

## Lesson 3

## Carbon Cycles through Ecosystems

Unit Title: <b>Carbon Cycles through Ecosystems</b>	
Theme: <b>Ecosystems &amp; Cycles</b>	Grade Level: <b>7</b>
# of sessions for the unit: <b>2</b>	Session #11: <b>Is there a difference in how much carbon upland forests store above and below ground?</b>
Date created: <b>Summer 2017</b>	Author: <b>B. Allia, C. McWilliams</b>



## Unit Description

Focusing on systems and cycles, students use their understanding of climate-change and how carbon and thermal energy interact with Earth's land and atmosphere. Students practice skills such as argumentation and collecting and analyzing data. Students gain experience with the interactions of humans and Earth processes with ecosystem dynamics, and with developing solutions to complex climate-change issues. The lessons generally follow this order:

- Introduce unit and culminating event: climate-change's effect upon fauna
- analyze global temperature and carbon dioxide trends
- understand personal climate-change experiences, such as weather, matter and energy uses
- collect wetland and upland forest soil carbon-stores
- sample atmospheric carbon-store
- analyze land and atmospheric carbon-stores
- understand the carbon cycle, pre-human and human era
- describe personal experiences with solid forms of carbon changing into atmospheric carbon
- develop and present solutions to save a fauna from climate-change issues

## Standard(s)

Based upon the 2016 MA Science & Technology/Engineering Curriculum Framework

**MA LS2** Ecosystems: Interactions, Energy, and Dynamics

**MA 7.MS-LS2-3** Develop a model to describe that matter and energy are transferred among living and nonliving parts of an ecosystem and that both matter and energy are conserved through these processes

## Unit Goals

1. Create an action plan to decrease carbon in the atmosphere, increase carbon stored by the land, and preserve natural carbon-stores in the ground
2. Build background knowledge of how carbon cycles within a local ecosystem
3. Understand relevant climate-change issues in order to make informed decisions
4. Identify authentic scientific processes, such as sampling, gathering, and analyzing land and atmospheric carbon-content data, in order to validate evidence regarding climate-change

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## Unit Objectives

### ■ Students will be able to

understand that:

1. Carbon cycles through the atmosphere and land
2. Human activities increases atmospheric carbon by burning fossil fuel
3. Atmospheric carbon is a “greenhouse gas”
4. Greenhouse gases increase global temperatures
5. Wetlands and uplands store different amounts of carbon above and below ground

and to:

1. Sample, collect, and analyze primary-source data
2. Collect and analyze secondary data as a means to validate causes of climate-change

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## Lesson Objectives

Collect & Analyze Data

1. Stored carbon amount in forest and wetland (above and below ground)
2. Primary data

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## Note any potential barriers to the lesson — consider variability

### ■ Student challenges

- physical challenges, such as degree of field work needed for mobility

### ■ Teacher challenges

- transporting soil back to classroom
- permission to take soil from site

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## Evaluation/Assessment

(directly linked to the goals, i.e., Formative/Ongoing Assessment or Summative/End of Lesson Assessment)

### ■ Formative Assessment

#### RAFT (Role, Audience, Format, Topic)

In small groups, students adopt the roles such as a maple tree and a grain of sand, in a conversation about how they store carbon. Students choose a format to demonstrate their knowledge, such as a: diary entry, love letter (ie: carbon to soil), petition, obituary, TV commercial, print advertisement.

### ■ Formative Assessment quick check for understanding

Homework options on soil topics for lesson's 3 days:

1. Create video of soil with companion questions (see below)
2. **Brain Pop** soil with companion questions (see below) [www.brainpop.com](http://www.brainpop.com)

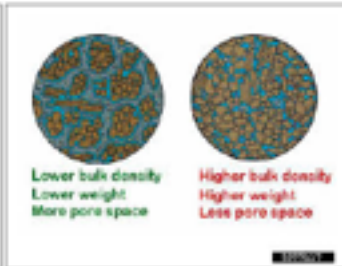
3. **Actively Learn** soil horizons reading activities at [www.activelylearn.com](http://www.activelylearn.com) (free subscription) with companion questions

### Upland Forest Sampling Soil Carbon Content

\* Required

1. One way to measure ABOVE-GROUND carbon in an upland forest is to measure \*

Mark only one oval.

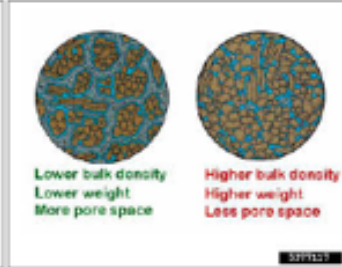


☐ tree circumference in a given quadrat

☐ Soil bulk density

2. One way to measure BELOW-GROUND carbon in an upland forest is to measure \*

Mark only one oval.



