Biomass Units Learning Activity

Purpose

- To introduce the concept of biomass.
- Relate biomass to carbon storage in living things.
- Explore differences in plant biomass and carbon storage between global biomes, as a foundation for collecting field data in their own biome, comparing student collected data from other biomes, and using the NPP-Biomass Model to investigate biomass and carbon storage now and under future conditions.

Overview

In this activity students will calculate the biomass of their classroom using an estimate of the total dry mass of students in the class as well as the classroom area. Students calculate current carbon storage in the classroom. Students consider vegetation biomass across global biomes.

Student Outcomes

Students will be able to:

- Determine the biomass of the classroom by calculating the total students' dry mass within the classroom area.
- Calculate differences in classroom biomass when the classroom area or students' dry mass changes.
- Investigate and discuss connections between basic biomass concepts (mass/area) and the amount of biomass in natural systems (biomes).

Questions

Content

- What is biomass and how is it measured?
- How does biomass relate to carbon?
- How does biomass compare across biomes?

Science Concepts

Grades 9-12

Scientific Inquiry

- Use appropriate tools and techniques to gather, analyze, and interpret data.

NGSS (Black- covered directly, gray-addressed, but not directly covered)

- *Disciplinary Core Ideas*
  - Gr.6-8: ESS3.A, ESS3.D, ETS1.B, ETS1.C
- *Science and Engineering Practices*
  - Planning and carrying out investigations
  - Analyzing and interpreting data
  - Using mathematics and computational thinking
- *Crosscutting Concepts:*
  - Scale, Proportion, and Quantity
  - Energy and matter

Time/Frequency

45-90 minutes

Level

Secondary (Middle & High School)

Materials and Tools

- Flexible tape measure OR meter stick (one per group)
- 50 meter tape measure (1 per class)
- Student Worksheet (one per student)
- Calculator (one per student/pair)
- Notebook and pencil (one per student)
- *Global Biome Table* (on presentation slide or overhead transparency)
- *Global Biome Map* (separate - on presentation slide or overhead transparency)
- Access to internet or other research sources
- Optional: Satellite imagery of global biomes
- Optional: Photograph slideshow or movie of global biomes

Prerequisites

None.

Preparation

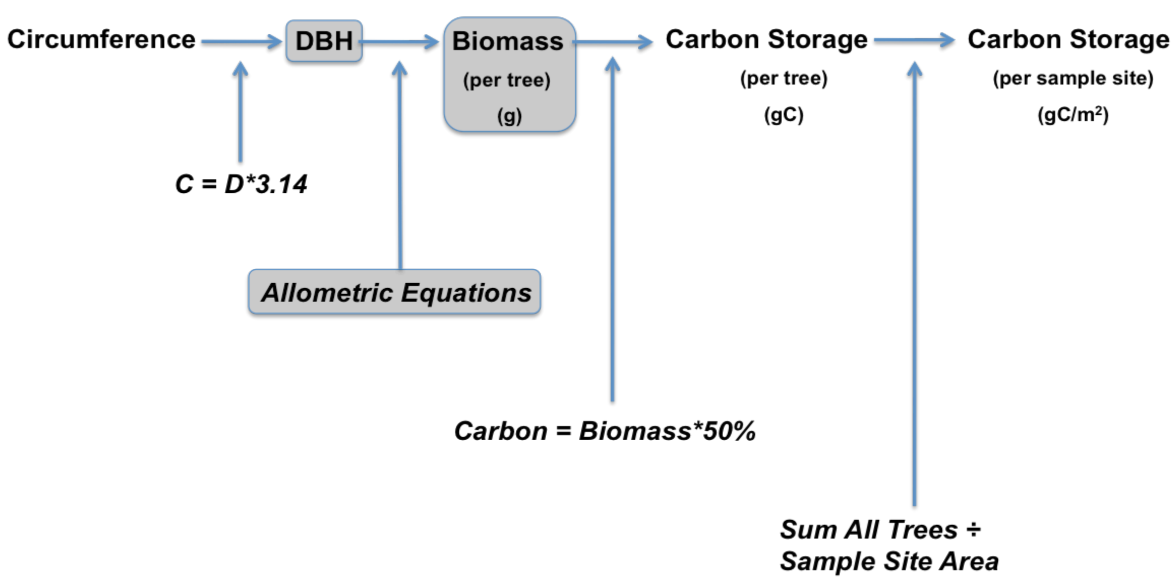
Write the content question on the board. Organize all materials for the activity. Make copies of student directions.

