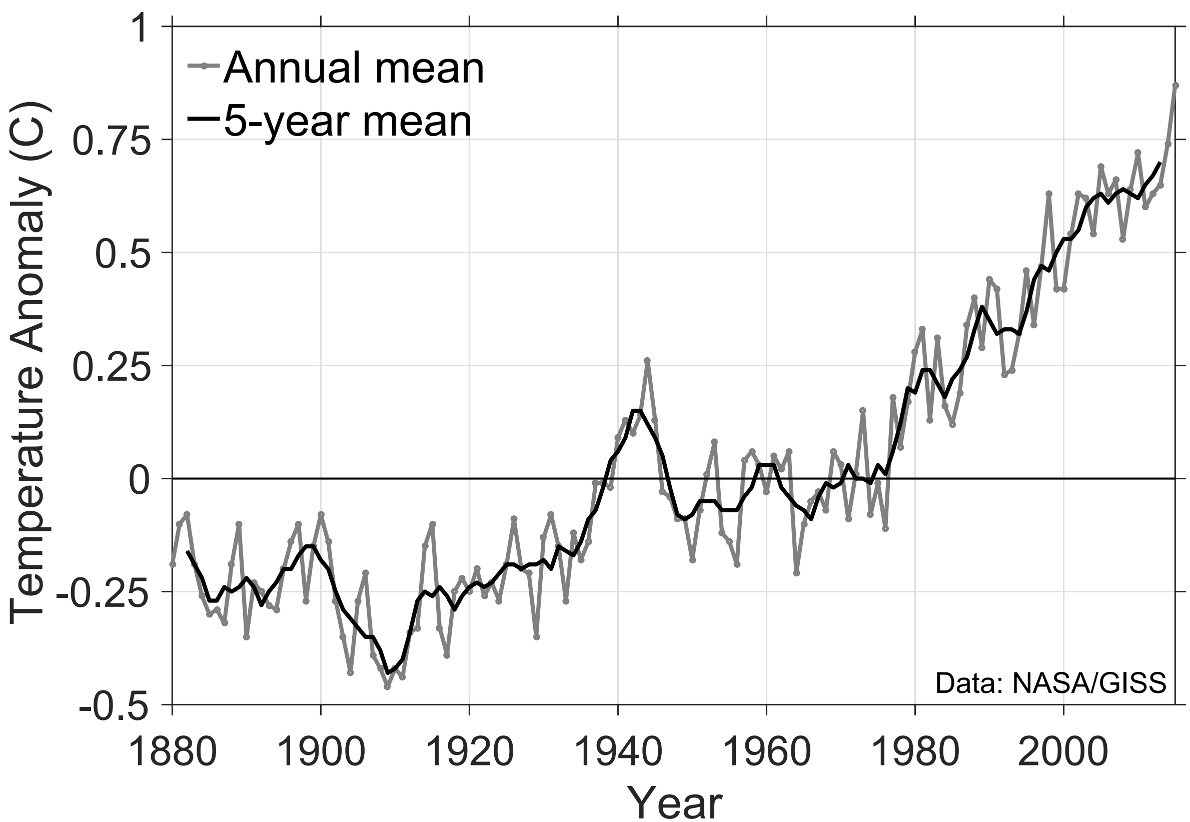


Image: NASA

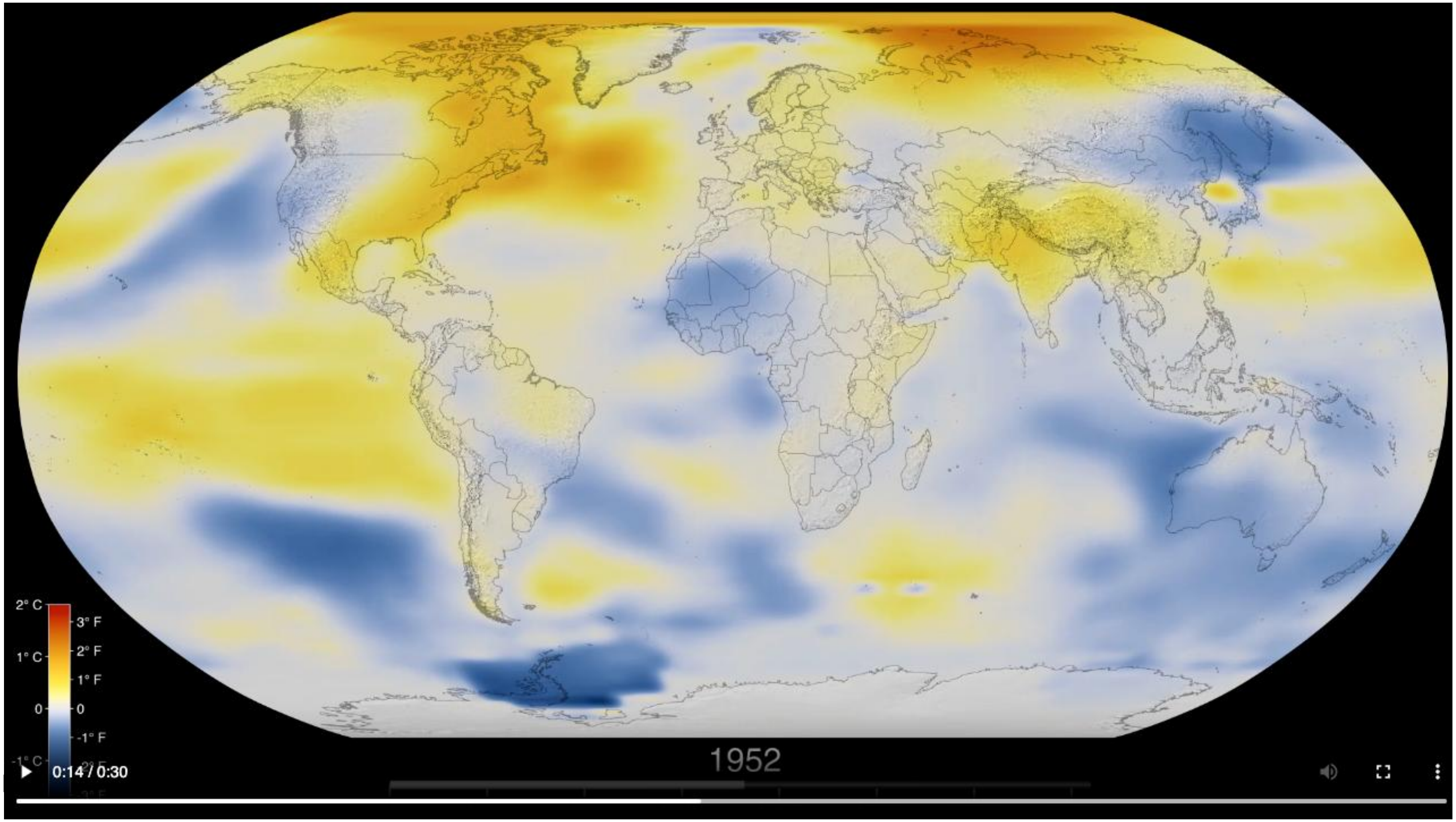
Increases in atmospheric CO_2 have contributed to a rise in Earth's temperature.



The term **temperature anomaly** means a departure from a reference value or long-term average, in this case 1951-1980. A positive **anomaly** indicates that the observed **temperature** was warmer than the reference value.

Increases in atmospheric CO_2 have contributed to a rise in Earth's temperature.

Play Global Temperature Anomalies from 1880 to 2023

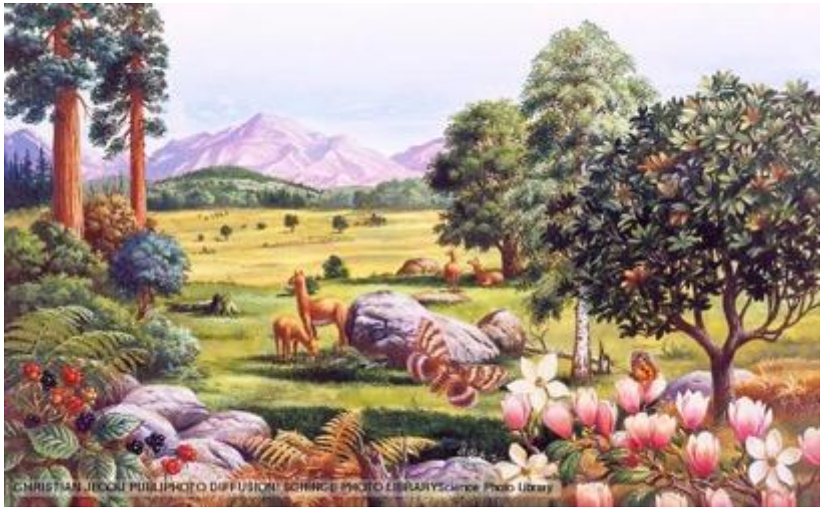


Why Collect Carbon Cycle Data?

The carbon cycle is no longer in balance due to human activities, specifically burning fossil fuels and land use change. CO_2 concentrations in the atmosphere are over 40% higher than the natural range over the past 800,000 years.

Why Collect Carbon Cycle Data?

The last time in Earth's history CO_2 levels were this high was over 3 million years ago, during the mid-Pliocene Warm Period. The increase in atmospheric CO_2 occurred over thousands of years. Sea level was 5-20 m higher, global air temperatures were 4°C warmer, and global sea surface temperatures were 2°C warmer. Today, we are increasing atmospheric CO_2 at a rate faster than we've ever seen in the geologic record.



Why Collect Carbon Cycle Data?

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

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.

Introductory Activities

The GLOBE Carbon Cycle materials include learning activities that introduce students to systems thinking, carbon, and the carbon cycle.

