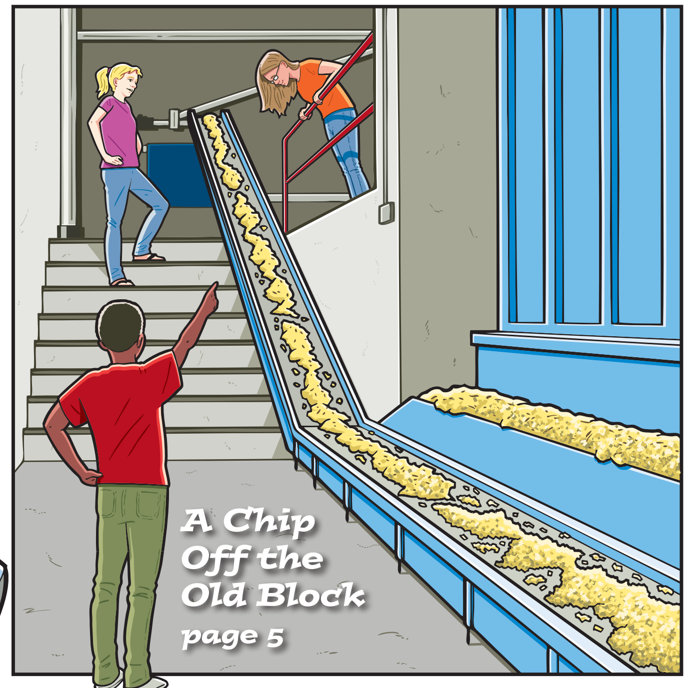
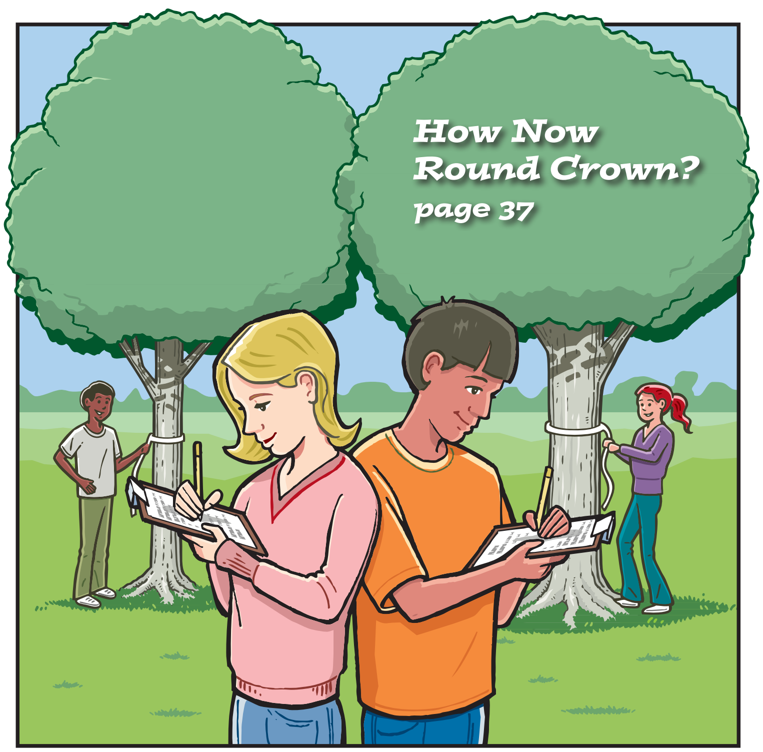
Natural Inquirer

Volume 9, Number 1

Bioenergy Edition





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Forest Service

Cradle of Forestry Interpretive Association

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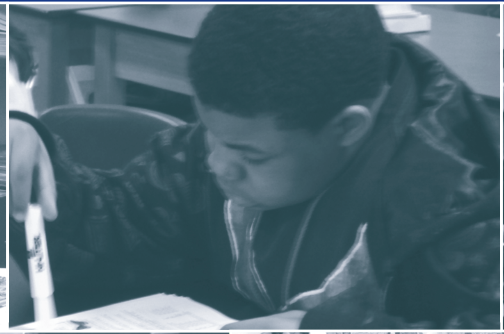
Contents

Editorial Review Boards


Natural Inquirer *editorial review boards hard at work.*

Comments from the *National Inquirer* editorial review boards:

"Thanks for the help to learn new words."

"It helped me to learn something new."

"I like the bees."

"The glossary should say which page each word appears on."

"Thinking About Science: Good ending—makes us think."

"I like how you put a glossary for words people might not know."

"Good work, I enjoyed looking at this."

"The pictures help out a lot."


Natural Inquirer *review boards.*
Michelle Rabold's 7th grade classes, Clarke Middle School, Athens, Georgia

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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 Forest Service, U.S. Department of Agriculture. If you want to know more about the Forest Service, you can read about it on the inside back cover of this journal, or you can visit the *Natural Inquirer* Web site at http://www.naturalinquirer.org.

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. 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 Bioenergy Edition of the *Natural Inquirer*!

What is energy? It is the ability to do work and the ability of certain forces in nature to do work. It is also thought of as the resources humans use to produce power, such as coal, oil, wood, wind, and gas. Everything living needs energy to grow, reproduce, and survive.

People use energy to do even more than grow, reproduce, and survive. People use physical energy to mechanically move from place to place; to heat, cool, and light buildings; to wash clothes; and to operate TVs and computers. As energy needs increase and our regular sources of energy become less available, society is more concerned with finding new sources of energy.

This edition of the *Natural Inquirer* is concerned with a new source of energy. The source of energy explored in this *Natural Inquirer* is really an old source. This type of energy was used before humans began using coal, oil, and gas. Can you guess what that energy source is? If you guessed wood, you are right! But it is actually more than just wood, because it can include a wide variety of plant material. Scientists now call this source of energy biomass, biofuel, or bioenergy.

What is bioenergy? The living (or once-living) material in an area is known as biomass. Bio means life. (Think of biology, the study of life.) Biomass can also refer to plant materials and animal wastes used as a source of fuel. In this case it is known as biofuel or bioenergy. In this edition of the *Natural Inquirer*, we'll explore ways that bioenergy contributes to our energy future.

Bioenergy is studied by scientists in a number of scientific areas. These areas include, for example, wood science; climate change; the development and care of forests (or silviculture [**sil** vuh **kul** chür]); and the production, distribution, and use of goods and services (or economics). Biomass studies help scientists understand how forest products can help address current and future energy questions. For example, bioenergy studies may look at the use of bioenergy for food, building materials, fuel, clothing, and paper.

How do you think the use of bioenergy for building materials can help address energy concerns? You will find out in this edition of the *Natural Inquirer*! Can bioenergy help a school save money so it can spend more on books and computers? You will see! You will also learn whether trees may be a future source of energy, and which trees might be best to heat your home or fuel your car.

Scientists believe we can replace 30 percent of our oil-based fuel with bioenergy. Of this bioenergy, 27 percent could come from forests, and 73 percent could come from agriculture. The use of bioenergy to address energy concerns has one very big advantage. Trees and crops are renewable! In contrast with oil, trees and crops can be planted, cared for, cut and used, and planted, again. The main sources of energy we use now, such as oil, coal, and gas, are not considered renewable because it would take hundreds or thousands of years to replenish their supply.

As you read the articles in this *Natural Inquirer*, think about the many ways forests can help address our energy future.

Educators: Review "Note to Educators" on page 47 before using this *Natural Inquirer*.