☐ tree circumference in a given quadrat

☐ Soil bulk density

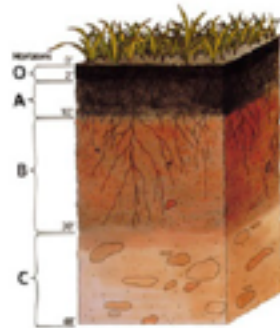
3. Horizon Layers exist \*

Mark only one oval.

☐ Above Ground Soil

☐ Below Ground Soil

4. Generally, the darker the soil looks, the more carbon it contains.\*



Mark only one oval.

- ☐ True  
☐ False

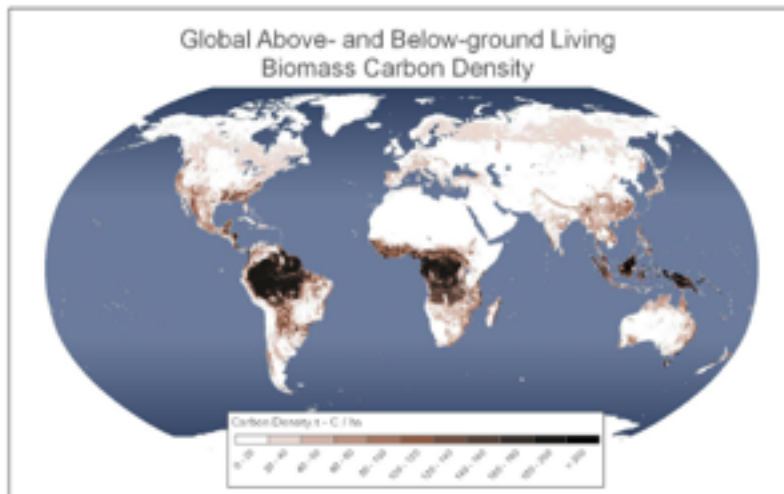
5. We dry our soil sample so\*

$$\text{density} = \frac{\text{mass}}{\text{volume}}$$

Mark only one oval.

- ☐ we can measure the density of just the water in the soil  
☐ we can measure the density of the just the soil, without water

6. Where in the world has the MOST carbon density?\*



Mark only one oval.

- ☐ The tropic zone  
☐ The temperate zone

in Google Forms <https://goo.gl/forms/mjLrAOC3u6ZNljus1>

## ■ Matching sample collection techniques

1. Question: In the field, we collected samples from

Answers:

- A. in a wetland ecosystem (correct)
- B. in a forest ecosystem
- C. in a desert ecosystem

2. Question: In the field, we collected samples to determine

Answers:

- A. the difference in nitrogen stores above and below the ground
- B. the difference in carbon-stores above and below the ground (correct)
- C. the difference in hydrogen stores above and below the ground

3. Question: To test the carbon-stores above the ground, we used the

Answers:

- A. Soil Core technique
- B. Clipping Vegetation Quadrat technique (correct)

4. Question: To test the carbon-stores below the ground, we used the

- A. Soil Core technique (correct)
- B. Clipping Vegetation Quadrat technique

5. Question: Soil collected in the field must have an appropriate label for tracking the sample back to the location from which it was collected

Answers:

- A. True
- B. False

## ■ Homework: Brain Pop Soil video & quiz <https://www.brainpop.com/science/earthsystem/soil/>

Formative Assessment — Watch video, take quiz

Video: Soil Organic Carbon — the treasure beneath our feet

Food and Agriculture Organization of the United Nations

<https://www.youtube.com/watch?v=Ymy0IO7nizw>

Google Forms Quiz, questions below, based on the video



At time 0:12, the video title says \*

- ☐ Soil Organic carbon the key to our food
- ☐ Soil Organic carbon the treasure beneath our feet
- ☐ Soil Organic carbon the treat it well

...

Around time 0:30, Soil holds massive amounts of organic matter, which increases its ability

☒ Multiple choice ▼

- ☐ to store and release the nutrients essential for plant growth
- ☐ to store carbon, removing it from the atmosphere



0:57 It carries out another crucial function. \*

- ☐ It captures carbon from the wind
- ☐ It lets humans build shelter upon it
- ☐ It captures carbon from the atmosphere as soil organic carbon

...

