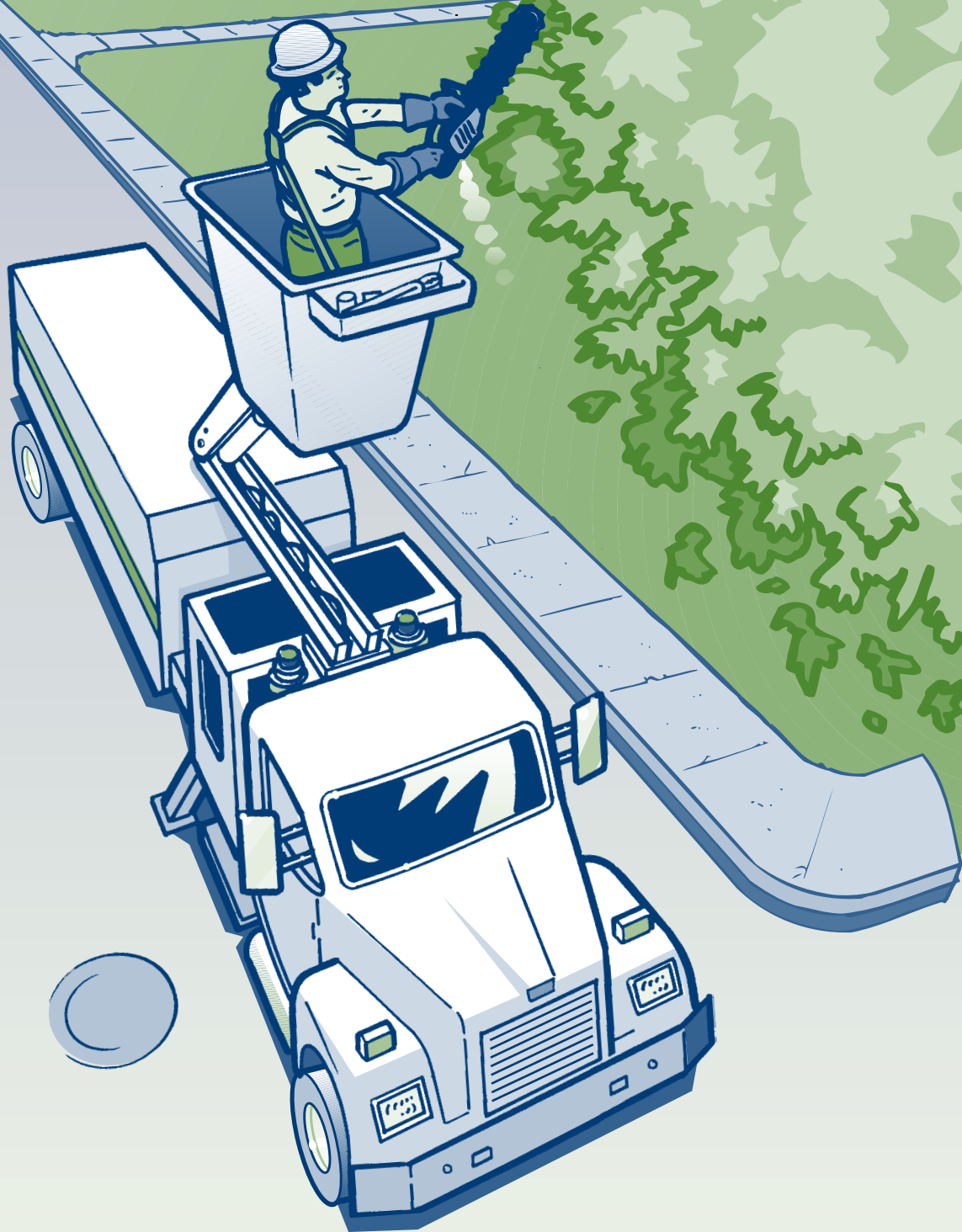


Balancing Act:

Urban Trees and the Carbon Cycle



Meet the Scientists



Dr. Nowak: ▲ My favorite experience in science is seeing people use the new information we generate to improve the urban environment.



Mr. Stevens: ▲ My favorite experience in science is being a part of the process of solving environmental problems that affect the health and well-being of urban residents.



Dr. Luley: ▲ My favorite science experience is watching a tree go through each season and understanding what is happening to the tree. Each season has its own unique set of changes that we all can see. There is also a whole set of changes that occur in the tree at the cell and subcellular level that correspond to these visual changes. Making the connection between the two and understanding how we better manage our trees with this knowledge has been a very rewarding experience.

