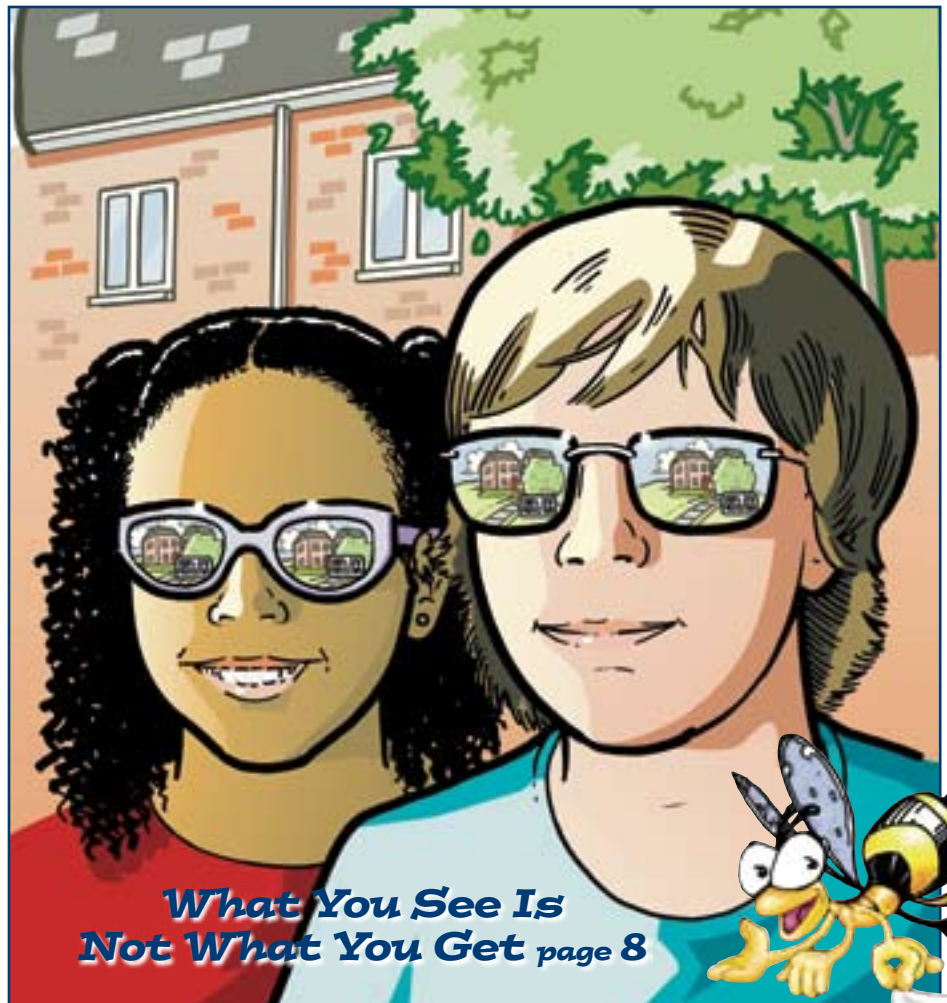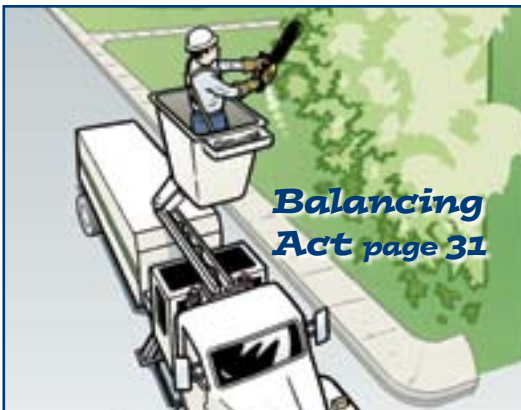# Natural
INQUIRER

Volume 6, Number 1 • Urban Forest Edition

Natural Inquirer

Urban Forest Edition • Volume 6, Number 1 • Spring 2005

Editorial Review Board

Todd Nickelsen's 8th grade class, Coile Middle School, Athens-Clarke County, GA

Comments about individual articles from this edition from the Natural Inquirer *Editorial Review Board:*

"The article overall was good because they used the right words to help explain what they were talking about."

"I got confused about the behavior of social groups."

"It was a good article to read for middle schoolers. It was also appropriate enough for us and very entertaining."

"Use enthusiasm. I think it needs more excitement. Use more actions and exclamations."

"I thought the article was alright but some stuff you really don't understand, but it is interesting."

"Nice equations. Made me think."

"I think it was okay but it had some words I didn't know."

"I thought it was very easy to understand. I like how they have the glossary on the first page. I learned a lot about street trees and sidewalk trees."

"Good title. Very catchy!"

"The article was okay. I learned a little from the experiment. I'm not into science so it was a little boring to me."

"The article is too complex. It was hard for me to understand but it did have some interesting information."

"I think this article is very good. I hadn't ever read about street trees and how much street they cover."

"These R some awesome equations! Excellent!"

"The pronunciation guide is unnecessary to include. Overall, I think the article was great."

"Most of the people who will be reading will probably already know how to pronunciate these words."

Shelley Master's 8th grade class, Coile Middle School, Athens-Clarke County, GA

Note to educators

As teachers of science, you want your students to acquire abilities that will enable them to conduct scientific inquiry, and you want them to gain an understanding of the scientific inquiry process. Scientific inquiry can best be taught by integrating minds-on and hands-on experiences. Over time, such experiences encourage students to independently formulate and seek answers to questions about the world we live in. As educators, you are constantly faced with engaging your students in scientific inquiry in new and different ways. In an age of abundant technology, standard teaching strategies can become monotonous to today's learners. The *Natural Inquirer* provides a fresh approach to science and a view of the outside world that is larger than the classroom and can still be used while in the school setting.

The *Natural Inquirer* is a science education resource journal to be used with learners from Grade 5 and up. The *Natural Inquirer* contains articles describing environmental and natural resource research conducted by the United States Department of Agriculture (USDA) Forest Service scientists and their cooperators. These are scientific journal articles that have been reformatted to meet the needs of middle school students. The articles are easy to understand, aesthetically pleasing to the eye, contain glossaries, and include hands-on activities. The goal of the *Natural Inquirer* is to stimulate critical reading and thinking about scientific inquiry and investigation while learning about ecology, the natural environment, and natural resources.

Science Education Standards and Evaluations: In the back of the journal, you will find a matrix that allows you to identify articles by the national science education standards that they address. You will also find evaluation forms in the back of the journal. Please make copies of these evaluation forms and have your students complete them after they complete each article. Also, please complete the evaluation form for teachers. Send the evaluation forms to the address listed below. The address is also listed at the bottom of the evaluation forms. You and your students may also complete the evaluation forms online by visiting http://www.naturalinquirer.usda.gov.

This journal was created by Environmental and Science Education, an education program of the USDA Forest Service. If you have any questions or comments, please contact:

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Educator Resources:
Visit the updated *Natural Inquirer* Web site at http://www.naturalinquirer.usda.gov. From this site, you can read and download lesson plans, word games, and other resources to help you use the *Natural Inquirer* in your classroom.

Visit the Natural Inquirer Web site:
http://www.naturalinquirer.usda.gov

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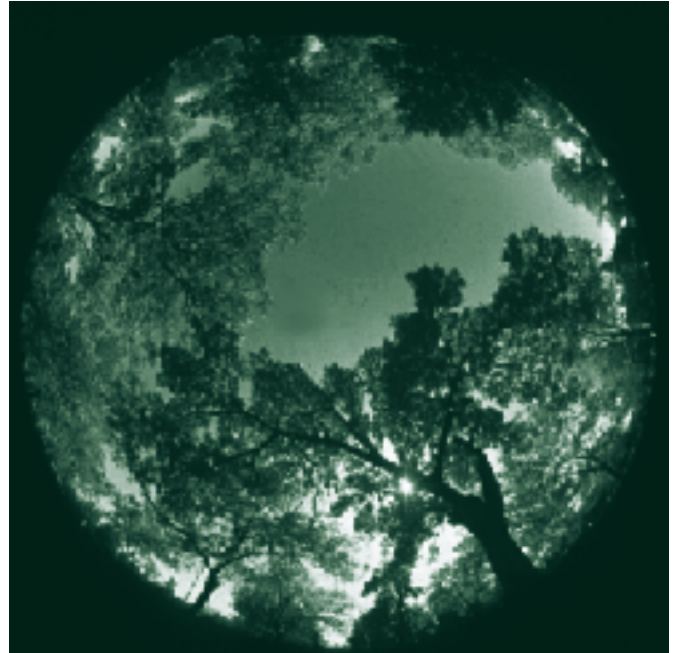
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About the Natural Inquirer

Scientists report their research in journals, which are special booklets that enable scientists to share information with one another. This journal, the *Natural Inquirer*, was created so that scientists can share their research with you and with other middle school students. Each article tells you about scientific research conducted by scientists in the USDA Forest Service. If you want to know more about the USDA Forest Service, you can read about it on the back cover of this journal, or you can visit the *Natural Inquirer* Web site at http://www.naturalinquirer.usda.gov.

All of the research in the *Natural Inquirer* is concerned with nature, such as trees, forests, animals, insects, outdoor activities, and water. First, you will "meet the scientist" who conducted the research. Then you will read something special about science and about the natural environment. You will also read about a specific research project. This is written in the format that scientists use when they publish their research in journals. Then, YOU will become the scientist when you conduct the FACTivity associated with each article. Don't forget to look at the glossary and the special sections highlighted in each article. These sections give you extra information.

At the end of each section of the article, you will find a few questions to help you think about what you have read. These questions are not a test! They should help you to think more about the research. Your teacher may use these questions in a class discussion.

Who are scientists?

Scientists are people who collect and evaluate information about a wide range of topics. Some scientists study the natural environment. To be a successful environmental scientist, you must:

❧ **Be curious**–You must be interested in learning.

❧ **Be enthusiastic**–You must be interested in an environmental topic.

❧ **Be careful**–You must be accurate in everything that you do.

❧ **Be open minded**–You must be willing to listen to new ideas.

❧ **Question everything**–You must think about what you read and observe.

Welcome

to the Urban Forest Edition of the *Natural Inquirer*!

What are urban forests? Urban forests are the trees and other plants that grow where people live, go to school, work, and play. Even if you live in a rural community, the trees in your yard, around buildings, and in parks are called urban forests. Calling them urban forests helps you to see that they are different from the kind of forests that grow in large undeveloped areas. Urban forests include trees in community parks and other public land, along streets, in neighborhoods, around businesses and industry, and just about everywhere in a community. You will find urban forests almost anywhere that you find people living, going to school, working, and playing.

Urban forests provide many benefits to people and to their communities. Trees and other plants help to slow soil erosion, reduce noise, provide homes for wildlife, and provide recreational opportunities. Can you imagine a park without trees? There are other benefits as well. Benefits of urban forests include—

- Reducing the amount of rainwater going down storm drains.
- Improving air quality.
- Increasing the value of property.
- Making communities more attractive.
- Keeping the temperature cooler in the warm summer months.

You will read about some of these benefits in this edition of the *Natural Inquirer*. Even though you may be surrounded by urban forests, you might never have thought about all of the benefits that they provide to you and your community.

Did you know that—
- Urban forests can help protect you from ultraviolet radiation?
- Different groups of people like to picnic in different ways?
- Urban forests can reduce the amount of fuel used by vehicles?
- The average tree growing in a yard could be worth almost $1,000?
- Urban forests can help reduce the amount of pollution being washed into streams and rivers?
- Urban trees and the machines used to take care of them are a part of the carbon cycle?
- Most of the benefits from urban trees come from their branches and leaves?

You will learn all about urban forests in this edition of the *Natural Inquirer*. You will also learn about the scientists who study urban forests. When someone says the word "forest," people usually think about the large forests located outside of cities and towns. Now, when you hear the word "forest," you will also think about the urban forest that makes your community more attractive, healthier, cooler, and a lot more fun!

What You See Is Not What You Get:

The Difference Between Visible Sunlight and Ultraviolet Radiation

Meet the Scientists

Dr. Grant: ▾ My favorite experience as a scientist is solving a puzzle of why something in nature acts like it does or discovering an explanation for something I have seen many times but did not know why it happened.

Dr. Heisler: ▲ My favorite experience as a scientist is getting to understand something about how nature works. I also like to successfully develop or use a method to measure how nature works.

Thinking About Science

Scientists use many ways to discover new knowledge. Sometimes collecting existing information from many sources and putting it together in one report is a valuable addition to science. This is similar to what you do when you write a paper using information from the library and the Internet. In this study, the scientists collected information from past research and added it to their own research findings. In this research, the scientists wanted to know how much is already known about *ultraviolet radiation* in urban areas.

Glossary:

ultraviolet radiation (**all** tra vi o let ra de a shun): Invisible rays of light lying beyond the violet end of the spectrum.

immune system (im **myoon** sis tem): The system within the body that protects the body from disease; includes white blood cells and antibodies.

relationship (re **la** shun ship): Two or more things that are connected in some fashion.

optical (**op** tuh kül): Relating to vision or to light.

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

quantity (**kwän** tä ti): An amount or portion.

tree crown (**tre** krown): The upper green section of a tree with leaves or needles.

reflectivity (re flek **tiv** uh te): The property of casting back light, heat, sound, etc.

average (**av** rij): The usual kind or amount. The number gotten by dividing the sum of two or more quantities by the number of quantities added.

canopy (**kan** uh pe): Anything that covers like a roof. On a tree, the area of leaves that cover the ground.

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 the Environment

All life on Earth needs the sun because it is the original source of all of our energy and food. Sometimes, however, we can get too much of a good thing. Take ultraviolet radiation, for example. Ultraviolet radiation, or UV radiation, comes from the sun and is invisible. UV radiation is a part of the **electromagnetic** (e **lek** tro mag **net** ik) spectrum (**figure 1**). What makes UV radiation good? UV radiation causes the skin to create Vitamin D, which helps people to absorb calcium. A little bit of sunlight can also protect people from some kinds of nonskin cancers. Too much UV radiation, however, can be hazardous to human health. If you are going to be in the sun for a long time, use sunscreen or cover your skin. Some of the negative impacts of too much UV radiation include sunburn, eye damage, and skin cancer. Because too much UV radiation may damage a person's *immune system*, other cancers and diseases may be related to having too much sun exposure.

Introduction

Scientists have known that there is a difference between the sun's visible radiation and invisible ultraviolet radiation from the sun. (**See figure 1.**) Ultraviolet radiation is separated into 3 types: UVA, UVB, and UVC. UVB radiation is best known for its ability to cause damage to human health. At the short end of the UVB wavelength, where UVB meets UVC, almost all of the radiation is absorbed by ozone in the atmosphere. At the longer end of the wavelength, UVB meets UVA radiation. Ozone does not absorb very much of the radiation at this end of the UVB spectrum (**figure 2**).

When it is hot or very sunny, people often seek the shelter of a tree's shade to protect them from the sun. This is because the tree's leaves provide shade from the sun's visible radiation. Although leaves protect people from the sun's visible radiation, they may not protect people from invisible UVB radiation. The scientists in this study were interested in trees growing in urban areas. They wanted to know whether the shade that we can see under urban trees protects people from UVB radiation. Ultimately, it is shade from the UVB radiation that is the most important for human health.

Reflection Section

🍁 What question did the scientists want to answer?

🍁 Why is this question important?

Figure 1. Electromagnetic Spectrum
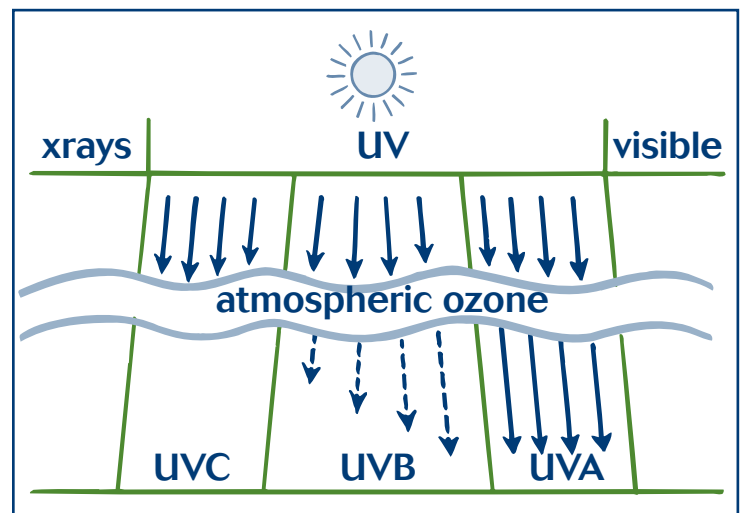
Figure 2. UVA, UVB, and UVC radiation and their *relationship* to ozone in the atmosphere.