1:20 It is when we lose soil organic matter \*

- ☐ through human activities that we face problems
- ☐ for food production, people could starve
- ☐ for city to build upon, we lose living space

By rehabilitating the world's degraded soils, from the atmosphere \*

- ☐ we can remove up to 51 gigatonnes of carbon from the atmosphere
- ☐ we can remove up to 61 gigatonnes of carbon from the atmosphere
- ☐ we can remove up to 71 gigatonnes of carbon from the atmosphere

At the end, look underneath the video. What organization produced this video?

☒ Checkboxes

- ☐ The United States
- ☐ Food and Agriculture Organization of the United Nations
- ☐ Disney
- ☐ The History Channel

1:33 Yet an estimated \*

- ☐ 2 847 gigatonnes remain in the first meter of soil across the globe
- ☐ 8 364 gigatonnes remain in the first meter of soil across the globe
- ☐ 1 417 gigatonnes remain in the first meter of soil across the globe

1:50 It's clear that losing soil carbon treasure would increase carbon emissions and accelerate climate change

- ☐ increase carbon emissions and decrease climate change
- ☐ decrease carbon emissions and decrease climate change
- ☐ increase carbon emissions and accelerate climate change

### Alternate Homework Brain Pop

<https://www.brainpop.com/science/earthsystem/tropicalrainforests/>

Example of Brain Pop quiz questions:

Tropical Rain Forests
10
BrainPOP

1 The Earth has a total land area of approximately 150 million square km. About how much is covered by rain forest?

A 1.5 million square km

✓ B 10.5 million square km

C 15 million square km

D 50 million square km

Flag this question for moderator review

2 Which statement is true?

A There are few animals that live in the rain forest, and they belong to a small number of species

✓ B The population of animals in the rain forest is large and diverse

C Many animals live in the rain forest, but there are just a few species that can survive there

D There are many animal species living in the rain forest, but their populations are usually very small

Flag this question for moderator review

3 What might happen to the earth's atmosphere if the rain forest disappeared?

✓ A We'd have less oxygen and more carbon dioxide

B We'd have more oxygen and less carbon dioxide

C We'd have more oxygen and more carbon dioxide

D We'd have less oxygen and less carbon dioxide

Flag this question for moderator review

4 The tropics can be found:

A Throughout the Pacific Ocean

B On every continent

C Only in the southernmost regions of the earth

✓ D Near the equator

Flag this question for moderator review

5 Which of the following can be found in the rain forest canopy?

A Burrowing insects

B Nutrient-rich soil

✓ C The tops of tall trees

D Shrubs and ferns

Flag this question for moderator review

6 What might you find on the rain forest floor?

A Nutrient-rich soil


✓ B Mushrooms

C Food crops like wheat and corn


D The majority of animal species in the rain forest

Flag this question for moderator review




▼ 8 What is the relationship between rain forests and medicine? 


- A Most diseases originate in rain forests
- B The bacteria found in the rain forest are powerful antibiotics
- C Vaccines can be made from the tissues of rain forest animals
- ✓ D Medicines can be made from rain forest plants

 Flag this question for moderator review


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▼ 9 The layer of rain forest between the canopy and forest floor is called: 


- ✓ A The understory
- B The undercarriage
- C The undergrowth
- D The underbelly


 Flag this question for moderator review

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▼ 10 In what country might you find a tropical rain forest? 

- A South Africa
- B Australia
- ✓ C Brazil
- D Italy


 Flag this question for moderator review

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## Vocabulary

- Biomass
- Upland Forest
- Tropical Rain Forest
- quadrant
- Soil Horizon
- weather
- climate
- carbon
- organic

## Differentiated Vocabulary Ideas

1. word wall
2. word splash
3. common prefixes and suffixes
4. content vocabulary roundtable
5. flashcards

*NOTE: Consider the [UDL Guidelines](#) in selecting methods and materials to ensure that you provide options for engagement, representation, and action and expression.*

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## Methods

(e.g., Anticipatory Set, Introduce and Model New KnowLEDge, Provide Guided Practice, Provide Independent Practice)



## Hook: at the beginning of class present hook

Anchor phenomena/hook for lesson: how to measure the stuff that makes trees?

### TREE MASS

A tree gets its mass from air and water. It “eats” air, chomps down on airborne carbon dioxide, then uses sunshine to pull the carbon dioxide apart, gets rid of the oxygen, which it spits back into the air, leaving the carbon and water, the stuff to make the substance of the tree.