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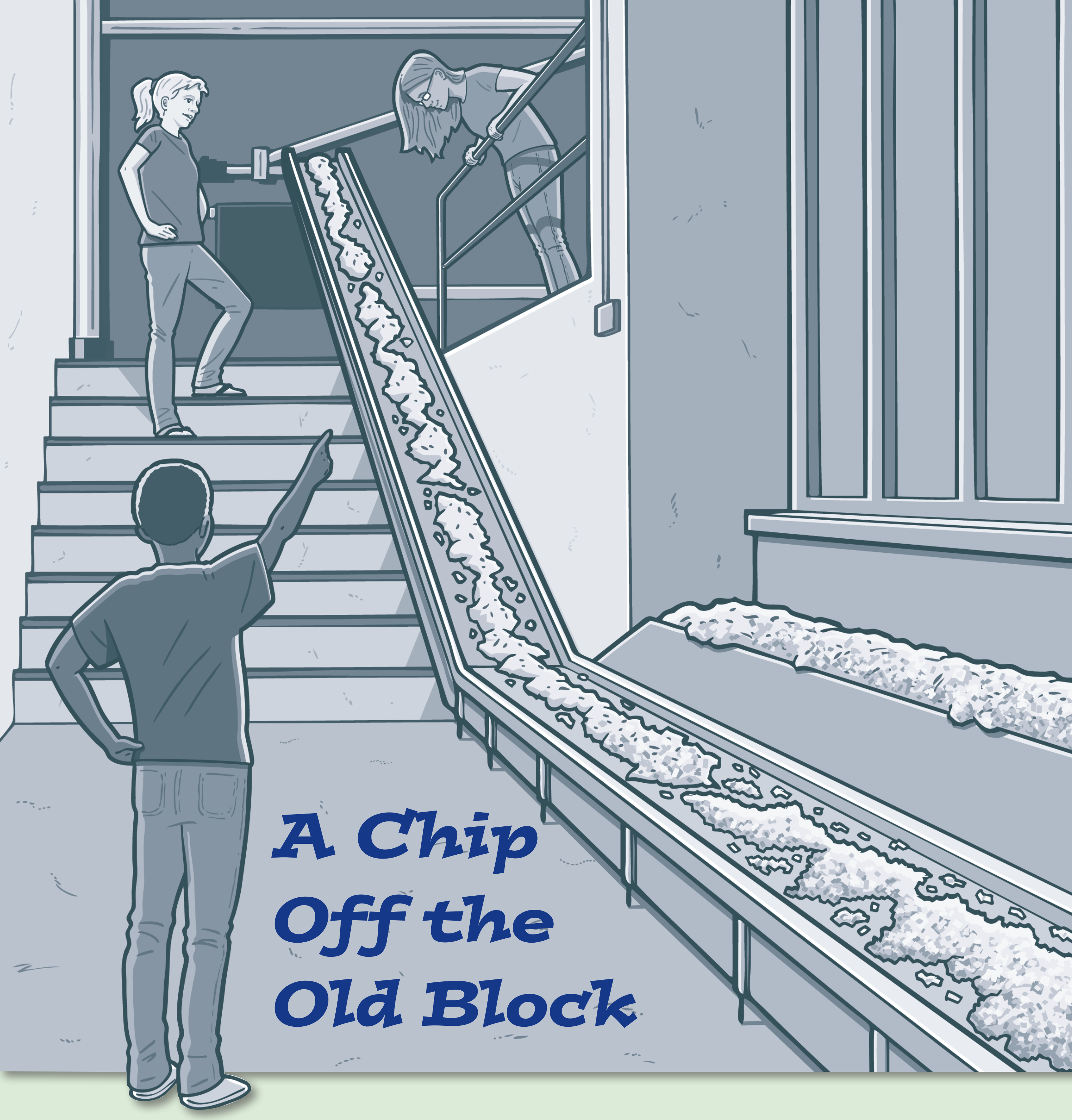
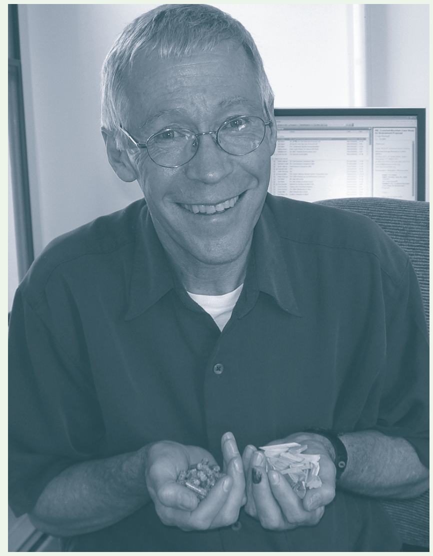


A Chip Off the Old Block

Using Wood Energy To Heat Schools

Meet the Scientists

Dr. Rick Bergman, Chemical Engineer: My favorite science experience was working with two communities in southern Mexico. The communities were hoping to use more of their *natural resources* to become more self-*sustaining* as a community. I was able to give them concrete ideas on how to dry wood that was cut from local trees. This allowed community members to manufacture wood furniture to sell to local schools. I was grateful to be a part of the team assisting other people who want a better life for themselves and their communities. ▼



▲

Dr. Tim Maker, Wood Energy Scientist: I studied engineering and physics in college. My memorable experience was when a professor explained to all of us in his physics class about what he did as a scientist. He had to know a lot about computers, electronics, and work very hard.

Glossary

natural resources (**na** cha rôl **re** sôrs es): Supplies of things in nature that take care of a human need, such as oil, wood, or water.

sustaining (suh **stan** ing): Keeping up or maintaining.

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

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

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

operational (**op** ür a shun ul): Of or relating to performance of practical work or operations.

renewable natural resource (re **nu** uh bool **na** cha rôl **re** sôrs): An environmental source of supply or support that can be renewed by ecological processes or management practices.

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.

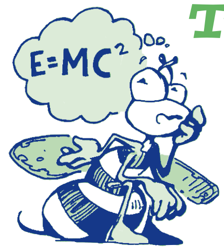
conventional (kän **ven** chun ul): Ordinary.

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



Research always has a purpose behind it. Is the research being done just to learn something new? Is its purpose to solve a problem? When scientists study a question to satisfy their curiosity about something, the research is called basic science. An example of basic science is when astronomers study the planet Mars. This kind of research is important, as it touches the mysteries of life. Often, basic science provides new information that can be used in the future to help solve problems. Most research being done today is done to solve problems. This kind of research is called applied science. Medical research is applied science, and most natural resource and environmental science is applied science. In the research you will read about in this article, the scientists hoped to solve a problem and help schools save money. Would you call this research basic or applied science?

Thinking About the Environment

You may have heard about the wildfires that sometimes burn in the Nation's forests. In some cases, wildfires now burn hotter, longer, and over a wider area than wildfires of the past. This is because many forests today contain a lot of fuel. This fuel is often made up of many small-sized trees, which are growing because forest fires have not been allowed to burn there in the past. Before human development occurred in and near forests, wildfires could burn and, when they burned, they burned the small trees and other vegetation near the forest floor. Now that development occurs near and in the forests, we have not allowed wildfires to burn. The result is a lot of fuel in the form of small trees. One way to address this problem is to cut the small trees.

Cutting trees is expensive. To many people, it makes more sense to have a use for any tree that has been cut. To other people, leaving the small trees to decay in the forest also makes sense. This is because a decaying tree returns *nutrients* to the forest soil. This article describes how schools used these trees to help them heat their buildings. In this research, the small trees were used in a wood heating system built just for the school. Do you think this is a good use for the small trees? Why or why not?

Introduction

As you read in "Thinking About the Environment," *forest managers* were looking for a way to use small trees that were being cut from the forests. One of the historic uses of wood was for heating. In recent years, however, most heating in the United States has come from other sources of energy, such as petroleum, gas, and electricity. The scientists in this study wondered if using wood for heating would save schools money compared to the way the schools are usually heated. The school district in Darby, Montana, was interested in the same question (**figures 1 and 2**).

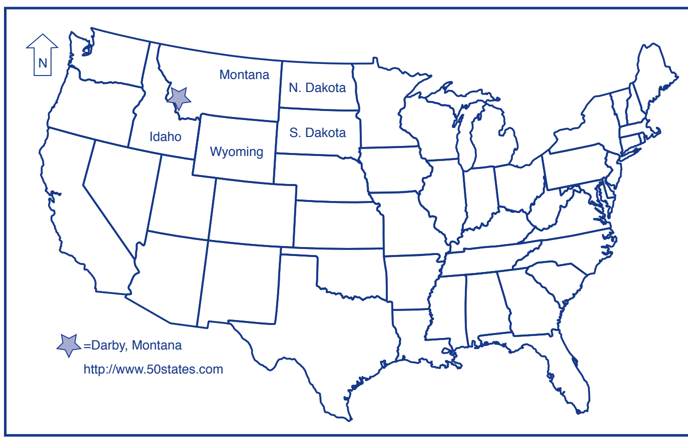


Figure 1. Location of Darby, Montana.