Method

The scientists read over 100 research papers that were related in some way to the question about the sun's radiation on urban trees. Urban trees are the trees that grow where people live, work, and play. The scientists also had the results from their own previous research. The scientists were most interested in the *optical* properties of leaves. They read research papers that reported how much of the sun's visible radiation and UVB radiation passes through leaves. They read research about how the leaves from different tree *species* reflect visible radiation and UVB radiation. They read research about how the *quantity* of visible radiation compares with the quantity of UVB radiation in the sunny areas near urban trees. They included the information they had collected themselves about the amount of radiation reaching the area under urban trees. Then, they put all of the information together into one report.

Reflection Section

🍂 Name two reasons why is it important to find out what is already known about something before doing an experiment or collecting your own information about it.

🍂 From your own observation, would you say that leaves allow the sun's visible radiation to pass through them? Why or why not?

Findings

The scientists found that while leaves allow some of the sun's visible radiation to pass through them, *tree crowns* do not allow much light to pass to the ground. This is because most of the sun's rays encounter many leaves as they attempt to get through the crown. Therefore, the scientists focused their attention on the *reflectivity* of leaves (**figure 3**). They found that the reflectivity of visible radiation is much higher than invisible UVB

Visible and UV radiation

Figure 3. The reflection of the sun's radiation off of a leaf.

radiation. For example, about 10 to 30 percent of the sun's visible radiation is reflected off of leaves. About 3 to 6 percent of the sun's UVB radiation is reflected off of leaves.

In dense forests you can usually only see a small part of the sky from the forest floor. In these forests, only a little visible radiation and UVB radiation reach the forest floor. This is because there are many layers of leaves shielding the forest floor from the sky.

The situation is very different in urban forests. In urban forests, trees either are planted alone or with just a few others (**figure 4**). In urban forests, people can usually see the

Figure 4. In an urban forest, people can see the sky beyond the edge of the tree crown.

Figure 5. Scientists use special sensor equipment placed under a tree or on the ground to measure the amount of the sun's radiation reaching the ground. Notice the clear bubble on the top of the equipment.

Figure 6. If the equipment could see, this is an example of what it would see.

sky beyond the edge of the tree crown. The scientists used special equipment to measure the amount of radiation reaching the ground, both in the open and under urban trees (**figures 5 and 6**). UVB radiation is widely scattered across the sky. If a person can see much of the sky, the UVB radiation reaches them even when they are under a tree.

The scientists reported some of their own research, in which they measured the amount of radiation reaching six types of areas (**table 1**). The six areas were:

1. Sunlit areas under a tree in summer (with leaves)
2. Shady areas under a tree in summer (with leaves)
3. Sunlit areas under a tree in winter (no leaves)
4. Shady areas under a tree in winter (no leaves)
5. Sunlit areas under a tree in winter with a building nearby (no leaves)
6. Shady areas under a tree in winter with a building nearby (no leaves)

Area Under Tree Canopy	Percent Reduction in UVB Radiation	Percent Reduction in Visible Radiation
1. Sunlit Area–With Leaves	39	3
2. Shady Area–With Leaves	63	84
3. Sunlit Area–No Leaves	40	6
4. Shady Area–No Leaves	56	73
5. Sunlit Area and Building–No Leaves	59	5
6. Shady Area and Building–No Leaves	70	47

Table 1. *Average* percent reductions in the sun's visible radiation and invisible UVB radiation below a street tree *canopy*.

Look closely at **table 1**. If our eyes were able to see UVB radiation, the shadows cast by UVB radiation would be different than the shadows cast by visible radiation. Compare the numbers in areas 1 and 2 in each column. Then look at the numbers in areas 3 and 4 in each column. Now look at the numbers in areas 5 and 6 in each column. You can see that the reduction in UVB radiation was more similar in sunny and shady areas than the reduction in visible radiation in sunny and shady areas. In sunny areas, not much visible radiation is reduced. In shady areas, a lot of the visible radiation is reduced. The radiation that we can see is not like the UVB radiation that we cannot see. The UVB radiation is scattered across the sky. When you can see a part of the sky from where you are standing, you are receiving some UVB radiation.

The scientists also found that in sunny areas close to urban trees, a greater percentage of UVB radiation was reduced even though the
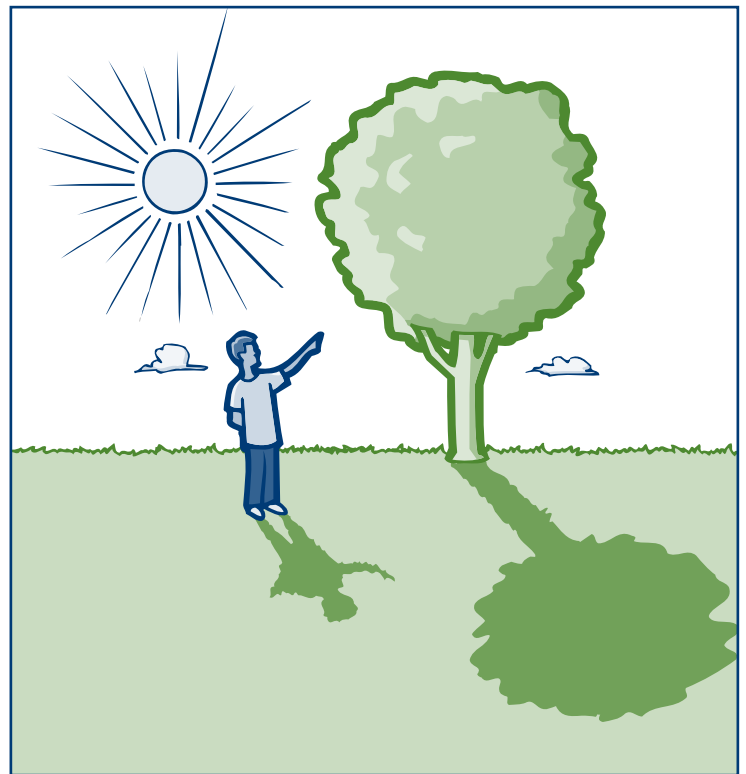
Figure 7. Sunny areas near urban trees experienced a greater reduction in UVB radiation than visible radiation.

Thinking About Ecology

No matter what you look at in nature, it is a part of a system. Systems can exist at a number of different levels, from small and simple to large and complex. Your body is a good example. You have different organs that are systems composed of cells. Your whole body is a larger, more complex system that is composed of different organs. As systems get larger and more complex, new properties appear that were not evident at the smaller and simpler levels. In this study on UVB radiation, the crowns of trees demonstrate this idea. Tree crowns are made up of many individual leaves growing on branches. An individual leaf is one type of system. When hundreds or thousands of leaves make up a tree crown, new things are possible. Now, visible radiation and UVB radiation from the sun can be partially blocked. The temperature under the tree is now lower in the warm summer months. Birds now have a place to build nests. As systems get larger and more complex, new things are possible that were not possible before. ■

visible radiation was not reduced (**figure 7**). This is because when people stand close to a tree, part of the sky is blocked by the tree. When a part of the sky is blocked, some of the UVB radiation is blocked as well.

Implications

If you are in a densely forested area and cannot see part of the sky above you, you are probably protected from UVB radiation. If you are standing under an urban tree or a small group of trees and you can see part of the sky beyond the edge of the tree crown, you still receive some UVB radiation. The amount of UVB radiation you receive depends on how much of the sky you can see. Larger, older

trees provide more protection from UVB than smaller, younger trees. If you are in the sun but just outside of the shade of a large tree, you receive a smaller amount of UVB than if you were standing in the sun farther away from the tree's shade. ■

From Heisler, G. M. & Grant, R. H. (2000). Ultraviolet radiation, human health, and the urban forest. USDA Forest Service General Technical Report NE-268, Newtown Square, PA.

FACTivity

In this FACTivity, you will conduct an experiment to test the different amounts of UV radiation. Compare your results with the results of the scientists in this study. For this FACTivity, you will need UV detection beads. Divide UV detection beads into six different plastic petri dishes.

Place one petri dish in each of the areas listed below.
1. Sunlit area under a tree (with leaves).
2. Shady area under a tree (with leaves).
3. Sunny area right next to a tree, but not directly under the tree.
4. Sunlit area under a tree with a building nearby.
5. Shady area under a tree with a building nearby.
6. Any other area you would like to compare.

Observe what happens to the UV detection beads placed in these areas and then record your results in the following table.

Were your results similar to the scientists' results in this study? If not, why do you think there is a difference?

Teachers—
UV detection beads are inexpensive and can be ordered from vendors on the Web. Search on "UV detection beads."

Placement of UV Detection Beads	Time of Year (Winter, Summer, Spring, Fall)	Observations
Sunlit Area Under a Tree (With Leaves)		
Shady Areas Under a Tree (With Leaves)		
Sunny Area Right Next to a Tree, but not Directly Under the Tree		
Sunlit Areas Under a Tree With a Building Nearby		
Shady Areas Under a Tree With a Building Nearby		
Any Area of Your Choice		

Alternate FACTivity

In this FACTivity, students will use information from the U.S. Environmental Protection Agency (EPA) Sunwise program. Visit EPA's Web site to can find out the daily UV radiation for your city: **http://www.epa.gov/sunwise/uvindex.html**

Record the daily UV Index for your hometown and for one city in each region of the United States. Record the results in the table below.

Compare the UV index results for each city. Calculate each city's 2-week average UV index recording. Discuss results and why there are differences among cities.

Web Site resources
Sun protection tips:
http://www.epa.gov/sunwise/kids.html

Activities
http://www.cdc.gov/excite/skincancer/index.htm

Name of Hometown	Southern City	Northeastern City	Midwestern City	Rocky Mountain City	Southwestern City	Northwestern City
Day 1						
Day 2						
Day 3						
Day 4						
Day 5						
Day 6						
Day 7						
Day 8						
Day 9						
Day 10						
Day 11						
Day 12						
Day 13						
Day 14						

I've Got You Covered:

The Amount of Pavement Covered by Street Trees

Meet the Scientists

Mr. Maco: ◂ As a research forester, my curiosity about the natural world is encouraged. I am offered opportunities to explore questions for which answers are not known. My favorite experience with science is when answering one of these questions leads to an improvement in how we manage our forests, so that future generations can enjoy what we enjoy today.

Dr. McPherson: ▸ My favorite science experience is seeing a paper finally in print or giving a presentation to a large group and sensing their interest and excitement. The process of planning and conducting research is long and painstaking. One has to be patient because results don't come quickly. However, the joy of seeing a project completed and knowing that it is valued by others is very gratifying.

Thinking About Science

Scientists work to solve problems. These problems are identified because their solution provides a benefit to people. Sometimes a scientist's research might be a part of a larger problem. By solving a small piece of the problem, scientists can provide information so that the larger problem might one day be solved.

In this study, the scientists wanted to know how much of a city's paved surfaces should be covered by trees. Paved surfaces include streets, sidewalks, and parking lots. Many benefits are provided by urban trees when they cover paved surfaces. To answer their question, they first needed a way to estimate the current amount of ground and pavement that urban trees cover. This is because the amount of benefits provided by urban trees is related to the amount of ground and pavement

Glossary:

global warming (**glo** bul **wôrm** ing): An increase in the average temperature of the Earth's atmosphere.

intercept (**in** tür sept): To stop or interrupt the progress or intended course of something.

canopy (**kan** uh pe): Anything that covers like a roof. On a tree, the area of leaves that cover the ground.

inventory (**in** ven tôr e): A complete list of goods, supplies, possessions, etc.

radius (**ra** de us): A straight line that extends from the center to the outside of a circle or sphere.

Pronunciation Guide

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

Accented syllables are in **bold.**

that their canopies cover. Unless the scientists found out how much of the city's paved surfaces were currently covered by trees, they could not determine whether more tree cover was needed.

Thinking About the Environment

Urban trees provide many benefits to people and their communities. Urban trees keep areas cooler in the summer, helping to lower energy use in buildings. Trees keep the air cleaner by reducing the amount of harmful pollutants in the air. They also help to prevent *global warming* by reducing the amount of carbon dioxide going into the atmosphere. Trees hold the soil in place and intercept rainwater. When trees *intercept* rainwater, they reduce the amount of water that runs into stormdrains and washes pollutants into streams and rivers. Urban trees also provide homes for birds and other urban wildlife and make urban areas more beautiful.

Most of these benefits depend on how much of the ground, including paved areas, the tree's *canopy* covers (**figure 1**). Usually, the larger the area of ground or pavement that is covered by urban tree canopies, the greater the benefits to people.

Figure 1. A tree canopy.

Introduction

The trees that grow along urban streets are called street trees. Some street trees are planted between the street and the sidewalk (**figure 2a**). Other street trees are planted in a strip of land called the median, which lies in between the lanes of traffic (**figure 2b**). Trees that grow in front yards are considered street trees if part of their canopy covers public areas, such as the sidewalk or the street (**figure 2c**). Often, sidewalks have cut out areas where trees are planted (**figure 2d**).

Figure 2a. Street tree planted between the street and sidewalk.

Figure 2b. Street tree planted in the median strip.

The scientists in this study wanted to know how much of the sidewalks and streets were covered by tree canopies in a particular urban area. Can you guess why they wanted to know this? If people do not know how much of something they have, then they do not know if they need more or less of it.

Think about your own money. Let's say that you want to buy a new DVD that costs $15. How do you find out if you need more or less money to buy the DVD? To determine this, you must count your money.

When you count your money, you are taking an *inventory* of how much money you have. The scientists in this study wanted to take an inventory of how much ground and pavement was covered by street trees. By estimating this, they eventually will be able to recommend how cities can change the number of trees growing in cities and where the trees are planted. By doing this, cities can increase the amount of benefits people are receiving from street trees.

Figure 2c. Street tree planted in a front yard.

Thinking About Ecology

All living things grow and develop. This happens for individual living things, such as you and your classmates. Development means that as living things get older, they are able to do different and more complex things. When you think about it, you can see that infants do not just grow. They also develop. You can see this by watching infants learn to walk, talk, and then ask more complex questions. The idea of development can be demonstrated by urban forests. As urban forests get older, they are able to "do" things that they could not do when they were younger and smaller. For example, as tree crowns get larger, they are able to shade more of the pavement. They are able to slow more of the rainfall and prevent more pollution of streams and rivers. They keep larger areas cooler and provide places for different kinds of urban wildlife to live. They are able to produce flowers, nuts, and seeds and, therefore, reproduce. As you read this article, think about how the development of urban forests affects their ability to provide benefits to people. ■

Figure 2d. Street tree planted within a sidewalk cut out.

Reflection Section

🍁 What were the scientists trying to do in this study?

🍁 Can you think of two other items that you took an inventory of this past week? What were they?

Method

The scientists estimated three types of tree canopy cover. First, they measured the *radius* of the area beneath each street tree canopy in the community. They assumed that this area would be roughly shaped in a circle. Then, they estimated the amount of canopy cover over streets alone. Finally, they estimated the amount of cover over streets and sidewalks together. They used mathematical equations to estimate the amount of cover over streets and sidewalks.

The scientists used existing information to estimate the total amount of pavement making up streets and sidewalks. For example, they added up all of the street lengths. They found that there were 240 kilometers of streets in the community. (How many miles is this? To calculate, multiply the number of kilometers by .621.) Then, they multiplied 240 by 10.7 meters (or 35 feet) to calculate the total area of street pavement. They estimated that the city had 256 hectares of street pavement. (How many acres is this? Multiply 256 by 2.47 to find out.) They also estimated that there were 58 hectares of sidewalks in the community. (How many acres of sidewalks?)

Reflection Section

🍁 What do you think the numbers 10.7 meters and 35 feet represent?

🍁 Do you think that the amount of tree canopy area covering streets and sidewalks was equal to the total amount of area that street tree canopies covered? Why or why not?

Findings

Overall, about 14 percent of the community's streets and sidewalks were covered by street trees. Of this, about 23 percent of the tree canopy was over streets. (What percentage of the tree canopy was over sidewalks and other surfaces? Hint: Subtract 23 from 100 to find out.) When the scientists compared sidewalks with streets, they found that about 24 percent of the community's sidewalks were covered by street tree canopies.