Background

Biomass is the total mass of living material measured over a particular area. Because all living things contain water (fresh mass) and the percentage of water can vary widely from species to species, biomass is calculated as a dry mass. Dry mass is the mass of life that is left after all the water is removed, much like squeezing out a sponge. For plants, scientists use an oven to remove all the water from the plant material before weighing it to determine its biomass. **Total biomass** is found by summing the dry mass biomass of all individuals in a given land area and then reported by naming the area of concern, e.g. biomass per plot, ecosystem, biome, classroom. To be able to compare biomass in different locations, scientists standardize biomass per unit of area. Typical units of biomass are grams per meter squared (g/m^2), although you will also see kg/m^2, lb/ft^2, etc.

While knowing an ecosystem's biomass is useful for many applications such as farming, logging, and wildlife management, another helpful unit of measure in an ecosystem is how much carbon is stored. Understanding how terrestrial ecosystems store and transfer carbon to and from the atmosphere is essential to understanding climate change, so biomass is often converted to carbon storage (For more information on the role of carbon in climate, see the *Carbon Cycle Introduction Activities*). But how do scientists know how much carbon is being stored? All life (biomass) is composed of carbon molecules, and as it turns out is approximately 50% carbon by dry mass. This means once biomass has been calculated, it can be multiplied by 0.50 to achieve approximate carbon content. (This value has been agreed upon by IPCC scientists and used to estimate carbon storage globally.)

The diagram below shows the progression of concepts students need to understand the amount of carbon being stored in forested ecosystems. The concepts addressed in this activity are highlighted in gray.



What To Do and How To Do It

ENGAGE	**Grouping:** Class	**Time:** 5 Minutes

- Generate a class list of ideas: How much does a tree weigh? How do scientists measure the amount of living matter in a given habitat?
- Define biomass.
- Identify the variables needed to calculate classroom biomass. Including classroom area and students' dry mass.
- To build students' inquiry skills, ask students to develop at least part of the method for calculating classroom biomass before handing out the Student Direction sheet.

EXPLORE	**Grouping:** Individual	**Time:** 15 Minutes

- Students calculate and record the total class fresh mass and the biomass of the classroom in Part 1 of the Student Worksheet.
- Students initially calculate their mass in grams. Each student's mass will need to be summed to get a total wet or fresh mass for the classroom. In order to protect students' anonymity, you may have students record their mass on a slip of paper and drop it into a box at the front of the room. You can now sum individual masses and report only a total classroom fresh mass to the class. You may also choose to have students write down an average human mass if you foresee a problem with using individual student masses.
- **Note:** Approximately 60% of the total mass of humans is water. (Although % water can vary slightly between men & women and will depend on each individual's make up.) Students must account for this because biomass is always calculated as a dry mass. Students are instructed here to use 60%.
- Students measure and record the classroom dimensions for use in classroom area calculations.
- Students conduct measurements and calculations as directed on the student sheet. This is a proof of concept exercise to show students how diameter and circumference are related.

EXPLAIN	**Grouping:** Class	**Time:** 15 Minutes

- Students discuss: What is the calculated classroom biomass? Are there any ways in which biomass could be different than what we calculated?
- Discuss the importance of understanding biomass as a means of determining carbon storage.
  - How does measuring biomass of the classroom relate to measuring biomass in a forest or grassland?
  - Why is understanding biomass important? What can it tell us about an ecosystem?
  - It tells us something about: carbon storage, the amount of timber available, and forest health.
- Calculate carbon storage in the classroom. (Multiply biomass by 50%)

ELABORATE	**Grouping:** Individual	**Time:** 30 Minutes

- Now that students understand how biomass can be very different depending on the mass of the living matter (which is based on size, density and water content) and the area that a particular group is located in, have them consider the biomass of global ecosystems (biomes).
  - Show slideshow or movie of global ecosystems/biomes while students work

- Students rank global biomes listed in **Part 2** of the Student Worksheet using prior knowledge, satellite images (e.g. Google Earth, Landsat), photos, Landcover Biometry images and the *Global Biome Table*.related.