Glossary:



emitted (**e mi** ted): Discharged or sent out.

fossil fuel (**fos ul fyoo**l): Fuel, such as coal, petroleum, or natural gas, formed from the fossilized remains of plants and animals.

photosynthesis (**fo to sin** thuh sis): The process by which green plants use sunlight to form sugars and starches from water and carbon dioxide.

species (**spe sez**): Groups of organisms that resemble one another in appearance, behavior, chemical processes, and genetic structure

Pronunciation Guide

a	as in ape	ô	as in for
ä	as in car	u	as in use
e	as in me	ü	as in fur
i	as in ice	oo	as in tool
o	as in go	ng	as in sing

Accented syllables are in **bold**.



Thinking About Science

To discover new things, scientists must work with information. They may take old information and look at it in new ways. They may collect new information and consider it in ways that no one has done before. Often, the information that scientists collect and consider is in the form of numbers. The numbers represent quantities of whatever it is the scientists are studying.

In this study, the scientists were interested in carbon dioxide, or CO_2 . The scientists estimated the amount of CO_2 absorbed by urban trees. They compared that number with another number. The other number indicated how much CO_2 was put into the atmosphere when machines were used to plant and maintain urban trees. Thus, they were looking at how much CO_2 was either being absorbed or *emitted* by planting and maintaining urban trees. By using numbers, the scientists could better understand how the management of urban trees affects the carbon cycle.



Thinking About the Environment

Carbon is one of the most interesting and widespread of elements. All plants and animals on Earth, including humans, are made up of carbon. Much of Earth's carbon is held deep in Earth as petroleum, coal, and natural gas. These forms of carbon are used by humans as *fossil fuels* to run machinery.

In the carbon cycle, carbon moves from the atmosphere, to Earth, into Earth, and back to the atmosphere (**figure 1**). When fossil fuels are burned in engines, carbon is taken from inside the Earth and then emitted into the atmosphere as CO_2 . If humans did not burn fossil fuels, the carbon cycle would stay in a natural balance. Too much CO_2 in the atmosphere disrupts Earth's climate and can cause the Earth's global temperature to rise.