Reflection Section

🍁 Why do you think a greater percentage of sidewalk area than street area was covered by tree canopies?

🍁 Did this tell the scientists how many benefits people were receiving from street trees? Why or why not?

Implications

Using studies like this one, people can find out how much of their streets and sidewalks are covered by street tree canopies. This will help them to determine whether they might want to plant more street trees to shade more of the pavement. For example, what if the community in this study would like to have 25 percent of their streets and sidewalks covered by trees? They now know that only 14 percent of their streets and sidewalks are covered by street trees. What might they do to reach their goal of 25 percent? ■

Reflection Section

❧ What is one reason it is important to know how much paved area street trees cover?

❧ Do you think it might be important to also estimate the amount of grassed areas that street trees cover? Why or why not?

From Maco, S. E. and McPherson, E. G. (2002). Assessing canopy cover over streets and sidewalks in street tree populations. *Journal of Arboriculture*, (286): 270-276.

FACTivity

The question you will answer in this FACTivity is: Were there more acres of streets or sidewalks covered by street tree canopies in this study? Before you answer this question, review the first Reflection Question under "Findings." To answer this question, go to the "Method" and "Findings" sections. Using the information from those sections, complete the table below.

Now that you have these numbers, answer the question posed at the beginning of the FACTivity. Why is the percentage of sidewalk coverage higher than street coverage? Why are there more acres of street coverage than sidewalk coverage?

	Number of Acres in Streets	Number of Hectares in Streets	Number of Acres in Sidewalks	Number of Hectares in Sidewalks	Total Number of Acres in Streets and Sidewalks	Total Number of Hectares in Streets and Sidewalks
Number from "Methods"					🍁	🍁
Add Street Numbers and Sidewalk Numbers	🍁	🍁	🍁	🍁		
Apply Percent from "Findings"	🍁	🍁	🍁	🍁		
Apply Percent from "Findings"	🍁	🍁			🍁	🍁
Subtract Sidewalk Numbers from Total Numbers			🍁	🍁	🍁	🍁

Alternate FACTivity

In this FACTivity, you will adopt-a-tree in your schoolyard. (Depending on how many trees there are around the school, you may need to adopt trees in pairs or groups rather than individually.) Create a tree journal from a notebook. Set time aside to make observations of the adopted tree. While observing the tree, perform some of the following activities:

1. Create bark rubbings.
2. Collect dried leaves from the tree.
3. Conduct leaf identification.
4. Draw the tree during different seasons, focusing specifically on tree canopy.
5. Measure the diameter (diameter at breast height, or dbh) of the tree. (Visit **http://www.cnr.vt.edu/dendro/forsite/si4.htm** for instructions on measuring dbh.)
6. Record insects and animals that live on or around tree. (Place a bed sheet on the ground underneath the tree. Shake the tree vigorously and then record insects that have fallen on to the bed sheet.)
7. Create a photo-biography of the tree.
8. Write a poem about the tree.
9. Develop a song about the tree and perform it for the class or other students in the school.
10. Celebrate Arbor Day by giving students in school a tour of all of the trees on the school grounds and provide information that you have collected about each tree.
11. Research the type of tree and create a Web page or PowerPoint® on the vital statistics of the tree.
12. Create a schoolyard map with tree location and types.
13. Calculate the amount of land covered by trees in your schoolyard. This could be tracked over time.
14. Identify a list of benefits provided by the trees at your school.

Teachers—

See the Schoolyard Tree Inventory and Biodiversity Project Lesson Plan on page 69 for more schoolyard tree activities.

Social Groupies:

How Different Groups Use Urban Parks

Dr. Gobster: ◄ My favorite experience as a scientist is talking with people. As a social scientist who studies how people think about and use *urban* parks, I get to visit some very nice places and talk with people about what they like to do best when they spend their free-time out of doors. I hope that the information I get from them helps *managers* to make parks even better for people.

Photo by Savanna Dickhut

Thinking About Science

Scientists study a lot of different things. Usually, people think about the kind of science that is concerned with things like Earth, or diseases, or space. There is another category of science known as the social sciences. The social sciences are concerned with the things that people think, feel, believe, say, or do. The social sciences may also be concerned about the behavior of groups of people. Groups could include American families living in South Africa, 12-year old boys in Oklahoma who play soccer, middle school science students in Tillman Middle School, or just about any group of people.

Pretend that you are a social scientist. Name three different groups of people that you might like to study. Any group that you identify should have a common characteristic. You should also limit the group by identifying a *geographic* limit. Use your imagination!

Glossary:

urban (**ür** bun): Living in or having to do with cities or towns.

manager (**ma** ni jür): A skilled person who directs or manages something.

geographic (je o **graf** ik): Having to do with Earth's division into areas such as continents, seas, countries, States, etc.

resources (re **sôr** sez): A supply of something to take care of a need.

public land (**pub** lik land): Land that is owned by the people as a whole; land that is taken care of for the good of all of the people.

ethnic (**eth** nik): Of or describing a group of people who have the same language, culture, etc.

survey (**sür** va): A method used to ask questions to collect information.

interviewer (**in** tür vyu ür): A person who asks another person about his or her opinions, activities, etc.

Pronunciation Guide

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

Accented syllables are in **bold.**

Thinking About the Environment

Have you ever planned how you are going to spend your weekend? Do you plan how you will spend your allowance? Planning is an important tool that helps people and communities to use their *resources* more wisely. Resources include things like money, time, or even school supplies. If you plan ahead about how you will use your resources, you will have a better chance of identifying future opportunities or problems.

People are not the only ones who plan ahead. Groups of people living in communities can also plan how they will use their shared resources. One of the resources they plan for is how they will use *public land*, including urban park land.

Introduction

People visit parks to do many different activities, such as play basketball, baseball, sunbathe, swim, walk, picnic, or go bicycling. If park managers know what people like to do in a particular park, they can do a better job of providing the opportunity. In the past, social scientists studied what some people like to do in parks. The scientists learned more about what White visitors liked to do in parks than people of other *ethnic* backgrounds. Because it is important to learn about all park visitors, the scientist decided to conduct another *survey*.

The question the scientist wanted to answer in this study was: What activities do people of different ethnic backgrounds do while visiting an urban park? This information could then be used to help park managers develop a plan for the park's future. That plan would provide better opportunities for people of different ethnic backgrounds.

Reflection Section

🍁 What is the question that the scientist wanted to answer?

🍁 If you were the scientist, how would you learn what kind of activities people of different ethnic backgrounds do when they visit a park?

Method

The scientists conducted a survey of park users in Chicago, Illinois (**figure 1**). Most of the people they talked with were White. The scientists wanted to learn about all of the people who visit the park, including people of different ethnic backgrounds. Therefore, they conducted another survey that focused on Latino, African American, and Asian visitors. The scientist trained people, called *interviewers*, to ask these people questions about their park use.

North ↑

Figure 1. Location of Chicago, Illinois

The scientist trained interviewers from different ethnic backgrounds. African American interviewers asked questions of African American park visitors. Latino interviewers asked questions of Latino park visitors. Asian interviewers asked questions of Asian park visitors. All interviewers asked the same questions and recorded the answers. In total, the interviewers talked with 500 African

American, Latino, and Asian park visitors. The scientist compared all of the answers with each other, including the answers given by White park visitors in the earlier survey.

Findings

All visitors, regardless of their ethnic background, liked to do some of the same activities. The activities everyone liked to do included (**figure 2**):
- walking
- swimming
- beach sunning
- picnicking and barbecuing
- visiting the zoo
- sitting and relaxing
- bicycling

There were also some differences between the ethnic groups. Latinos picnicked and watched sports more than other groups. African Americans got together more often
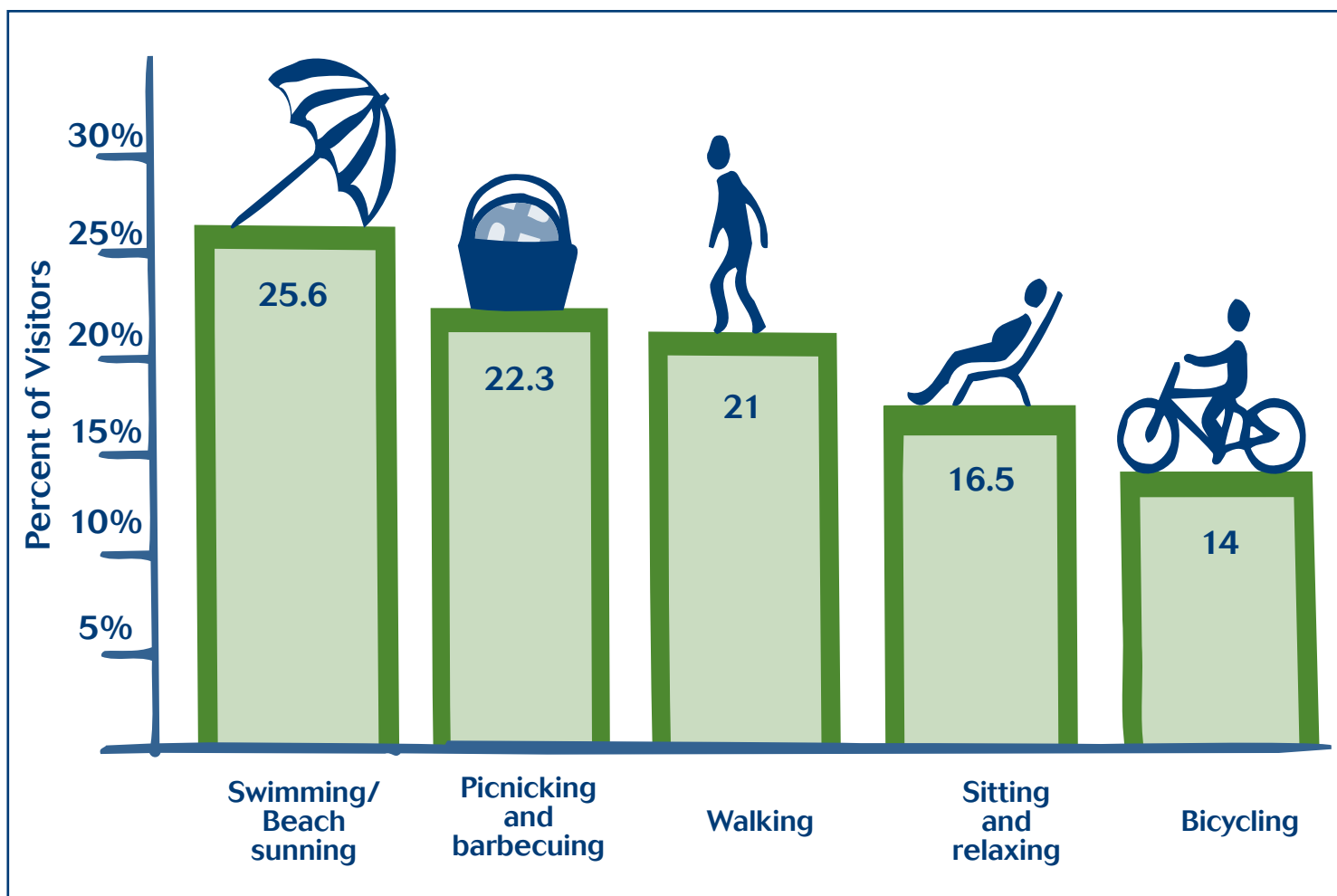
Figure 2. The percentage of visitors participating in the five most popular activities

with family and friends. Like Latinos, Asians picnicked more; and they also participated in festivals more than other groups. Whites bicycled, walked, jogged, and walked their dogs more often.

The scientist also discovered another difference between Whites and other ethnic groups. Whites usually came to the park alone or with one other person. African Americans, Latinos, and Asians came more often with a larger group that usually included family members (**figure 3**). More than 10 percent of the Latinos and Asians who visited the park came with groups of more than 10 people.
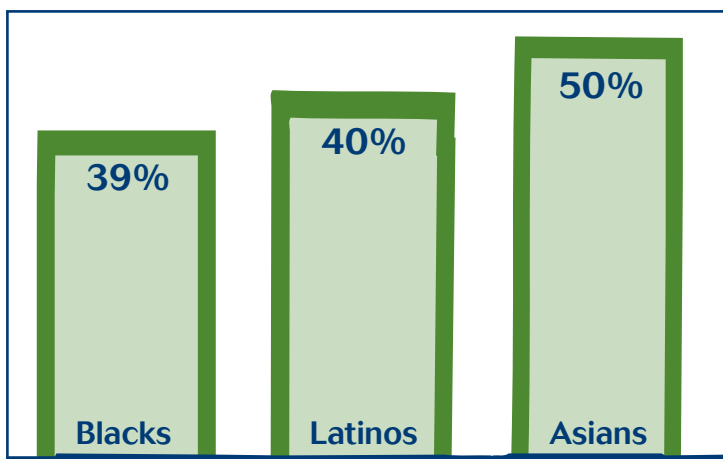
Figure 3. Percentage of park use by families for African Americans, Latinos, and Asians.

Implications

There were some similarities in all of the visitors' activities in the urban park, regardless of their ethnic background. There were also differences. This study tells park managers what different groups might like to do. Information like this helps managers to consider the choices of people who come from different ethnic backgrounds. When managers are making plans for improvements to their park, they can use information like this to do a better job for all park visitors. ■

Reflection Section

🍁 Why is it important to think about all of the users of urban parks?

From: Gobster, P. H. (2002). Managing parks for a racially diverse clientele. *Leisure sciences*, 24: 143-159.

Reflection Section

🍁 Are you surprised by the similarities and differences between the groups? Why or why not? Discuss with your class about whether you have observed the same things in your local parks. If your observations are different, how are they different? Why do you think that they are different?

🍁 When you visit a local park with others, how would you describe your group? Do you go with your family? With friends? What kind of things do you do when you visit a park?

Thinking About Ecology

You've probably heard the saying, "Diversity is the spice of life." It is not only the spice of life, diversity is a property of all living things. When you think about Earth, you will realize that Earth has a great diversity of living things. There are insects, microorganisms, plants of all sizes, small and large animals living in the wild, and humans. Within each of these groups of living things, there is also a great amount of diversity. This idea is demonstrated in this research by the diversity of people and the diversity of their choices when visiting a park. When you think about it, you may realize that while there are similarities among living things, diversity helps to keep our Earth and its living things healthy. ■

FACTivity

In this FACTivity, you will use the findings from this research to design a picnic area. The picnic area must be suitable for park users from different ethnic backgrounds. After your teacher divides the class into groups of four, each group will design a picnic area.

First, list the ways different ethnic groups use the park. (Hint: Re-read the Findings section.) Beside this list, describe the kind of picnic area and equipment that could be used to make this picnic area an enjoyable place for all different types of ethnic groups. You can use the example on the next page to get you started.

You should now have a list of items that you might want to include in your picnic area. Unfortunately, you do not have enough resources to provide for all of the items. (What are resources? In this case, your resources are land and money.) You must set priorities for the types of items that you will provide in your picnic area. Each team will design a picnic area for .5 acres. You will have $10,000 to complete your picnic area.

In the table on the next page, list the items you would like to buy, how many of each item you would like to buy, and how much they will cost.

As a team, decide on how you will set priorities for the activities you will provide in your picnic area. Your team should consider providing activities for all ethnic groups. Also, think about things like—is your picnic area accessible to people with disabilities? The team should strive make the picnic area the most accessible and user-friendly area for all ethnic groups.

The picnic areas should be designed on a large sheet of paper with all items and areas identified. Design the picnic area from a bird's-eye view or draw an "artist's concept" of the picnic area.

After completing your design and budget, your teacher will have you present them to class. The class can vote on the best design.

