Name _____ Teacher _____ Date _____

Activity 7.1: Preparation for Future Learning Introduction

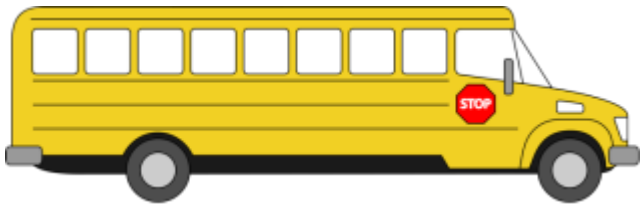
You will be determining the carbon dioxide emissions from your school's bus fleet and will calculate how many trees you would have to plant per year to completely offset these emissions. In this activity, you will be introduced to the activities that will enable you to make this determination.

Background: There are roughly a half million school buses in the United States that are used to transport students to school. Each of these buses uses an average of about 1700 gallons of fuel per year, and that fuel is mostly converted into carbon dioxide and water when it is combusted.

Because the amount of carbon dioxide in the atmosphere continues to rise each year, there is a growing interest in becoming **carbon neutral**. This means that actions are taken to remove the carbon dioxide from the atmosphere that was emitted as a result of human activity. Becoming carbon neutral is one way to reduce your **carbon footprint**, or the amount of carbon dioxide that is emitted as a result of human activity.

One option for becoming more carbon neutral is to plant trees. Trees sequester carbon dioxide and water to produce glucose and oxygen during photosynthesis. While some of that glucose is converted back into carbon dioxide when trees undergo cellular respiration, trees can also **sequester** carbon atoms as they undergo biosynthesis. In other words, trees store carbon atoms as part of the molecules that comprise the wood and other solid materials of the tree. The more carbon atoms that are sequestered as a part of trees and other plants, the lower the carbon dioxide levels in the atmosphere.

In this activity, you will determine how many trees you would have to plant per year to negate the carbon footprint of your school's bus fleet. In other words, you will determine how many trees it would take to completely sequester the carbon dioxide that is emitted from bus transportation at your school. You will also consider whether or not it would be better to ride the bus to school or ride in a car.



A. Overview: this activity will consist of four parts:

a. **Introduction –** you will be introduced to the primary question and background information. You will work with individuals in your school to determine how much fuel your buses use in a given year and how much carbon dioxide is released from this amount of fuel.
b. **Media Evaluation –** you will utilize internet sources to determine how much carbon dioxide a tree can sequester and will critique your sources and the other sources for credibility.
c. **Local Information –** you will determine how much space is available for planting trees based on satellite map images. You will then calculate the amount of CO2 sequestered in a log and in a live tree.
d. **Presentation of Conclusions –** you will determine how many trees it would take to offset the carbon dioxide emissions from your school's bus fleet and present your findings to the class.

B. Protocol: you will work in small groups to determine how much fuel the bus fleet of your school uses in a typical year. There are multiple ways you can obtain this information. One is to simply contact the department or company that your school uses for bus transportation. Another option is to contact your school or district's administration to determine if they have this information on hand (for example, in a budget report).

You should work with your instructor to determine the guidelines for obtaining this information (for example, you may need to ask for permission to use a classroom phone for this purpose). You can and should consider working with other groups to share information. For example, your class may decide to have different groups contact different people and share the information they collect with everyone if and when they obtain it. You may not get this information today. As long has you have this information by the time you complete the last portion of this project (7.4), you will be ok.

C. Questions

1. How much fuel does your school's bus fleet use in a year? -OR- How many miles do all of the buses of your school travel in a year and what do these bus get for an average number of miles per gallon?

_____

2. How did you acquire this information? Briefly describe the person or source the provided you with the information needed to answer the question above.

_____

_____

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Activity 7.2: Preparation for Future Learning Media Evaluation

You will be determining the carbon dioxide emissions from your school's bus fleet and will calculate how many trees you would have to plant per year to completely offset these emissions. In this activity, you will use internet sources to determine how much carbon dioxide a tree can sequester.

A. Protocol: you will work in small groups and use internet search browsers to find credible information on how much carbon dioxide a tree can sequester and store. You will need this information to determine how many trees it would take to completely sequester the carbon dioxide emitted from combustion of fuel in your school's buses over the course of a year.

To begin, type the following phrase into a search engine (such as Google) exactly as you see it here:

tree carbon dioxide sequestration

Review the websites that are listed on the first page of search results. As a team, determine which of these websites provides information that is most useful for your needs and is credible.

Your instructor will have each group present which website they determined to be most useful and credible and defend their choice using evidence. You may choose to use a different group's website after everyone has presented to complete this project, or you can decide to keep using the same website you originally chose.

B. Questions: answer each of the following prior to the whole-class discussion.

1. Of the search results, which site did you decide was most useful and credible?

_____

2. Why did you choose this site? How do you know it is credible?

_____

3. Will you use this site for your project or did you determine that another website was better? Explain your choice.

_____

Questions: answer each of the following *after* the whole-class discussion.

4. How much carbon dioxide can be sequestered by a tree? Use the information from your website to determine how to best answer this question. Be sure to include as many specifics as possible. For example, taller trees with a greater circumference should be able to sequester more CO_2 than a shorter tree with a smaller circumference.