Figure 2. Darby Junior High School

Reflection Section

- What is the question the scientists wanted to answer?
- What would the scientists have to do to answer their question?

Method

The scientists worked with partners to build the wood heating system. Such a system uses biomass heat energy. The new heating system included the following parts:

1. Boiler house: A central building that houses the wood-burning boiler and a large wood storage bin (**figure 3**).
2. Wood heating system: Includes the boiler, the storage bin, and automated belts to carry the wood from the storage bin to the boiler (**figure 4**).
3. Heat distribution system: A series of underground pipes to carry the heat to the three schools. This system used existing pipes but improved them as needed.
4. Improvements to existing heating equipment: Wherever possible, existing equipment was used for the new system. Also, the existing oil heating system was improved so it could be used as a backup to the new wood heating system.

The scientists kept careful records of all costs to build and operate the new heating system. They tracked *operational* costs for 2 school years.

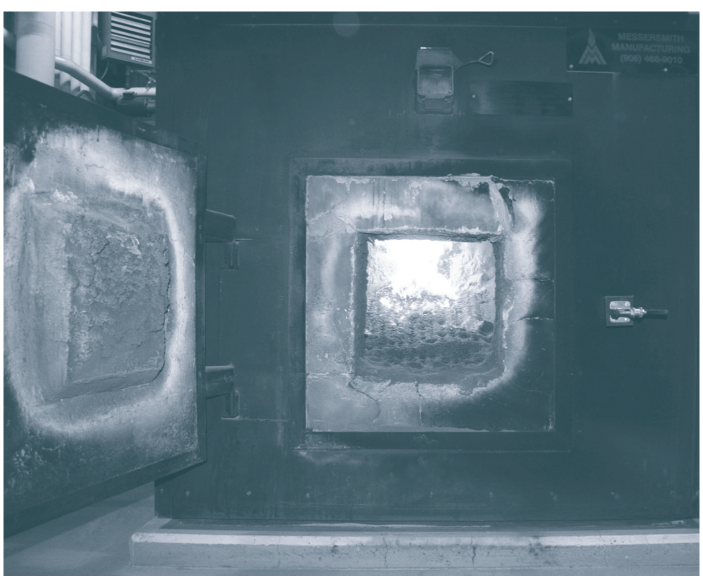


Figure 3. The Darby school's wood-burning boiler.

Figure 4. The Darby wood heating system. Note the wood is cut into wood chips and carried on a moving belt before it is stored in the storage bin.

Reflection Section

- Should the scientists include the following costs in their calculations: The cost of cutting trees, the cost of transporting cut trees to a mill for cutting into chips, and the cost of transporting the wood chips to the school? Why or why not?
- Biomass heat, which comes from wood chips, is considered a *renewable natural resource* because trees can be replanted. What is one advantage of using biomass energy over a nonrenewable resource such as oil? What is one disadvantage?

Findings

The scientists compared the costs of the new biomass heating system with *average* historical costs of heating with oil and gas (**table 1**). Previously, oil had been used to heat the schools, and liquid propane (LP) gas was used to produce hot water. The new biomass heat system heated both the schools and the water, eliminating the need for LP gas.

------Average Historical Usage-----------			--------------------2003–2004 School Year -------------			
OIL COST ($)	COST OF LP GAS ($)	TOTAL COST OF OIL/LP GAS ($)	OIL COST ($)	WOOD COST ($)	TOTAL COST OF WOOD/OIL	SAVINGS ($)
51,884	2,080	53,964	11,080	18,357	29,437	24,527

------Average Historical Usage-----------			--------------------2004–2005 School Year -------------			
OIL COST ($)	COST OF LP GAS ($)	TOTAL COST OF OIL/LP GAS ($)	OIL COST ($)	WOOD COST ($)	TOTAL COST OF WOOD/OIL	SAVINGS ($)
88,060	2,500	90,560	2,451	26,660	29,051	61,509

Table 1. Comparison of historic costs for heating and the new biomass energy system. Note that in 2004–2005, historical usage costs included an estimate for the rising cost of oil.

Reflection Section

- Look at **table 1**. You can see the cost of oil had risen between 2003 and 2005, and, therefore, the cost savings rose over the 2 years. Based on what you know about oil prices now, do you think the cost savings for Darby schools went up, down, or stayed the same during the last school year as compared with 2004–2005?
- Do you think the cost savings would be the same for a school located in Kansas as in Montana? Why or why not?

Number Crunches

- Estimate the percentage of the cost savings for both school years. You can do this by rounding the average total historic cost and the total yearly cost for both years. Round each to the nearest 1,000. For each year, divide the yearly cost by the average total historic cost, and subtract that number from 100. This will give you an estimate of the percentage cost savings for each year. Did the percentage of cost savings increase or decrease between the 2003–2004 and 2004–2005 school years? By how much?

Discussion

By using biomass wood energy for heating, the Darby School District saved almost 50 percent of its fuel costs in 2003–2004, and almost 70 percent in 2004–2005. These costs do not include the cost of building the new biomass energy system and improving the old heating system. For a moment, let's include those costs, which were a little less than $1,000,000. The scientists concluded that over a 20-year period of saving energy costs, the biomass heat energy system would pay for itself. This is largely due to the increasing costs of oil compared with the cost of wood chips.

It is costly to convert a *conventional* heating system into a biomass energy system, as was done in Darby. The scientists suggest the best time to install a biomass heating system is when new schools are being built. If new schools are close to a local source of wood chips, they should save a lot of money in energy costs.

Reflection Section

- Should the cost of replacing a conventional heating system with a new biomass system be considered when calculating cost savings? Why or why not?
- Should the cost of building a new biomass heating system at a new school be considered when calculating cost savings? Why or why not?

Adapted from Bergman, R. and Maker, T. M. 2007. *Fuels for schools: Case study in Darby, Montana*, Forest Service General Technical Report FPL-GTR-173. Madison, WI: Forest Service, Forest Products Lab. 21 pp. http://www.fpl.fs.fed.us/documnts/fplgtr/fpl_gtr173.pdf.

FACTivity

Time Needed

5 minutes at the end of a previous class period
1 class period

In this FACTivity, you will consider the source and availability of different types of energy for heating your school. The questions you will answer in this activity are:

1. What is the most reliable source of energy for our school right now?
2. What might be the most reliable source of energy for our school in 10 years?

Method

At the end of a previous class period, take approximately 3 minutes to do the following activity.

In a rapid brainstorming session with the entire class, list as many types and sources of energy as you can. Examples include U.S. offshore oil, oil imported from other countries, local wind power, electricity from water sources (turbines at dams), geothermal energy, electricity from nuclear power, etc. You may want to start by listing the types of power (such as electricity), then the sources for each (such as nuclear, water, etc.).

In the next 2 minutes, class members should organize into groups of four students, based on a type of energy identified. For example, one group might be the windpower group. Another group might be the biomass energy group.

For homework, research the sources and availability of your energy type. Take windpower, for example. Where are the best locations to place windmills? To use energy from windmills, what is the maximum distance a school can be located from the windmills? Write up one-half page to turn in for the assessment.

When you have had enough time to do your independent research, your teacher will take one class period to do the following:

10 minutes:

In your energy groups, you will compare and discuss your homework findings. In particular, you and other members of your group will discuss the sources available for your type of energy. You will evaluate how reliable the various sources of energy are for your school. On a scale of 1 to 4, your group and the other groups will assign a number to each energy source. If a source is very reliable for your school, assign the source a 1. Assign a 4 to sources that are not reliable. Consider such things as price and how much control the school would have over getting the energy, as well as whether the source is readily available.

Here is the scale:

1	2	3	4
Very reliable source	Somewhat reliable	Not very reliable	Not reliable source

In your group, identify reasons for your assessment. For example, if biomass energy is rated as a very reliable source of energy, there should be a reliable source of either crop-based or forest-based energy nearby.

