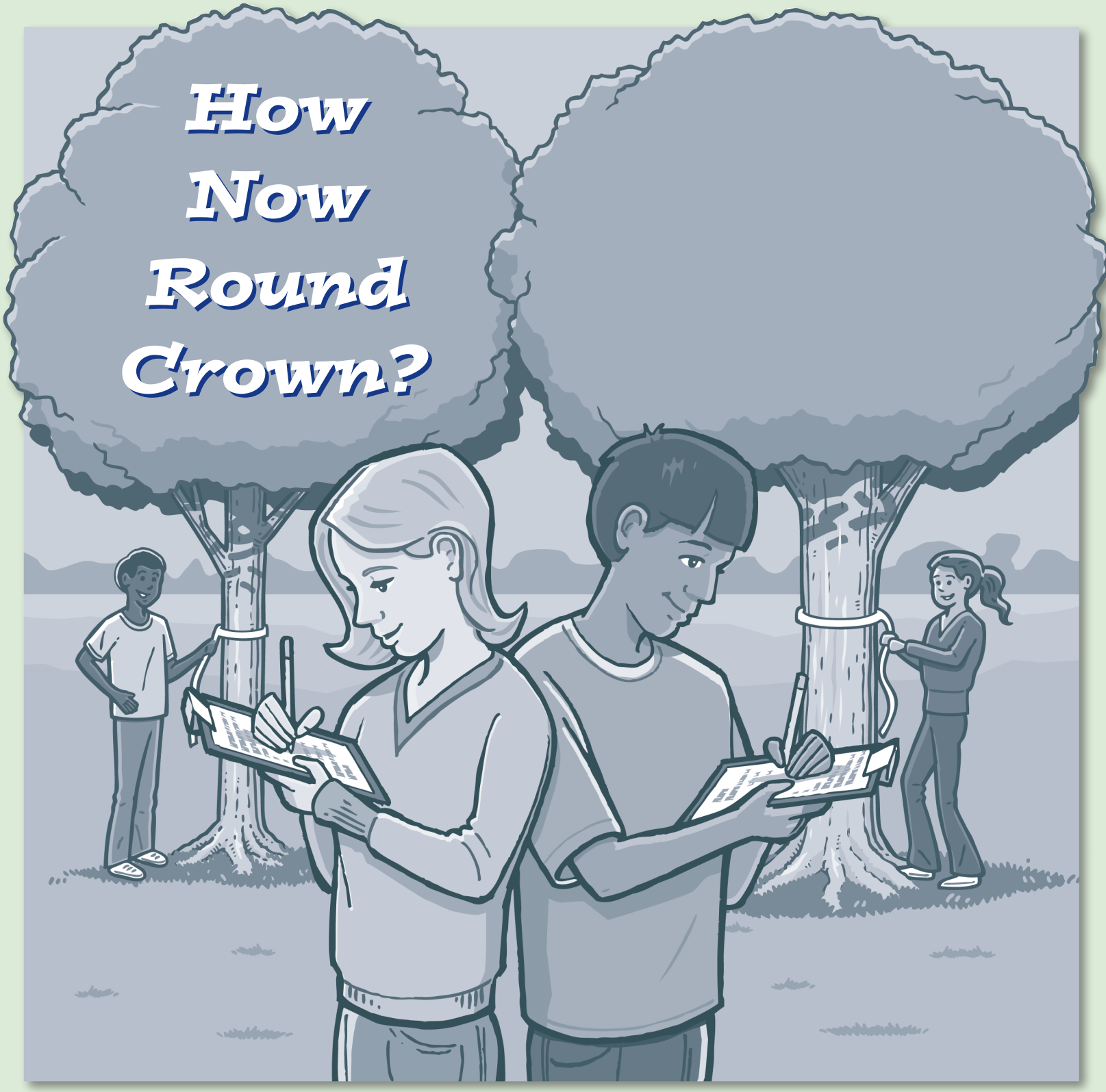


Predicting the Future Energy Benefits of Tree Crowns

Meet the Scientists

Andy Scott, Soil Scientist: I enjoy science because I get to continually learn about things and help others learn. Every experiment has three great parts for me. First, each experiment means I'm doing something new, either in a new place or in a new way. Continually doing new things makes science exciting. Second, by doing science I discover new things that help us understand forests and soils and how to best manage them. Analyzing *data* can be very rewarding when it tells you something you didn't already know (think "Eureka!"). Finally, my favorite part of science is helping others understand the forest. I know I've done a good job when I've helped somebody else learn something.

Tom Dean, Soil Scientist: My favorite science experience is discovering how trees work: how they stand up, how they grow, and how they withstand changes in the environment year after year.

Glossary:

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

economically (e ko **nom** ik le): Having the characteristic of little waste or at a savings.

crowns (krowns): The top parts of things.

resource (**re** sôrs): Any physical or virtual thing of limited availability, or anything used to help one earn a living.

renewable (re **nu** uh bool): Capable of being made like new again.

nutrients (**noo** tre ents): Any of the substances found in food that are needed for the life and growth of plants and animals.

hectare (**hek** tär): A metric measure of land area equal to .405 acre.

megawatt hours (**meg** uh wat **ow** ürs): one joule of energy per second. If a 100-watt light bulb is turned on for 1 hour, the energy used is 100 watt-hours.

biomass (**bi** o mas): All the living or once-living things in a particular area.

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.

megagram (**meg** uh gram): A unit of mass equal to 1,000,000 grams. A megagram is equal to 1.1 ton, or 2,200 pounds. Symbol: Mg