5. Do different trees sequester different amounts of carbon dioxide? For example, does it matter if a tree is a deciduous or a coniferous tree? Use a search engine if needed.

   Yes No (circle one). Explain: _____

6. If you know how many trees it takes to sequester the carbon dioxide emitted from your school's buses over the course of a year, how many times would you have to plant that number of trees to completely negate the CO_2 emissions? Explain.

7. Which option would result in fewer carbon dioxide emissions – if more students rode the bus to school or if more students rode to school in cars. Use credible internet sites to determine the answer to this question and provide an explanation.

   It would be better if more students: *rode the bus* *were driven separately*
   (circle one)

   because _____

   Source*:* _____

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Activity 7.3: Preparation for Future Learning Local Information

You will be determining the carbon dioxide emissions from your school's bus fleet and will calculate how many trees you would have to plant per year to completely offset these emissions. In this activity you will collect local information to determine the carbon dioxide emissions from your school's bus fleet and determine how much space is available for trees.

A. Protocol: In these activities, you will determine the amount of space available for planting trees, and the amount of carbon dioxide sequestered by a given tree and/or a log. Your instructor may choose to do only some of these options.

B. Space Available for Trees: for this portion of the activity, you will need a computer, tablet, or a smart phone with internet access. First, use a search engine or online map program (such as Google Maps) to find a satellite image of your community surrounding your school. Next, estimate how much land is available for planting trees on your school's grounds and in the areas surrounding your school. You may want to keep the following considerations in mind:

- *Some open areas may need to remain open and free of trees to stay useful (e.g. a football field would not work if it was covered in trees).*
- *Some (if not most) of the land around your school's property is probably privately owned. The owners of this land would have to voluntarily plant more trees. They may not be willing to do this.*
- *Some of the largest open areas of land are used for agricultural purposes. Because the owner's income is dependent on agricultural use, these owners are not likely to be willing to convert large portions of it to forested land. Some farmers can receive small amounts of federal financial support for converting a part of their land into wildlife habitat through a program called CRP.*
- *Some open space is not suitable for trees or would only be suitable after extensive effort (e.g. an abandoned parking lot would not be feasible without major efforts to restore the soil).*

Complete the questions below. Be prepared to discuss as a class.

1. How much land is available for planting trees in the area around your school?

Circle one: A lot A limited amount Hardly any at all

2. How does this affect the plan to neutralize carbon dioxide emissions from your school's buses by planting trees in your area?

_____

_____

C. Carbon Dioxide Sequestered in a Log: in this step, you will use a dry log provided by your instructor to see how much CO2 it has sequestered. This log needs to be a completely dry and free of any other materials (like mold or fungi).

1. First we need to determine the weight of the carbon atoms in the dry weight of the tree. Because trees are roughly 50% carbon (when dry), we simply have to multiply our dry weight by 0.5 to find the weight of carbon in the tree.

   Dry weight: _____ x 0.5 = _____ (lbs. of carbon)

2. Next we need to determine how much CO2 can be sequestered by a tree based on its carbon content. Because carbon is a little over a third of the weight of CO2, we simply multiply our carbon weight by 3.67 to determine the weight of CO2 sequestered.

Weight of carbon: _____ x 3.67 = _____lbs. CO2 sequestered

3. A school bus emits an average of 38,000 lbs. of CO2 per year. How many logs of this size would it take to sequester the average annual emissions of one school bus?

_____

Show your work!

D. Carbon Dioxide Sequestered by a Tree: in this step, you will go outside and determine how much carbon dioxide has been sequestered by a tree. You will need a measuring tape and a pen or pencil for this activity.

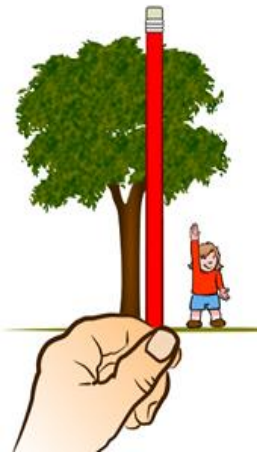

Figure 1 Source: ncetm.org.uk

1. **Determine the height of your tree**. Work with a partner. One person (Partner A) should stand under the tree. The other person (Partner B) should move 20 paces away from the tree. Partner B should hold a pen at arm's length and cover part of the pen so that the visible part of the pen is the same as the Student A's height. Student B should then move the pen up the tree and measure how many times taller the tree is than Student A. Use the height of Student A to determine the height of the tree (e.g. if the tree is 4 times taller than Student A, and Student A is 6 feet tall, then the tree would be 24 feet tall).

2. **What is the estimated height of your tree? _____**feet

3. **What is the diameter of your tree?** (Use a measuring tape to measure your circumference and divide by 3.14).