Ethnic Group	Number of Individuals in Groups That Use Park	Description of Picnic Area Needed
Latino	Larger groups, sometimes 10 or more people	Large picnic pavilions, extra picnic tables, large trash cans

Item	How Many You Would Like To Buy	How Much the Item Costs
Picnic Tables	5	$300 each

Balancing Act:
Urban Trees and the Carbon Cycle
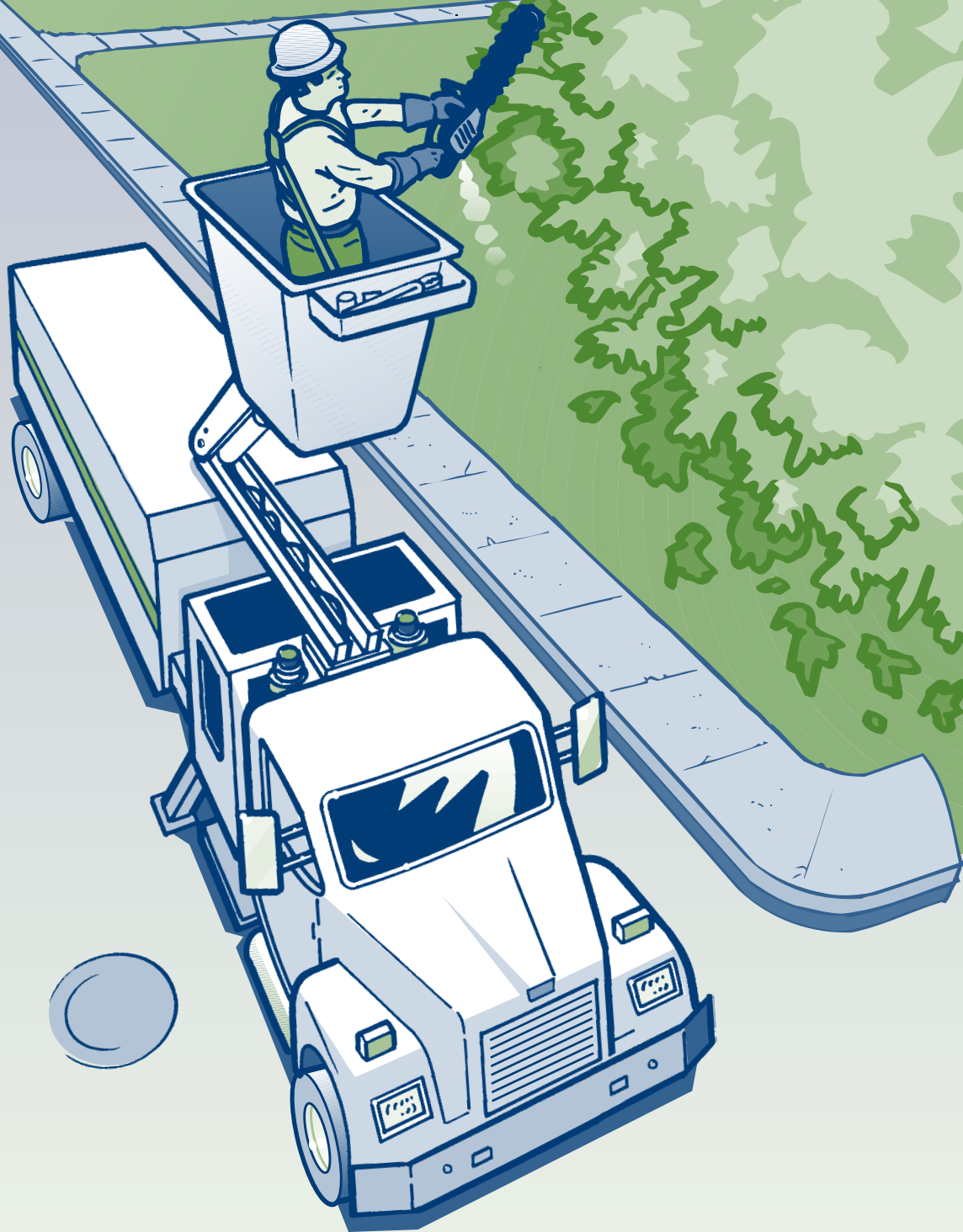
Meet the Scientists

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 fy<u>oo</u>l): Fuel, such as coal, petroleum, or natural gas, formed from the fossilized remains of plants and animals.

photosynthesis (**f<u>o</u>** t<u>o</u> **sin** thuh sis): The process by which green plants use sunlight to form sugars and starches from water and carbon dioxide.

species (sp<u>e</u> s<u>e</u>z): Groups of organisms that resemble one another in appearance, behavior, chemical processes, and genetic structure

Pronunciation Guide

<u>a</u>	as in ape	ô	as in for
ä	as in car	<u>u</u>	as in use
<u>e</u>	as in me	ü	as in fur
<u>i</u>	as in ice	<u>oo</u>	as in tool
<u>o</u>	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.

Carbon is emitted by:
A Volcanic eruptions
B Forest fires
C Burning of fossil fuels
D Burning of fossil fuels
E Decomposers

F Atmospheric carbon

Carbon is held on Earth by:
G Carbon in water
H Photosynthesis
I Carbon in soil
J Underground carbon
K Respiration
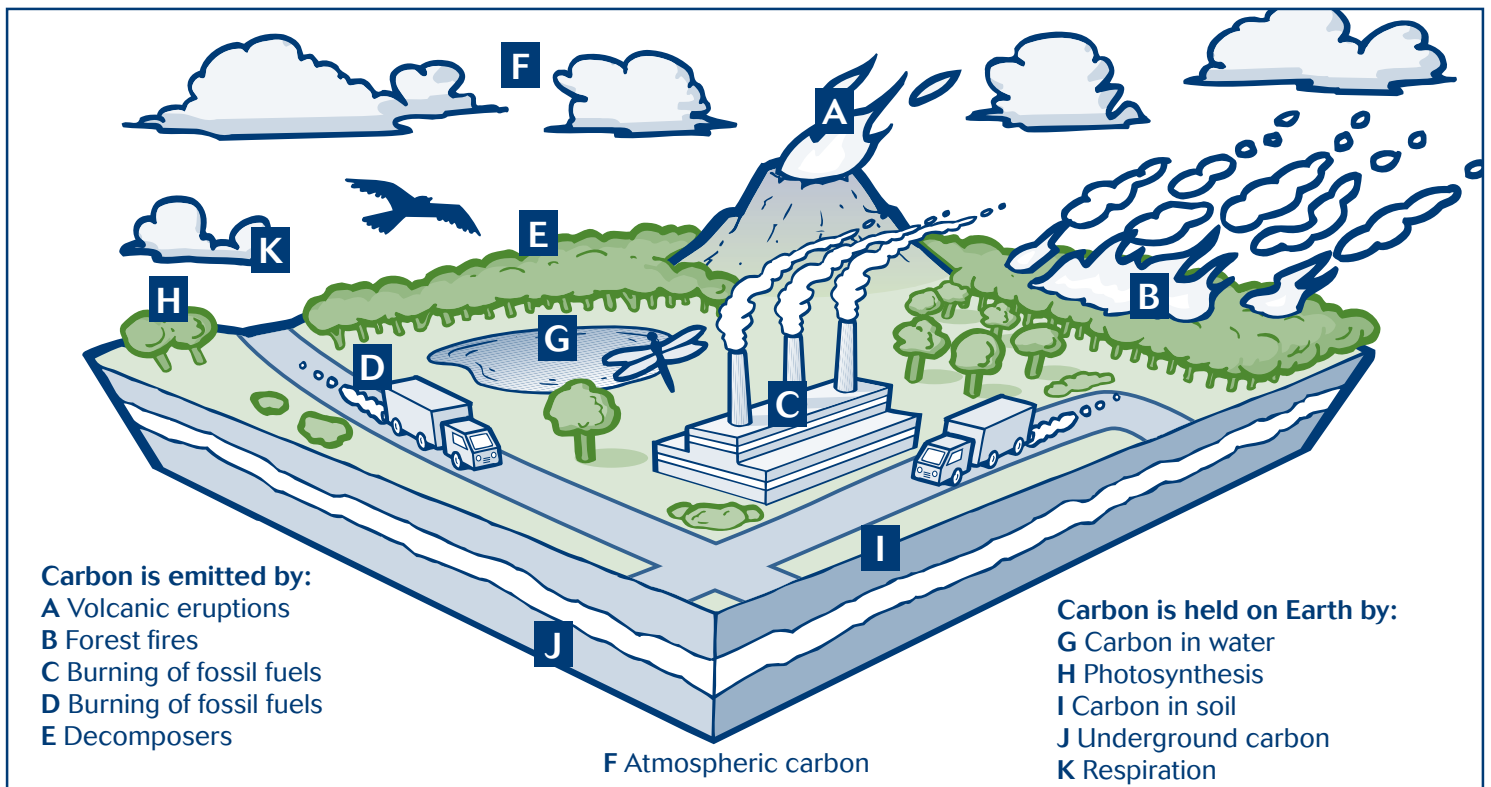
Figure 1. The carbon cycle.

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 CO_2 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 CO_2 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 CO_2 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 CO_2 is absorbed and emitted during the life of an urban tree.

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 than12 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 CO_2 emitted from trucks, chainsaws, and other machines was greater than the amount of CO_2 that the trees absorbed. In general, the longer a tree lived, the better the balance between CO_2 absorption and emission. This is partly because of the large amount of CO_2 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 CO_2 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. ■

- This research identified the amount of CO_2 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 CO_2 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 CO_2 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 CO_2 was emitted by engines used to plant and maintain urban trees. What is one way that CO_2 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 CO_2. 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 Aboriculture*, 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.

Good to the Last Drip:
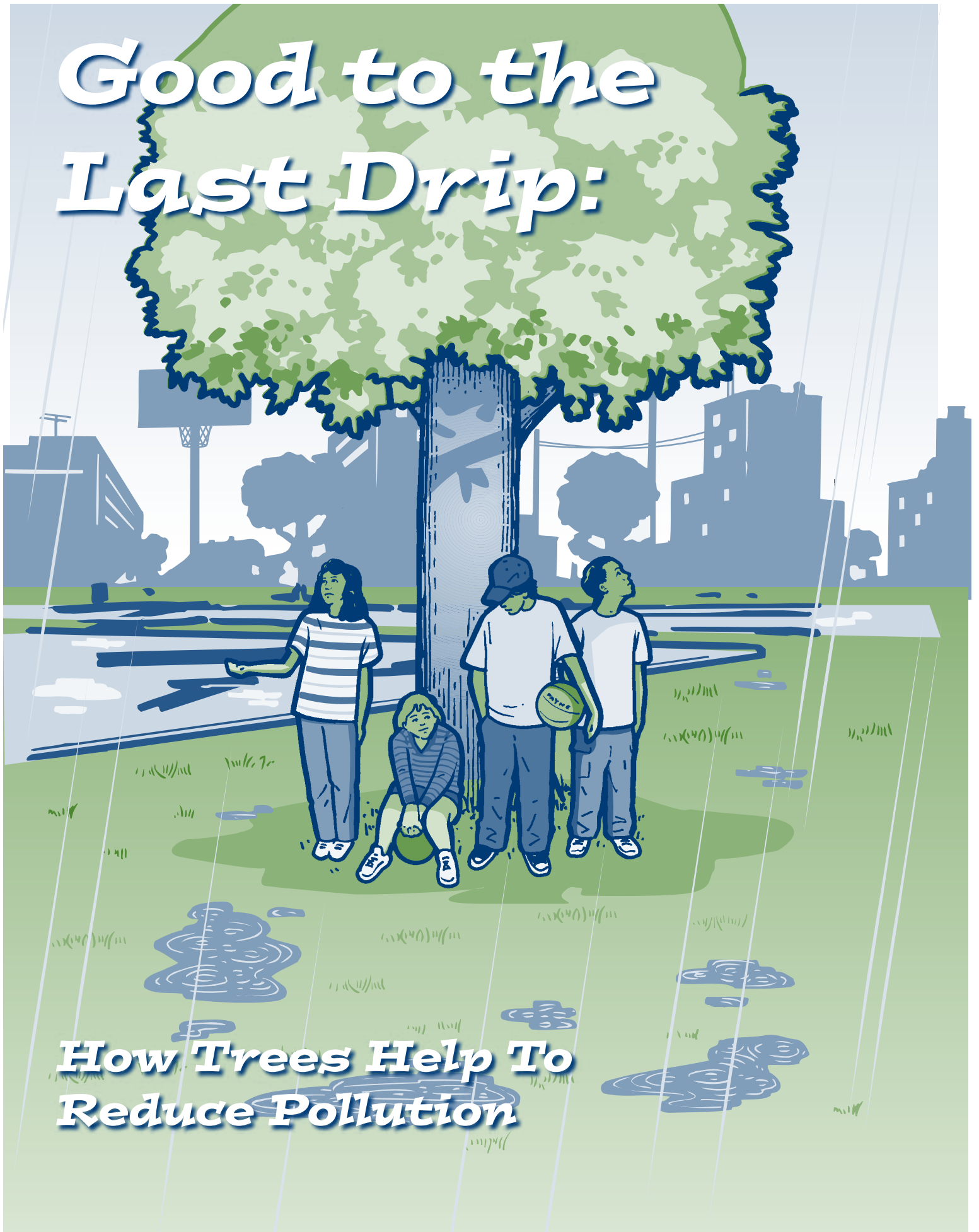
How Trees Help To Reduce Pollution

Meet the Scientists

Dr. Xiao: ◄ I enjoy working to discover the secrets of the natural environment, such as the interactions between water and the surrounding environment. My favorite experiences in science are when I find these secrets and then use them to improve our environment. With these discoveries, we can improve the quality of our lives and care for our natural resources. Future generations will benefit from our work.

Dr. Ustin: ◄ I have always thought that it was important to preserve our natural *heritage* and wanted to work as an *ecologist*. Working with information collected from satellites has allowed me to view the environment from a large-scale perspective. It is a privilege to work on problems that have great benefit to society and to help improve the way we take care of our environment.

Dr. McPherson: ◄ My favorite science experience is seeing a paper finally in print or giving a presentation to a large group and sensing their interest and excitement. The process of planning and conducting research is long and painstaking. One has to be patient because results don't come quickly. However, the joy of seeing a project completed and knowing that it is valued by others is very gratifying.

Dr. Simpson: ◄ One of my favorite experiences in science was to participate in a *meteorological* field study in western Colorado. We camped out in the mountains. We flew on a helicopter to put some of our equipment on surrounding mountain ridges. We also had an opportunity to meet and work with other scientists from all over the United States.

Glossary:

heritage (**hair** uh tij): Something handed down from the past.

ecologist (e **kol** uh jist): A scientist who studies the relationships between living things and their environment.

meteorological (**me** te or o **loj** uh kôl): Having to do with weather or climate.

intercepted (in tür **sep** ted): Stopped or interrupted.

erosion (e **ro** shun): The process or state of wearing or washing away.

regulation (**reg** ya **la** shun): The act of controlling according to a system.

equation (e **kwa** shun): A written statement that indicates the equality of two expressions.

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

aerial (**air** e ul): Of or in the air.

deciduous (de **sij** oo us): Shedding its leaves every year; not evergreen.

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

One of the best things about science is that scientists will never learn everything. Even when scientists are pretty sure of something that they've learned, new information may cause them to revise their thinking. Scientists, therefore, will never run out of new things to study! In this research, the scientists wanted to know how much rainfall is *intercepted* by trees growing in urban areas. In the past, other scientists had estimated how much rainfall was intercepted by trees growing in rural areas. Since urban areas and rural areas are different, the scientists in this study felt that urban trees should be studied separately. When this study was finished, do you think that the scientists knew everything about rainfall interception by urban trees? Why or why not?

Thinking About the Environment

Natural systems are organized so that the environment will remain balanced. For example, when there is a lot of rainfall and few trees in an area, the rainfall can cause soil *erosion* and might cause flooding. When trees are growing in an area, the leaves, branches, trunk, and roots help to reduce soil erosion and flooding. Rain falls on the tree, where it is stopped or slowed down. Roots absorb water for the tree's use. The trees are a form of control that helps to protect the soil from erosion and the area from flooding. In natural areas that have a lot of rain, you will find a lot of trees. You can find this kind of *regulation* in all natural systems, including your own body! Can you think of one way that your body keeps your own amount of water balanced?

Introduction

Urban areas are different than rural areas. In urban areas, there are many more human structures and activities that are sources of pollution. When it rains, the rainfall washes the pollution from lawns, streets, sidewalks, and other surfaces. Water is carried from city streets through stormdrains and pipes that eventually lead to our streams and rivers (**figure 1**). If too much rain falls at one time, these pipes can get backed up and cause flooding.

Trees help to slow the amount of rainfall entering storm drains. The rainfall is stopped or slowed down by leaves, branches, and the trunk of trees. Some of the rain evaporates off of the leaves and branches before it can reach the ground (**figures 2 and 3**). The roots of trees also absorb some of the rain. This keeps even more of the water from going down the stormdrains.

In the past, scientists had estimated how much rainfall is intercepted by trees growing in rural areas. The scientists in this study wanted to know how much rainfall is intercepted by the trees that grow in an urban county in California.

Figure 1. Storm drains.