net (net): An amount, profit, weight, price, result, that is left after another amount is subtracted.

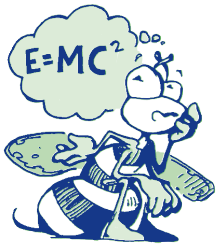
forest managers (**för** est **mä** ni jürz): Skilled individuals who takes care of natural resources.

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

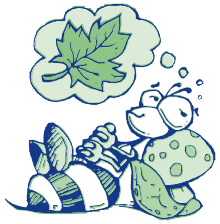
Accented syllables are in **bold.**

Thinking About Science



Scientists try to solve problems that are important to society. In some cases, scientists try to solve problems before they are even recognized as problems. In this study, for example, the scientists were aware that energy prices were continuing to rise. They reasoned that, at some point, it might become *economically* possible to use tree *crowns* for wood energy in the Southeastern United States (**figure 1**). The scientists developed a study to better understand how much energy is available from tree crowns. As you can see, science is not just about solving today's problems. Scientists also look into the future and anticipate future problems that may need to be solved.

Thinking About the Environment



Trees are a valuable *resource* for the planet. They help to keep the air clean and hold soil in place. Trees absorb and hold carbon to reduce global climate change. They provide homes for animals and other plants. Trees are also *renewable*, meaning they can be planted, grown, and used for human needs. Some forests are planted and managed to eventually be used for wood products. Examples of wood products include furniture, lumber, and plywood.

When a forest is cut down to be used for wood products, only the tree's trunk is used. Foresters call the tree's trunk its bole. The rest of the tree, which is mostly the tree's crown, is left behind. The crowns are usually piled and burned or left to decay (**figure 2**). In this way, the crown's *nutrients* are returned to the soil to nourish the next generation of trees (**figure 3**).