EVALUATE **Grouping:** Individual **Time:** 30 Minutes

- Discuss what students noticed about the patterns of biomass (per unit area) across biomes.
    - How would this be different if you considered total biome area (use Global Biome Map)
- Generate a list of student's ideas about how scientists measure biomass for biomes.

**See activity example with sample calculations and answers in *BiomassUnits_example.xls*

Assessment

- Option1 - Changing Biomass: Do students understand the two components of biomass, mass and area?
    - Each individual/group calculates how biomass would change if the area of the room changed or if the number/composition of students in the room changed. Below are a few possible ideas:
        - → Area: football field, gym, maintenance closet
        - → Mass: the whole grade, a group of first graders, a group of athletes (football/hockey players)
    - Students answer the following questions, including all calculations and present in small groups or to the class.
        - → What new scenario did you choose? Indicate which component of biomass you changed in your scenario (area or mass).
        - → What is your new biomass? Show all of your calculations.
    - Students compare the new biomass values.
    - Bring the class to a maintenance closet or football field to make the activity visual.
- Option 2 - Estimate carbon storage: Do students understand biomes, biomass and carbon storage?
    - Students use their knowledge of biomass, biomes, and their local area to make a hypothesis about the carbon storage of the vegetation in their schoolyard.
        - → Think about the area around your school. What type of vegetation is present? How much vegetation covers the ground area? Using the Global Biomass Table and your basic knowledge, estimate the amount of carbon storage in g C/m^2 for the vegetated area around your school. Record your estimate and your reasoning.
    - Assess student's estimate and reasoning of carbon storage in the area around the school.

Extensions

- Use Landsat images of biomes and Image J image analysis software to compare difference in percent cover of major vegetation categories (e.g. trees, shrubs, herbaceous).
- Connect to the GLOBE Seasons & Biomes Project

Resources

- Image J: http://rsbweb.nih.gov/ij/

Name: Date:

Biomass Units – Calculating Classroom Biomass

Content Question: What is biomass and how does it relate to carbon?

Background

Biomass is the mass of living material measured over a particular area. Biomass can be calculated for all organisms present or for a particular group (vegetation, bacteria) or species (eastern white pine). Because all living things contain water, and the percentage of water can vary widely from species to species, biomass is often calculated as a dry mass. Dry mass is the mass of life that is left after all the water is removed, much like squeezing out a sponge. For plants, scientists use an oven to remove all the water from the plant material before weighing it to determine its biomass. Total biomass is found by summing the dry mass biomass of all individuals in a given land area and then reported by naming the area of concern, e.g. biomass per plot, ecosystem, biome, classroom. To be able to compare biomass in different locations, scientists standardize biomass per unit of area. Typical units of biomass are grams per meter squared (g/m^2), although you will also see kg/hectare, lb/ft^2, etc.

Conversions:

1 pound = 454 grams

1 kilogram = 1000 grams

While knowing an ecosystem's biomass is useful for many applications such as logging, forest health and wildlife management, another helpful unit of measure in an ecosystem is how much carbon is stored. Understanding how terrestrial ecosystems store and transfer carbon to and from the atmosphere is essential to understanding climate change (think photosynthesis, global carbon cycle and the greenhouse effect), so biomass is often converted to carbon storage. But how do scientists know how much carbon is being stored? All life (biomass) is composed of carbon molecules, and as it turns out is approximately 50% carbon by dry mass. This means once biomass has been calculated it can be multiplied by 0.50 to achieve approximate carbon content.

Part 1: Calculate Classroom Biomass

1. Calculate your mass in grams (see conversions above). Follow your teacher's instructions about what to do with this information. Your mass will be used by the teacher to determine total classroom fresh mass.