Figures 2 and 3. The leaves on trees intercept some of the rainfall.

Reflection Section

🍃 What is the question that the scientists were trying to answer?

🍃 Do you think that the amount of rainfall being intercepted by trees is different in urban areas than rural areas? Why or why not?

Method

The scientists developed two *equations*. The equations helped the scientists to identify what they needed to measure to find out how much rainfall is intercepted by a tree. Using symbols, the equations describe that when rain falls on a tree, it stays for a short time on the tree's leaves, branches, and trunk. Then, the rain water either runs down these surfaces, drips to the ground, or evaporates. Here are the two equations:

1. **Rainfall Interception = L + E**
2. **Rainfall Interception = R−TH−F−D**

Here is an explanation of the symbols.

L = The amount of rain that stays on leaves and branches.
E = The amount of rainfall that evaporates from leaves and branches.
R = The total amount of rain falling on the tree.
TH = The amount of rain that falls through the tree without hitting any leaves or branches.
F = The amount of rain that drips down the stems and trunk.
D = The amount of rain that drips from leaves and branches.

First, try to read these equations yourself using the explanation of the symbols.

This is how to read the equations:

Equation 1: The amount of rain that is intercepted by a tree is equal to the amount of rain that stays on the tree's leaves and branches plus the amount of rain that evaporates off of the leaves and branches.

Equation 2: The amount of rain that is intercepted by a tree is equal to the total amount of rain falling on the tree minus the amount of rain that falls through the tree without hitting any leaves or branches, minus the amount of rain that drips down the stems and trunk, minus the amount of rain that drips from leaves and branches.

In other words, any rain that reaches the ground underneath a tree has **not** been intercepted by the tree.

The scientists needed to determine how much rain is intercepted by various *species* of urban trees. They also needed to know how much rain is intercepted by different tree species during different weather conditions. For example, some rains are gentle and some are hard. Sometimes there is wind and sometimes the air is still. Rainfall can occur for a short period or a long period of time. Then, the scientists needed to determine two more things. They needed to know which tree species, and how many of each, were growing in the county. They discovered these two things using *aerial* photography and by walking around and actually looking at the trees.

The scientists calculated how much rainfall is intercepted by different tree species during different rainfall conditions. They knew how many trees of different species were growing in the county. They looked at weather records. This allowed them to determine what kinds of rain storms occurred in the past and in what season they occurred. With all of this information, they were able to estimate how much rain was intercepted by all of the trees growing within the county.

Findings

The scientists expressed the amount of rainfall interception in two ways. First, they calculated the percentage of rainfall that was intercepted only in the areas where trees were growing in the county (**figure 4, area A**). Then, they calculated the total percentage of rainfall that was intercepted by trees across all of the land in the county (**figure 4, areas A+B**). They reported the total amount of rain that was intercepted over the entire year. They found that 11 percent of the rain that fell directly on trees was intercepted (**figure 4, area A**). Across the entire county, including areas where there were no trees, 1 percent

Thinking About Ecology

Nature has a way of taking care of itself. For example, most systems in nature are self-regulating. This means that although things may fluctuate, the systems in nature keep things pretty even. This idea is demonstrated in this study by the idea of rain and trees.

If there are few trees and a lot of rain in an area, the rain can wash soil into streams and rivers. In natural areas where there is a lot of rain, however, there are usually a lot of trees. The leaves on the trees help to slow the rainfall, and trees absorb the rain water, which protects

the soil. Where there are a lot of trees (like in a forest), the leaves or needles that fall create a spongy forest floor that absorbs rain water. When nature is left undisturbed, things work together to keep the system stable. ■

of the rain that fell was intercepted by trees (**figure 4, area A**+**B**). *Deciduous* trees intercepted less rain than evergreen trees.
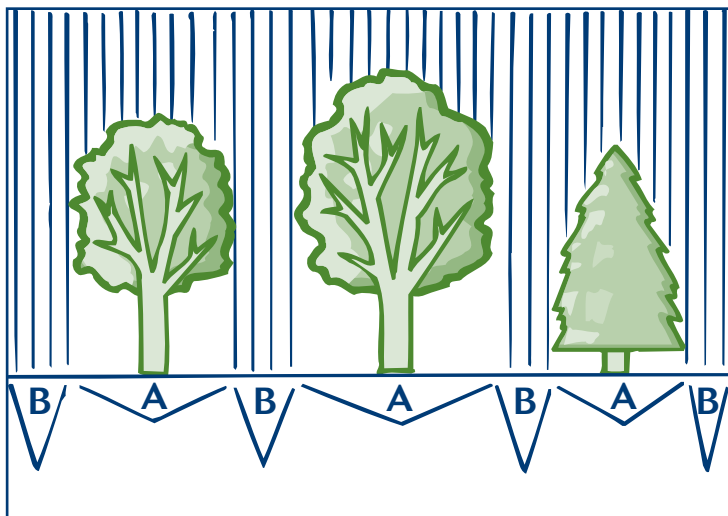
Figure 4. Areas that are under the tree canopies (A) and areas that are in the open (B).

Implications

Evergreen trees intercepted more rain than deciduous trees. This was partly because most of the rainfall in that county occurs in the winter. In some areas of the country, most of the rainfall occurs in the summer. In those areas, deciduous trees would be much more important as rainfall interceptors. Urban trees are helpful in part because they reduce the amount of rain hitting the ground, so they help to reduce the amount of pollutants and the amount of soil being washed into streams and rivers. ■

FACTivity

In this FACTivity, you will work with equations using symbols.

Write the statements below as equations using symbols, and then write what each of the symbols means. See the example below.

Example: The number of ears in a classroom is equal to the number of warm-blooded animals in the classroom times two.

$E = A \times 2$

E = The number of ears in a classroom.

A = The number of warm-blooded animals in a classroom.

1. The area of sunshine reaching the roof of a house is equal to the total area of the roof, minus the area of the roof that is not receiving sunshine.

2. The total number of miles of streams in the United States is equal to the number of miles of streams in each State multiplied by the number of States.

3. The number of candybars in a middle school at 6 p.m. is equal to the number of candybars in the candy machine, plus the number of candybars brought to school by people, minus the number of candy bars eaten by 6 p.m.

As a class, see if you can develop more equations based on things that you see around you or topics that you are studying. You can get into small groups and hold a contest to see which group can come up with the most true equations within a time limit.

Use your imagination! Using the equation below, write out your own statement of what it might represent. You can do this in small groups and share your equation with the rest of the class.

$N = I + M1 + M2 - W - C$

Don't Be So Fuel-ish!

How Much Fuel Is Saved When Cars Are Parked in the Shade?

Cougar

Dr. Scott: ▲ The most fun I've had as a scientist was the time I operated a "cherry picker" truck to lift a colleague and I up to the top of some pine trees. We were trying to collect some gases *emitted* from pine needles. The truck was the type you might see a technician use to reach telephone lines. We stood cramped together inside the "bucket" with our scientific equipment. It was hilarious. But the view from the tree tops was great.

Dr. Simpson: ▲ One of my favorite experiences in science was to participate in a *meteorological* field study in western Colorado. We camped out in the mountains. We flew on a helicopter to put some of our equipment on surrounding mountain ridges. We also had an opportunity to meet and work with other scientists from all over the United States.

Dr. McPherson: ▲ My favorite science experience is seeing a paper finally in print or giving a presentation to a large group and sensing their interest and excitement. The process of planning and conducting research is long and painstaking. One has to be patient because results don't come quickly. However, the joy of seeing a project completed and knowing that it is valued by others is very gratifying.

Thinking About Science

Scientists sometimes design their experiments so that they can compare different things. In this experiment, the scientists wanted to explore some of the differences between parking lots that are shaded and parking lots that are not shaded. When scientists compare different things, they carefully identify what is similar about and different between the things. (What do you think is similar about and different between these two parking lots?) Scientists then take the same kind of measurement from each thing to see if there are differences. In this study, the scientists were interested in the temperature of each of these two areas.

Thinking About the Environment

Cars use petroleum as a fuel that runs their engines. When the fuel is burned, its energy is transformed into hot gases that leave the car through the tailpipe. The form of the energy in liquid petroleum is different than the form of the energy that comes through the tailpipe. None of the energy is destroyed in the burning process, but it is more spread out and less useable. Burning petroleum as a fuel is an example of the First Law of Energy. This law states that energy cannot be created or destroyed. No matter what kind of energy you can think of, it has to obey this law!

Introduction

You probably know that most of the dangerous gases that come from cars come from the tailpipe while the engine is running. Did you know that cars still produce some gases while the engine is turned off? Parked cars produce more of these gases when the air temperature is hotter than when it is cooler. The scientists in this study wanted to know if cars parked in shady parking lots emit fewer gases than cars parked in sunny parking lots. If that is the case, it would give people another reason to plant trees in parking lots, especially where the *climate* is hot.

Glossary:

meteorological (**me** te or o **loj** uh kôl): Having to do with weather or climate.

emit: (e **mit**): To throw out or eject.

climate (**kli** met): The average condition of the weather over large areas, over a long time, or both.

data (**dat** uh): Facts or figures studied in order to make a conclusion.

Pronunciation Guide

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

Accented syllables are in **bold.**

Method

The scientists parked two identical cars in a parking lot in Davis, California (**figure 1**). One of the cars was parked in the sun. The other was parked in the shade (**figure 2**). The scientists parked the cars facing the same direction. They tried to make both of the parking spaces exactly the same, except for the amount of sunlight hitting each of the cars.

In the shady parking space, the scientists measured the percentage of the sky that was visible when looking up through the tree. In

Reflection Section

❀ Why do you think hotter temperatures cause more gases to be emitted from parked cars?

❀ What is the question that the scientists were trying to answer?

North ↑
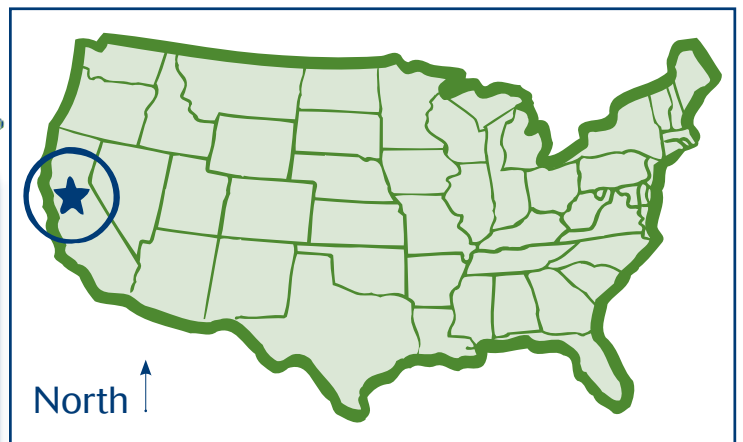
Figure 1. The location of Davis, California

Figure 2. The cars parked in the parking lot. The cars were dark metal-flake blue 1996 Chevrolet Corsicas.

Figure 3. The instruments collected the data automatically.

both parking spaces, here are the things that they measured:

1. The outside temperature
2. The amount of energy coming from the sun (solar radiation or solar energy)
3. The car's inside temperature
4. The car fuel tank's temperature

The scientists collected this information from August 5 to August 10 when the climate is hot in Davis, California. They used instruments to collect the data automatically every 5 minutes (**figure 3**).

To determine how much dangerous gases were coming from the parked cars at different temperatures, the scientists used mathematical equations that had already been developed. These equations estimated how much gas would evaporate from a parked car at different temperatures. The scientists used a computer to do the calculations, using the temperature data that they collected. The scientists estimated the differences in the amount of evaporating gas under different amounts of shade over the car (**figure 4**). The scientists also compared the cars' surfaces and inside temperatures, fuel tank temperatures,

8% Shade Cover   **25% Shade Cover**   **50% Shade Cover**
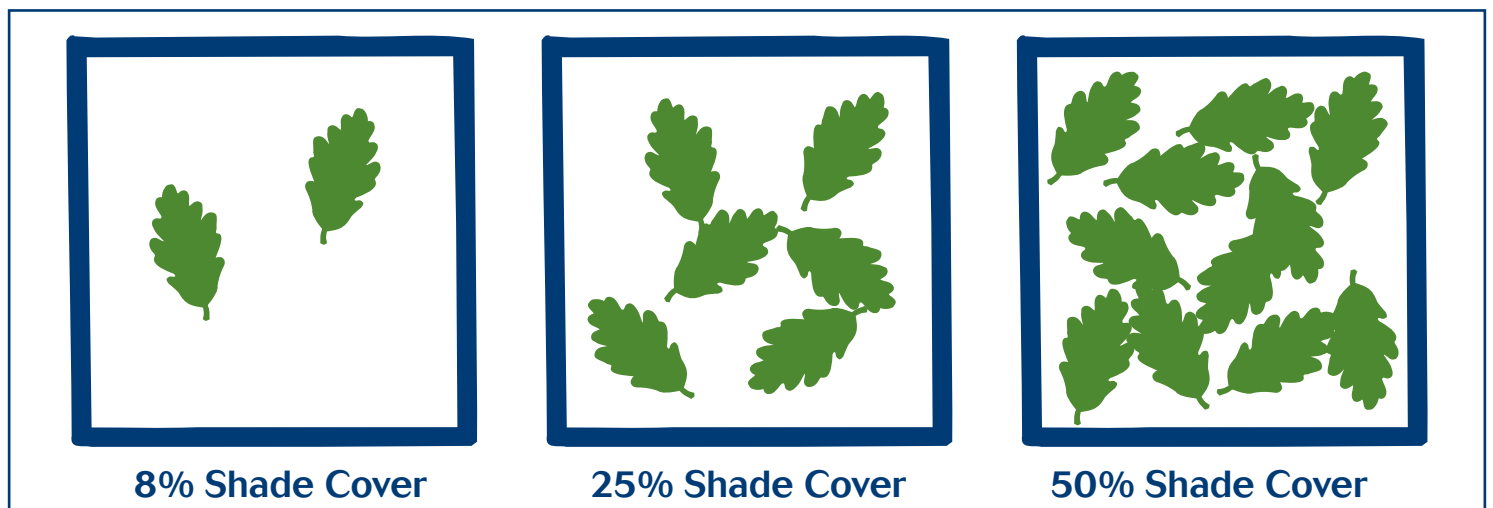
Figure 4. The scientists collected data under different amounts of shade.

and the amount of the sun's energy reaching each car.

Reflection Section

🍁 Why do you think that the scientists used identical cars?

🍁 Why do you think that the scientists collected their information when the climate was hot?

Findings

The temperature was warmest from August 5-7. **Table 1** shows the differences in temperatures in degrees Celsius on the warmest days. (To calculate the degrees in Fahrenheit, multiply the temperature by 9/5 then add 32).

Only 20 percent of the amount of solar energy reaching the car in the sunny parking space reached the car in the shady space. From the data in **Table 1** and this information on the amount of solar energy reaching the cars, the scientists concluded that the reduction in temperature in the shady parking

Table 1. Temperature differences in the shady and the sunny parking spaces.

Temperatures for Aug. 5-7	Shady Parking Lot ˚C	Sunny Parking Lot ˚C
Average Afternoon Air Temperature	39	40
Average Afternoon Temperature Inside Car	50	65
Average Maximum Fuel Tank Temperature	38.6	41.6

Thinking About Ecology

All living things have environmental limits beyond which they can no longer survive. People, for example, cannot survive long without air, water, or in temperatures that are either too low or too high. In this article, the scientists measured the temperature inside of cars that were parked in the sun and in the shade. The internal temperature of the car parked in the sun was 15^0C higher or 27^0F higher than the car parked in the shade. Even so, the car parked in the shade, with the windows rolled up, had a temperature of 50^0C or 122^0F. At this temperature, living things such as people and dogs cannot live for very long. In this article, the scientists were concerned about dangerous gases evaporating from cars. Do you think that these gases have something to do with environmental limits? Why or why not? ■

space was due to the lower amount of solar energy under the tree.

The amount of gas evaporating from the car in the shady parking space was only 2 percent less than from the car in the sunny space. The scientists reported that if the amount of shade over parking lots was increased from 8 percent to 50 percent, the amount of gas evaporating from parked cars would be reduced by 2 percent.

Reflection Section

🍁 From the information in **Table 1**, would you say that the amount of sunlight reaching a parked car has an impact on its inside temperature?

🍁 Do you think that a 2-percent difference is a very big difference in the amount of gas evaporating from a car? Why or why not?