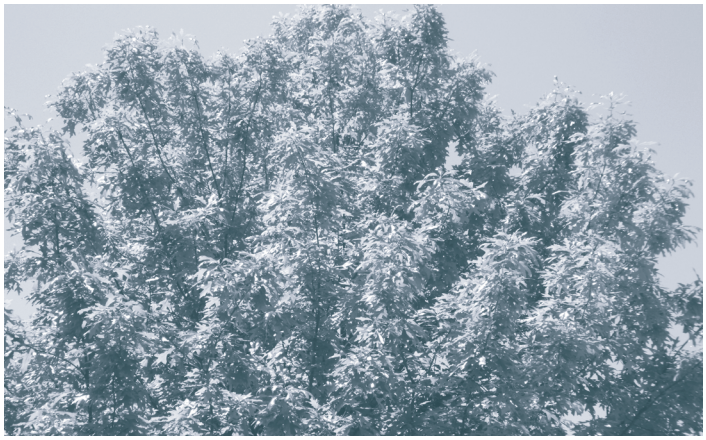


Figure 1. A tree crown.

Figure 2. Tree crowns piled together are called slash.

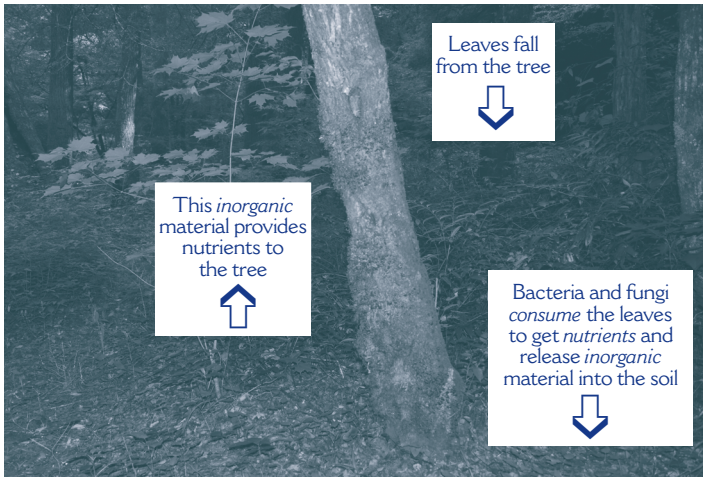


Figure 3. The movement of nutrients from trees to the soil. Most of the nutrients in a tree are stored in the crown. After a tree is cut or burned, the leafy crown and branch material is returned to the soil as it decays. The inorganic material comes from minerals.

Introduction

Pine trees cover much of the Southeastern United States (**figure 4**). When older pine trees are cut for making wood products, only the trees' boles are used (**figure 5**). The scientists in this study wondered if there might be a use for the trees' crowns as well. In particular, they wondered whether the trees' crowns might one day be a source of energy. A tree's crown can be cut into small pieces and used in a wood-burning furnace or converted to liquid fuels, such as ethanol.

Based on the scientists' research, they estimated an average *hectare* of southern pine forest contains 968 *megawatt hours* (MWh) of energy stored in its wood. Of this 968 MWh of energy, 112 MWh are stored in tree crowns and 856 MWh of energy are stored in the boles. With over 36,000,000 hectares of southern pine forest, this amounts to a lot of stored energy.

After trees are cut, the crowns could be removed and burned to make energy. This also takes energy, however, as machines must be used to cut and haul the trees. Another thing to consider is that the crowns contain nutrients that should be returned to the soil. If the crowns are removed with the tree boles, the soil could become less healthy for the next generation of trees.

The scientists wanted to compare the amount of potential wood energy contained in southern pine tree crowns in three situations (**figure 6**). The first situation is when only the tree boles are removed from the area. The second situation is when entire trees are removed and tree crowns are used for energy. The third situation is a little more complicated. In this situation, whole trees are removed, the crowns are used for energy, and fertilizer is applied to the area to help new trees grow.