2. Your teacher will announce the total classroom fresh mass. Record this value.

   - To calculate dry mass you must assume what percent of the human body is comprised of water. According to literature humans, on average are 60% water by mass. Multiply total classroom fresh mass by percent water to get the water mass.
     For example: 1,207,640g (class fresh mass) x 0.60 = 724,584g (water mass)

   - Calculate your classroom dry mass in grams by subtracting the water mass from total fresh mass.
     For example: 1,207,640g – 724,584g = 483,056g

3. As a class, measure the classroom dimensions using a tape measure or meter stick. Calculate the total area in square meters.
   - Area of a rectangle: Area = length x width

4. Find the biomass of your classroom in g/m^2. (Using total classroom dry mass and classroom area)

5. How would biomass change if one of the biomass components, either area of the room or the number/composition of students in the room changed? For each scenario state whether there would be an increase or a decrease in biomass.

- Football field

- Elementary school students

- Maintenance closet

- All the students in the school

- Professional hockey players

6. Calculate the current carbon storage of the classroom in g C/m^2.

Part 2: Biome Biomass

1. Rank the following **14** terrestrial (land) biomes from **least (1) to greatest (14)** plant biomass. *Remember that we are considering biomass as living dry mass per unit area.
   a) Initially, draw diagrams to help you conceptualize.
      i. Where is biomass stored in vegetation? Think about plant components (leaves, branches, stem and roots).
      ii. How does a forest look from the side view? From a top view? How about a grassland?
      iii. How large is 1 square meter?
   b) Optional: Check your rankings using satellite imagery (e.g. Google Earth) - How does vegetation look from the air? Use the *Global Biome Map* to locate different biomes you would like to view.
   c) Confirm rankings using the *Global Biomass Table*.

	Biomass Ranking	
Ecosystem Type	**Initial**	**Global Biomass Table**
Boreal Forest		
Cultivated Land		
Desert Scrub		
Lake and stream		
Rock, ice, and sand		
Savanna		
Swamp and marsh		
Temperate deciduous forest		
Temperate evergreen forest		
Temperate grassland		
Tropical rainforest		
Tropical seasonal forest		
Tundra and alpine meadow		
Woodland and scrubland		