Implications

A 2-percent reduction in evaporation from cars parked in the shade does not seem very large. However, this amount is equal to the amount of fuel that could be saved if printing presses, hospitals, and waste-burning and car scrapmetal businesses throughout the county updated their fuel-burning equipment.

Sometimes, just a little bit of improvement can be very important.

The scientists caution that the costs and benefits of planting trees in parking lots need to be determined. It takes money, fuel, equipment, and time to plant and take care of trees. Falling leaves, birds droppings, and falling branches are other things to consider. On the other hand, trees in parking lots keep cars cooler, protect the pavement, protect people from the sun's harmful rays, absorb air pollution, soak up rainwater, reduce the amount of gases evaporating from cars, and make the parking lot more attractive. ■

Reflection Section

🍁 Which would you prefer—a parking lot with trees or one without trees? Why?

🍁 Do you think that evaporation from cars will continue to be a problem in the future? Why or why not?

FACTivity

In this FACTivity, you will answer the question: What is the relationship between temperature, the amount of visible sunlight, and the amount of water evaporating from two identical glass jars?

Get two identical glass jars. Mark each of them with a permanent marker at 1/8-inch intervals from 1/8 to 1 inch from the bottom of the jar. Fill the jars with water to the 1-inch mark. Place them on a window sill that receives at least 3 hours of full sun. Place branches of leaves (or pine boughs) near one of the jars so that it is shaded throughout the day.

Get two thermometers. Place them beside the jars. Make sure that the thermometer beside the shaded jar is also shaded.

Every day for 1 week during the sunny time of the day, check the temperature of each jar and the amount of water in the jar. Make a record of your observations. Create a chart for your observations. At the end of the week, compare the temperatures of the two jars and the amount of water in the jars for the entire week. Create two bar charts. One bar chart should display the temperature of the two jars for each day.

The second bar chart should display the amount of water in each jar for each day. See the following example.

Discussion–

What is the relationship between the temperature, the amount of sunlight reaching the jar, and the amount of evaporation? Where did the water go? Which jar of water evaporated faster? Why? How is this experiment like the evaporating gas? Where does the gas go? Does the gas or the water lose their energy when they evaporate?

Temperature in degrees F

Legend
Jar in sun
Jar in shade
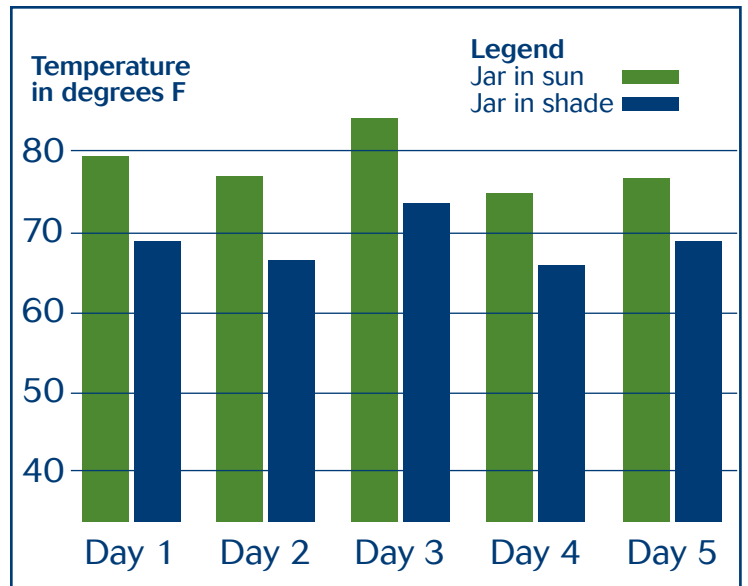
Sample observation chart

	Day 1	Day 2	Day 3	Day 4	Day 5
Jar in Sun—Temperature					
Jar in Sun—Amount of water					
Jar in Shade—Temperature					
Jar in Shade—Amount of Water					

Yard Sale!
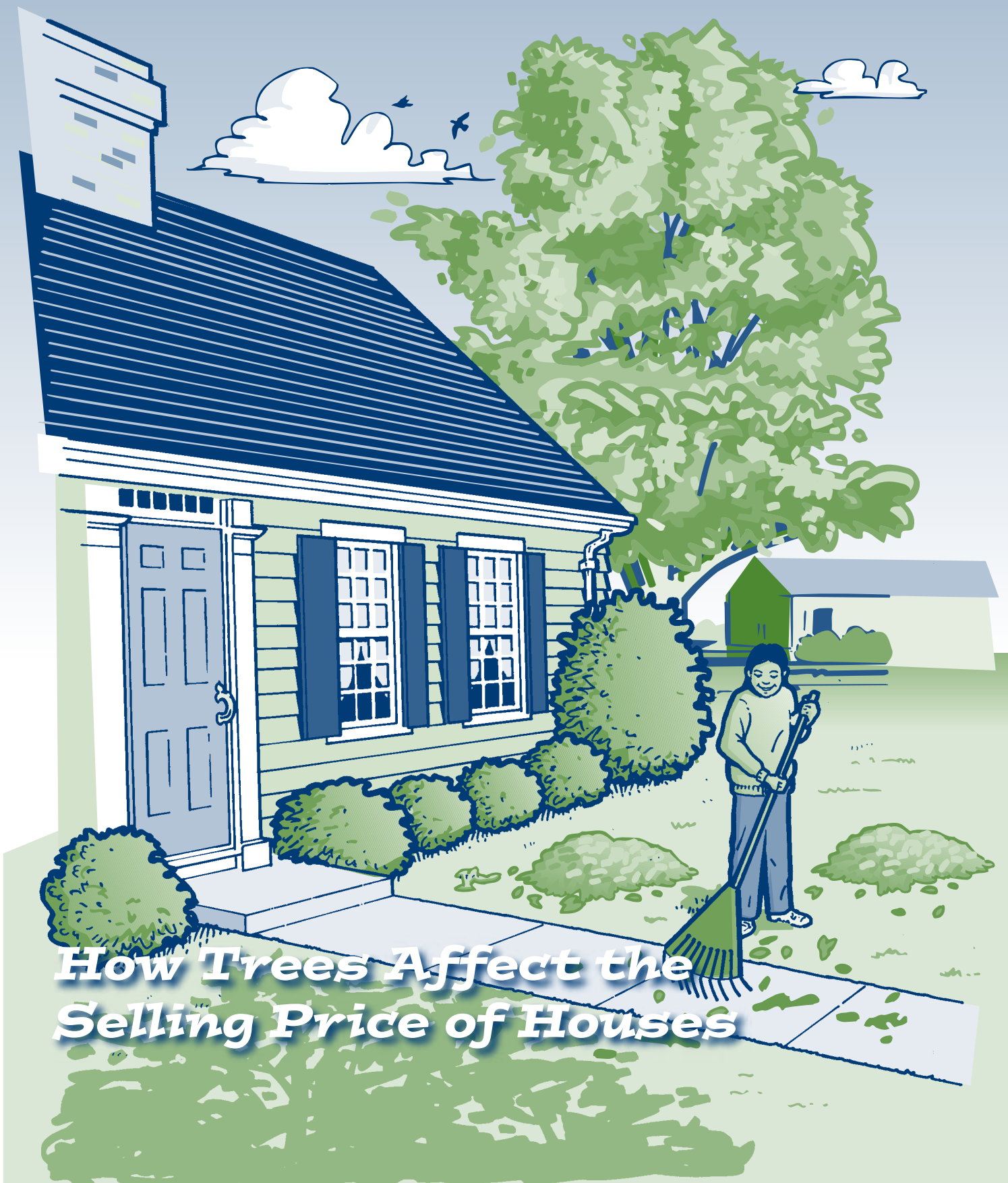
How Trees Affect the Selling Price of Houses

Meet the Scientists

Mr. Sydor: ▲ My favorite science experience is walking the road from knowing little about a specific problem to knowing almost everything. I also enjoy being able to apply the knowledge that I learned from textbooks to real-life situations.

Dr. Bowker: ▲ My favorite science experience is using what I learned in school to help solve problems related to people and nature.

Dr. Newman: ▲ My favorite science experience is discovering new things that help people to protect our environment and our *natural resources*.

Dr. Cordell: ◄ My most memorable and rewarding science experience came early in my career. It was the publication in a science journal of an article that I had written. The article was based on my *dissertation* research about urban forests. My research was about estimating the value of urban green spaces, including trees and forests in urban areas. It was a thrill to see my name on an article in a science publication. It was also great to get praise for my work from a person I greatly admired and respected.

Thinking About Science

What does the price of something represent? To *economic* scientists, the price of something represents its value to people. Economic scientists conduct a type of science called economics. Economics is the study of the way in which goods and wealth are produced, distributed, and used in a society. This can include any good, including ones that you normally would not think of as being bought and sold.

Glossary:

natural resource (**na** cha rôl **re** sôrs): A supply of something in nature that takes care of a human need, such as oil.

dissertation (**dis** ür **ta** shun): A written essay, usually written by someone earning a Doctor of Philosophy degree.

economic (e ko **nom** ik): Having to do with the management of money.

habitat (**hab** uh tat): Environment where a plant or animal naturally grows and lives.

indicator (**in** di ka tôr): Something that measures or shows something.

average (**av** rij): The usual kind or amount. The number gotten by dividing the sum of two or more quantities by the number of quantities added.

canopy (**kan** uh pe): Anything that covers like a roof. On a tree, the area of leaves that cover the ground.

aerial (**air** e ul): Of or in the air.

equation (e **kwa** shun): A written statement that indicates the equality of two expressions.

relationship (re **la** shun ship): When two or more things are connected in some fashion.

Pronunciation Guide

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

Accented syllables are in **bold**.

Thinking About the Environment

When people decide to buy a house, they have a lot of things to consider. They have to think about how many bedrooms and bathrooms they need. They have to think about where the house is located. For example, is it close to any schools or shopping, or to the bus stop? They have to think about how much they can afford to pay. One of the things that may be important is the amount of the yard that is shaded by trees.

Usually, when people think about the environment, they think about things like forests, lakes, or oceans. The environment also surrounds your home. It is important to think about the environment that surrounds your home, as well as the environment that might be far away.

Introduction

People who own houses usually have a yard that surrounds their house (**figure 1**). The yard might be big or small. It might not have any trees, or it might have a lot of trees. For people who have trees surrounding their

Figure 1. A yard with trees surrounding a house.

In this study, the scientist wanted to discover the value of trees growing in the yard around a house. Why do you think that it is important to know the value of trees growing around a house? Do you think that the value of something is reflected by its price? Why or why not? Think of something from this week's news that shows how the price of something is related to its value to people.

house, the trees provide many benefits. The benefits include privacy, shade, *habitat* for birds and other wildlife, and beauty.

If people value the benefits provided by trees growing around a house, they might be willing to pay more money to purchase a house that has trees growing in its yard. The scientists in this study were interested in knowing whether the benefits provided by trees are valued by people buying a new house. They also wanted to know how much money those benefits are worth.

Reflection Section

❧ What questions were the scientists trying to answer?

❧ If you were the scientist, how would you determine how much money trees are worth to people buying a new house?

❧ The first paragraph of the "Introduction"section lists some benefits that are provided by trees surrounding a house. Name two other possible benefits.

Method

The scientists decided to use the selling price of houses as an *indicator* of the value of trees surrounding a house. They collected information about houses that had been sold during a 3- year period. If a house had a lot size larger than 3 acres, they did not include it. (How many hectares is equal to 3 acres? Multiply by .405 to find out.) The lot size is the area of the yard plus the area that the house and other buildings take up. The scientists collected the following information about each house:

1. Selling price
2. Total amount of heated space in the house

3. Number of rooms and bathrooms in the house
4. Whether or not the house had brick construction
5. Whether or not the house had an outside porch
6. Age of the house
7. Size of the lot
8. *Average* price of land in the neighborhood
9. Year of the sale
10. Amount of tree cover (the percentage of the lot covered by tree *canopies*)

Tree cover is the percentage of the total lot size that was covered by the canopies of trees. The scientists collected this information using *aerial* photographs (**figure 2**). They used an aerial photograph of every house and yard included in the study. On each photograph, they placed a 1-centimeter (cm) X 1-cm grid (**figure 3**). (How much is this in inches? Multiply 1 X .394 to find out.) They estimated the percentage of the entire lot size that was covered by trees. The scientists collected this information for 272 houses in Athens-Clarke County, Georgia (**figure 4**).

Figure 2. Aerial photographs were used to determine the amount of tree cover in a yard. Photo courtesy of Barrow County, Georgia.
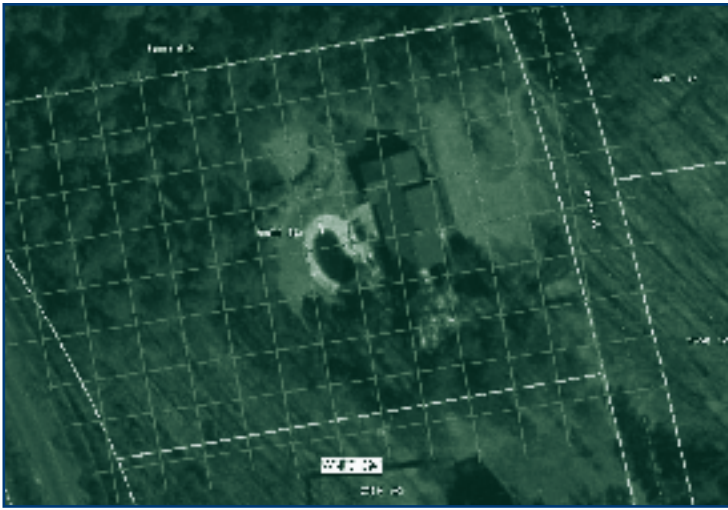
Figure 3. Aerial photograph with the grid placed over it. Photo courtesy of Barrow County, Georgia.

The scientists then used the following equation for every house studied:

Selling price = amount of heated space + number of rooms and bathrooms + brick construction + outside porch + age of house + lot size + average price of land + year of sale + percentage of lot size covered by trees

The scientists put the values for each house into the equation. They put all of the information into a computer. A computer program was used to determine how much each of the features, such as the number of bathrooms, affected the price. Using this method, the scientists were able to determine how much the percentage of tree cover affected the price of the houses.

North
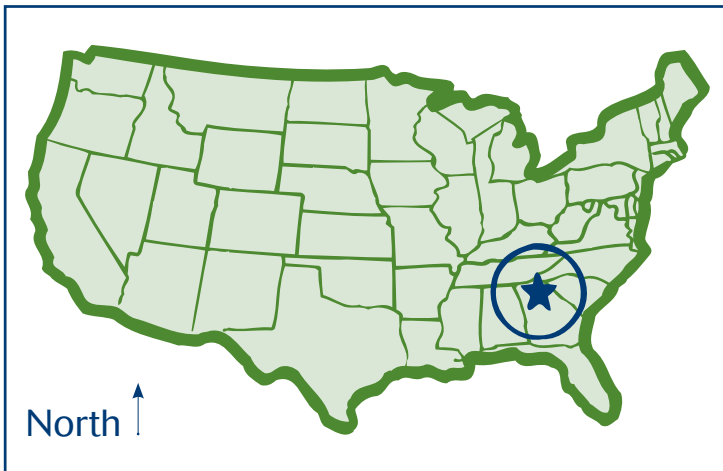
Figure 4. Location of Athens-Clarke County, Georgia.

Reflection Section

* Why do you think that the scientists collected information about the number of rooms, the amount of heated space, and other things for each house they studied?

* Do you think that the percentage of tree cover on a lot affected the price of the houses? Why or why not?

Thinking About Ecology

All living things exhibit behavior. Behavior is the response of an organism to something in its environment. Usually, organisms behave so that their chances of survival are increased. If their survival is not in danger, organisms will usually behave in a way that increases their benefit. For humans, the definition of what is beneficial might vary from person to person. In this research, the behavior of humans is demonstrated by their purchase of a house. People will buy a house based on which house is thought to be most beneficial for the amount of money they are able to spend. The scientists were interested in the amount of tree cover surrounding a house. They wanted to know if tree cover was considered beneficial by people buying houses. If tree cover was considered beneficial, it would influence the behavior of people when they chose which house to buy. ■

Findings

Of the 272 houses studied, the average house was 46 years old and had 6 rooms and 3 bathrooms. The average selling price was $122,267. The average lot size was 0.65 acres. (How many hectares is that? See the "Method" section to calculate the size in hectares.) The average price of the lot was $91,428 per acre. (Calculate the price of the lot for the average house in this study. To do this, multiply the price of the lot per acre times the average lot size.) The average lot had almost 60 percent tree coverage (**figure 5**). Most of the trees are on the border of the lot or in the backyard (**figure 6**).