10 minutes:

Choose one student from your group to report your findings to the class. As a class, identify the three most reliable sources of energy for your school. A student volunteer will write these on the whiteboard or blackboard.

10 minutes:
Now repeat the groups' exercise, projecting 10 years into the future. Based on what you know now, what do you think will be the most reliable source of energy in 10 years for your school? Why? What might the community need to do to develop that source of energy? Appoint a different spokesperson from your group to share the results of this second discussion.

10 minutes:
Hold a class discussion to identify which three energy sources are predicted to be the most reliable in 10 years. A student volunteer will write these on the whiteboard or blackboard.

10 minutes:
Hold a class discussion about what the community might do to achieve success in having a reliable source of energy in 10 years. Identify any actions you can take today to help achieve this goal.

If you have time, your class may implement some of the actions identified in the class discussion.

FACTivity Extension

If you have access to the Internet in your classroom, visit http://www.naturalinquirer.org, Educator Resources, Lesson Plans, for an additional lesson plan. This lesson plan allows your students to play the role of a community deciding whether to heat its schools with wood chips.

Additional Information For Your Classroom

The title of this article, "A Chip Off the Old Block," is a phrase that dates to 1621. The block to which the phrase originally referred probably would have been wood or stone. The phrase refers to a person or a thing that comes from the same thing or parentage, and implies its similarity (http://www.phrases.org.uk/).

Additional Web Resources

The Fuels for Schools Program: http://www.fuelsforschools.info/.

PLT

If you are a Project Learning Tree-trained educator, you may use Activity # 86: "Our Changing World"; and #14: Renewable or Not?"

Which Do You A-Door?

Comparing the Energy Needed to Make Wood and Steel Doors

Meet the Scientists

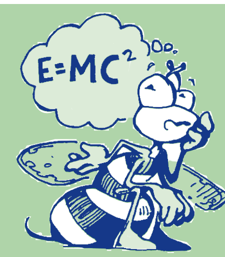
Melissa Huff, Chemical Engineer: My favorite science experience was when my physics classmates in college and I watched our professor dip a rubber ball into liquid nitrogen. He then dropped it, and the ball shattered. This is due to the temperature of the liquid nitrogen (-196 degrees Celsius or -321 degrees Fahrenheit). As you cool a gas down, the atoms move less and less rapidly. Eventually, the attractive forces between the atoms hold them together as a liquid. If you cool the rubber ball down in the liquid nitrogen, the atoms in the rubber become locked into position so they can't move past each other. The ball becomes very brittle, and it can easily shatter. ▼

▲

Janet Stockhausen, *Patent* Attorney: My favorite science experience is working with inventors. Inventors are excited about their inventions, and they love to show how their invention works. They also love to explain why it works, and why it is better than everything else like it. Inventors like to talk about the potential for making the world a better place. It is really fun to work with them. I love hearing the enthusiasm in their voices.

Robert Ross, Wood Engineer: My favorite science experience is working on research projects that ultimately result in technical advances that help people. For example, scientists like me do work that influences all of the building codes in the United States. Building codes directly affect how homes, schools, churches, gymnasiums, and other buildings are constructed. The research you will read about in this article focused on understanding the differences between wood and steel doors—ultimately, it will result in beautiful doors, made of wood that will provide the security of steel doors. ▶

Thinking About Science



When scientists want to compare things, they must use a common language. In this research, the scientists wanted to compare the environmental impact of making two different kinds of doors. The scientists went to the International Organization for Standardization (**stan** dürd uh **za** shun) for help. This organization creates *standards* for a wide variety of products and processes. The organization reported that two products can be compared if they provide the same *utility* to a *consumer*. The scientists decided that they could compare two different doors if both of those doors could be used to enter a house. Based on this standard, could you compare the utility of a plastic and metal fork? Why or why not?

Glossary

patent (**pat** ent): A document giving the exclusive right to make, use, or sell an invention for a number of years.

standards (**stan** dürds): Things set up as a rule or model with which other things like it are to be compared.

utility (u **til** uh te): The quality of being useful.

consumer (kän **sum** ür): A person or thing that consumes or uses something.

manufacture (**man** u **fak** chür): The making of goods or articles.

natural resources (**na** cha rôl **re** sôrs es): Supplies of things in nature that take care of a human need, such as oil, wood, or water.

fiberglass (**fib** ür glas): Glass in a fiber form used for making products, such as insulation.

partial (**pär** shul): Of a part, or in only a part.

database (**dat** uh bas): A large collection of information stored in a computer and organized so that it is available for use.

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.

extraction (ek **strak** shun): The act of extracting or pulling out by effort.

emissions (e **mish** ens): Something discharged or sent out.

solid waste (**saw** lid wast): Any solid or semi-solid liquid, or contained gaseous materials discarded from industrial, commercial, mining, or agricultural operations; and from community activities, including garbage.

waterborne (**wa** tür bôrn): Carried in or by water.

kiln (kiln): A furnace or oven for drying bricks, pottery, or other items.

molten (**môl** tun): Melted by heat.

carbon dioxide equivalent (**kär** bun di **ox** id e **kwiv** uh lent): A quantity that describes, for a given greenhouse gas, the amount of carbon dioxide that would have the same global warming potential when measured over a specific time period.

unit of measurement (**u** nit of **mezh** ür ment): A standardized quantity of a physical property, such as inches, meters, kilograms, etc.

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

Every product you buy was produced using energy. Every process used to create products also creates waste. In this research, the scientists wanted to compare the amount of energy used and amount of waste created in the *manufacture* of two different types of doors. This kind of comparison is called a life-cycle inventory (**figure 1**). Most life-cycle inventories include the amount of energy used and waste created from when the raw materials are gathered to make the product to when a consumer no longer wants and disposes of the product. In this research, the scientists were interested only in the energy used and waste created until the time the doors were ready to be shipped to a store.

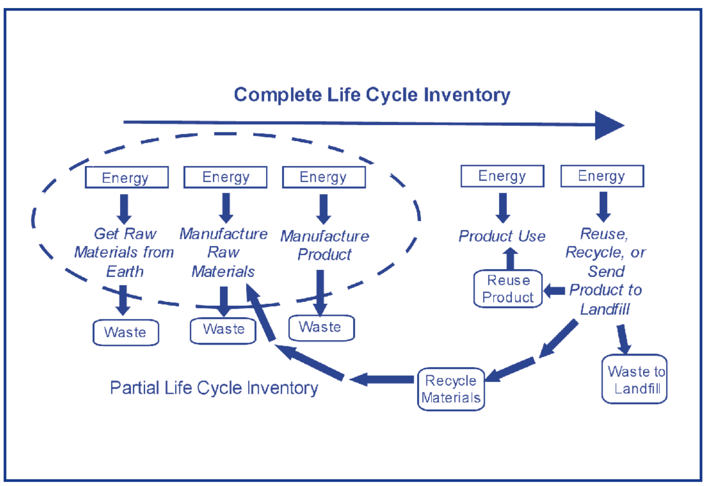


Figure 1. Life-cycle inventory. This shows the entire life-cycle inventory process. The part of the life-cycle inventory used in this research to compare the utility of two different kinds of doors is also shown. The result of a life-cycle inventory is a measurement of the environmental impact of one or more products. (Image courtesy of Franklin Associates http://www.fal.com)

Figure 2. The Forest Products Laboratory.

Introduction

The Forest Products Laboratory, located in Madison, Wisconsin, is a place where scientists work to develop wood products for human use (**figures 2 and 3**). The scientists at this laboratory develop processes for making wood products that use as few *natural resources* as possible. One of the wood products they developed was a wood door. The door was made using a process to strengthen the wood by including a small amount of *fiberglass*. The fiberglass made the wood door strong enough to be used in place of a steel door.