## Lesson Objectives: Determine above- and below-ground carbon stores in upland forests

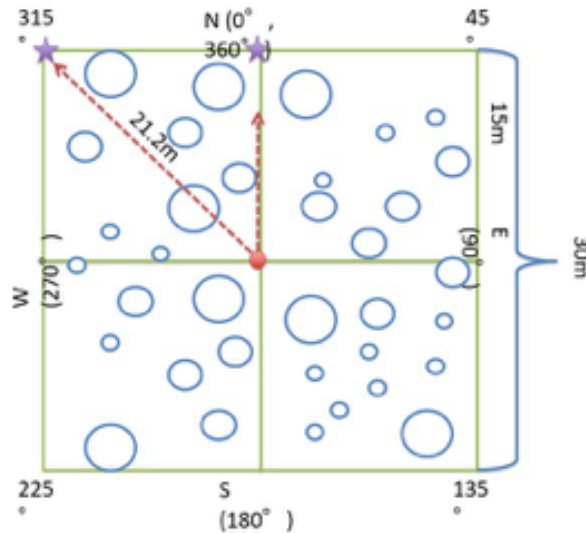
1. Students will collect and measure upland-forest carbon store samples
  - A. Above-Ground: Carbon stored in trees

- Set up an above-ground biomass plot — sample below. Plot size can vary depending on your location. Suggestion: make a map of your plot and assign numbers to each tree in the plot for the data entry.

#### Sample Site Corner Team

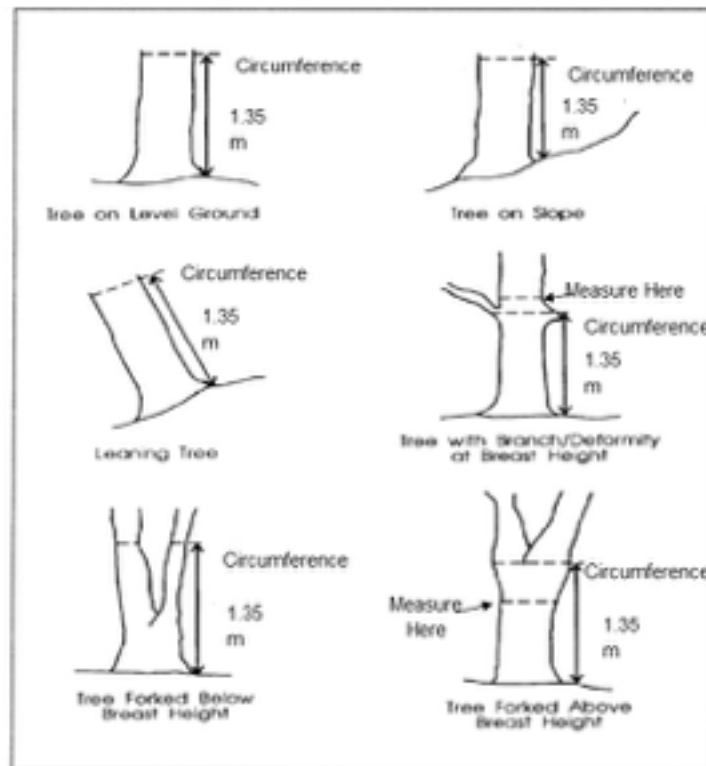
1. Start at the center of the sample site.
2. Select one person to stand at center with the compass. Turn the housing to an azimuth of one of the sample site corners (e.g. 315).
3. Instruct a second person to stand at the given azimuth some distance from the center. (This person will keep the pacer on the correct azimuth.)
4. The third group member should pace 21.2 meters along the azimuth toward the second person.
5. Place a temporary flag or stake at 21.2 meters. Each corner will be checked by the Perimeter team.
6. Repeat the process for the cardinal direction (e.g. North) to your right. Pacing only 15 meters before placing a flag. [These flags divide the sample site into 4 quadrants.]

#### Aboveground biomass plot set up



- Tree Circumference Measurement Guide - use this guide to determine where to measure the tree

This shows examples of where to measure the tree circumference when the trees are on different ground surfaces.



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

- Tree Circumference Data Table — MS Excel spreadsheet linked in the curriculum folder. Linked spreadsheet automatically calculates when you insert tree circumference. When using this spreadsheet, first update your actual plot size if you are not using 30 meters x 30 meters plot size. Next, be sure to check species group tab for proper tree identification.

Tree Tag #	Species Group	Circumference (cm)	Field Notes

Circumference at breast height

Only live trees

This example template is used in the field to collect information and then to fill out the data entry page in the excel template Aboveground biomass template.xlsx

- From the spreadsheet, enter data on the data entry tab
- Select the biomass calculation tab that looks like this:

- The yellow total above-ground is your total of above-ground carbon stored in the trees, within your plot.