Front Yard

Figure 6. Location of trees on the lots.

40%   60%

Figure 5. The average lot had almost 60 percent tree coverage.

The scientists found that trees make a difference in the selling price of a house. For every 1-percent increase in the amount of tree cover, the selling price of a house was increased by almost $300. If the amount of tree cover was increased by 10 percent, the average price of a house was increased by almost $3,000. The scientists also calculated the average value of different size trees for the 272 houses in this study (**figure 7**).

$29 $211 $566 $1,066

|←6'→| |←16'→| |←26'→| |←36'→|
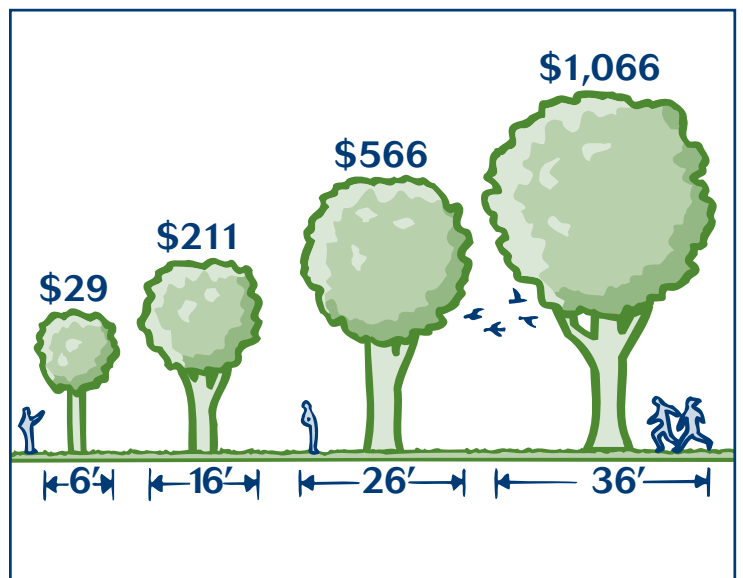
Figure 7. The average value of different size trees.

Reflection Section

🍁 Why do you think that most of the trees were growing on the border of the lots or in the backyard?

🍁 Athens-Clarke County is located in the Southeastern United States, where there is plenty of rain. Do you think that the amount of tree cover would affect the selling price of houses in other areas of the United States? Why or why not?

🍁 Look at **figure 7.** What is the *relationship* between tree size and the value of a tree?

Reflection Section

🍁 Think about how you feel about trees. Now pretend that you are getting ready to buy a house. Do you think that you would be willing to spend more money to buy a house that had more trees growing in its yard? Why or why not?

From Sydor, T., Newman, D. H., Bowker, J. M., & Cordell, H. K. (2004). Trees in residential landscapes: Comparison of empirical data from two southern states. Presented at 2004 Southern Forest Economist Workshop, St. Augustine, FL, March 14-16.

Implications

This study provides an estimate of the value of the trees that surround a house. It indicates what people are willing to pay for different percentages of tree cover when they buy a house. The study shows that trees are a positive feature of houses, and that people will pay more for a house if there is more tree cover on the lot. ■

FACTivity

The question you will answer with this FACTivity is: According to your own research, do your findings support the findings of this study? The method you will use to answer this question is given below.

Students—

Take three sets of six photographs home and poll three adults. For each set of six photographs, have each adult place the photographs in order of preference, from their first choice to their last choice. Ask the adult to make his or her selection based on which house he or she would pay the most to buy to which house that he or she would pay the least to buy. Ask the adult to write on the back of each card what influenced him or her to rank that particular house in the order that he or she did. Record the rank order, from 1-6, on the front of each set of six cards.

Bring your cards back to class to be analyzed with your classmates' cards. After the results have been recorded on the board, count the number of times each photograph was ranked number 1, number 2, number 3, etc., all the way to number 6. Based on the frequency of each ranking, identify, as a class, which photo was ranked overall the first choice (and most likely to bring the highest price) of the 6. Identify which photo was ranked the least favorite (and most likely to bring the lowest price). If possible, determine the overall rank order of all six photographs, based on the results of the polling. Read some of the reasons each house was placed in its order.

Answer the question posed at the beginning of this FACTivity. Do the results of this research support the findings in this article? If they do, either House number 2 or 5 should be the first choice overall, and House number 3 or 1 should be the last choice overall.

As a class, discuss your research project. What were the reasons given for the choices made? How often did people mention the trees that surrounded the house? What might be some of the problems with the research? Other than the amount of tree cover surrounding the houses, what other things could have made people rank the photographs the way that they did? Think about things such as the way the houses looked, whether each student asked their questions in the same way, etc.

Teachers—

Before the FACTivity, make three copies of the following page on cardstock for each student. Cut the cardstock to make three sets of six photographs.

After the FACTivity, analyze the results in class. Appoint someone to record the answers on the board. Use the following form as a template.

Rank order 1= first choice to 6= last choice.

House Number 1

House Number 2

House Number 3

House Number 4

House Number 5

House Number 6

	House 3 10% Tree Cover	House 1 20% Tree Cover	House 6 30% Tree Cover	House 4 40% Tree Cover	House 5 50% Tree Cover	House 2 60% Tree Cover
Number each photograph according to your choice 1 = first and 6 = last choice.						
Student 1						
Student 2						
Student 3						
Student 4						
Student 5						
Student 6						
Student 7						
Student 8						
Student 8						
Student 9						
Student 10						
Student 11						
Student 12						
Student 13						
Student 14						
Student 15						
Student 16						

Reflection Section Answer Guide

The follow section provides a guide to possible answers to the reflection questions found in each section of the articles. Reflection Sections are meant to stimulate critical thinking about the article, not to test knowledge. Use the answers below as a guide to stimulate critical thinking and discussion in your classroom.

What You See Is Not What You Get: Visible Sunlight and Ultraviolet Radiation in Urban Forests

Introduction

- **What question did the scientists want to answer?** The question was—Does the shade under urban trees protect people from the sun's UVB radiation?
- **Why is this question important?** Because getting too much UVB radiation causes a lot of human health problems. If you think you are being shaded from UVB radiation but are not, then you might be unknowingly exposing yourself to danger from UVB radiation.

Method

- **Name two reasons why is it important to find out what is already known about something before doing an experiment or collecting your own information about it.** (1) You might conduct an experiment that discovers something that is already known, wasting your time and money. (2) If you know as much about something as possible, you will design a better experiment or research method. Your students may come up with many other reasons.
- **From your own observation, would you say that leaves allow the sun's visible radiation to pass through them? Why or why not?** Leaves allow a little bit of the sun's visible radiation to pass through them. You can tell this by looking up at the undersides of the leaves and seeing the light green color of the leaves that are in the sunlight. The light green color is caused by some of the sunlight penetrating the leaf's surface. Leaves that are shaded are a darker green color when viewed from underneath.

Findings

- **Look at table 1 and read the paragraph below it. Put the scientists' findings in your own words.** This could be done many ways. Essentially, the findings show that when you think you are protected from UVB radiation because you are in the shade, you are actually not as protected as you think. It also means that when you are under a tree, you are receiving some protection from UVB radiation, even if you are in a sunny area under the tree.
- **What do you think these findings mean for protecting yourself from harmful UVB radiation?** If you are under a tree canopy and you can see around the tree canopy to part of the sky, you are not as protected from harmful UVB radiation as you think you are. You might want to take additional actions to protect yourself from UVB, such as use sun protection lotion.

Implications

- **In urban areas, some UVB radiation can be reflected off of buildings, sidewalks, streets, and fountains. Should you consider this source of UVB radiation when trying to protect yourself from the sun? Why or why not?** Yes, because UVB radiation is the same, regardless of whether it is reflected from buildings and other objects in an urban area.
- **Reread the last sentence in the last paragraph above. Why do you think that you receive less UVB radiation when standing in the sun next to a tree than when standing in the sun away from a tree?** When you are close to a tree, the tree's crown blocks part

of the sky from which the UVB radiation comes. When you are farther from the tree, less of the sky is blocked and you receive more UVB radiation.

Introduction

- **What were the scientists trying to do in this study?** They were trying to take an inventory of the amount of sidewalks and streets covered by street tree canopies.
- **Can you think of two other items that you took an inventory of this past week? What were they?** Examples of items that students could have taken an inventory of include—homework assignments; how many clean socks they had for the week; the number of CDs they have; and frozen foods in the kitchen freezer; which friends they were meeting after school. Your students should be able to think of many examples of taking inventories.

Method

- **What do you think the numbers 10.7 meters and 35 feet represent?** They represent the average width of the streets in that community.
- **Do you think that the amount of tree canopy area covering streets and sidewalks was equal to the total amount of area that street tree canopies covered? Why or why not?** No, because the trees also covered front yards and median strips, and may have covered other things like planter boxes and even small buildings.

Findings

- **Why do you think a greater percentage of sidewalk area than street area was covered by tree canopies?** Because street trees are planted closer to sidewalks, and the area of street pavement is much greater than the area of sidewalk pavement.

- **Did this tell the scientists how many benefits people were receiving from street trees? Why or why not?** No, all the scientists know now is how much of the sidewalks and streets are covered by street tree canopies. They will have to do more research to estimate how much people benefit from this amount of tree canopy coverage.

Implications

- **What is one reason it is important to know how much paved area street trees cover?** In communities, people need to know how many trees to plant to achieve the amount of benefit that they hope to receive from urban forests. If you do not know how many trees or how much of the ground and pavement is now covered in trees, it is impossible to say whether you need more or not. Doing this inventory provides a starting point, or baseline, for understanding. This is an important point to make to your students, since in many situations, you must understand the baseline before you can discover more about the topic.
- **Do you think it might be important to also estimate the amount of grassed areas that street trees cover? Why or why not?** Yes, because street trees do more than keep areas cool. They also hold the soil in place and their roots absorb rainwater. They help to clean the air and provide homes for wildlife. The amount of area covered by tree canopies is a good measure of the total amount of trees growing in an area. If you know how much total area street trees cover, including grassed areas, you will have a more complete idea of the benefits being provided by urban trees.

Introduction

- **What is the question that the scientist wanted to answer?** He wanted to know what kind of activities people of different ethnic backgrounds do when they visit an urban park.

- **If you were the scientist, how would you learn what kind of activities people of different ethnic backgrounds do when they visit a park?** Watch people when they visit a park and record what they do and what you think their ethnic background is. Talk to people of different ethnic backgrounds while they were visiting a park. Call people at their homes and ask them about their park activities. Students may come up with other ideas.

Method

- **Why do you think that it was important to ask all of the visitors the same questions?** Because if the visitors were asked different questions or the questions were asked in different ways, the answers could not be compared with each other.

- **Based on your own experience, do you think that people from different ethnic backgrounds like to do the same things or different things when visiting an urban park?** This is a personal question and has to be based on each student's own experience. It provides an opportunity to discuss similarities and differences between ethnic groups, and misconceptions people can have about other groups of people.

Findings

- **Are you surprised by the similarities and differences between the groups? Why or why not? Discuss with your class about whether you have observed the same things in your local parks. If your observations are different, how are they different? Why do you think that they are**

different? The answer to these questions will be based on the experiences and perceptions of your students. These questions should stimulate discussion about observation and about the differences and similarities between people of different ethnic backgrounds.

- **When you visit a local park with others, how would you describe your group? Do you go with your family? With friends? What kind of things do you do when you visit a park?** The answer to this question will be based on the individual experiences of your students. These questions can stimulate a discussion about the students' use of local parks.

Implications

- **Why is it important to think about all of the users of urban parks?** Because urban parks are managed for the use of all Americans, not just one ethnic group. This question provides a good opportunity to discuss the provision of public goods for all ethnic groups on an equal basis, including things like police protection, public schools, and any other public good or service.

Introduction

- **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?** Urban trees are a part of the carbon cycle because they absorb CO_2 from the air. Urban tree maintenance is a part of the carbon cycle because the engines emit CO_2 from the burning of fossil fuels. The scientists wanted to discover which trees absorbed the most CO_2 over the longest period of time. They wanted to find the point at which the engines used to plant and care for the tree emit more CO_2 than the tree is able to absorb.

- **Why do you think the scientists wanted to know which tree species absorb the most CO_2**

over time? Because these tree species will be the most beneficial to plant and maintain. They will cause less CO_2 to be emitted over time.

Method

- **What did the two sets of numbers represent?** They represented (1) the amount of carbon in the tree and (2) the amount of CO_2 that was emitted from engines used to plant and care for the tree.

- **Why do you think each tree was maintained exactly alike?** So that the scientists could compare the amount of carbon in each tree every year with the same amount of CO_2 being emitted by the machinery used to maintain each tree. If the amount of CO_2 being emitted by machinery was different for each tree, the comparisons would be meaningless.

Findings

- **This study looked at how much CO_2 was emitted by engines used to plant and maintain urban trees. What is one way that CO_2 emissions could be reduced without changing the type of tree species being planted?** Trees could be planted and maintained without using machines, or the use of machines could be reduced. Also, more energy efficient engines could be used.

- **This study examined the advantages and disadvantages of planting and maintaining different urban tree species for balancing CO_2. What might be some other advantages and disadvantages of different tree species?** One thing to consider is whether there are nuts that could fall from trees. Another thing might be whether the tree is more or less likely to get a disease. Another thing to consider is how much water the tree needs or how much space it needs to grow.

Implications

- **This research identified the amount of carbon dioxide 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? We could have more energy-efficient machines that either emit less CO_2 or use renewable sources of energy, such as hydrogen or solar power. If our equipment is more energy-efficient and emits less or no CO_2, you would not have to think as much about the balance of CO_2 absorbed by trees compared to the amount emitted by equipment. The scientists might not need to do this kind of research anymore.

- **If people want to increase the amount of CO_2 that is absorbed in urban areas, should they plant more or fewer urban trees?** They should plant more trees.

- **Of the tree species characteristics in figure 4, which kind of species should they plant?** They should plant trees that live a long time and grow fast or moderately fast.

Good to the Last Drip:
How Urban Trees Help To Reduce Pollution

Introduction

- **What is the question that the scientists were trying to answer?** The question was— How much rainfall is intercepted by trees growing in an urban county in California?

- **Do you think that the amount of rainfall being intercepted by trees is different in urban areas than rural areas? Why or why not?** Yes, because in a rural area, there usually are many more trees to intercept the rain. The trees grow differently in rural areas because they are not pruned. They are able to grow taller and closer together.

Method

- **How did the equations help the scientists to answer their question?** The equations helped the scientists to identify what they needed to measure by defining exactly what is involved in rainfall interception, as well as what is not involved in rainfall interception.
- **Why did the scientists need to know which tree species were growing in the county?** Because different kinds of trees have different shapes and sizes, different sized leaves, and different kinds and amounts of leaves. All of these differences will influence how much rainwater is intercepted by trees.

Findings

- **Why do you think it is important to calculate the amount of rain intercepted over the entire county, and not just where trees were growing?** The important thing is how much rainwater is going into stormdrains and into creeks and rivers. The rain falling all over the county has a potential to run into the drains and creeks, not just the rain falling over the trees.
- **Why do you think that deciduous trees intercepted less rain than evergreen trees? (Hint: The scientists collected information for an entire year.)** Because deciduous trees lose their leaves in the winter, and evergreen trees keep their leaves and needles all year.

Implications

- **We need to have a certain amount of rain hitting the ground, but how can too much rain hitting the ground at one time be a bad thing?** Too much rain at one time washes pollutants and soil into streams and rivers.
- **What is one way that people living in urban areas can reduce the impact of rainfall on soil erosion?** They can plant and care for a larger number of urban trees.

Introduction

- **Why do you think hotter temperatures cause more gases to be emitted from parked cars?** When the temperature is hotter, more evaporation will occur. Evaporation can come from improperly connected hoses; from gas caps that are not sealed properly or have been lost; and from permeable, easily punctured, or deteriorating materials.
- **What is the question that the scientists were trying to answer?** Is there a difference in the amount of gases coming from cars parked in the shade vs. cars parked in the sun?

Method

- **Why do you think that the scientists used identical cars?** So that any differences they found in the car's surface temperature, inside temperature, and gas tank temperature could be attributed to the air temperature and/or amount of solar radiation, not the type or color of the car.
- **Why do you think that the scientists collected their information when the climate was hot?** (1) If the temperature was cool, there would be less difference between the temperature in the sun and the shade, making it harder to identify any differences in measurement. (2) The amount of solar radiation would be different coming through trees in the summer than in the winter.