If these concepts are new to your students, they are highly recommended prior to conducting field protocols or modeling activities. The activities include:

1. **Paperclip Simulation:** introduction to systems thinking and using the '1-box model'
2. **Carbon Cycle Adventure Story:** follow a carbon atom through the carbon cycle
3. **Carbon Travels Game:** follow a carbon atom as it travels through the Earth's carbon pools
4. **Getting To Know Global Carbon:** learn the basics of the carbon cycle through diagrams

Introductory Activities

Paperclip Simulation - Introduction to Systems Thinking (60 minutes + 30 math extension).

Student Outcomes:

- Simulate a basic system
- Collect, record, and analyze data
- Create a 1-box model to learn modeling and system terms
- Manipulate variables to obtain an expected outcome

Materials:

- Simulation materials: paperclips, bell, signs, and roles
- Class Data Table (paper OR .xls) and Projector AND/OR Whiteboard/large paper with markers
- *Student Worksheets & Paper Clip Simulation Data Table*

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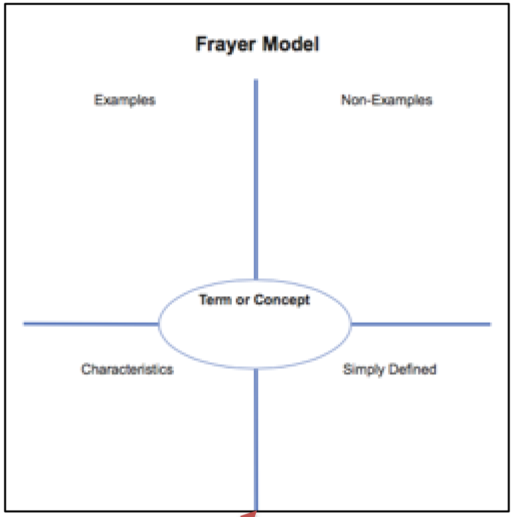
What is a System?

Definition: A collection of interconnected parts that function as a complex whole, through which matter cycles and energy flows.

Why does GLOBE use a 'systems thinking' approach to understand the Carbon Cycle?

1. Systems are an important unifying concept across the K-12 curriculum.
2. The actual carbon cycle is extremely complicated. Simplifying it as a system that focuses on the most important elements can help us understand why the atmosphere is changing and what it might look like in the future.



***Use the Frayer Model template to help students define the word 'system'*

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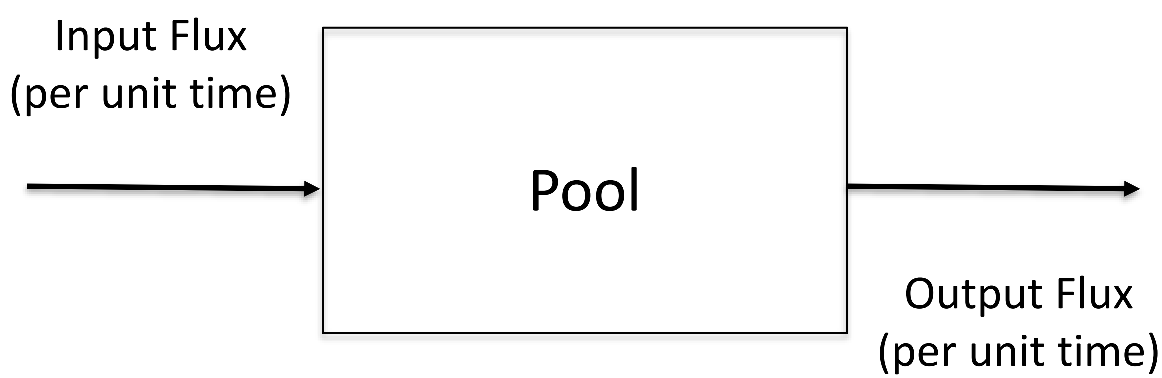
Modeling Systems with the 1-Box Model

The 1-box model represents an individual component of a system. It introduces concepts like inputs, outputs and residence time and shows how these can produce particular patterns of change over time.

In the GLOBE Carbon Cycle Learning Activities, students use the 1-box model to diagram and manipulate movement of matter through systems.



**A pool can also be referred to as a stock or reservoir, a flux can also be referred to as a flow.*

Modeling Systems with the 1-Box Model

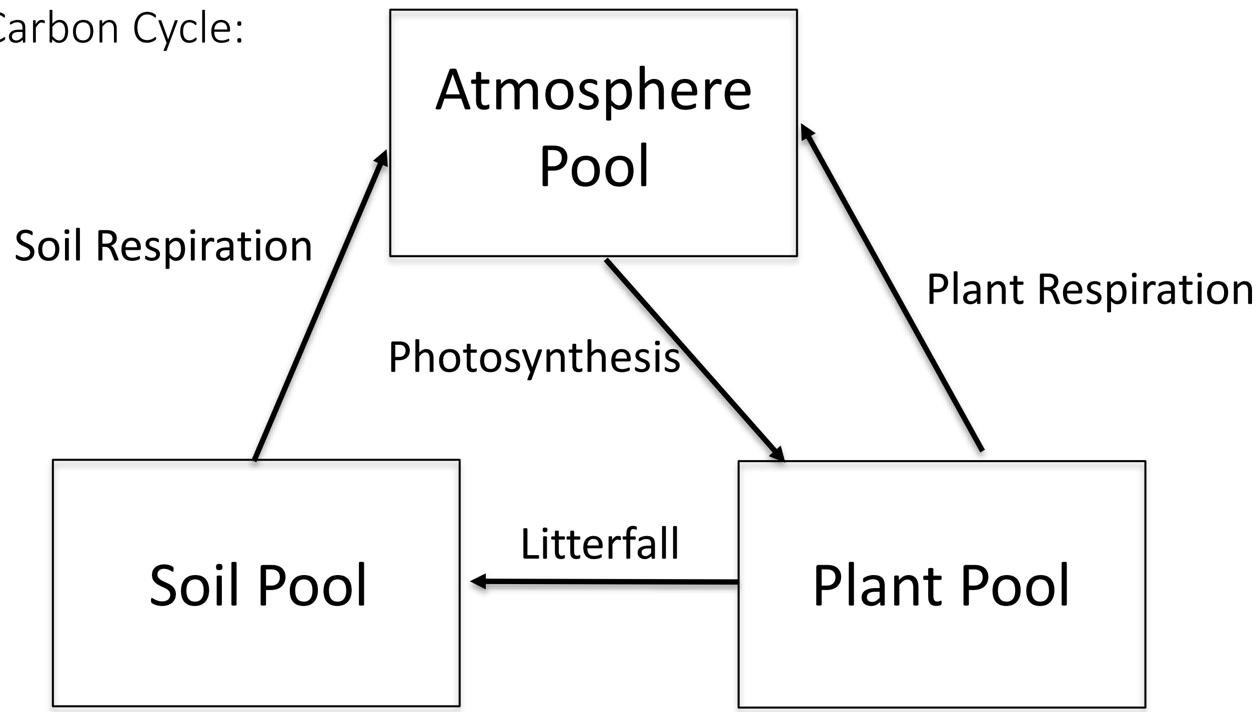
The 1-box model can be used to represent many different systems.

In the paperclip factory simulation to understand the components of a system:

Or to model parts of the Global Carbon Cycle:

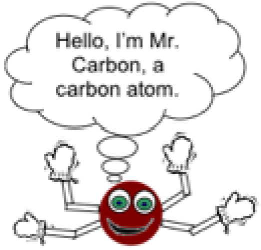
Putting many '1-Box Models' together makes a box and arrow model that shows how individual components of an entire system are connected.

Putting together many boxes (pools) and arrows (fluxes) allows you to model the movement of matter through more complex systems. For example, the model below shows the movement of carbon through the Atmosphere, Soil and Plant Pools of the Carbon Cycle:



Introductory Activities

Carbon Cycle Adventure Story – Follow a carbon atom through the carbon cycle in a self-guided adventure story (60-90 minutes).



Student Outcomes:

- List major pools and fluxes of the carbon cycle
- Diagram the carbon cycle using box and arrow models
- Describe what components of the carbon cycle make it a system

Materials:

- *Carbon Cycle Adventure Story booklets (one per student or pair)*
- *Carbon Story Journey Table (one per student or pair)*
- White board, chalk board, large paper, or overhead projector & markers/chalk

Introductory Activities

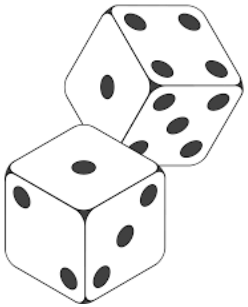
Carbon Travels Game – roll the dice to determine the fate of a carbon atom as it travels through Earth's carbon pools (60-120 min)

Student Outcomes:

- Research a specific carbon pool and present to peers
- List all major pools and fluxes in global carbon cycle
- Define residence time
- Compare and contrast the carbon cycle pre- and post-1700

Materials:

- Resources about carbon cycle
- Large sheets of paper
- *Carbon Cycle Station Instructions and Signs*
- *Journey Table* (1 per student)
- 1 six-sided die per student or station



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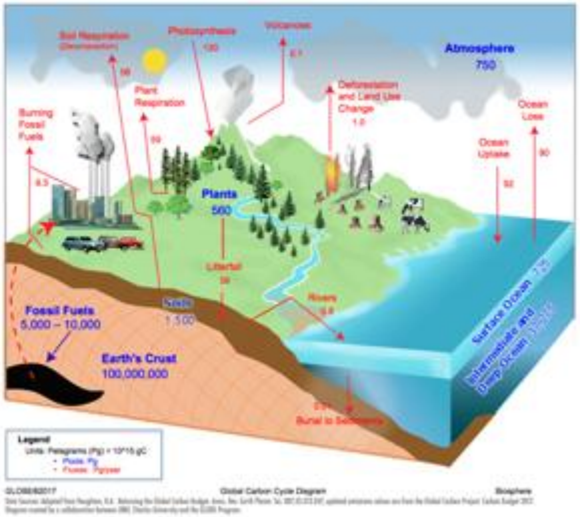
Introductory Activities

Getting to Know Global Carbon – learn the basics of the carbon cycle through diagrams (70-100 min)



Student Outcomes:

- Create diagrams of complex systems
- Conceptualize 1 Pg of carbon
- Describe why the carbon cycle is not in equilibrium

Materials:

- White board, chalk board, large paper or overhead projector & markers/chalk
- Materials for students to draw their own carbon cycle diagram
- Global Carbon Cycle Diagram – student copies or projected image

Quiz Questions

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

1. What is the carbon cycle?
2. What is the difference between *pools* and *fluxes*?
3. What are the major *pools* of carbon in the Earth System? Which contain the most carbon? The least?
4. Why is studying the carbon cycle important?
5. When atmospheric carbon dioxide concentrations increase, what happens to Earth's temperature?
6. Does photosynthesis add or remove carbon from the atmosphere? Does respiration add or remove carbon from the atmosphere?
7. What process has caused the most recent (past 150 years) increase in atmospheric carbon dioxide?
8. What activity could you use to introduce students to systems thinking?
9. What is a system?
10. What is a 1-box model? What are two examples of a 1-box model?