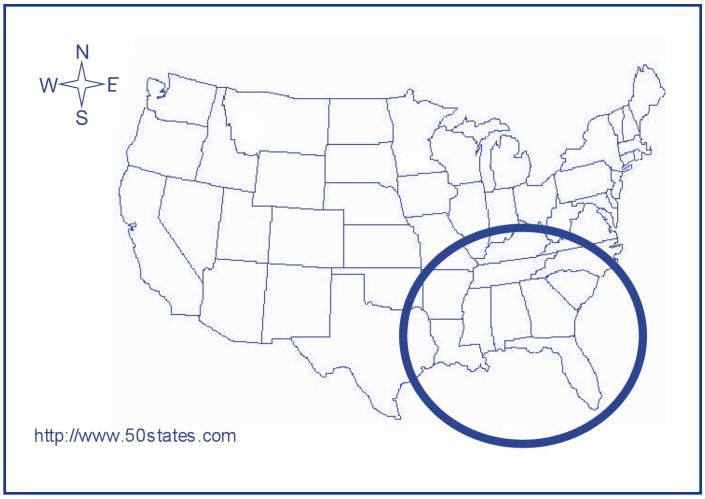


Figure 4. The Southeastern United States.

Figure 5. Only the boles of large southern pine trees are used for wood products.

Number Crunches

One MWh of energy is the amount of electricity you would use if you played 15,000 CDs. How many CDs could be played with the energy stored in 1 hectare of southern pine forest? (Remember, a hectare of southern pine forest contains 968 MWh of energy.) How many CDs could be played with the energy stored in the crowns of that 1 hectare of forest? (One hectare of tree crowns contains 112 MWh of energy.)

The Situations	The area is left with....	Soil preparation	Tree planting	Wait 10 years to assess new amount of *biomass* per hectare
Boles only removed	Tree crowns piled into slash (see **figure 2**)	None (Some nutrients available through the slash) (see **figure 3**)	Yes	Yes
Entire trees including crowns removed	Soil only	No	Yes	Yes
Entire trees including crowns removed	Soil only	Yes	Yes	Yes

Figure 6. The three situations compared by the scientists.

Reflection Section

- What larger social issue does this research address? (Hint: it has to do with something we use everyday for just about everything we do.)
- Describe the questions the scientists wanted to answer.

Method

The *average* amount of energy contained in a hectare of southern pine forest had already been calculated by other scientists. As well, the amount of energy used when fertilizer is produced, packaged, transported, and applied had been calculated earlier by other scientists (**table 1**). The scientists in this study were able to use this information without having to calculate it themselves. This is similar to what you do when you use information from the Internet, the library, or other source.

Table 1. Amount of energy in megawatt hours contained in a *megagram* (Mg) of forest *biomass*; and amount of energy needed to produce, package, transport, and apply 1 kilogram (kg) of phosphorus and nitrogen fertilizer.

Amount of energy contained in a Mg of forest biomass	5.64 MWh
Amount of energy used to produce, package, transport, and apply 1 kg of nitrogen fertilizer	0.0021 MWh
Amount of energy used to produce, package, transport, and apply 1 kg of phosphorus fertilizer	0.022 MWh

The scientists identified an area of forest with 37-year-old southern pines on the Kisatchie (kuh **sach** e) National Forest in Louisiana (**figure 6**). The size of the area was 0.6 hectares. First, they divided the area into three experimental plots. Each plot was the same size.

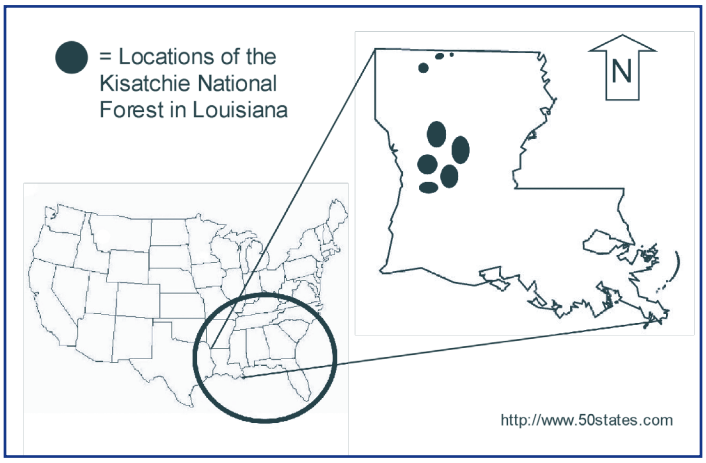


Figure 6. Locations of the Kisatchie National Forest in Louisiana.