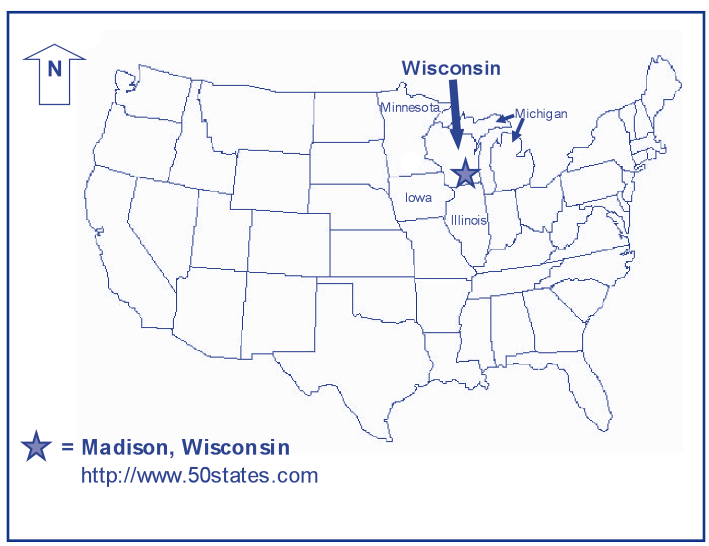


Figure 3. Madison, Wisconsin.

The scientists believed that wood doors and steel doors provide the same utility to a consumer (**figures 4 and 5**). If that is the case, they wondered which door would use less energy and create less waste up to and including the manufacturing process. To answer their question, the scientists conducted a *partial* life-cycle inventory to compare the two doors. In this article, the manufacturing process includes gathering and processing the raw materials for each door. As an example, for the wood door this includes harvesting the tree and transporting it to a mill.

Reflection Section

- In your own words, state the question the scientists wanted to answer.
- Where do people get the raw materials they need to manufacture products?

Method

The scientists first had to identify which raw materials are needed for a wood door made with fiberglass and which materials are needed for a steel door. They then had to identify where those raw materials come from. They made a diagram of the process used to manufacture a steel door and a wood door (**figures 6a and 6b**).

The scientists also had to identify how much energy is used for gathering raw materials and manufacturing each door, and how much waste is created in each process.

The scientists collected their information from a special *database*. The database is kept by a company that does a variety of life-cycle inventories. The scientists collected information about the *average* energy used to manufacture each kind of door. The categories of information collected were:

1. *Extraction*, transportation, and processing the <u>fuels</u> used in all the manufacturing processes.

Figure 4. Wood door. Photo courtesy of Lowe's.

Figure 5. Steel door. Photo courtesy of Lowe's.

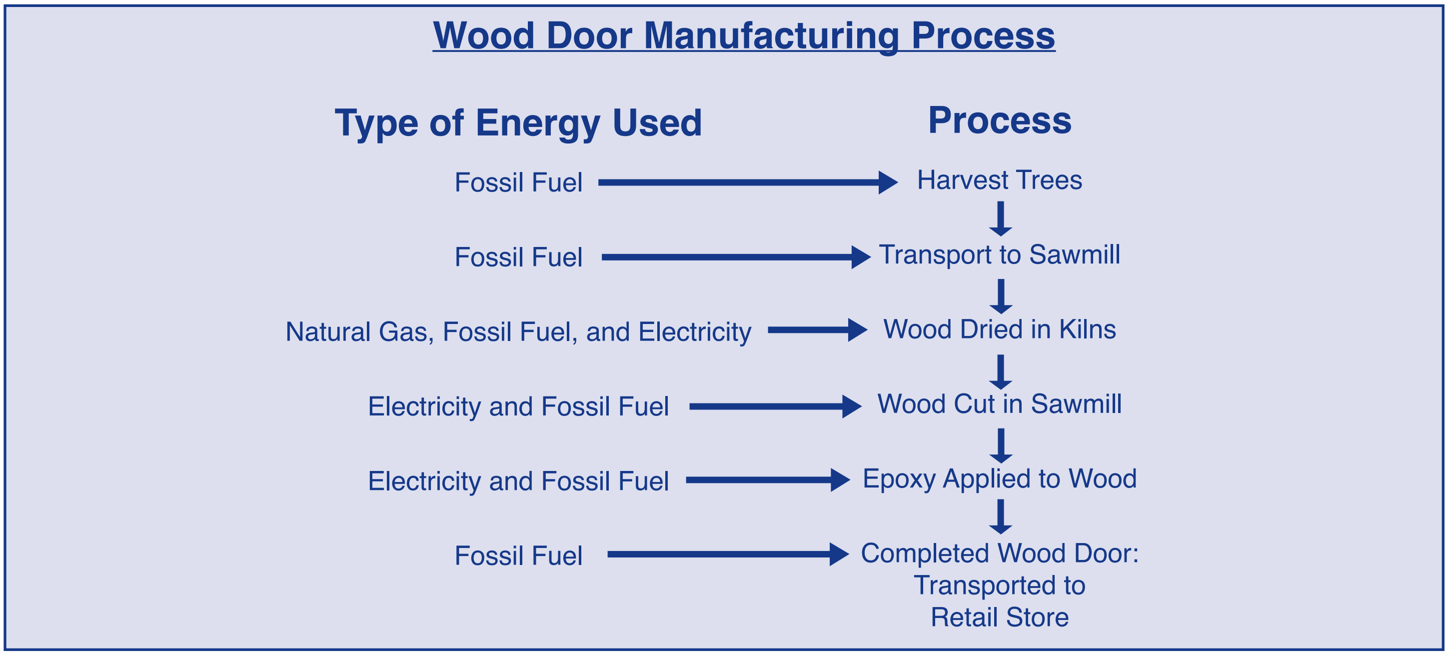


Figure 6a. A diagram, or flow chart, of the manufacturing process of a wood door.