Part 2 :
Standard Site Field Protocols

Overview

This section…

- 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

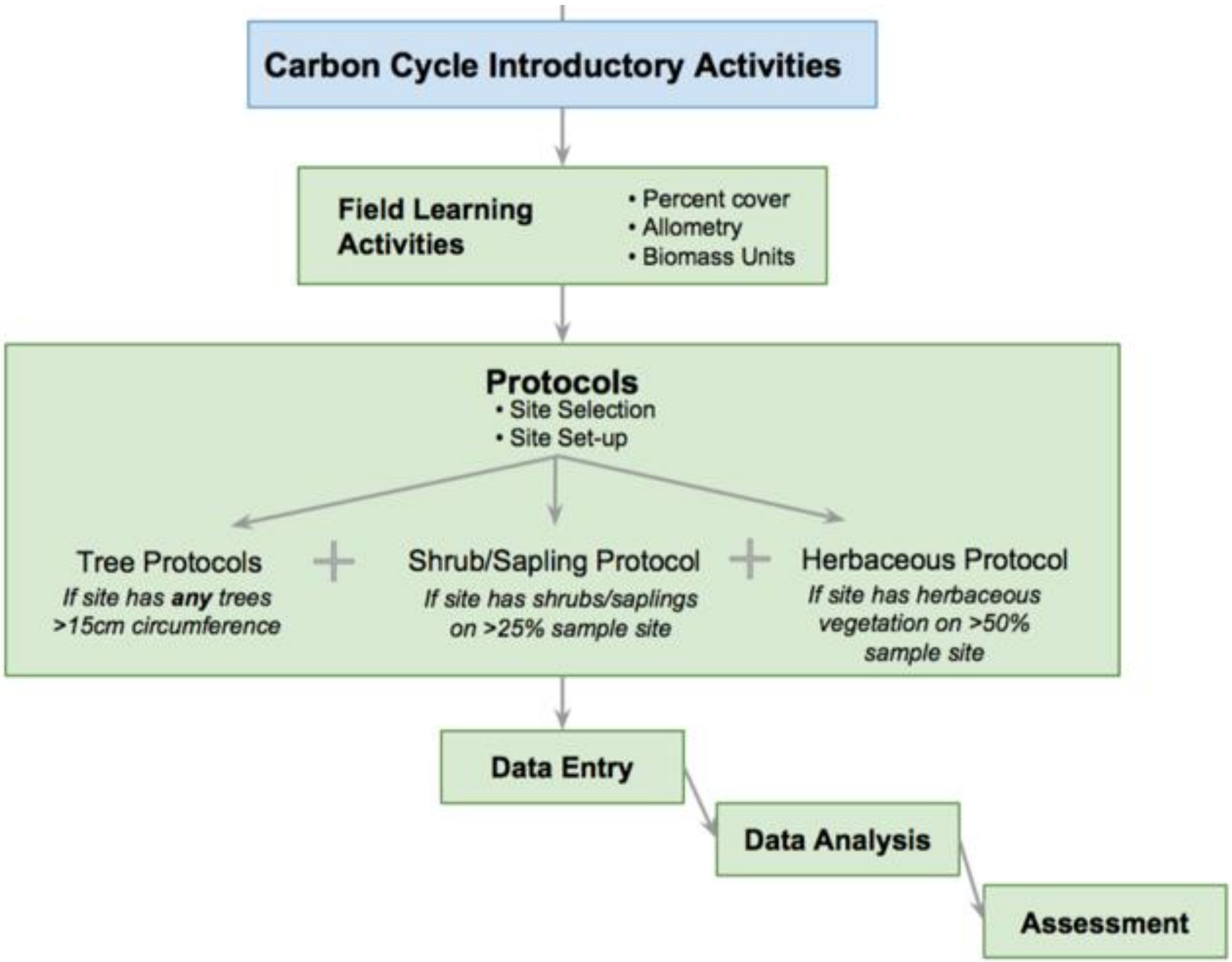
Learning Objectives

After completing this module, you will be able to:

- 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: 1.5 hours

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*

A. Overview
B.Learning Objectives
C. Field Measurements Overview
D. Field Learning Activities
E. Site Selection and Set-up
F. Tree, Shrub/Sapling, and Herbaceous Protocols
G. Enter data on GLOBE site
H. Understand Your Data
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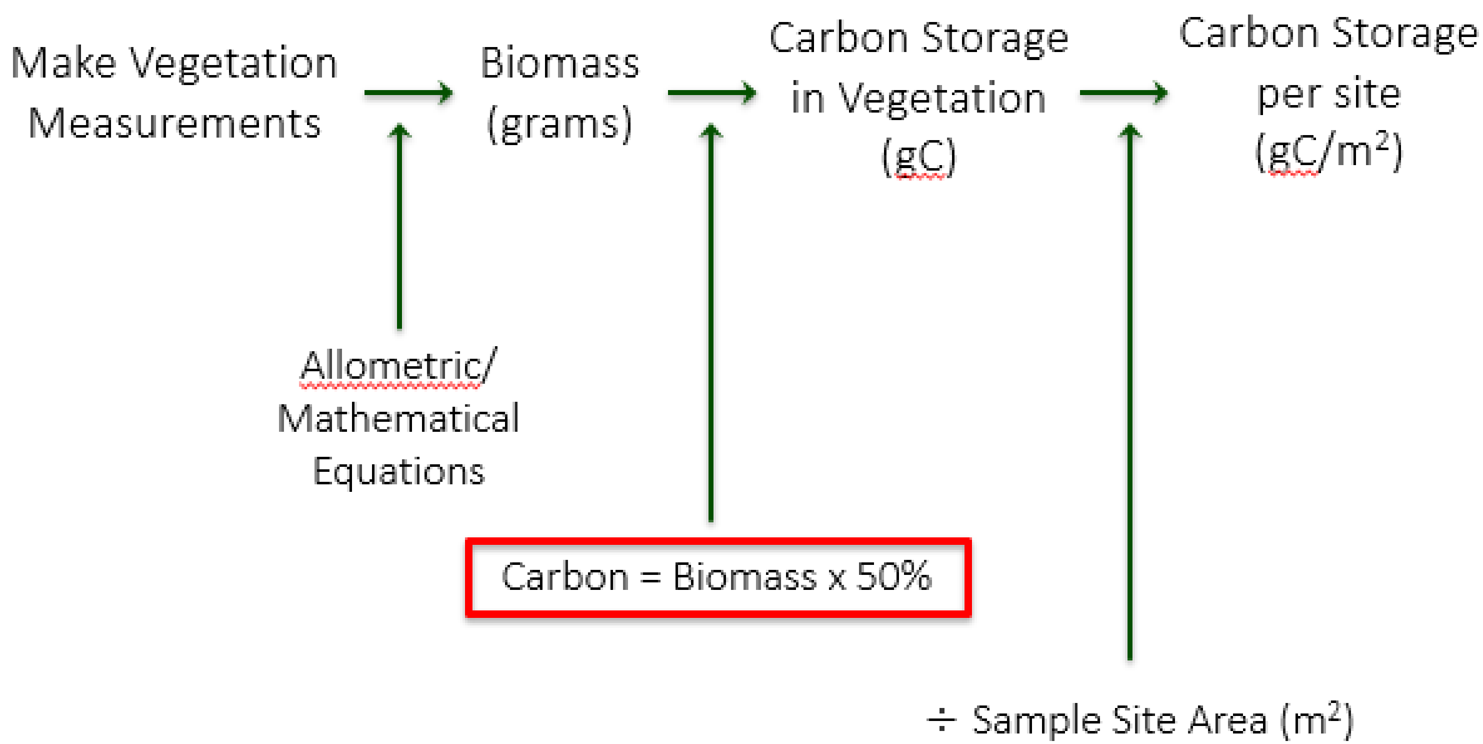
How Will You Calculate Carbon?