## 2. Below-Ground — Carbon stored in soil

### A. Soil Core — use a core sampler



- The soil core purpose is two-fold:
  - 1) to demonstrate the soil horizon layers (different colored layers based on carbon content); and
  - 2) to allow use the measurement of bulk density.
- When you pull the soil core, take a picture for students to analyze the horizon layers when they return to the classroom.

#### **B.** Horizon Layers from core sampler

- Use the Munsell Chart, available as a Google Image
- The Munsell System allows for direct comparison of soils anywhere in the world. The system has three components: hue (a specific color), value (lightness and darkness), and chroma (color intensity) that are arranged in books of color chips. Soil is held next to the chips to find a visual match and assigned the corresponding Munsell notation.
- For example, a brown soil may be noted as “hue value/chroma (10YR 5/3)”. With a soil color book with Munsell notations, a science student or teacher can visually connect soil colors with natural environments of the area, and students can learn to read and record the color, scientifically. Assignment of soil color by Munsell notation is one of many standard methods used to describe soils for soil survey.



- The Munsell Chart illustrates the visual carbon layers. This differentiates between the carbon and non-carbon layers. If the teacher is unable to access the Munsell Chart, he or she can explain to students that the darker soil color contains more carbon content than a lighter soil color.
- Soil color and other properties, including texture, structure, and consistency, are used to distinguish and identify soil horizons (layers) and to group soils according to the soil-classification system called Soil Taxonomy. Color development and distribution of color within a soil profile are a result of weathering. As rocks containing iron or manganese weather, the elements oxidize. Iron forms small crystals with a yellow or red color, organic matter decomposes into black humus, and manganese forms black mineral deposits.
- Photographing the core sample while in the field allows you to analyze it with students in the classroom

#### **C.** Soil Bulk density from core sampler - sample carbon amount

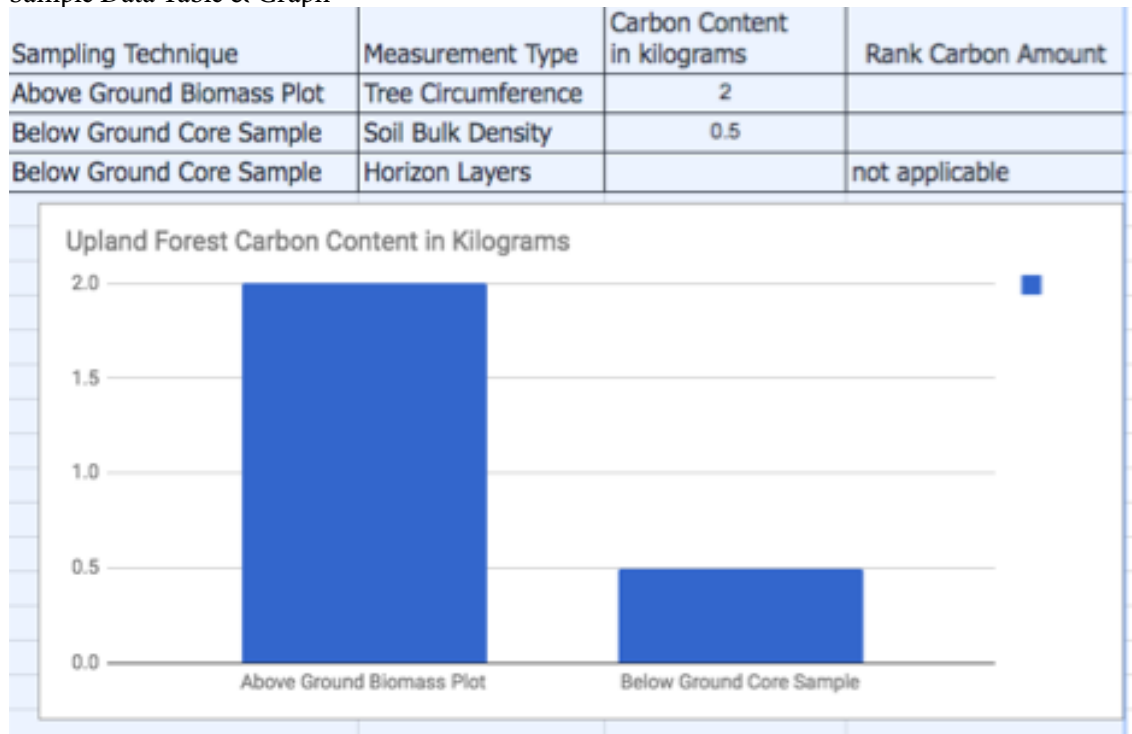
- To sample the stored-carbon amount in upland soil sample:
  - a. Determine Soil Sample Biomass Bulk Density in grams / cubic centimeter (below ground)
    - Dry mass density — remove water content
    - Oven temperatures
      - iii. forest soil ~ 105 degrees C for 24 hours
    - If no oven is available, air dry in a sunny warm place for at least 2 weeks. Option to have students weigh it regularly until the weight becomes stable.