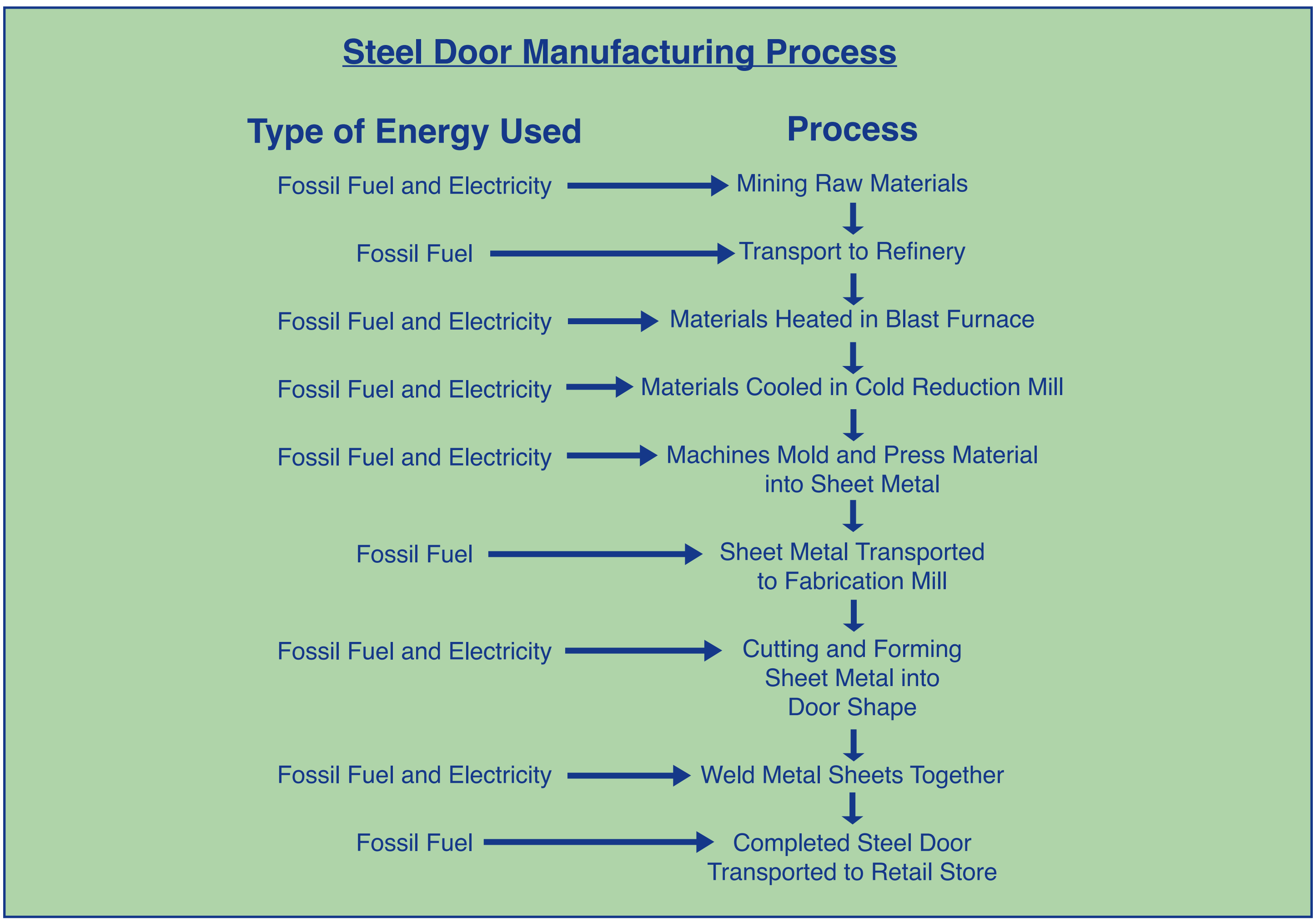


Figure 6b. A diagram, or flow chart, of the manufacturing process of a steel door.

2. Extraction, transportation, and processing the raw materials used in all the manufacturing processes.

The scientists also collected information about the average amount of waste products, including *emissions*, resulting from the manufacture of each kind of door. The categories of information collected were:

1. Air emissions.
2. *Solid waste*.
3. *Waterborne* waste.

Before a wood door can be manufactured, the raw materials for the door must be collected. For a wood door, trees are the main raw material used. When trees are harvested, energy is used and pollutants are produced. Pollutants are produced from the cutting equipment and machinery, and include more than air emissions (**figure 7**). Soil erosion can result in water pollution in the form of soil particles in the water. The cut logs are taken to a sawmill, the bark is taken off, the logs are cut into boards, and then dried in a *kiln*. The wood door is strengthened with fiberglass. All of these processes require energy and result in environmental emissions.

Figure 7. Wood harvesting operation.

Before a steel door can be manufactured, mining for raw materials must be done. Mining for iron ore, zinc, limestone, and coal is necessary to manufacture steel (**figures 8a and 8b**). Most of these materials are placed in a blast furnace to produce a substance called pig iron. The *molten* pig iron is further heated and poured into molds, where it is cooled and made

Figures 8a and 8b. Surface mining operations. Photos courtesy of Peter Robey Mining Photography.

into sheet metal. The sheet metal is galvanized (**gal** van izd) by being coated with a thin layer of zinc. This process protects the sheet metal from rust. During manufacture, the inside of steel doors are filled with a material, a form of polystyrene (**paw** le **sti** ren), like Styrofoam. All of these processes require energy and produce environmental emissions.

When steel doors are manufactured, the sheet metal must be cut, welded, stamped, and the door filled with polystyrene. Then the door must be painted. While these processes create a lot of emissions and solid wastes, some of the solid waste products can be recycled.

The scientists calculated how much energy is used and how much emissions are created in the manufacture of each door. The information they collected included:

1. Number of airborne substances released.
2. Number of waterborne substances released.
3. Total energy use in gigajoules (**gig** uh julz).
4. Solid waste in kilograms.
5. Greenhouse gas emissions in kilograms of *carbon dioxide equivalents*.

Reflection Section

- The scientists included the energy used and emissions produced when the raw materials were collected, as well as the manufacture of each door. Why do you think they included the gathering of raw materials in the life-cycle inventory?
- Do you think the scientists found it takes more energy to manufacture a wood door or a steel door? Why?

Findings

The scientists calculated amounts for 44 airborne emissions released to the environment, including 3 greenhouse gases. They also calculated amounts for 32 waterborne wastes released to the environment, as well as solid wastes and the amount of energy used in the manufacturing process. **Tables 1–5** show the results of their research.

Table 1. Number of airborne emissions produced by the manufacture of a wood door and a steel door.

Airborne emissions for which:	Number of emissions
Steel door was higher	31
Emissions were reported for steel door but not for wood door	5
Steel door was lower	7
Emissions were reported for wood door but not for steel door	0
No difference found	1

Table 2. Number of waterborne wastes produced by the manufacture of a wood door and a steel door.

Waterborne wastes for which:	Number of emissions
Steel door was higher	28
Emissions were reported for steel door but not for wood door	4
Steel door was lower	0
Emissions were reported for wood door but not for steel door	0
No difference found	0

The amount of energy used in the manufacture of a steel door and a wood door was measured in gigajoules (**GJ**) (**table 3**). One GJ is equal to about 278 kilowatt hours (kWh), or 238,000 nutritional calories. The joule is a member of the international system of units (SI), the modern form of the metric system.

Table 3. Total amount of energy, measured in GJ, used in the manufacture of a wood door and a steel door.

	Total energy (GJ)
Steel door	2.17
Wood door	0.10

The amount of solid waste produced in the manufacture of the doors was measured in kilograms (kg). **Table 4** shows the amount of solid waste produced in the manufacture of each door, measured in kg.

Table 4. Amount of solid waste produced in the manufacture of a wood door and a steel door.

	Total amount of solid waste produced (kg)
Steel door	22.3
Wood door	0.51

Number Crunches

- Let's say the average daily energy use in a home is 15 kWh. How many days will it take before the amount of energy used in that home is equal to the total amount of energy used to manufacture a steel door? How many days will it take to equal the amount of energy used to manufacture a wood door? (Remember: 1 GJ is equal to about 278 kWh.)
- While doing vigorous exercise such as running, an adult burns about 100 nutritional calories each hour. How many hours will it take to burn 1 GJ of energy? How many days of vigorous exercise will it take the adult to burn 1 GJ of energy? How many days of vigorous exercise will it take for the adult to burn the amount of energy used in the production of a steel door and a wood door? (Remember, 1 GJ is equal to 238,000 nutritional calories.)
- One kilogram is equal to about 2.2 pounds. Create your own **table 4** using pounds, instead of kilograms, as the *unit of measurement*.

Table 5 presents the potential of three greenhouse gases to contribute to global warming during the manufacture of each door. This amount is expressed in relation to the global warming potential of carbon dioxide over a 100-year period, which is set at 1. In other words, if another greenhouse gas has a value of 2, it has twice the global warming potential of carbon dioxide over a 100-year period. The gases listed in **table 5** are the three largest contributors to global warming.

Table 5. The amount of greenhouse gases produced during the manufacture of wood and steel doors.

Gas	Global warming potential of gas	Steel door (kg of carbon dioxide per door)	Wood door (kg of carbon dioxide per door)
Carbon dioxide	1	135	5.11
Methane	23	5.87	0.13
Nitrous oxide	296	0.10	0.0051
TOTAL	No Total	141	5.25

Reflection Section

- Examine **tables 1–5**. What conclusion can you make about the production of a steel door in comparison with the production of a wood door?
- Based on the findings you have just read, what would you predict about the environmental impact of manufacturing a steel table compared with manufacturing a wood table?

Discussion

According to this research, the manufacture of a steel door results in more air emissions, more waterborne pollutants, and more solid waste than the manufacture of a wood door. A steel door also requires more energy in its manufacturing and results in a greater potential to contribute to global warming. The manufacture of a steel door, in fact, consumes 21 times the amount of total energy and produces over 40 times the amount of solid waste compared to the manufacture of a wood door.

Reflection Section

- This life-cycle inventory showed that more energy is used and more waste produced in the manufacture of a steel door. What might be one advantage of using a steel door instead of a wood door in your home? Do you think this advantage of using a steel door outweighs the disadvantage of its greater environmental impact? Why or why not?
- If you were employed by a home improvement store in your community, what would you tell a homeowner who has come into your store wanting to buy a new door for his or her home?

From: Knight, L., Huff, M., Stockhausen, J. I., and Ross, R. J. 2005. Comparing energy use and environmental emissions of reinforced wood doors and steel doors. *Forest Products Journal*, 55 (6): pp. 48-52, http://www.fpl.fs.fed.us/documnts/pdf2005/fpl_2005_knight001.pdf.