   Circumference: _____ in. ÷ 3.14 = **_____(Diameter of your Tree)**

4. To determine the green weight of your tree, use ONE of the following formulas:

   a. If your tree has a diameter greater than 11 inches, use this formula:

   (_____ inches)^2 x (0.15) x (_____ feet) x (1.2) =
   diameter *height*

   _____**lbs. Green weight.**

   b. If your tree has a diameter less than 11 inches, use this formula:

   (_____ inches)^2 x (0.25) x (_____ feet) x (1.2) =
   diameter *height*

   _____**lbs. Green weight**

5. Next we need to determine how much CO2 is absorbed by the tree. To determine this, we have to convert the green weight of the tree to dry weight (dry weight = 72.5% of green weight), then take half of this weight (the weight of the carbon atoms is half the dry weight of the tree), and then multiply that amount by 3.67 (because carbon is a little over a third of the weight of CO2).

   For example, a tree with a 1000 lb. green weight would absorb 1330 lbs. of CO2.
   Use the green weight you calculated in Step 4 to answer the question below.

   Green weight: _____ x 0.725 x 0.5 x 3.67 = _____ lbs. of CO2

   This is the amount of CO2 sequestered by this particular tree ↑ over its lifespan.

6. A school bus emits an average of 38,000 lbs. of CO2 per year. How many trees of this size would it take to sequester the average annual emissions of one school bus?

   _____

   _____
   Show your work!

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Activity 7.4: Preparation for Future Learning Presentations of Conclusions

You will be determining the carbon dioxide emissions from your school's bus fleet and will calculate how many trees you would have to plant per year to completely offset these emissions. In this activity you will use the internet information that you have collected and the local information about your school's bus fleet to make and present a final determination.

A. **Protocol: Our goal was to have carbon-neutral bus transportation for the school. The only way to get the CO2 emitted from bus transportation back from the atmosphere is to re-sequester it through photosynthesis in plants.** You will work in your assigned groups to determine how many trees you would have to plant per year to offset the carbon dioxide that is emitted as a result of the fuel combusted by your school's buses.

First, you will need to determine how much carbon dioxide is emitted based on how much fuel is used by all of the buses in a single year. A helpful website for this question can be found at http://www.eia.gov/tools/faqs/faq.cfm?id=307&t=11 .

Next you will have to determine how much carbon dioxide is sequestered by a tree over the course of its life (we are assuming that if we plant a certain number of trees, each will eventually re-sequester and store the carbon dioxide that was emitted from bus transportation over the course of its life by converting it into the cellulose and lignin molecules found in its wood). You should use the credible information you found during your web search on the second day or the amount you calculated on the third day, depending on which you think is more credible (you may want to discuss this first as a class).

Once you know how many pounds of carbon dioxide are emitted from your school's bus transportation and how many pounds of carbon dioxide can be sequestered by a tree over the course of its life, you can do a simple math problem to determine how many trees you would need to plant per year. That equation would be:

[lbs. of CO2 emitted by buses] ÷ [lbs. of CO2 sequestered by a tree] = # of trees

Show your work in the space below. Be ready to present your findings to the class.

B. Questions

1. How many trees would your school need to plant per year to re-sequester and sequester the carbon dioxide emissions from your school's buses?

   We would need to plant_____trees per year to re-sequester the CO2 from our buses.

2. Does it seem feasible for your school to plant this many trees per year? _____

   Explain: _____

   _____

   _____

3. There are roughly 500,000 buses used for school transportation in the United States, each emitting an average of 38,000 lbs. of CO2 per year. Based on your data, how many trees would have to be planted *each year* to offset school bus transportation emissions?

   _____

   Show your work!

4. If a typical tree needs an area of roughly 20 x 20 feet, how much space would be needed per year in the US to offset the emissions from school bus transportation?

   _____

   Show your work! Hint: 20x20 = 400 square feet.

5. What is something (city, state, country) that is similar to this size? _____
   Hint: use a search engine to convert this into simpler units (e.g. square miles). Use a search engine to create a list of cities, states, & countries by land area.

6. In 2014, the US emitted a total of 12 *trillion* pounds of CO2[1] from energy production and use. Based on your data, how many trees would have to be planted *each year* to offset these emissions?

   _____

   _____

   Show your work!

[1] 5406 million metric tons. Source: U.S. Energy-Related Carbon Dioxide Emissions, 2014 http://www.eia.gov/environment/emissions/carbon/

7. If a typical tree needs an area of roughly 20 x 20 feet, how much space would be needed per year in the US to offset the emissions from US energy production & consumption?

_____

Show your work! Hint: 20x20 = 400 square feet. Use a search engine to convert from square feet to square miles.

8. What is something (city, state, country) that is similar to this size? _____
Hint: use a search engine to convert this into simpler units (e.g. square miles). Then use a search engine to create a list of cities, states, and countries by their land area.

9. What are some other changes that a you, a school, or a society could make to prevent carbon dioxide levels in the atmosphere from increasing?

Changes individuals could make: _____

_____

Changes a school could make: _____

_____

Changes a society could make: _____

_____

10. What would happen to the CO2 emissions in the atmosphere if they are not re-sequestered through photosynthesis?

_____

_____

11. To decrease the amount of CO2 in the atmosphere, we would need to: (circle all that apply)

A) Use less fossil fuel B) Use no fossil fuels C) Increase photosynthesis

Explain: _____

_____

_____