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

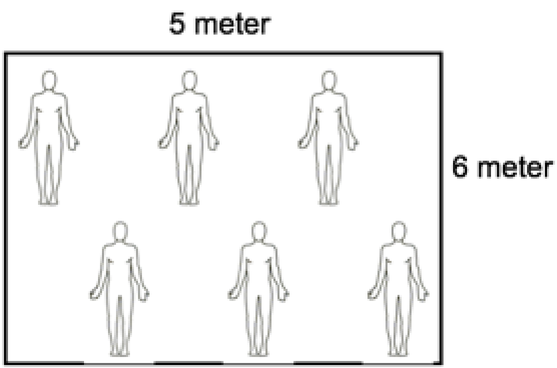
Field Learning Activities

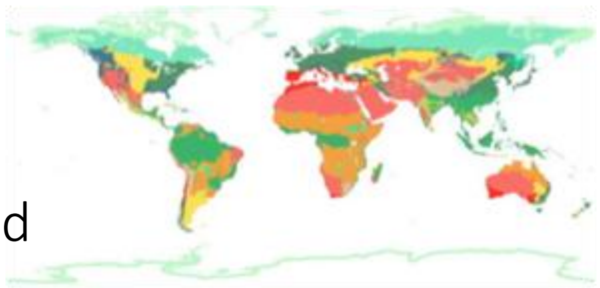
These activities teach important concepts and skills for understanding and conducting Carbon Protocols.

1. Biomass Units
2. Percent Cover
3. Allometry

Biomass Units

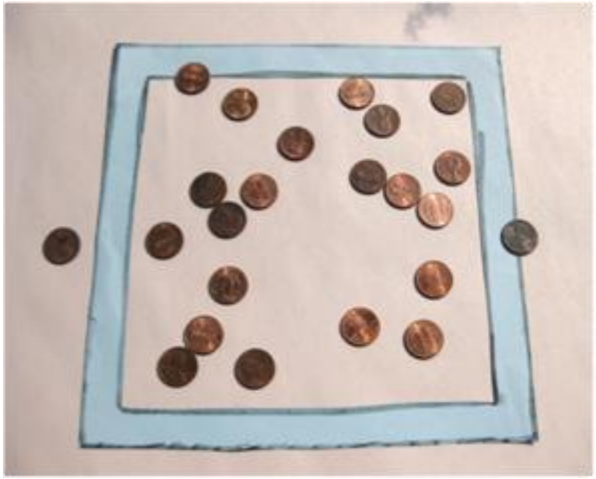
- Students calculate the biomass of the classroom in g/m^2.
- Students assess how biomass would change if size or mass of a sample area were different.
- Students rank global biomes from greatest to least biomass and compare their guess to available data.
- Students estimate how much carbon is stored in their schoolyard ($g\ C/m^2$) based on their biome classification and what they see.

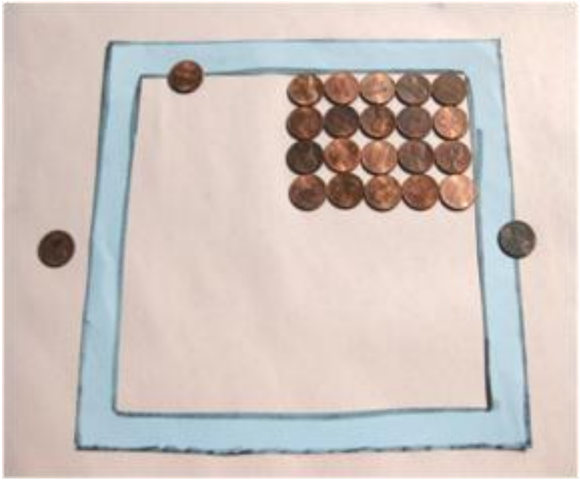




Percent Cover

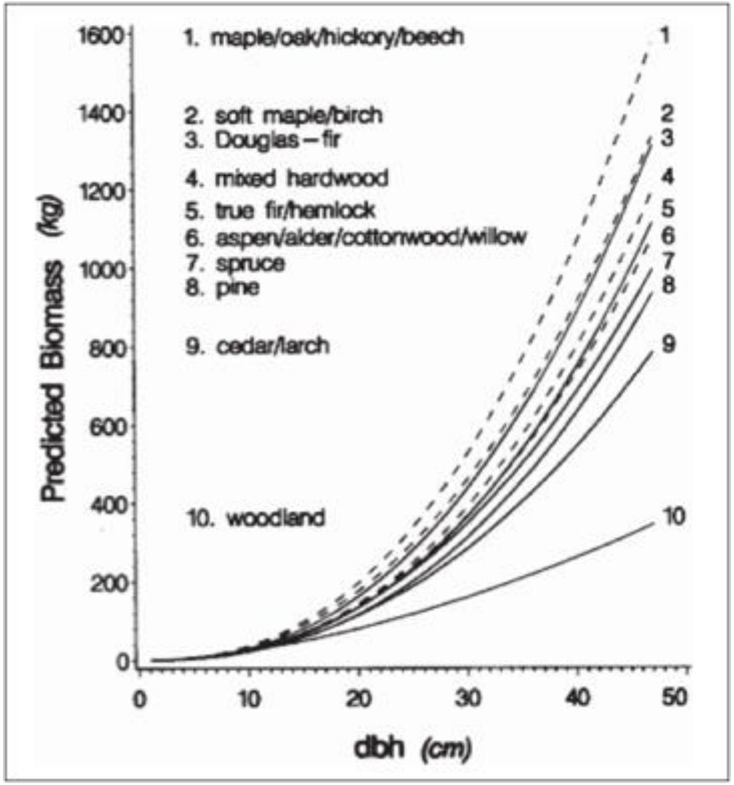
- Students practice estimating percent cover
- Students use these to determine if shrubs/saplings and/or herbaceous vegetation should be measured in the sample site.





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



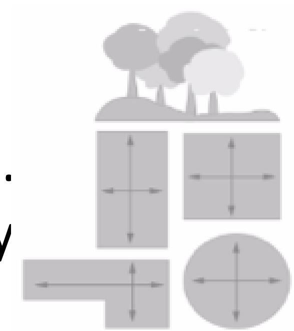
Jenkins et al. 2003

Site Selection

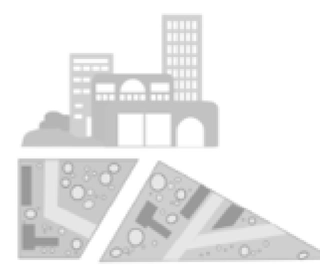
Site selection can be completed with or without student involvement

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.



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). ***Please complete Carbon Cycle Non-Standard Site Field Protocols eTraining***

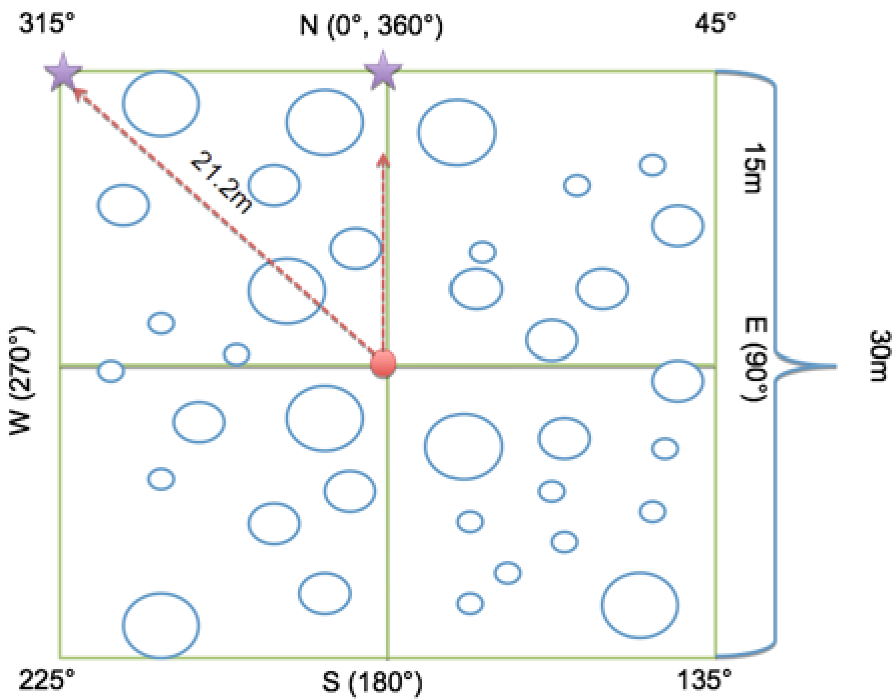


Standard Site Set-Up

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. Corner Team
3. Center Team



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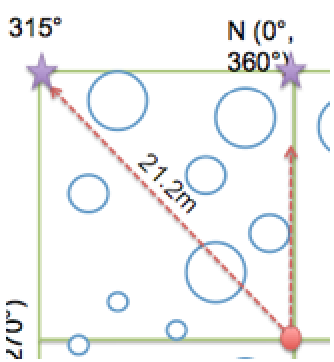
Standard Site Set-up (Cont'd)

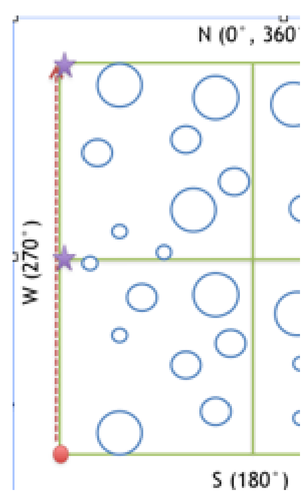
Corner teams

Use compass to pace from plot center to each corner. Place a temporary flag. Repeat for corresponding sides.



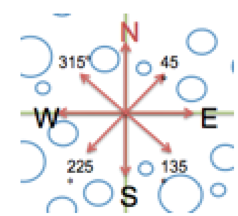
Perimeter Team

Start at first corner completed by a Corner Team. Pace along perimeter to check flags placed by Corner Teams.