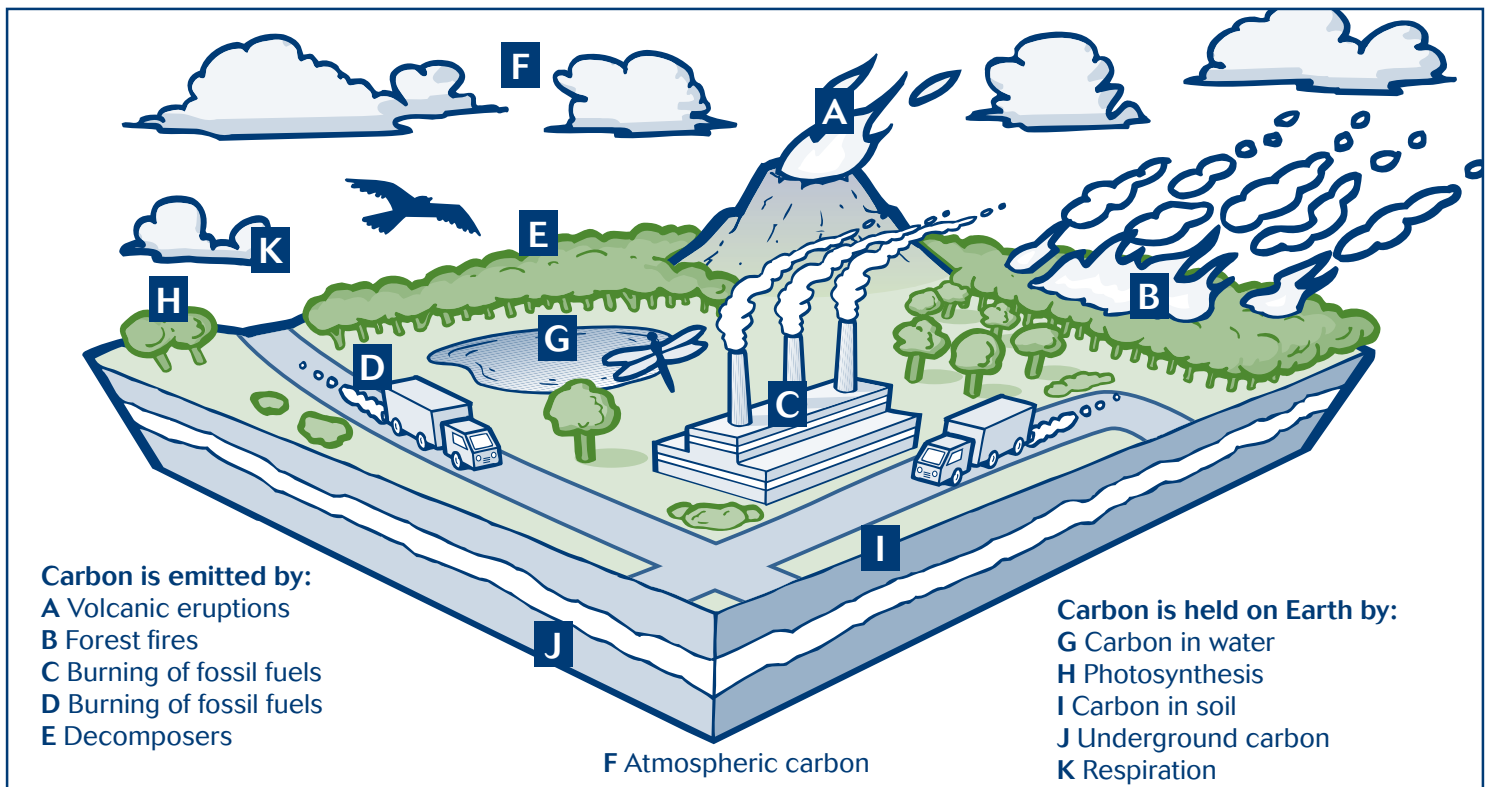


Figure 1. The carbon cycle.

Introduction

Too much carbon dioxide (CO_2) in the atmosphere is mostly caused by two things: burning fossil fuels and the loss of trees. Fossil fuels are made up of carbon. When they are burned as fuel, the carbon is released in the form of CO_2 . Trees absorb CO_2 during *photosynthesis*. When trees are removed or die, their ability to absorb CO_2 is lost.

When people plant trees in urban areas, they expect the trees to do many things. Urban trees help to keep urban areas cooler, they hold soil in place, they make urban areas prettier, and they help to keep urban areas quieter. They also absorb CO_2 from cars, buses, and the many engines that are used in urban areas. When people think about the benefits of having urban trees, they often think of these things. There is also something that they may not think about.

When people plant and maintain urban trees, they usually use machines with engines. These machines include trucks, chainsaws, and other machines (**figure 2**). As you know, these engines emit CO_2 . When people think about how much CO_2 is absorbed by urban trees, they should also consider how much CO_2 is emitted from the engines used to care for the trees. When a tree is cared for using machines with engines, there is a point in the tree's lifetime at which more CO_2 will be emitted from the engines than the tree has absorbed. The scientists wanted to know which tree *species* can grow the longest before reaching that point.



Figure 2. Urban trees are maintained using trucks and other machines that emit CO_2 .

Reflection Section



- ✿ Think about how a part of the carbon cycle is illustrated by urban trees and urban tree maintenance. With that in mind, what is the question that the scientists were trying to answer?
- ✿ Why do you think the scientists wanted to know which tree species absorb the most CO_2 over time?

Method

The scientists thought about all of the ways that CO² is absorbed or emitted during the life of an urban tree. These included the growth of the tree, the engines that were used to plant and maintain the tree, and what happened to the carbon in the tree after the tree was removed at the end of its life (**figure 3**).

The scientists created 14 categories to describe the lifespan, growth rate, and size of urban tree species. The 14 categories were formed from some combination of tree species size, life span, and growth rate (**figure 4**). In other words, one category was a small tree with a short life span that grows slowly. Another category was a medium-size tree with a short life span that grows slowly. A third category was a small tree with a medium life span that grows slowly. By using different combinations of these three characteristics, the scientists created 14 separate categories.

The scientists studied one tree from each tree species for each of the 14 combinations of size, life span, and growth rate. They used

existing information that estimated how much each type of tree would weigh every year of its life. From this estimate, they subtracted the estimated weight of the water in the tree. This gave the scientists a measurement of the weight of the dry matter in each tree. (Remember that scientists often put numbers on what they are studying.) To estimate the amount of carbon in the tree, they divided the weight of the tree's dry matter by two. They divided by two because half of the dry matter of a tree is composed of carbon. The amount of carbon in the tree was considered equal to the amount of CO² that the tree had absorbed.

Each tree was maintained exactly alike. This included things like planting the tree, pruning the tree, bringing water to the tree, and removing the tree at the end of its life. The amount of fossil fuel used every year was recorded. The scientists used existing mathematical equations to estimate how much CO² was emitted from the engines.