FACTivity

Time Required

One class period

Materials Needed

1. One large raw potato
2. One 10-ounce bag of plain potato chips
3. One blank sheet of paper and a pencil for each group

The research question you will answer by doing this FACTivity is: "Does a baked potato or a 10 ounce bag of potato chips require more energy when it is produced for human consumption?" This question is similar to the question asked by the scientists in this research, except the scientists compared two doors instead of two kinds of potatoes. You may want to re-read the last paragraph of the "Introduction" to remind you of the scientists' research question.

When the scientists compared doors, they compared doors of equal utility. This means that both doors could serve the same purpose for an individual. When you compare two kinds of potatoes, are you comparing products that serve the same purpose for an individual? How do the two types of products (doors and potatoes) compare?

Method

The method you will use to answer the research question is:

Consider the following: Just as doors have a premanufacturing stage and a manufacturing stage, the two potato products have a preprocessing and a processing stage. Potatoes must be planted, grown, dug, and transported to a facility for processing before they can be shipped to a supermarket shelf.

In small groups, brainstorm the steps that must be taken before potatoes are shipped to a facility for processing. For both kinds of potato products, this preprocessing stage will be the same. Once the potatoes get to their facilities for processing, each type of potato will be processed differently. Write down the steps that must be taken, and identify the kind of energy needed for these steps.

Example:

STEP	ENERGY NEEDED
Plow field before planting	Diesel fuel for machinery
Plant potatoes	Diesel fuel for machinery

Once you have done this, you must now consider what kind of processing is needed to prepare each potato product and transport it to a store. In the case of the potato, processing may only include cleaning, sorting, bagging, and transporting. It takes more steps to create potato chips, even before they are placed in bags for shipping to stores. Although you may have never been to a potato chip processing plant, see if your group can imagine what steps must be taken from the time a potato arrives at the plant to the time it leaves the plant as a bag of potato chips. Use the same format to record the steps that you used when you imagined the steps required to get a potato to the processing plant. Remember to do this for a potato, as well as for the potato chips.

Remember that you must consider all steps needed before human consumption for both kinds of potatoes.

You should now have a good idea of the steps and types of energy required to process a potato and a bag of potato chips for human consumption.

As a class, compare the steps each group has developed for each type of potato. Discuss the amount of energy that might be required by each type of potato product. Although you will not know exactly how much energy each type of potato product requires for processing, you should have a good idea of which type of potato processing requires more energy.

Now answer your research question: Which potato product requires more energy to be processed for human consumption?

FACTivity: Go Outdoors

Time required

One class period

Materials needed

One 12″ new or used clay pot
One 12″ new or used clay saucer
One 12″ new or used plastic pot
One 12″ new or used plastic saucer
One new or used metal trash can lid (with no holes)
One large new or used sturdy plastic bucket
Acrylic sealant (brush-on or spray can)
Paint brush (if using brush-on sealant)
Heavy-duty outdoor glue
24″ rope
Two bricks (one preferably with holes)
Flat rock, about 4″ in diameter

In this FACTivity, you will answer the question: How does the energy use involved in the construction of three home-made bird baths compare when they are constructed?

This FACTivity involves a partial life-cycle inventory. The research article you read described a partial life-cycle inventory involving the manufacturing process up to production of the product. Complete life-cycle inventories include use, reuse, recycling, or disposal of the product. You will construct three bird baths from either new or recycled materials.

Method

The method you will use to answer the research question is:

Your class will construct three different bird baths using either new or used materials. After construction, each bird bath will be compared on the basis of whether its construction involved new or recycled materials.

Birdbath #1: Clay pot, clay saucer, sealant
Birdbath #2: Plastic pot, plastic saucer, glue, flat rock
Birdbath #3: Plastic bucket, metal trash can lid, bricks, rope

Divide into three groups. Each group will construct one birdbath. Construction and placement should occur at about the same place. Place your birdbaths in an area away from bushes or other low vegetation, but close to a tree if possible. Low vegetation may hide predators, and trees will provide a place for birds to perch.

Birdbath #1:

1. The day before, seal the clay saucer with sealant.
2. Turn the clay pot over and position it where you want to place the birdbath.
3. Place the clay saucer on the over-turned pot.
4. Fill the saucer with water. Place fresh water in the saucer every day.

Birdbath #2:

1. Turn the plastic pot over and position it where you want to place the birdbath.
2. Glue the plastic saucer on the over-turned pot.
3. Place a flat rock in the center of the birdbath for stability.
4. Fill the saucer with water. Place fresh water in the saucer every day.

Birdbath #3:

1. Place the plastic bucket where you want to place the birdbath. This birdbath should be placed where there is complete shade during the hottest part of the day.
2. Place one of the bricks in the bottom of the bucket for stability.
3. Measure the bucket's height and subtract 4 inches. Cut the rope to this length.
4. Tie one end of the rope to the handle on the trash can lid.
5. Tie the other end of the rope around the second brick.
6. Place the trash can lid upside down on the bucket, letting the brick dangle inside the bucket. The brick will provide stability for the trash can lid.
7. Fill the trash can lid with water. Place fresh water in the lid every day.

Now that you have made your birdbaths, it is time to compare them. Each group will assess its own birdbath. This can be done inside the classroom.

Make a list of the materials used for your birdbath. Note if the material is new or used. You may use the example below to create your chart.

Type of Birdbath:

MATERIAL	NEW OR USED?	NUMBER OF POINTS
Clay pot	New	
Trash can lid	Used	
Glue	New	
TOTAL POINTS	-----------------	

If the material used is new, give it one point. If the material is used, give it a zero. Now add the points for your birdbath. If your birdbath was built entirely from used materials, it should have received zero points.

As a class, compare the point values of each birdbath. What do those values tell you about the energy needed to construct each birdbath? What does this comparison tell you about the energy involved in the use of new and used materials for construction?

If you are a Project Learning Tree-trained educator, you may use Activity #69: "Forest for Trees."

Chip and Truck

Comparing the Cost of Using Trees to Heat Buildings

Meet the Scientists

Dr. Silverstein, Landscape Ecologist: I enjoyed studying coyotes (ki **ots**) in Yellowstone National Park because it involved trying to understand the mysteries of the daily life of a wild animal. I watched coyotes' behavior, tracked their movements, and recorded their interactions with other animals. I got to know them better than I ever could from reading books or watching television. There is no better experience than getting out in nature to learn.

▼

Dr. Jones, Research Forester: My favorite science experience is making a scientific discovery that people find useful. Recently, we discovered that using cut, small trees for energy reduces the production of greenhouse gases by 50 percent compared to burning the small trees in the forest.

▼

▲

Dr. Loeffler, Forest *Economist*: My favorite science experience is canoeing brackish water areas in the Chesapeake Bay, observing estuary (**es** chu wair e) wildlife like birds, crabs, snakes, and fish. An estuary is a body of water at the mouth of a river with open access to the ocean and under the influence of ocean tides.

▲

Dr. Calkin, Forest Economist: My favorite science experience is working with forest fire managers to apply economic concepts. Applying these concepts helps us understand how best to balance taxpayers' costs of managing wildfires against the changes to natural resources that come from wildfires.

Meet the Scientists

Dr. Zuuring, Mathematical Scientist: My favorite science experience is being a judge at the Montana Science Fair held annually in March. I get to interact with students from grades 6 to 12 and learn about their science projects. ▼

▲ Mr. Twer, Landscape Ecologist: My favorite science experience is working with a Stirling engine. A Stirling engine is an engine that can use any heat source to create energy. A Stirling engine is quieter and requires less maintenance than the kind of engines used today. In the future, we may be using Stirling engines for more of our energy needs.

Glossary:

economist (e **kän** uh mist): A scientist who studies economics. Economics is the study of the way goods, services, and wealth are measured, produced, distributed, and used.

variables (**ver** e uh bulz): Things that can vary in number or amount.

simulate (**sim** yoo lat): To create the effect or appearance of something for purposes of evaluation.

abstract (**ab** strakt): Not associated with a specific instance; theoretical.