- Below ground 0.5% – 3% x dry weight = represents average range. This represents the amount of forest-stored carbon in the sample.

**D.** Students complete Data Summary Chart and Graph

Primary-Source Data Table			
Upland-Forest Carbon-stores			
Date:			
Location:			
Sampling Technique	Measurement Type	Carbon Content in kilograms	Rank Carbon Amount
Above-Ground Biomass Plot	Tree Circumference		
Below-Ground Core Sample	Soil Bulk Density		
Below-Ground Core Sample	Horizon Layers		not applicable

Sample Data Table & Graph



## Materials

- tape measure
- compass
- flagging
- chalk
- soil corer
- shovel
- Munsell Color Chart
- ziplock bags/containers
- 10x10 cm quadrat
- sissors
- drying oven
- graphing spreadsheet

## Munsell Color System

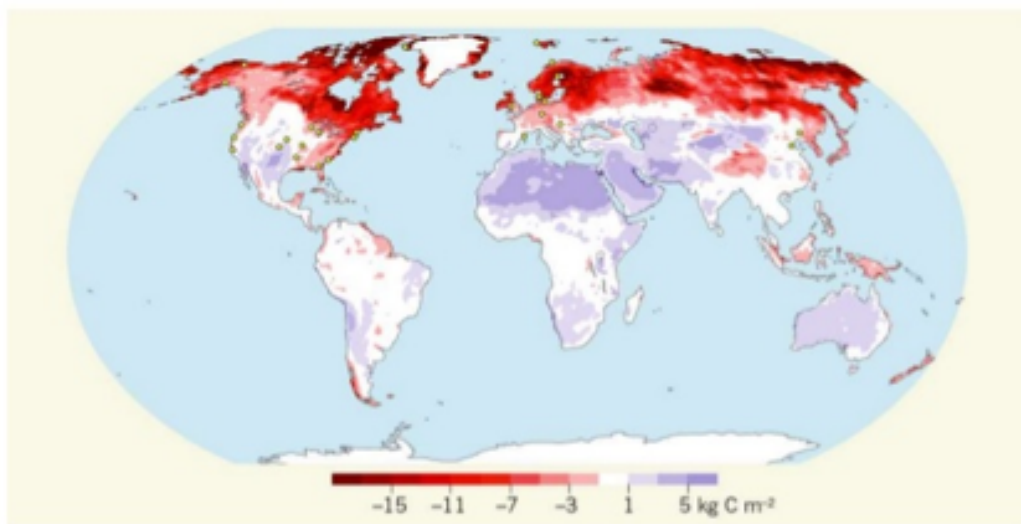
Red, brown, yellow, yellowish-red, grayish-brown, and pale red are all good descriptive colors of soil, but not very exact. Just as paint stores have pages of color chips, soil scientists use a book of color chips that follow the Munsell System of Color Notation ([www.munsell.com](http://www.munsell.com)). The Munsell System allows for direct comparison of soils anywhere in the world. The system has three components: hue (a specific color), value (lightness and darkness), and chroma (color intensity) that are arranged in books of color chips. Soil is held next to the chips to find a visual match and assigned the corresponding Munsell notation. For example, a brown soil may be noted as: hue value/chroma (10YR 5/3). With a soil color book with Munsell notations, a science student or teacher can visually connect soil colors with natural environments of the area, and students can learn to read and record the color scientifically. Soil color by Munsell notation is one of many standard methods used to describe soils for soil survey. Munsell color notations can be used to define an archeological site or to make comparisons in a criminal investigation. Even carpet manufacturers use Munsell soil colors to match carpet colors to local soils so that the carpet will not show the soil tracked into the house.

## Notes and Comments

4. Anchoring Phenomena: explore how forests “store” carbon
5. TREE MASS
6. A tree gets its mass from air and water. It “eats” air, chomps down on airborne carbon dioxide, then uses sunshine to pull the carbon dioxide apart, gets rid of the oxygen, which it spits back into the air, leaving the carbon and water, the stuff needed to make the substance of the tree.