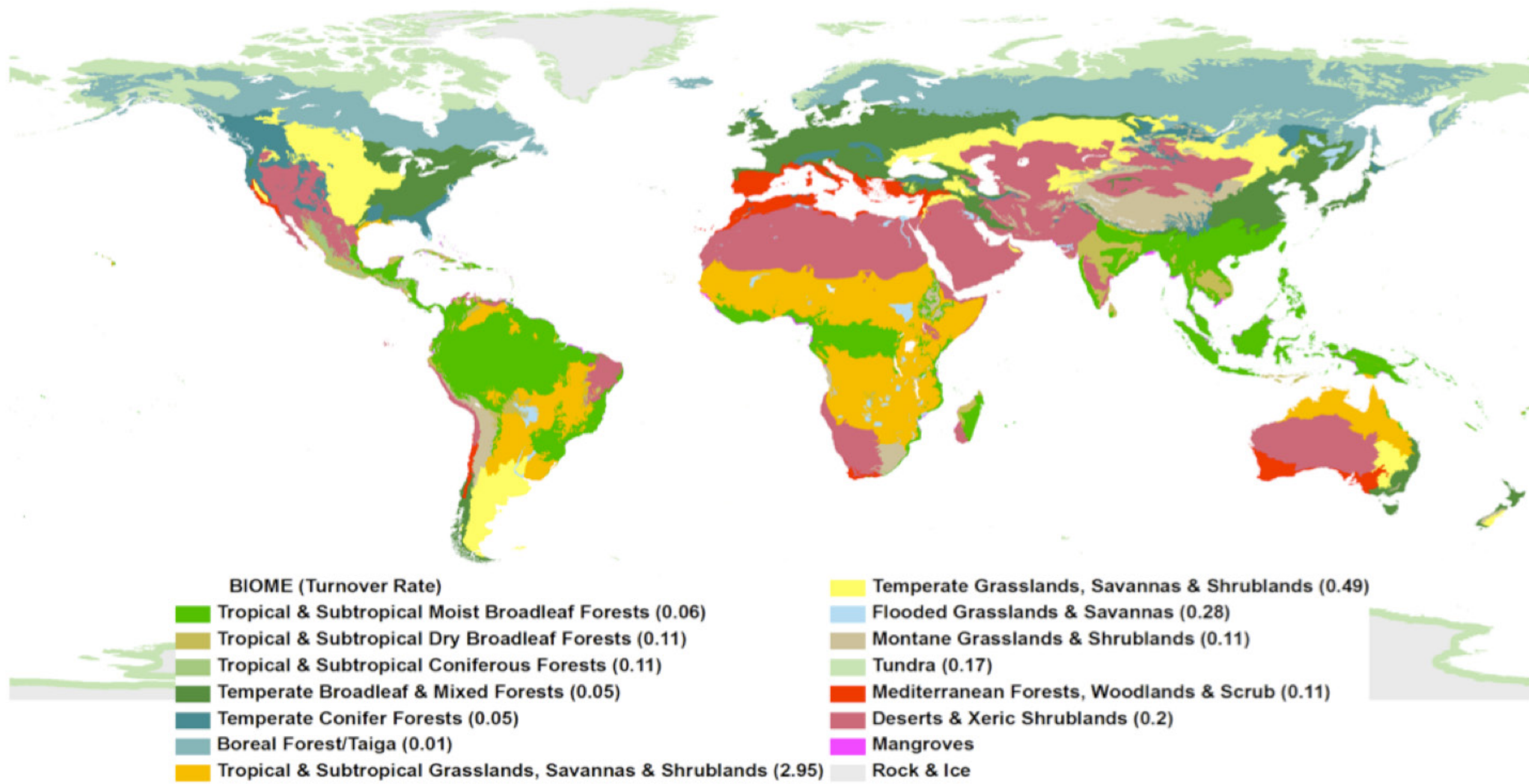
2. Were the actual biomass rankings different than you expected? Why do you think this was the case?

3. Biomass can vary widely between biomes, what do you think is driving that difference?

4. How is biomass related to carbon? Why is our knowledge of carbon storage in biomes important?

Global Biome Map

(adapted from World Wildlife Fund)



From: Olson et al. (2001)Terrestrial ecoregions of the world: New map of life on earth. Bioscience 51:933-938

Global Biome Table - Ranked

The Carbon Component of Primary Production and Biomass for the Biosphere

(adapted from Whittaker and Likens 1973)

Ecosystem Type	Area ($10^{12}m^2$)	Total Plant Carbon (Pg C)	Mean Plant Biomass (g/m^2)	Mean Plant Carbon Storage (gC/m^2)	Rank
Boreal forest	12	108	18000	9000	10
Cultivated land	14	7	1000	500	5
Desert scrub	18	5.4	600	300	4
Lake and stream	2.5	0.02	20	10	2
Rock, ice, and sand	24	0.2	20	10	1
Savanna	15	27	3600	1800	7
Swamp and marsh	2	13.6	13600	6800	9
Temperate deciduous forest	7	95	27000	13500	11
Temperate evergreen forest	5	80	32000	16000	13
Temperate grassland	9	6.3	1400	700	6
Tropical rain forest	17	340	40000	20000	14
Tropical seasonal forest	7.5	120	32000	16000	12
Tundra and alpine meadow	8	2.4	600	300	3
Woodland and shrubland	8	22	5400	2700	8
Total Continental	**149**	**827**	**11100**	**5550**	
Open ocean	332	0.46	3	1.4	1
Continental shelf	26.6	0.13	10	5	2
Upwelling zones	0.4	0.004	20	10	3
Estuaries	1.4	0.63	900	450	4
Algal bed and reef	0.6	0.54	1800	900	5
Total Marine	**361**	**1.76**	**10**	**4.9**	