Carbon Storage in the Trees of Crusher Lot

Grade: Grade 8
Place of Focus: Crusher Lot, Arlington MA
Citizen Science Protocol: Modeled after the Harvard Forest Plot Survey protocol

Massachusetts Curriculum Framework for Science and Technology/Engineering Standards

Primary Standard:

- **8.MS-ESS3-5.** Examine and interpret data to describe the role that human activities have played in causing the rise in global temperatures over the past century.

Additional Standards:

- **HS-ESS2-6.** Use a model to describe cycling of carbon through the ocean, atmosphere, soil, and biosphere and how increases in carbon dioxide concentrations due to human activity have resulted in atmospheric and climate changes.
- **HS-ESS3-5.** Analyze results from global climate models to describe how forecasts are made of the current rate of global or regional climate change and associated future impacts on Earth systems. Climate model outputs include both climate changes (such as precipitation and temperature) and associated impacts (such as on sea level, glacial ice volumes, and atmosphere and ocean composition).
- **8.MS-PS1-2.** Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred. *(cont. next page)*

Curriculum Frameworks for Middle School Science and Engineering Practices:

1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in an argument from evidence
8. Obtaining, evaluating, and communicating information

Learning Objectives

By the end of the field lesson, students will:

Understand the role of trees in carbon storage and estimate the amount of carbon stored in the trees of Crusher Lot.

Note: Crusher lot is a 6-acre plot of undeveloped land directly adjacent to the school. The lot is comprised of both coniferous and deciduous trees of varying species, ages, and diameters. *Friends of Crusher Lot website* *Map*

Pre-Visit Learning

Prior to the site trip, students should (over the course of several activities & units):

- Visit Crusher Lot (during class time) and make observations of the trees.
  - Use ABCD Scientific Drawing Protocol
- Understand the species of trees present in Crusher Lot.
  - Use plant identifier apps, like iNaturalist or PlantID or iPhone camera
- Review concepts related to climate change, including the greenhouse effect and greenhouse gases.
- Learn/review the carbon cycle and the role that trees play in reducing the amount of CO_2 in the atmosphere.

Essential Questions

- How are human activities contributing to the changes in the climate patterns on Earth?
- What natural systems help to minimize the effects of increasing CO2 in the atmosphere?

Guiding Questions

1. What types of trees are in Crusher Lot?
2. How much carbon is stored in one tree? (Pick a tree. Using data and resources, estimate the amount of carbon that the tree is storing in its biomass.)
3. How much carbon is stored in all the trees of Crusher Lot? (Working together with your classmates, estimate the amount of carbon stored in all the trees of Crusher Lot.)
4. How much CO2 did those trees remove from the atmosphere - or - how much CO2 will be released if the trees are removed?

Field Visit Preparations

Time

The visit to Crusher Lot for this particular lesson will take 1 class period = 45 minutes. Over the entire lesson sequence during the year, students will visit Crusher Lot approximately 3-6 times.

Materials and Supplies

- Clipboard and pencil
- Data collection sheet
- Tree identification guide
- Tape measures - soft, reel-style tape measure, 100 ft.
- Flagging tape - different color for each class
- Data calculation spreadsheet (Day 2) including:
- Online/printed tool for estimating the mass of carbon in a tree
- Challenge level 1 resource
- Challenge level 2 resource

Logistics

Crusher Lot is a wooded lot directly adjacent to the school. As such, it is easily accessible during the school day and does not require permission slips or special accommodations to visit. The lot can easily be accessed in one 45 minute class period, and so each class can be taken out during their designated class time. Students will have access to bathroom facilities in the school and the school nurse is directly available.

Scientific Protocol

See detailed steps in Day 1 and Day 2 below. (Not repeated here.)

Modeled after the Harvard Forest protocol for measurement of tree development in a 10 m^2 survey area.

Field Visit Outline

Introduction: Expectations/Guidelines

Expectations for site visits will be discussed prior to each outing. Students will be reminded both in class and on Google Classroom to be prepared for the site visit. Site visits can be rescheduled due to changes in weather. During site visits students will:

- Wear appropriate footwear
- Stay within visual range and hearing range of teachers
- Stay with partner or lab group
- Stay on task
- Use tools/materials appropriately

Learning Tasks

NOTE: Lesson plan focuses on tasks on the day of and day after the site visit. These two days fit in with a series of lessons that build toward the site visit and work from data gathered during the site visit.

Day 0: All learning tasks/protocols will be previewed the day before the site visit.

Day 1: Day of Site Visit

1. Students arrive in classroom. They get out their data collection sheet (previewed the day before), and gather a clipboard, writing utensil, flagging tape, reel tape measure and stakes. Field procedure is included on the data collection sheet.
2. Students walk with teacher out to the field site.
3. Working in lab groups (3 - 4 students), groups spread out in visual range and hearing range. They select the tree at the corner of their sample area. Tie on flagging tape.
4. Groups measure a length of 10m and mark with flagging tape.

(cont. next page)

Learning Tasks (cont.)

Day 1: Day of Site Visit (cont.)