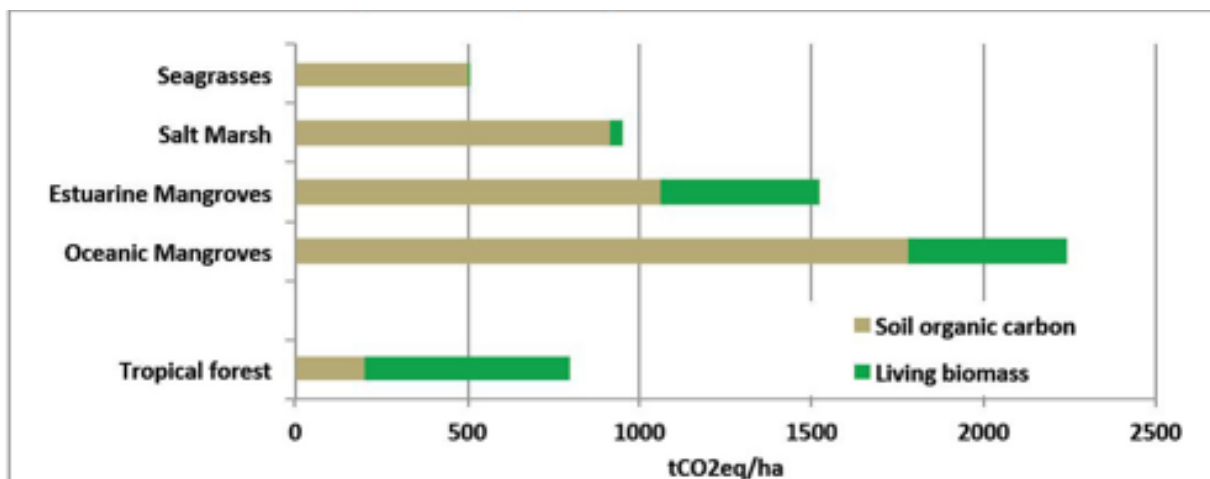
### A new twist to our story: Soils are losing carbon across the northern part of the globe

Map of predicted changes in soil C stocks due to a 1°C rise in temperature by 2050 under a ‘no acclimatization’ scenario.



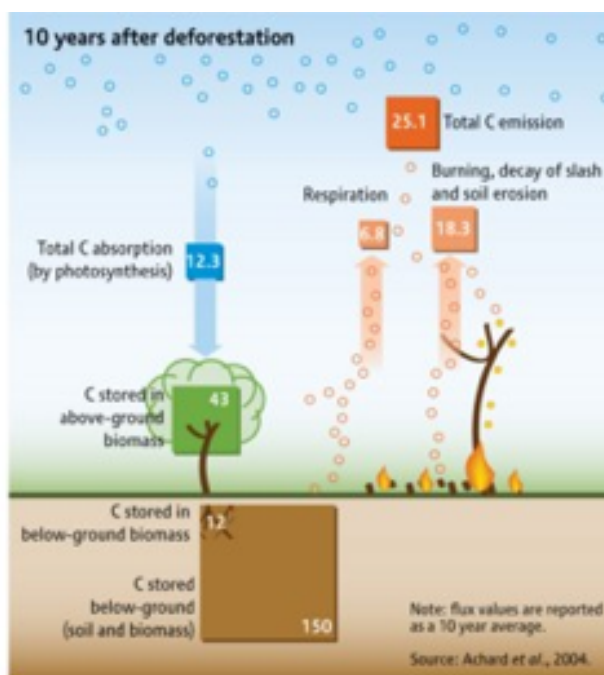
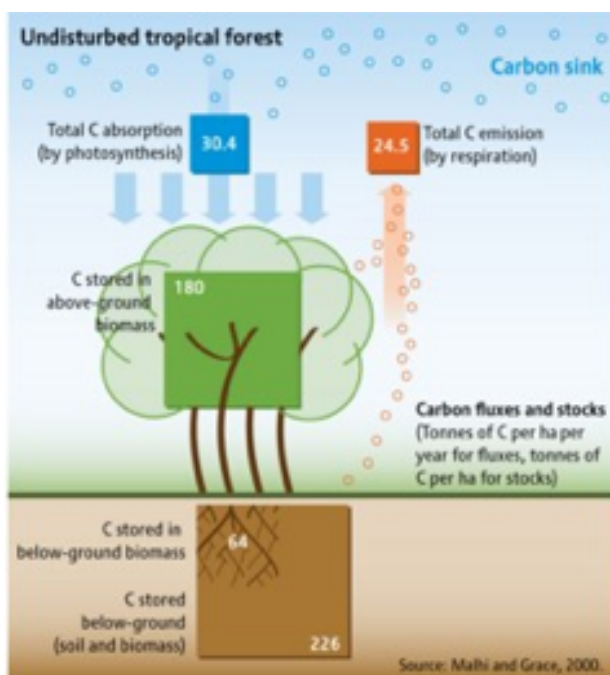
Source: Crowther et al., (2016)