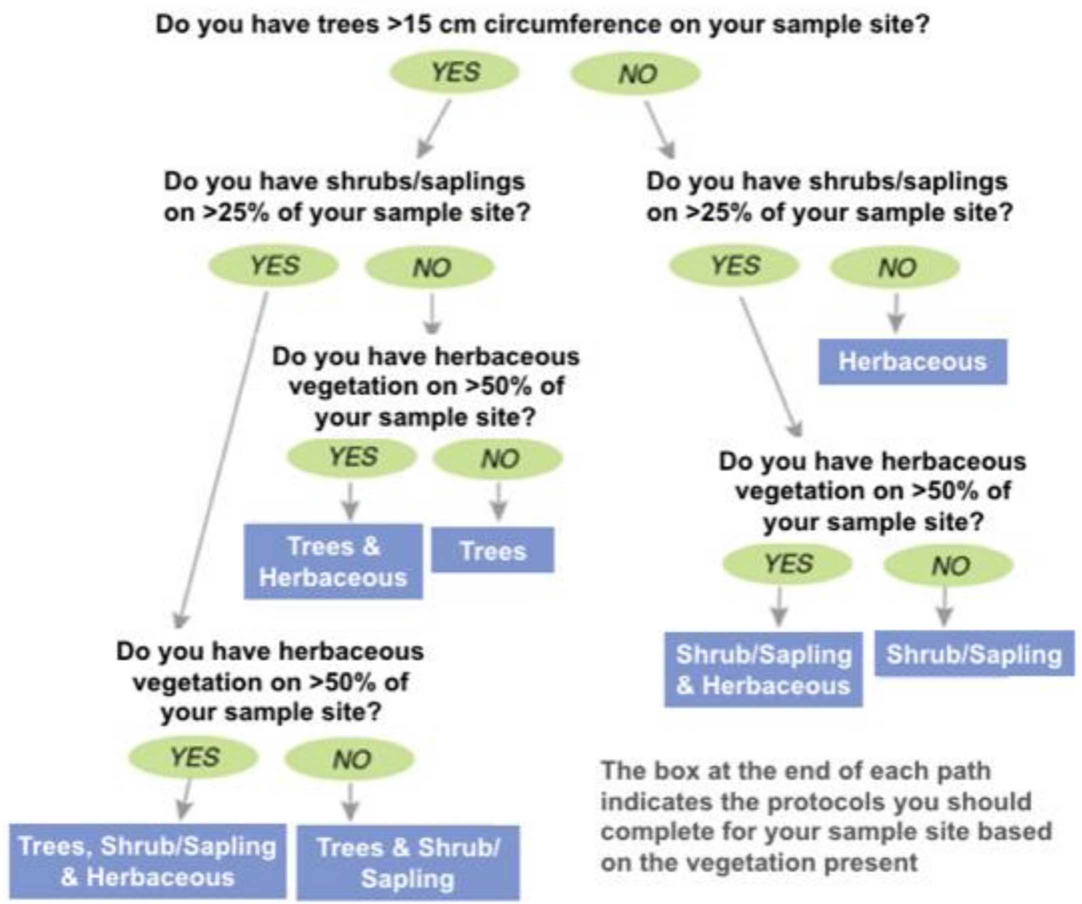
Center Team

Record the appropriate site location information on the *Sample Site Data Sheet.* Conduct vegetation analysis by estimating percent cover of shrubs/saplings and herbaceous cover. Take site photos.



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

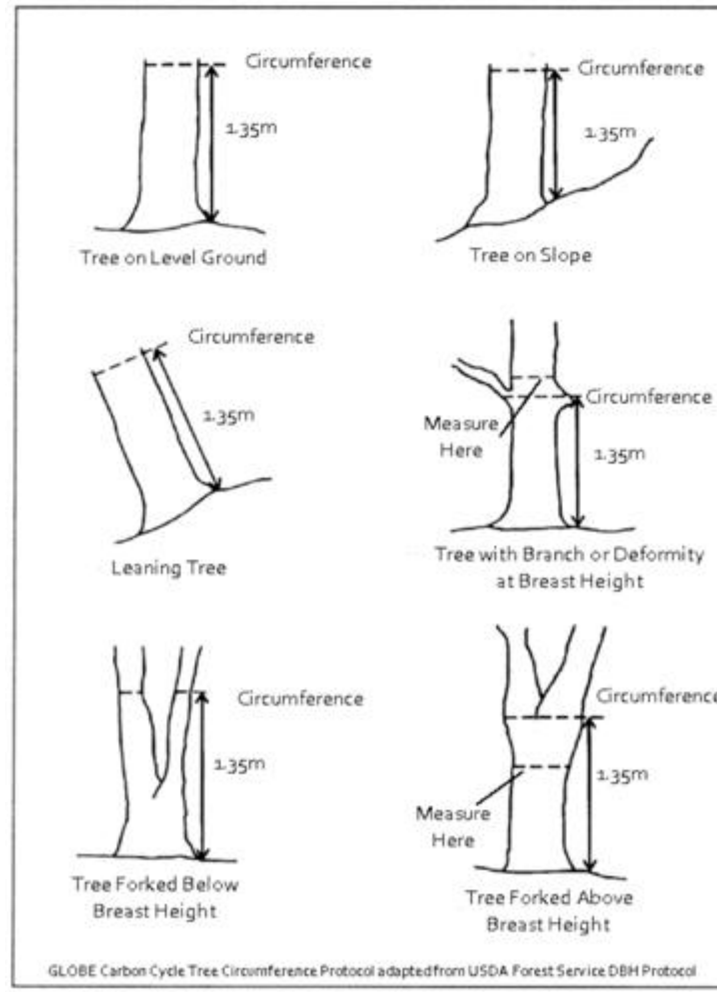
How to Measure Trees ***(Supporting Protocol)***	**Time: 60 minutes** **Instruments: tree cookies, small flexible measuring tape, calculator** **Prerequisites: None**
Tree Mapping **This can be done simultaneously with tree circumference, shrub/sapling & herbaceous measurements (if applicable). Complete once per site.*	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).Complete each year.*	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)

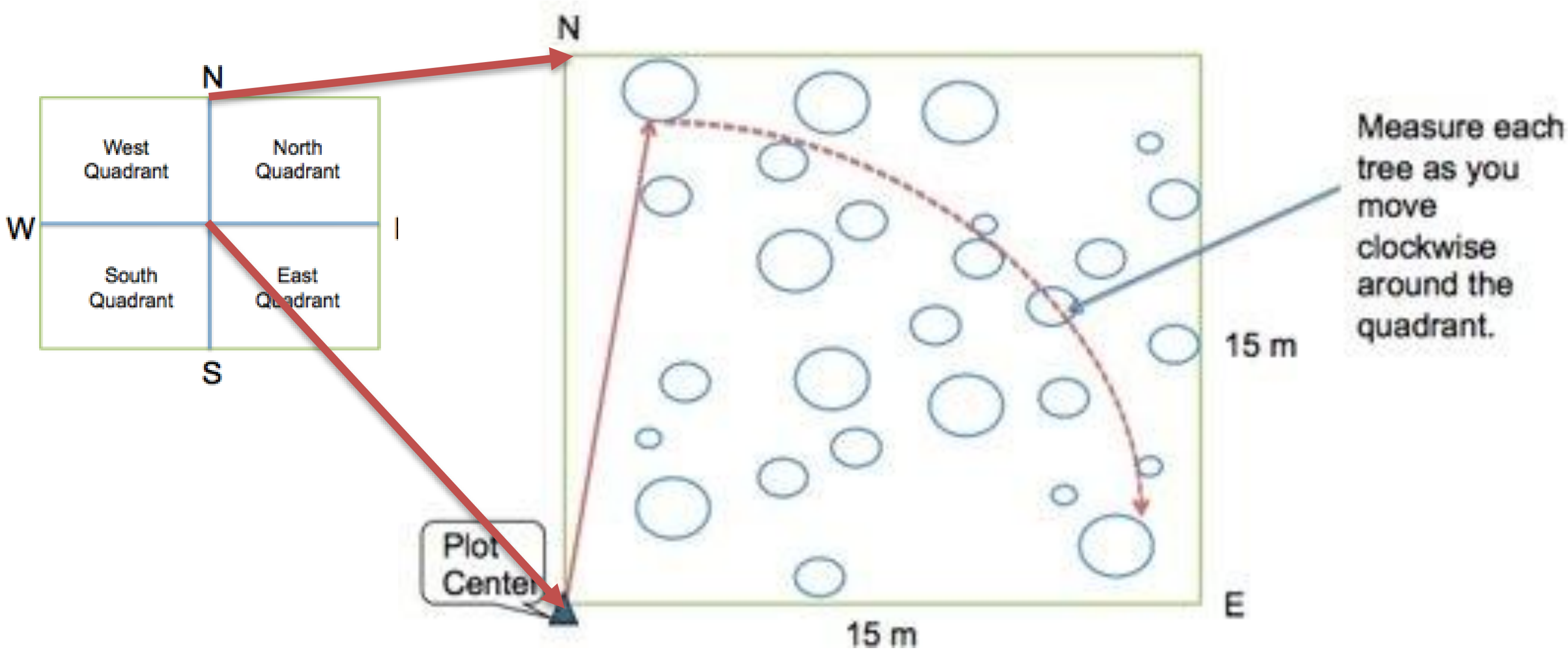


GLOBE Carbon Cycle Tree Circumference Protocol adapted from USDA Forest Service DBH Protocol

Tree Mapping

only needs to be completed once per site

Students divide into 4 quadrant teams and use a compass and measuring tape or pacing to map the location of each tree in the quadrant so the biomass and growth of each tree can be tracked over time.