The scientists calculated how much energy, measured in megawatt hours, is contained in the crowns of the three plots. They assumed each of the plots were equal in the amount of energy they contained.

The scientists then arranged to have the trees cut and removed (**figure 7**). In the first plot, only the boles were removed. The tree crowns were left on the ground. In the second two plots, entire trees, including the crowns, were removed. They applied fertilizer to the third plot. Then, they planted seedlings on all three plots so that a new generation of trees could grow (**figures 8 and 9**).

Figure 7. The scientists arranged to have the trees cut.

Number Crunches

What was the size in hectares of each of the experimental plots? What was the size in acres? (One hectare is equal to 2.47 acres.)

Figure 8. Seedlings were planted on all three plots.

Figure 9. Over time a new generation of trees were allowed to grow.

The scientists calculated how much energy was used to acquire and apply nitrogen and phosphorus fertilizers to the third plot. Then, the scientists waited 10 years. At the end of the 10 years, the scientists calculated how much energy might be available in the tree crowns growing on each of the three plots. They added the amount of energy available in crowns before the trees were cut with what they calculated was available in tree crowns after 10 years of growth.

Reflection Section

- The scientists used information that had been previously calculated by others. For the scientists' research to be accurate, what do you think they needed to do and how should they feel about this information? In what ways do you or should you do the same thing when accessing information over the Internet?
- What three things were the scientists comparing in this study?

Findings

The results of the experiment are shown in **table 2.**

Table 2. Amount of biomass and energy used in each of the plots. See key on page 44.

Experimental plots	Gain in energy in megawatt hours per hectare from the present cutting and use of tree crowns	Gain in energy in megawatt hours per hectare after 10 years of growth	Loss in energy in megawatt hours per hectare due to cutting trees and fertilizing after 10 years	Net amount of energy gain in megawatt hours per hectare after 10 years
Removal of tree boles only	0 (Because the crowns were left on the ground and not used for energy)	0 (Because the crowns were left on the ground and not used for energy)	0 (Because the crowns were left on the ground and not used for energy)	0 (Because the crowns were left on the ground and not used for energy)
Removal of whole trees	115*	0 (Because no additional fertilizer was added to the soil.)	– 43****	72
Removal of whole trees and fertilizing	115*	137**	– 1.2*****	250.8

The last column of **table 2** is the most important. The scientists discovered that fertilizing the soil after cutting trees and removing the whole tree is a good way to ensure a higher energy potential in tree crowns after 10 years. Some scientists previously thought that the energy it takes to fertilize might not pay off in potential energy gains.

Key to Table 2

* Remember the scientists assumed that all plots started with the same amount of energy in their tree crowns that might one day be used.

** This number represents the gain in energy potential in the tree crowns after 10 years of growth. The gain is a result of adding fertilizer to the soil after cutting the trees and before planting new trees.

**** This number represents a loss in energy potential. This loss is caused because the trees did not grow as large as they could have. They did not grow as large because the crowns were removed from the site after the trees were cut. Remember that the crowns provide some nutrients to the soil that help trees grow.

***** This number represents the loss of energy caused by having to package, transport, and apply the fertilizer.

Reflection Section

- Look at the last column of table 2. Why do you think the third plot shows a much higher energy potential than the second plot?
- In 10 years, tree crowns might be an important source of energy. Based on this research, what one thing would you recommend to someone wanting to plant southern pine trees for energy?

Discussion

This study focused on southern pine forests. *Forest managers* believed that on southern soils, the energy used to apply fertilizer would be greater than future gain in energy from tree crowns. This research shows the gains in potential energy are greater than the energy used to fertilize soil before planting trees.