Ways that CO ² is absorbed or is kept from being emitted	Ways that CO ² is emitted
As a tree grows and gets larger with more leaves, more CO ² is absorbed.	Trucks and shovels with engines are used to plant the tree.
When a tree is removed and its wood is used for furniture or other items, its carbon is not emitted.	Chainsaws and trucks are used for pruning the tree's branches and then chipping the branches into small chips for mulch. The engines emit CO ² . As the mulch decomposes, it also emits CO ² .
When a tree is removed and put into a landfill, only a small portion of its carbon is emitted.	Chainsaws and trucks are used to remove the tree at the end of its life. The tree may be chipped into small chips for use as mulch. CO ² is emitted when machines are used and when the mulch decomposes.
When a tree is planted in the right location around a building, it can shade the building to reduce energy use and CO ² emissions from power plants.	

Figure 3. Ways that CO² is absorbed and emitted during the life of an urban tree.



Reflection Section

- What did the two sets of numbers represent?
- Why do you think each tree was maintained exactly alike?

Size of tree species	Life span of tree species	Growth rate of tree species
Small Size (less than 40 feet)	Short (20 years)	Slow (less than 12 inches per year)
Medium Size (40-60 feet)	Medium (40 years)	Moderate (12-24 inches per year)
Large Size (greater than 60 feet)	Long (60 years)	Fast (> 24 inches per year)
		Moderate to Fast

Figure 4. Characteristics that were used to create 14 categories of urban tree species.

The scientists now had two sets of numbers for each of 14 tree species for every year of each tree's life. One set of numbers had to do with the carbon dioxide emitted every year by equipment used to maintain the tree. The other was a measurement of the amount of carbon absorbed by the tree every year. They compared these numbers to answer their question.

Findings

Trees species with a long life span and a moderate growth rate lived the longest before the CO² emitted from trucks, chainsaws, and other machines was greater than the amount of CO² that the trees absorbed. In general, the longer a tree lived, the better the balance between CO² absorption and emission. This is partly because of the large amount of CO² that is emitted by engines when a tree is planted or removed. It is also because trees that live longer are usually larger and have more leaves. This means that they photosynthesize more and, therefore, absorb more CO² than smaller trees.



Thinking About Ecology

All living things exist on Earth because of the one-way flow of energy from the sun. Plants use sunlight to make sugars and starches from water and carbon dioxide, a process known as photosynthesis. Plants are eaten by animals, and some animals eat other animals. As

plants and animals are eaten, their energy is transformed into energy that can be used by the one who is doing the eating. When plants and animals die, their bodies decompose, providing energy for microorganisms in the soil.

Over time, much of Earth's energy is held deep

and in earth in the form of coal, petroleum, and natural gas. Although energy changes form, energy that comes from the sun cannot be created or destroyed by anyone or anything on Earth. ■

Reflection Section



- ✿ This research identified the amount of CO² emitted by equipment that was used to maintain urban trees. What might happen in the future to the design of the equipment used to maintain urban trees? How could that change affect the scientists' research?
- ✿ If people want to increase the amount of CO² that is absorbed in urban areas, should they plant more or fewer urban trees?
- ✿ Of the tree species characteristics in figure 4, which kind of species should they plant?

Implications

We often consider doing things without looking at the complete picture. The scientists in this study suggest that people should think carefully before selecting an urban tree species to plant. People should compare the amount of carbon that the tree will absorb with the amount of CO² being emitted when the tree is planted and maintained using machines.

The scientists suggest that people should plant urban trees that live a long time and grow either fast or moderately fast. They also suggest that people use machines that are energy efficient, or they should do some of the things by hand. ■

Reflection Section



- ✿ This study looked at how much CO₂ was emitted by engines used to plant and maintain urban trees. What is one way that CO₂ emissions could be reduced without changing the type of tree species being planted?
- ✿ This study examined the advantages and disadvantages of planting and maintaining different urban tree species for balancing CO₂. What might be some other advantages and disadvantages of different tree species?

From Nowak, D. J., Stevens, J. C., Sisinni, S. M., and Luley, C. J. (2002). Effects of urban tree management and species selection on atmospheric carbon dioxide. *Journal of Arboriculture*, 28(3):113-122.

FACTivity



As a class research project, create a list of different types of native trees for the area in which you live. In groups, research each tree and find out how long the tree lives and how fast it grows as well as leaf type, special characteristics of the tree, etc. Your group should make a presentation about your tree. After all of the presentations have been made, your class should vote on which type of tree to plant in your schoolyard. The tree should be successful in your particular schoolyard environment.

Teachers—

A possible extension to this Factivity is to have students engage in a service learning project. After researching the trees and voting on type of tree to plant, students can go out into the community and find businesses that would be interested in helping to plant urban trees. Schools could get businesses to donate funds to buy trees appropriate for the area and the students could plant them.