\*Data is per unit area, where tCO<sub>2</sub>eq/ha is tons of carbon dioxide equivalents per hectare

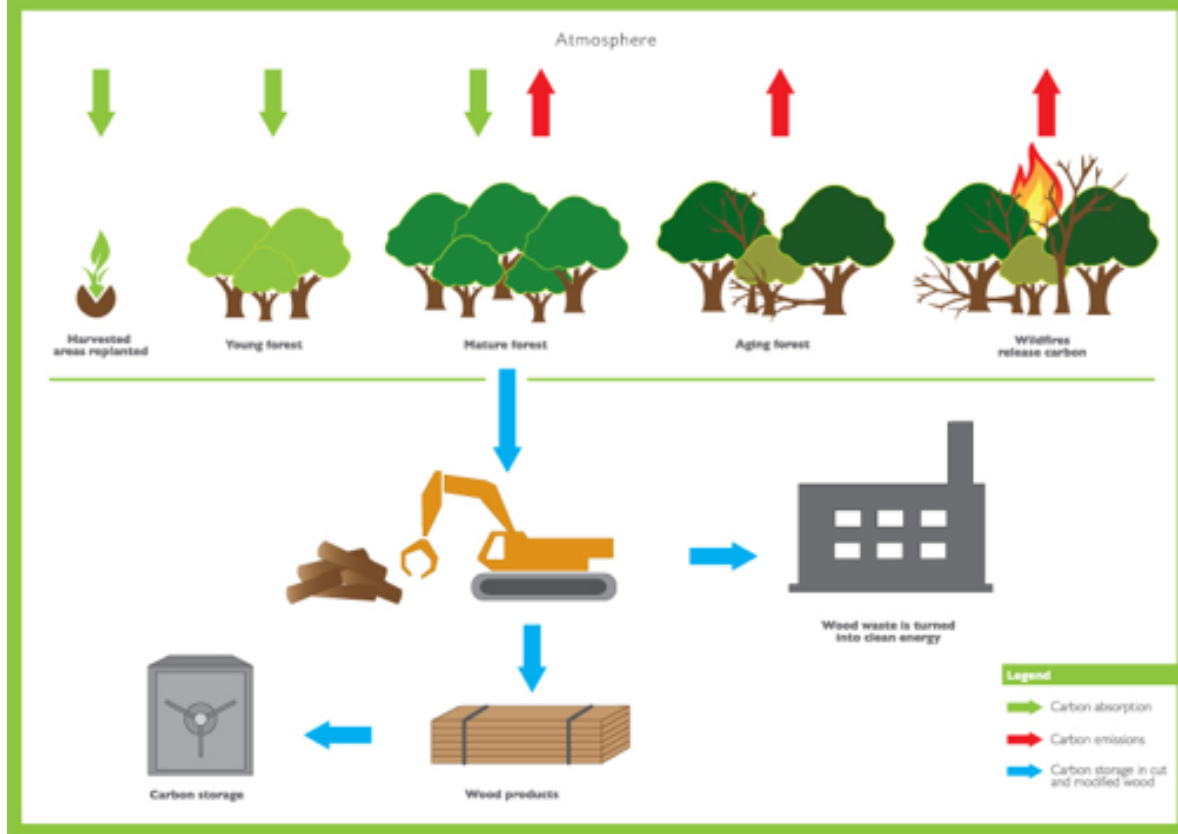
Source: Murray, Brian, Linwood Pendleton, W. Aaron Jenkins, and Samantha Sileet. 2011. Green Payments for Blue Carbon: Economic Incentives for Protecting Threatened Coastal Habitats. Nicholas Institute Report. NII R 11-04



7.



# CARBON CYCLE



## Sample Site Corner Team

1. Start at the center of the sample site.
2. Select one person to stand at center with the compass. Turn the housing to an azimuth of one of the sample site corners (e.g. 315°).
3. Instruct a second person to stand at the given azimuth some distance from the center. (This person will keep the pacer on the correct azimuth.)
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## Aboveground biomass plot set up