Tree Mapping (Cont'd)

only needs to be completed once per site

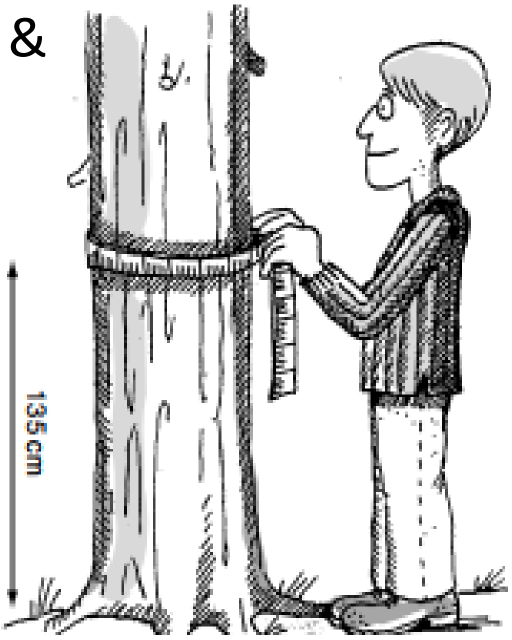
- Measure and record azimuth and distance of each tree from center, and identify the genus and species.
- If completing in conjunction with the Tree Circumference protocol, you will also measure circumference at this time.

Azimuth	Distance	Species	Notes	Circumference
15°	14m	Acer rubrum	Red maple	50cm
85°	6.5m	Pinus strobus	White pine, Forked, Measured at 1.25m	27cm

Tree Circumference

Complete each year

- 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**

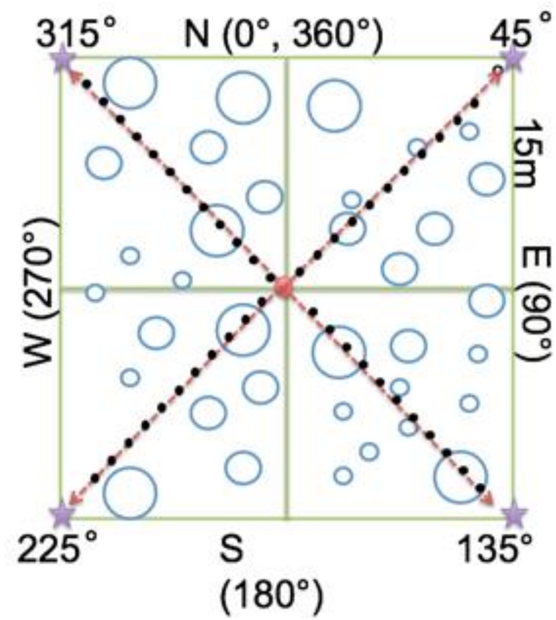
Shrub/Sapling Protocol

Complete each year

For each plot corner:

- Pace from the center towards a corner. At each pace (two steps), place the measuring stick straight down.
- Record 'H' (hit) if the stick is touching a shrub or sapling.
  - 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.
- Use the measuring stick to measure a representative height of the whole shrub/sapling.
- Record 'M' (miss) if the stick is not touching a shrub or sapling.
- Repeat these steps until you reach the corner.
- Repeat for each corner.

Standard Shrub/Sapling Measurements - Student Field Guide



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**

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Herbaceous Protocol

Complete each year

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)

Complete each year

Dry the herbaceous samples by either:

(a) **Drying oven:** Set oven temp to 50-70ºF, 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.

Image: censam.mit.edu

(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.

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 .

For years 2+ Data Review - Compare Data To Previous Years

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 (ie: ice storms, insects, hurricanes).

Data Entry at Globe.gov (2/3)

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

1. Desktop Data Entry: Log environmental data directly on the GLOBE website.
2. Email Data Entry: If connectivity is an issue, data can also be entered via email.
3. GLOBE Observer 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 or on the GLOBE Observer App

1. Create a new site
2. Add site coordinates
3. Describe site, indicate standard or non-standard, and vegetation measured
4. Submit
5. Optional: add site photos

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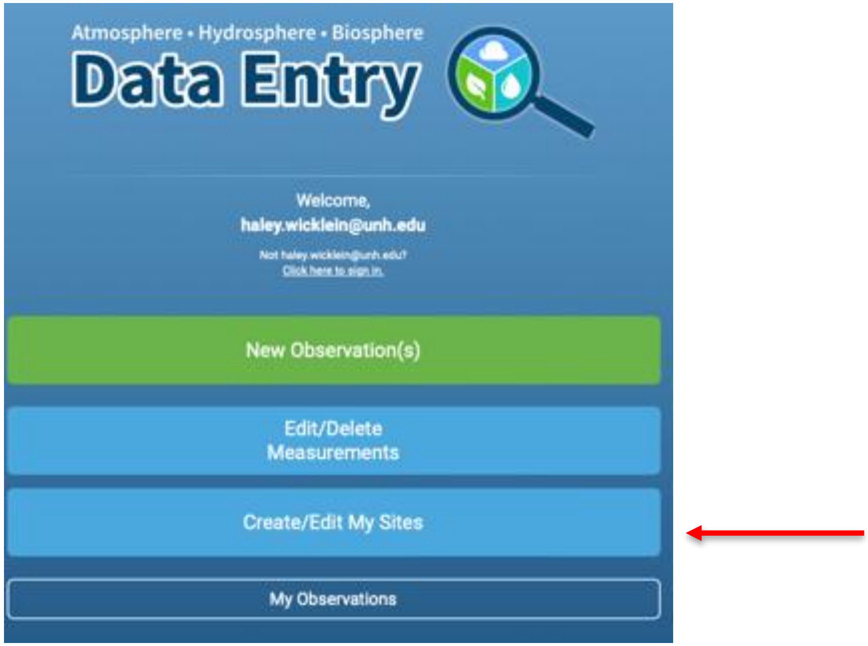
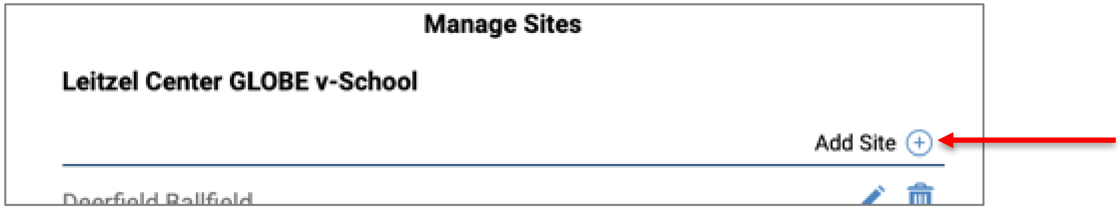
1. Create a new site

Log in to the GLOBE Data Entry webpage and click “Create/Edit My Sites”.



Then click “Add site”.



2. Add site coordinates

Choose a name for your site

New Site

Name: *
Carbon Cycle Site Name

(use coordinates or move/zoom map)

Latitude:
43.13191

Longitude:
-70.92353

Elevation: *
18.4

Type in coordinates or move the map to add your latitude and longitude

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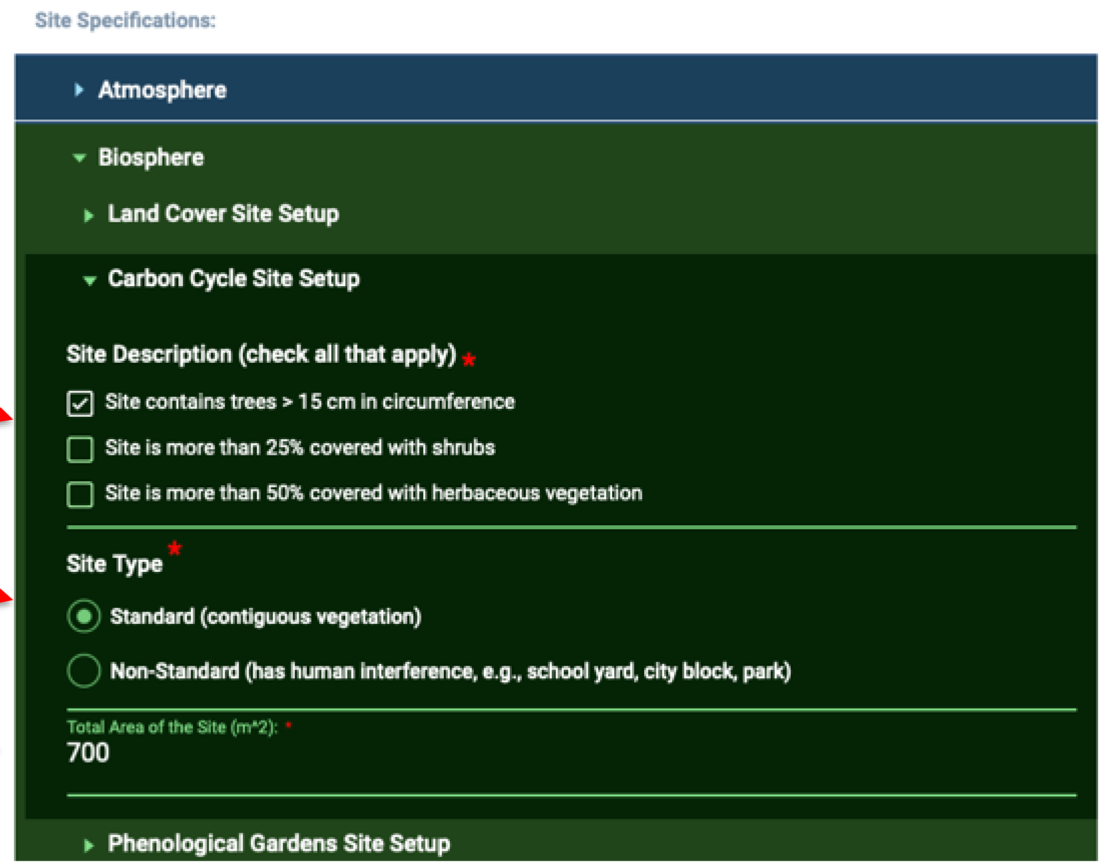
3. Describe site; indicate standard or non-standard, and vegetation types measured

Check the vegetation types you will measure

Select Standard or Non-Standard*

Add the area of the site in m^2



*This will determine the data entry form you see!

4. Submit!

At the bottom of the screen, click the "Save Site" button.

Your site will now appear in the list of GLOBE data collection sites under your school/organization.