The scientists will do their calculations again when the trees are 25 years old. When the trees are 25 years old, the scientists will cut the trees and measure how much energy is contained in the tree crowns. They will do this for all three plots. At that time, they will again compare energy gain with energy used to fertilize the soil.

Reflection Section

- Imagine you are living 10 years in the future. Do you think energy from tree crowns will be more or less important than it is now? Why or why not?

From: Scott, D. A. and Dean, T. J. (2006). Energy trade-offs between intensive biomass utilization, site productivity loss, and ameliorative treatments in loblolly pine plantations. *Biomass and Bioenergy* 30, pp. 1001-1010. http://www.srs.fs.usda.gov/pubs/ja/ja_scott007.pdf

If you are a Project Learning Tree-trained educator, you may use Activity #15: "A Few of My Favorite Things," or Activity #89: "Trees for Many Reasons"

FACTivity

Time Needed

1 class period

Materials

Blank sheets of white paper (one for each student), markers, and photos of different tree stands (on page 46).

Note: In advance, your teacher may want to examine the trees in the schoolyard to identify potential trees for this activity.

The questions you will answer with this activity are:

1. Why are trees managed differently?
2. What are some of the differences in managed trees versus unmanaged trees?

Before you begin, recall that trees are a valuable resource for the planet. They help to keep the air clean and hold soil in place. Trees absorb and hold carbon to reduce global climate change and provide homes for animals and other plants.

Trees are also renewable, meaning they can be planted, grown, and used for human needs. Some forests are planted and managed to eventually be used for wood products. Examples of wood products include furniture, lumber, and plywood. Any tree could be a source of biofuel, but some trees are better for different needs. Trees in managed areas—plantations, around houses, buildings, or schoolyards—can be groomed to create different forms. A tree farm manager may cut off limbs of trees to make them grow straighter and have fewer limbs. Some tree managers want the tree to have a wide low crown, so the tree will be cut on the top to grow out.

These different forms provide different uses as mentioned before. Straighter growing trees and trees with fewer limbs on the trunk may be better for lumber or pole products. Trees with many limbs may be used by wildlife for protection. Larger crowns provide a shady place for people and wildlife. Can you think of other forms of trees with different uses? Remember not all trees should be managed by people. Think of natural forests. How do trees grow and look in those areas?

Now, as a class:

With other classmates, brainstorm about how trees are managed in different ways other than for wood products. How are these trees similar or different from trees used for lumber? For example, ornamental trees in a schoolyard or around a home may not have a straight form, like pine trees grown for lumber. However, trees around the school and house need to be pruned and de-limbed so not to damage the house or school. Other trees are managed to provide food, such as fruits and nuts. See how many different things you can identify for which trees are managed.

Activity

1. Go outside. Select a tree and draw the tree's form on your sheet of paper. Focus on limb, crown, and trunk form.
2. If time allows, draw a second tree (preferably a different form) to have a comparison.
3. Inside: Examine the photos on the next page of differently managed trees and compare them with the trees you have drawn.
4. Think about the managed trees in the photos and their uses compared to the trees you drew. Can you guess how your drawn tree might be used and who might use it? Don't forget uses of the tree by wildlife, including mammals, insects, birds, reptiles, and amphibians.

Courtesy of Stephen Fraedrich, Forest Service

Courtesy of Barbara McDonald, Forest Service

Courtesy of Barbara McDonald, Forest Service

Courtesy of Barbara McDonald, Forest Service

Courtesy of Howard Schwartz, Colorado State University, http://www.bugwood.org

Courtesy of Barbara McDonald, Forest Service

Courtesy of Barbara McDonald, Forest Service

Additional information for the classroom

The title of this article, "How Now Round Crown?" is a take-off on the phrase, "How Now Brown Cow?" This phrase is nonsensical, having no real meaning, but has sometimes been used as a jovial greeting. The phrase was once used to teach rounded vowel sounds for proper public speaking. (From http://www.phrases.org.uk/)