5. Groups measure 10m perpendicular to the first line and mark it with flagging tape to set up a 10m x 10m survey area.
6. Groups write some observations of their survey area on the data collection sheet.
7. For each tree that reaches a height of 1.5m in the survey area, students will measure the circumference of the tree at 1.5m (using the reel measuring tape).
8. Record circumference. Using tree identifier tool (iNaturalist or iPhone camera or other app), make best effort to identify the species of the tree.
9. Once data and observations are collected for all groups, students return to the classroom and return materials.
10. Students in each class of the day will use the same survey areas set up during the first class of the day, for comparison and averaging.
11. Last class of the day will remove the flagging tape from the survey areas.

Day 2: Follow-up/Calculations

Students will continue to work in their lab groups using data collected from the site visit and using a data calculation worksheet along with carbon storage estimating resources (linked in worksheet).

Step 1: Each student will use the group's data calculation spreadsheet to estimate the amount of carbon stored in one tree in the survey area.

Step 2: Pairs of students will check each other's calculations to ensure the group is using the carbon storage estimating resources correctly.

Step 3: Groups will work together to estimate the amount of carbon stored in the full survey area. (Complete carbon calculations for each tree measured in the survey area.)

(cont. next page)

Learning Tasks (cont.)

Day 2: Follow-up/Calculations (cont.)

Step 4: Class will share data in order to calculate the total mass of carbon in all of the survey areas combined.

Step 5: Class will find an average of carbon stored per unit area for the lot. (Total mass of carbon in all survey areas divided by total area of survey areas.)

Step 6: Project/estimate amount of carbon stored in all of Crusher Lot. Compare projections/estimates with other classes. Find an overall average.

Step 7: Estimate/calculate equivalent amount of CO2 captured in trees alone. Use a real world comparison (ex. Number of cars or number of households equivalent - provide references)

Day 3 - 4: Use the Data and Reflect

- Students will work in pairs to graph/visualize data. Emphasis is on making the data tell a compelling story by creating a graph or infographic (statistics).
- Students will use the collected data, both for survey area and projections for the lot.
- Students will share their visualized data in a short presentation to the class.

Reflection

At the end of Day 4 (after presentations): Free write in science notebooks

- What have you learned in our explorations over the last 2 days? What are some observations or impressions that have stuck with you?
- The Town of Arlington is in constant need of new housing, commercial/economic development, and expansion of existing town infrastructure. The Town of Arlington has very little undeveloped land that is not already protected. Crusher Lot is a protected area. Do you feel that Crusher Lot should be conserved as green space or developed for specific human uses?

Post-Visit Learning

See Day 3 - 4 and reflection listed above. See also Day 5 - 8 listed below (conceptual outline).

Full Unit Outline

The Climate Change subunit comes at the end of our third major unit of the year:

(Lessons or activities related to place-based learning are in blue.)

- Unit 1: Scientific Thinking
  - Tie-in to Crusher Lot (with site visit)
    - Lesson: Observation and Inference
      - Make observations of the trees and underbrush in Crusher Lot
      - Make inferences based on your observations
      - Use ABCD Science Drawing protocol to complete a scientific sketch of a tree (including bark, leaves, seeds, etc) in Crusher Lot
- Unit 2: Physical Science: Introduction to Chemistry
  - Properties of Matter, incl. density and convection
  - States of Matter and Phase Changes
  - Physical and Chemical Changes
    - Tie-in to Crusher Lot (with site visit)
      - Observe and list physical changes to trees and natural materials in Crusher Lot
      - Observe and list chemical changes in Crusher Lot
  - Elements/Compounds/Mixtures
  - Chemical Reactions and Conservation of Mass

(cont. next page)

Full Unit Outline

- Unit 3: Earth and Space Science
  - Orbits and Gravity
  - Seasons and Tides
  - Earth Systems
    - Circulation in the geosphere
    - Circulation in the oceans
    - Weather patterns and circulation in the atmosphere
    - Climate
  - Climate Change - human influence on climate
    - Review of greenhouse gases/greenhouse effect
    - Review of carbon cycle
    - Look at interactive climate indicators site - Climate Time Machine (visualizing climate change)
    - Jigsaw activity - compiling key causes and impacts of climate change
    - Climate change close to home: Carbon Storage in the Trees of Crusher Lot (see lessons outlined above)
      - Day 0: Prep for site visit
      - Day 1: Site visit, observations, data collection
      - Day 2: Carbon storage calculations
      - Day 3 - 4: Making the data visual - telling the story of the data and reflection
      - Day 5 - 8: Open Meeting Debate Activity - the Fate of Crusher Lot
        - Should Crusher Lot be preserved or developed?
        - Assign stakeholder roles in order to debate the importance of Crusher lot either as climate-mitigating green space or as a resource for human use (housing, commercial, rebuild the school)
        - Stakeholder roles include: climate scientist, ecologist, student, neighbor, community planner, developer, investor, school committee

(cont. next page)

Full Unit Outline

- Unit 4: Life Science: Genetics, Reproduction, DNA, Natural Selection, Evolution
  - Natural Selection - Outline and explain 4 steps in the process of natural selection
    - Tie-in with Crusher Lot: Use the trees in Crusher Lot to explain the process of natural selection
      - Pick a species of tree in Crusher Lot
      - Use this species as an example to explain the process of natural selection:
        - Genetic variation in species
        - Overproduction of offspring
        - Struggle for survival / competition for resources
        - Reproduction of organisms with successful variations
- Unit 5: Physical Science: Motion, Forces, Newton's Laws of Motion