To return to the data entry home page, use the home icon at the bottom of the screen.

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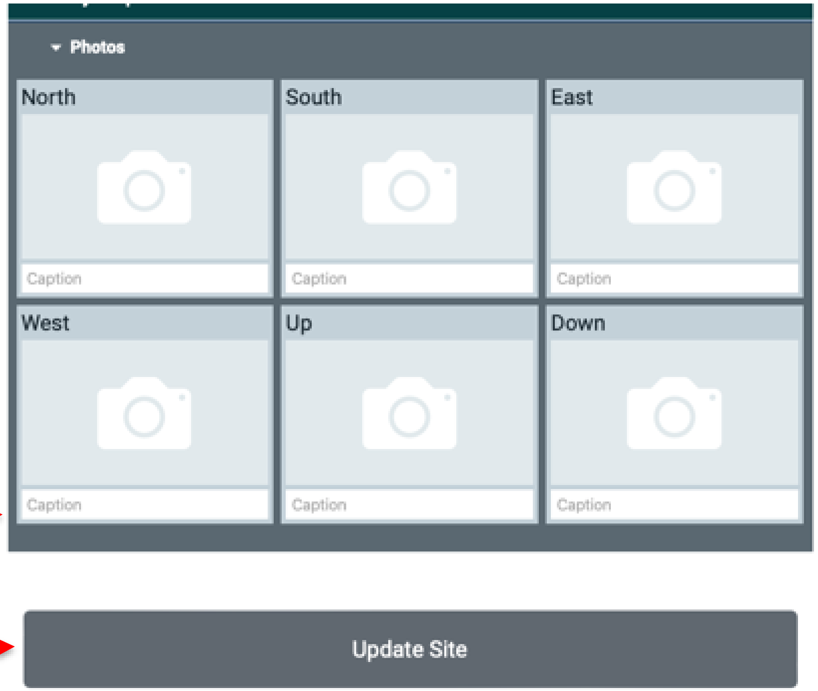
5. Optional: Add site photos

After your site is created, you can add site photos by going to “Create/Edit My Sites” from the data entry home page and clicking on your carbon site name. Scroll down to the photo section:

Click on the camera icon to upload a photo.

Optional: add a caption

Click “Update Site”

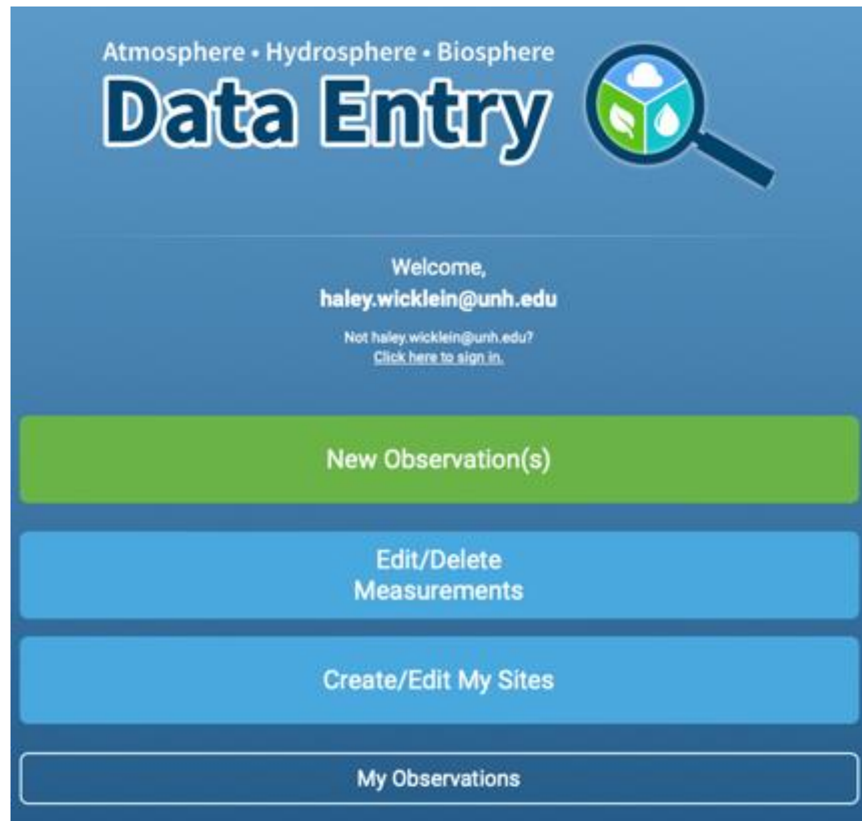


Make sure that your photos do not contain people!

Add Carbon Cycle data

Once your site has been established in the database, you or your students are ready to upload carbon data. Learn how to manage student accounts.

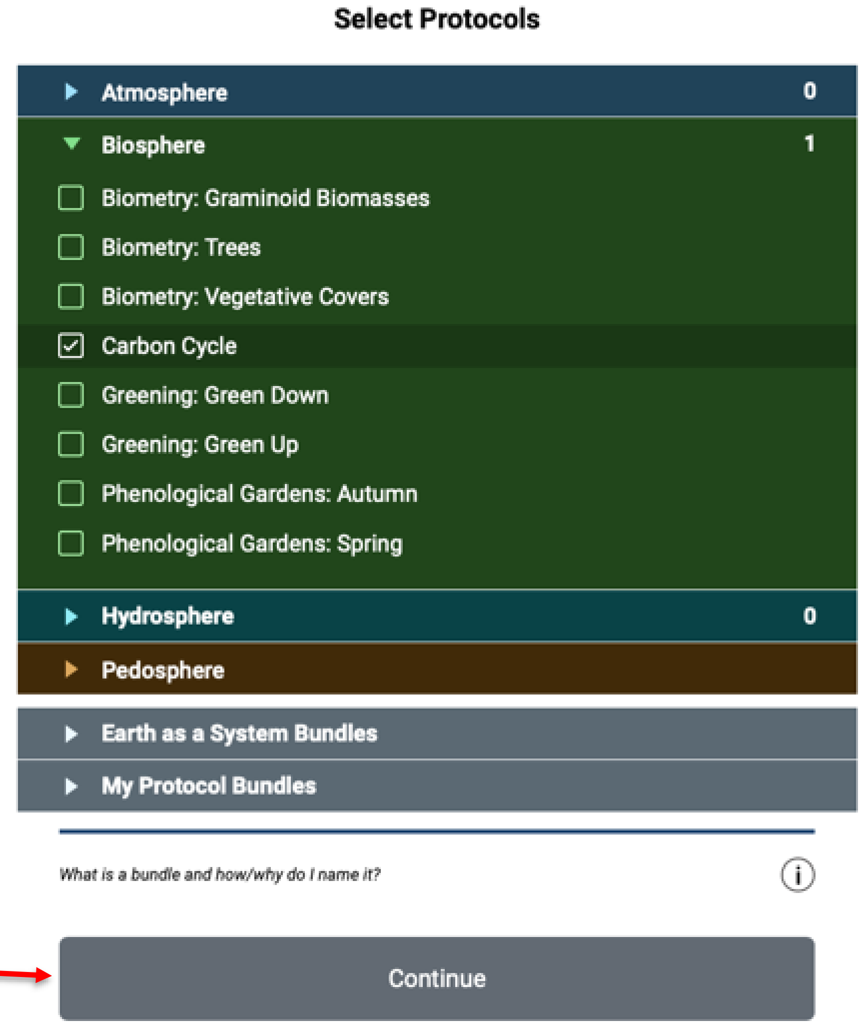
From the data entry homepage. Click "New Observation"



Add Carbon Cycle data (Cont'd)

Under Biosphere, select Carbon Cycle

Click Continue



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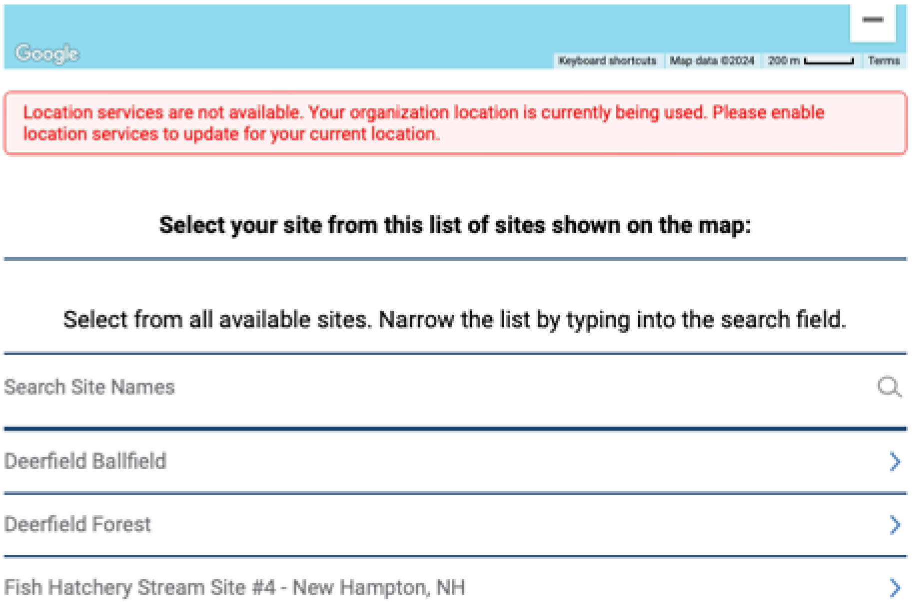
Add Carbon Cycle data (Cont’d)*

Scroll down the page and choose the Carbon site you created



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Add Carbon Cycle data (Cont’d)*

Update the date and time to when you collected your carbon data →

Enter the local date and time of the observation:

Local Date:
2024-09-24

Local Time (24hr):
09:21:00

Get Current Time

Observation Date: **2024-09-24 UTC**
Observation Time: **13:21 UTC**
Solar Noon: **16:35 UTC**

Click “Carbon Cycle” →

Carbon Cycle

Add carbon cycle tree* data

Enter data from your data sheet for each tree.