Findings

- **From the information in Table 1, would you say that the amount of sunlight reaching a parked car has an impact on its inside temperature?** Yes, because the inside temperature was 15 degrees higher in the car parked in the sun than the one in the shade (in Fahrenheit, the temperature difference was 122° to 149°).

- **Do you think that a 2-percent difference is a very big difference in the amount of gas evaporating from a car? Why or why not?** Although 2 percent is not a very large amount, over the millions of cars parked every day, it could add up to a large amount of wasted and dangerous fuel being emitted into the air.

Implications
- **Which would you prefer–a parking lot with trees or one without trees? Why?** This question can be used as a basis for discussion over the costs and benefits of urban trees.
- **Do you think that evaporation from cars will continue to be a problem in the future? Why or why not?** As cars become more fuel efficient and new fuel technologies are developed, evaporation from parked cars will probably become less of a concern. On the other hand, the millions of cars still being driven every day are getting older and, therefore, are more likely to have evaporation problems.

Yard Sale!
How Trees Affect the Selling Price of Houses

Introduction
- **What questions were the scientists trying to answer?** (1) Are yard trees valued by people buying a new house? (2) How much money are those benefits worth to people buying a new house?
- **If you were the scientist, how would you determine how much money trees are worth to people buying a new house?** Talk to different people who are buying a house and ask them how much more they would be willing to pay for a house with trees. Do some research about the price of similar houses with different amounts of trees growing in their yards. Your students may come up with other ideas. This is a good opportunity to brainstorm ways that your students might try to answer the scientists' questions.

- **The first paragraph of the "Introduction" section lists some benefits that are provided by trees surrounding a house. Name two other possible benefits.** (1) Trees can be places for tree houses. (2) Trees can hold swings. (3) Trees might provide nuts or fruits that can be eaten. (4) Trees provide shady places to have picnics or just to sit and relax. (5) Trees can make the neighborhood quieter by absorbing sound. Your students may come up with other benefits. You can list them on the board and discuss the value of trees surrounding houses (and schools!).

Method
- **Why do you think that the scientists collected information about the number of rooms, the amount of heated space, and other things for each house they studied?** The price may have also been affected by these other things.
- **Do you think that the percentage of tree cover on a lot affected the price of the houses? Why or why not?** This is an individual question. It would depend on each student's own assessment of the value of trees surrounding a house. This question could be used to stimulate discussion regarding how and why different people might or might not value trees.

Findings
- **Why do you think that most of the trees were growing on the border of the lots or in the backyard?** This is a question for which we do not have a definite answer, but some reasonable guesses are—(1) Trees are planted on the border of the property and in the backyard to provide privacy from next-door neighbors. (2) Trees are planted in the backyard for picnics, relaxing, tree houses, and other recreation. (3) Leaving the front yard open allows the house to be seen from the street. This

question can give you an opportunity to challenge students to think about why people who own houses plant trees where they do.

- **Athens-Clarke County is located in the Southeastern United States, where there is plenty of rain. Do you think that the amount of tree cover would affect the selling price of houses in other areas of the United States? Why or why not?** This question will allow you to discuss whether people buying houses in dry areas of the United States, such as New Mexico and Arizona, would spend more money on a new house if there were trees on the lot. It would also allow you to examine the practices and preferences of house buyers in the community where you live.

- **Look at figure 6. What is the relationship between tree size and the value of a tree?** As a tree gets larger, its value goes up.

Implications

- **Think about how you feel about trees. Now pretend that you are getting ready to buy a house. Do you think that you would be willing to spend more money to buy a house that had more trees growing in its yard? Why or why not?** This is an individual question and every student will have a different answer. This question will give you an opportunity to discuss the findings and compare what the scientists found with your students' own experiences and preferences.

Natural Inquirer Lesson Plan

Schoolyard Tree Inventory and Biodiversity Project

Adapted from Web Site: Virginia Tech Biodiversity Study: http://www.cnr.vt.edu/dendro/forsite/si4.htm

Subjects Covered
Science: Biology, Ecology
Math: Addition, multiplication, division, solving equations
Reading: Comprehension

Science Skills: Observing, comparing, recording, classifying, analyzing
Science Education Standards Addressed: Abilities necessary to do scientific inquiry, Populations and ecosystems, Diversity and adaptations of organisms, Science as a human endeavor, Nature of science

Objectives:
1. Students will be able to observe, identify, measure, transform, and record data associated with trees.
2. Students will be able to analyze and synthesize collected data.
3. Students will be able to compare results and discuss results with peers.

Estimated Time for Lesson: 5 Class Periods

Materials:
Day 1: Plastic tags, wire, and permanent markers (You will need enough tags and wire to tag all of the trees and samples from each tree). Plastic bags for samples.

Day 2-3: Tree identification book. Pencils and sheets of paper to record tree identification information. Or visit http://www.oplin.org/tree/.

Day 4: Pencils and identification sheets prepared from Days 2-3. Extra paper.

Day 5: Pencils, paper, and calculators (optional).

Procedures
Day 1
1. Introduce the topic of biological diversity and discuss why diversity is important in natural systems.* Explain that the project will involve an inventory of all trees on the school grounds (or other area), followed by a calculation of the measure of biological diversity represented by those trees.

2. Divide the school ground or other area into two sections. Assign two for each section. Tag and number sequentially all of the trees in each section of the school grounds or other area. Alternatively, one team can inventory the school grounds, and another can inventory an adjacent area. From each tree, take a few samples of branches with leaves. (Take enough so that students can identify whether the leaves are opposite or alternating, and simple or compound.) Put the samples in plastic bags that are numbered sequentially to match the tree from which they came.

Day 2: 1. Have each student guess which area they think has more tree diversity. Have each student record their guess.

2. Identify the trees using the samples and a tree identification book (or a Web-based tree identification key).

3. Record each tree's name (common and biological) on a sheet of paper according to the sequential tag numbering.

Day 3: Using a sample from each tree species, do leaf rubbings or have students draw each leaf on a sheet of paper, along with the common and biological name and the location of the tree. Other characteristics of the tree may be noted on the sheet as well. These characteristics should come from direct observation of the tree and from the tree identification book. For example, is the tree native to the area? Does it produce nuts? Each student should have a collection of sheets showing all of the trees inventoried in their area.

Day 4: 1. Count the total number of trees growing on the school grounds (or other area). This should equal the total number of samples collected. This number will be identified as N. (N=the total number of trees of all species.)

2. Count the number of each individual tree species identified on the school grounds. This number will be identified as n. (n=the total number of trees of each species.)

Day 5: 1. Calculate the amount of diversity using Simpson's Index. Simpson's Index is calculated using this equation:

D= $\frac{3n(n-1)}{N(-1)}$ D=Diversity. In this equation, the value of D ranges between 0 and 1.

Now, to calculate Simpson's Index of Diversity, subtract the value of D from 1.

Simpson's Index of Diversity also ranges between 0 and 1. 1=infinite diversity and 0=no diversity.

For example—

Species	Number (n)	n (n-1)
Red maple	4	4X3=12
White oak	2	2X1=2
Holly	9	9X8=72
TOTAL (N)	15	86

N (–1) = 15 (14) = 210
D = 86/210
D = .4095 or .41
Simpson's Index of Diversity = 1-D   1-.41 =.59

2. Now compare Simpson's Index of Diversity between the two areas. Which area is more diverse? How many students had guessed correctly about which area is more diverse?

3. Hold a class discussion about biological diversity as represented by the diversity of tree species.

4. Have students put their own leaf rubbings and information sheets into a notebook or on a poster. Any additional information learned could be added to demonstrate the biological diversity (or lack of it) of the area that they studied.

Do not forget to remove the sequential tags from the trees when you have finished with the project!

Assessment—
Formal assessment: Create a rubric for the student notebooks or posters. You could require the student projects to clearly display the leaf specimen, common and biological names, and location. You could require students to identify what they know about that species within the area they studied. For example, how many trees from that species were found in the area? How much additional information did they add? You should also require correct spelling and punctuation.

Informal assessment can be done through class

discussions, observations of group interactions, and participation.

Modification:

- Students that have difficulty reading or doing the other tasks can be paired with a partner or the educator may want to assist the student.
- Students that need an extra challenge can go to http://www.cnr.vt.edu/dendro/forsite/si4.htm. At that Web site, they can learn how to measure the trunk diameter and height of the trees in their area. They can measure the trunk diameter and the height of trees in their area, and add this information to their poster or notebooks.

* What is biological diversity? Scientists use the word biological diversity to describe the variety of life on Earth. Over the past 550 million years, the diversity of life has increased, meaning that more different kinds of organisms exist today than when the first multicellular animals appeared.

Species diversity is important. Recent ecological research shows that an area of land with many plant species is more productive and resistant to drought, pests, and other stresses than a comparable area with only a few species.

The diversity of genes, cells, organisms, and ecosystems is a hallmark of life on Earth and one of the reasons that life has survived and prospered despite periodic catastrophes.

Biological diversity is measured in different ways. The two main factors are richness and evenness. Richness is the number of different species in an area. Evenness is the abundance of individuals within a species. In this project, students will assess the richness and evenness of the tree species growing on the school grounds or in another area.

STUDENTS—Tell Us What You Think About The *Natural Inquirer*

1.   The article I read was entitled: _____

Circle the answer that best describes how you feel about the article you just read.

2.   The article was: Easy to understand   Hard to understand   Very hard to understand

3.   The article was: Very interesting   Somewhat interesting   Not interesting

4.   Did you learn something from reading the article?   Yes   No

5.   Did you try to answer the Reflection Questions?   Yes   No   Some of them
      If you read and tried to answer any of the reflection questions, did they help you to think
      about the article?   Yes   No

6.   Would you like to read another article?   Yes   No

7.   How old are you?   9   10   11   12   13   Other age:

8.   What grade are you in?   4th   5th   6th   7th   8th   9th

9.   Are you a girl or a boy?   Girl   Boy

      Now write in your answer:
10.   What did you learn from reading the article? _____

_____

_____

_____

11.   What is your favorite subject in school? _____

Along with your class or by yourself, please send this form to:
Dr. Barbara McDonald • Forest Service • 320 Green St. • Athens, GA 30602-2044

Thank You!

The Natural Inquirer
Teacher's Evaluation

For each article that you read, please answer the following:

Name of Article:_____

1. Would this article help you meet any of the required statewide science curriculum standards?

        Yes   No

2. How close to the appropriate reading and comprehension level for your students is this article written?

    Very close   Somewhat close   Not close

3. If the article is somewhat close or not close to the appropriate reading and comprehension level, is it: Too hard   Too easy

4. Would or did you use this article in your classroom as an educational resource?

      Yes   No

Why or why not? _____

_____

_____

5. Please rate the article sections on a scale of 1 to 5. One means the section was not useful at all, five means the section was very useful.

	Not useful			Very useful	
Glossary	1	2	3	4	5
Introduction	1	2	3	4	5
Methods	1	2	3	4	5
Results	1	2	3	4	5
Implications	1	2	3	4	5
Graphs, figures, photos	1	2	3	4	5
Reflection Questions	1	2	3	4	5
FACTivity	1	2	3	4	5

For any of the sections you rated with either a "one" or a "two" in question 5, please indicate why the section was not useful or how it can be improved:

Glossary_____

Introduction _____

Methods _____

Results _____

Implications _____

Graphs, figures, photos _____

Reflection Questions _____

FACTivity_____

6. Was the "Note to Educators" useful to you?

      Yes   No   Somewhat

7. What grade(s) do you teach? _____

8. What subject(s) do you teach? _____

9. Other comments or suggestions: _____

_____

_____

_____

Please send this evaluation, along with your students' evaluations, to
Dr. Barbara McDonald
Forest Service
320 Green St.
Athens, GA 30602-2044

Thank you! Your evaluations will help us to continually improve The *Natural Inquirer*.

Which National Science Education Standards* Can Be Addressed by the *Natural Inquirer*?

	What You See is Not What You Get	I've Got You Covered	Social Groupies	Balancing Act	Good To the Last Drip	Yard Sale!	Don't Be So Fuelish!
Science as Inquiry							
Abilities Necessary To Do Scientific Inquiry	✔	✔	✔	✔	✔	✔	✔
Understandings About Scientific Inquiry	✔	✔	✔	✔	✔		✔
Physical Science							
Properties and Changes in Properties in Matter					✔		✔
Motions and Forces							
Transfer of Energy	✔						✔
Life Science							
Structure and Function in Living Systems				✔	✔		
Reproduction and Heredity							
Regulation and Behavior		✔		✔	✔		
Populations and Ecosystems	✔			✔			✔
Diversity and Adaptations of Organisms					✔		
Earth and Space Science							
Structure of the Earth System					✔		
Science in Personal and Social Perspectives							
Personal Health	✔			✔	✔	✔	
Populations, Resources, and Environments				✔			✔
Natural Hazards							
Risks and Benefits	✔			✔	✔		✔
Science and Technology in Society	✔	✔	✔	✔	✔	✔	✔
History and Nature of Science							
Science as a Human Endeavor	✔	✔	✔	✔	✔	✔	✔
Nature of Science	✔	✔	✔	✔	✔	✔	✔
History of Science							

* National Research Council, Content Standards, Grades 5-8

What Is the USDA Forest Service?

The Forest Service is a part of the United States Department of Agriculture (USDA). It is made up of thousands of people who care for the Nation's forest land. The USDA Forest Service manages over 150 national forests and almost 20 national grasslands. These are large areas of trees, streams, and grasslands. National forests are similar in some ways to national parks. Both are public lands, meaning that they are owned by the public and managed for the public's use and benefit. Both national forests and national parks provide clean water, homes for animals that live in the wild, and places for people to do fun things in the outdoors. National forests also provide resources for people to use, such as trees for lumber, minerals, and plants used for medicines. Some people in the USDA Forest Service are scientists, whose work is presented in this journal. USDA Forest Service scientists work to solve problems and provide new information about natural resources so that we can make sure our natural environment is healthy, now and into the future.

What Is Agriculture in the Classroom?

Agriculture in the Classroom (or Ag in the Class-room) is a grassroots program coordinated by the USDA's Cooperative State Research, Education, and Extension Service (CSREES). The goal of Ag in the Classroom is to help students and teachers gain a greater awareness of the role of agriculture in the economy and in society. The program is carried out in each State, according to State needs and interests. People involved at the State level represent farm organizations, agricultural businesses, education, and government.

The mission of the CSREES is to advance knowledge for agriculture, the environment, human health and well-being, and communities. The CSREES provides leadership to identify, develop, and manage programs to support university-based and other institutional research, education, and extension.

What Is the Urban and Community Forestry program?

The Forest Service's Urban and Community Forestry program promotes the management of forests and other natural resources in cities and communities so that urban forests can be healthy now and into the future. The program works with people, organizations, and communities to plan for, protect, establish, and manage trees, forests, and other natural resources in urban areas and local communities.

Visit these Web sites for more information:

USDA Forest Service:
http://www.fs.fed.us

The Natural Inquirer:
http://www.naturalinquirer.usda.gov

Conservation Education:
http://na.fs.fed.us/spfo/ce

USDA Kid's Page:
http://www.usda.gov/news/usdakids/

Agriculture in the Classroom:
http://www.agclassroom.org

Urban Forest Links
http://www.treelink.org

Urban Forestry Resources:
http://www.urbanforestrysouth.usda.gov

Urban Forestry Glossary:
http://www.lpb.org/programs/forest/glossary.html

NatureWatch:
http://www.fs.fed.us/outdoors/naturewatch/

Woodsy Owl:
http://www.fs.fed.us/spf/woodsy

Smokey Bear:
http://www.smokeybear.com

National Forests by Map:
http://www.fs.fed.us/recreation/map/finder.shtml

National Forests by State:
http://www.fs.fed.us/recreation/map/state_list.shtml

Visit these Web sites for more urban forest information:

Northeast Center for Urban and Community Forestry:
http://www.umass.edu/urbantree/

Midwest Center for Urban and Community Forestry:
http://www.na.fs.fed.us/spfo/urbanforestry/ucf.htm

Mid-Atlantic Center for Urban and Community Forestry:
http://www.fs.fed.us/na/morgantown/macucf/index.htm

Urban Forestry South Expo:
http://www.urbanforestrysouth.org

Center for Urban Forest Research:
http://cufr.ucdavis.edu/

Urban Forestry South:
http://www.urbanforestrysouth.usda.gov

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