Trees

Tree #1

Species Group *
Maple Oak

Circumference (cm) *
30 cm

Genus: *
Acer

Species: *
saccharum

Common Name:
Sugar Maple

Comments:

Tree#2 — Add Tree

Click "Add Tree" to enter data for each subsequent tree you measured.

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

Enter shrub and sapling* data

Add shrub and sapling data from your data sheet.

Shrubs and Saplings

Sample #1

Shrub/Sapling Presence *
Hit

Type *
Evergreen

Height (m) *
2.5 meter(s)

Sample #2 — Add Sample

Click "Add Sample" for additional shrubs or saplings as necessary.

* not all sites will have shrubs and saplings. Skip if not applicable to your site.

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Enter herbaceous* data

Add data from your three herbaceous samples.

Herbaceous Biomass Measurements

Sample #1

Bag #1

Mass of Sample and Bag, a (g) *

Mass of Empty Bag, b (g) *

Herbaceous Biomass:
a - b = 0 g/m^2

Biomass is automatically calculated.

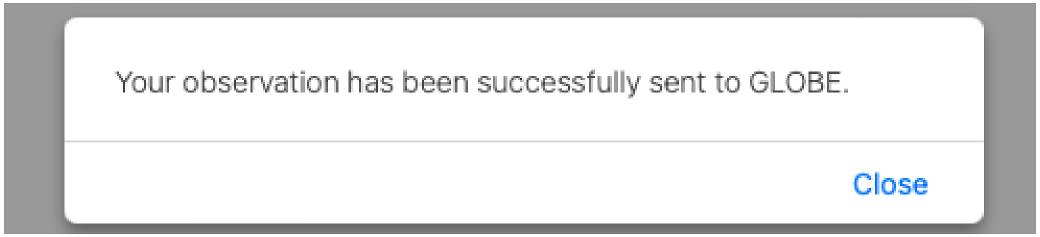
Bag #2 — Add Bag

Click "Add Bag" if you had multiple bags per sample.

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

Send Data to GLOBE

1. Click the “Review” button at the bottom of the screen.
2. Open the Biosphere drop down and review the data you entered.
3. If it is correct, click “Send Observations”.
4. Wait to receive the message that your observations were successfully sent!



Understanding Your Data: Data Analysis

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

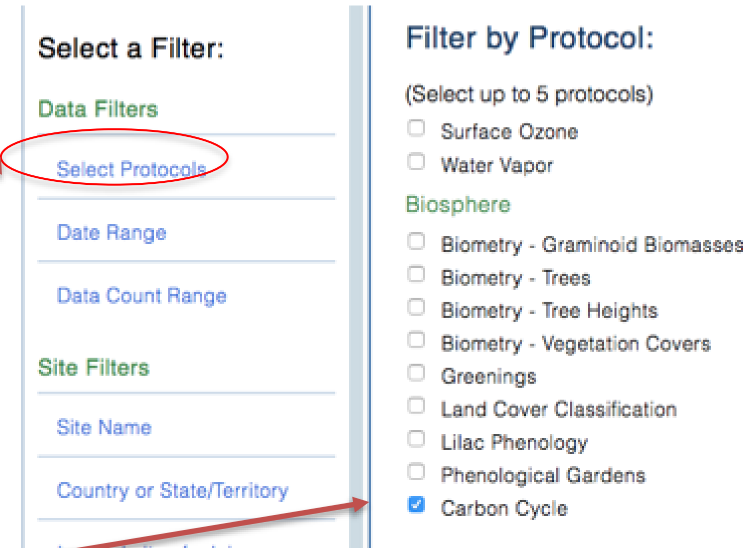
Requires:

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

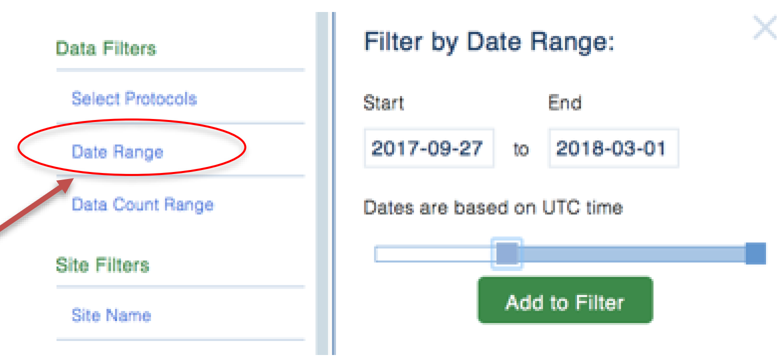
Download Data From GLOBE (1/3)

*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 Add to Filter. Add to Filter



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



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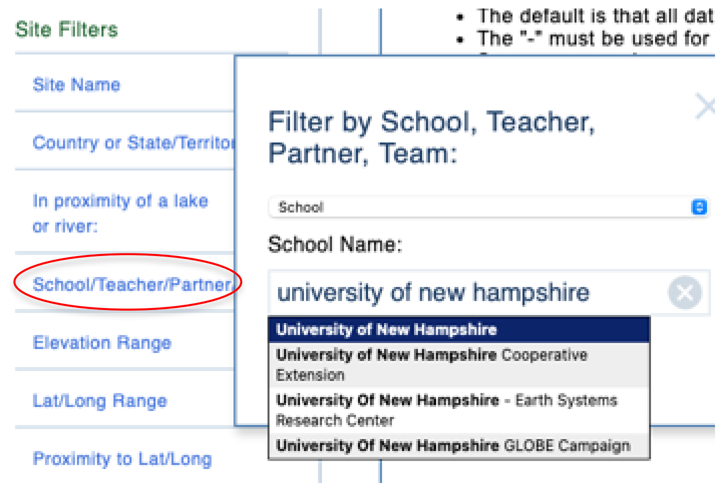
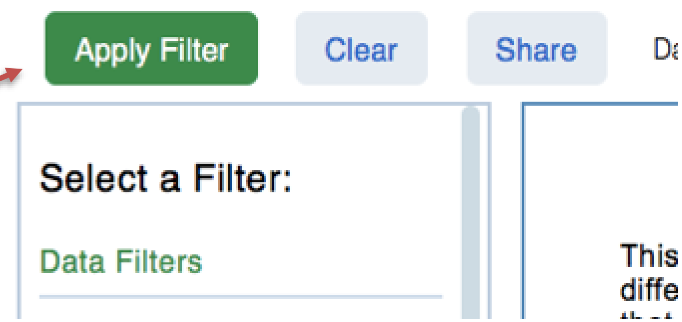
Download Data From GLOBE (2/3)

6. Under Site Filters, click ‘School/Teacher/Partner/Team’, and select your school.



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

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



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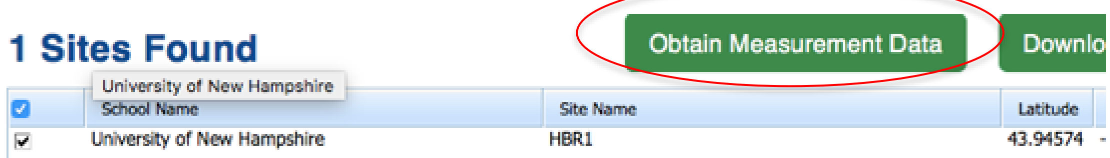
Download Data From GLOBE (3/3)

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 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

Use the GLOBE Carbon Cycle data interpretation teacher guides and activities to give students context for understanding their data.

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

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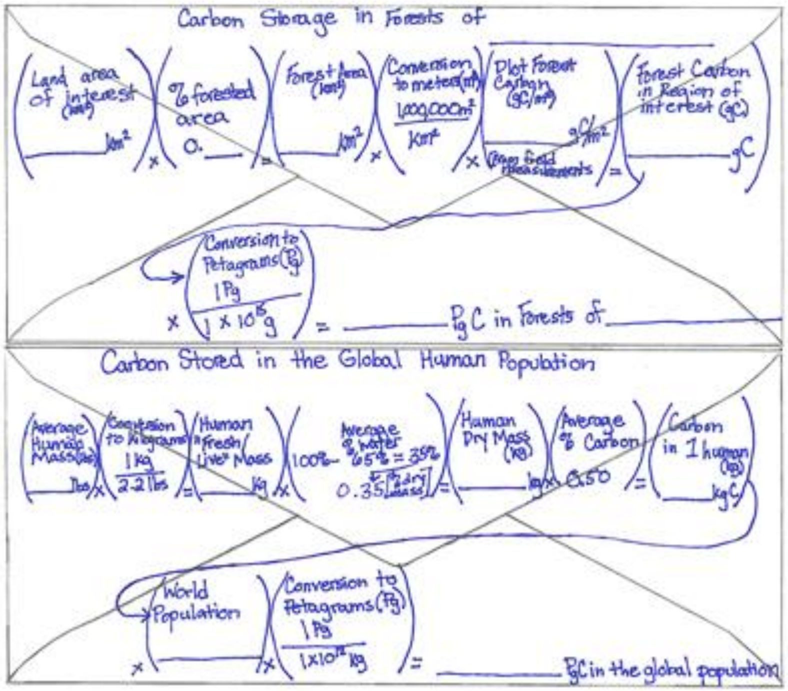
Human Carbon vs. Tree Carbon

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

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 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. What is the percent cover needed to take herbaceous vegetation measurements? Shrub/sapling measurements?
8. How are tree measurements converted to biomass? To carbon storage?
9. If you measure shrub/saplings, what data will you record?
10. How might someone calculate carbon storage of vegetation over the entire town based on your field measurements?

Additional Resources:

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

Questions about this module?
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