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

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

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

wildfire (**wild** fir): An uncontrolled wildland fire started naturally or by careless human action.

facility (fuh **si** luh te): Something that is built to serve a particular purpose.

thermal (**thür** mul): Of, related to, or caused by heat.

revenues (**reh** vuh nooz): The total incomes produced by a given source.

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

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.**

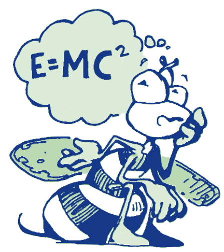
Glossary:

net revenues (net **reh** vuh nooz): What is left of the revenue after costs are paid.

economically (e ko **nom** ik le): Having to do with the management of money in a home, business, or government.

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.

Thinking About Science



Some scientists study complex systems. Complex systems are ones in which many different *variables* are related and affect one another. An example of a complex social system is your school or even your classroom. An example of a complex natural system is a forest, a pond, or even a single tree. Scientists use computer models to help them better understand complex systems. A computer model is a computer program that attempts to *simulate* an *abstract* model of a system. The computer model contains the assumed relationships between variables. When *data* are entered into the model and the computer program is run, scientists can see what might happen under different circumstances. An *equation* in algebra is a simplified version of a computer model.

Thinking About the Environment

Forest managers have a number of choices when they manage an area of forest. Each possible choice creates a different outcome. You face a similar situation in your own life. Think about one situation in your life where a different choice would have created a different outcome. In this research, the scientists wanted to help forest managers understand the outcomes of different choices.

When trees are cut from a forest, the largest trees may be used for lumber and other wood products. The smaller trees may be left standing or cut to reduce the threat of *wildfire*. After being cut, small trees may be piled together and burned. Another option is to cut the small trees into pieces, called woodchips, and take them to a special *facility*. At this facility, the woodchips are burned to create thermal energy that heats buildings.

As you may know, the cost of oil goes up and down. The supply of oil is less secure. One option for fuel is to use woodchips to provide energy. In this study, the scientists compared the cost of using woodchips for *thermal* energy with the cost of burning the small trees in piles in the forest.

Introduction

In the Western United States, many of the forests have too many small trees (**figure 1**). These small trees increase the risk of wildfire. Forest managers, therefore, want to remove the small trees. Some scientists believe these small trees may be a good source of fuel. To explore this possibility, a program called "Fuels for Schools" was created in Montana. As a part of this program, a special facility was built near the schools. This facility takes woodchips from surrounding forests and burns them to create thermal energy. Schools were chosen because they are public buildings and might benefit from being able to save fuel costs.

Figure 1. Western forest with too many small trees.

When small trees are cut into woodchips and hauled by a truck to the facility, money is spent on fuel to cut the woodchips and haul them (**figures 2a and 2b**). When small trees are burned instead, less money is spent on fuel. The scientists in this study wanted to compare the costs of and *revenues* gained from using the small trees for thermal energy with the cost of piling and burning the small trees. In both cases, the larger trees were sold to a mill to be made into lumber.

Are Forest Fires Bad?

Many people think forest fires are always a bad thing. Before the United States was settled by Europeans, fire was a normal part of a forest's life. Fire can provide many benefits to a forest. Fire helps return *nutrients* to the soil as it burns leaves, small branches, and bark on the forest floor. This also helps to reduce fuel so fire is not as likely in the next year. When the forest floor is opened by fire, sunlight can reach the ground, enabling new plants and trees to get their start.

Fires usually kill weakened trees. These are trees with destructive insects or diseases. When weakened trees are killed, the spread of destructive insects and diseases is slowed. Without fire, too many trees can grow in a forest. When too many trees are present, it is more difficult for trees to grow to a large size. The smaller trees increase the risk of a large wildfire. Removing smaller trees where there are too many makes it possible to have the type of fire that benefits a forest.

You can see that fire is not always a bad thing for a forest. In fact, occasional fires can help keep a forest healthy.

Figures 2a and 2b. Diesel fuel must be used to cut woodchips and haul them.

Reflection Section

- What question did the scientists want to answer?
- What are the sources of the two types of fuel being compared in this study? Which of these fuels is renewable?

Method

The scientists selected areas in the Bitterroot National Forest in western Montana (**figures 3 and 4**). These areas provided everything the scientists needed to answer their question. Forest fires had not been allowed to burn for many years in these study areas, so there were a lot of small trees growing. More people were moving to the Bitterroot area, so there was a need for energy to heat buildings. There were two facilities in the area that could turn woodchips into thermal energy. There was also a mill that could take the larger trees and turn them into lumber for wood products.

Using a computer program, the scientists simulated cutting trees with a d.b.h. of 7 inches or less. (See sidebar to learn about d.b.h.) The scientists also simulated cutting some of the larger trees, which could then be sold for wood products. The scientists estimated the costs of and revenues gained from cutting small trees into woodchips. They estimated the costs of and revenues gained from hauling the chips to one of the two facilities to create thermal energy. They also estimated the revenues gained from selling the larger trees for wood products. The scientists then estimated the costs of piling the small trees and burning them after they were cut.

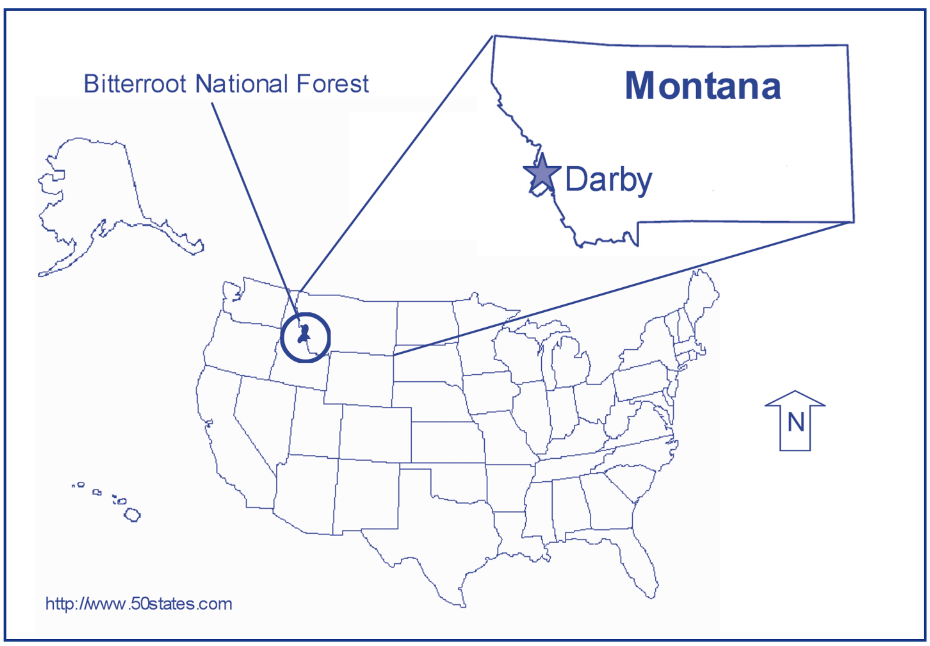


Figure 3. The Bitterroot National Forest in western Montana.

What is d.b.h.?

Diameter at breast height, or d.b.h., is a standard way to measure the size of trees. The diameter of a tree's trunk is measured at 4.5 feet, or 1.37 meters, from the forest floor. If the tree is on a hill, the measurement is made from the uphill side of the tree. What would happen if the diameter of tree trunks was measured anywhere a forester felt like measuring it? Would such a measurement be useful? Why or why not?

Figure 4. Landscape of the Bitterroot National Forest in western Montana.

The scientists created an equation to include all of the costs and revenues. In their equation, the small trees could be treated in one of four ways: (1) Cut down and burned; (2) Cut down, cut into woodchips, and hauled to a facility in Darby, Montana; (3) Cut down, cut into woodchips, and hauled to a facility in Frenchtown, Montana; or (4) Cut down, cut into woodchips, and hauled to either Darby or Frenchtown. Each of these options costs something. For example, it takes fuel to cut down trees. It also takes fuel to cut trees into woodchips and drive them to a facility. In each situation, the larger trees were cut down and hauled to a mill to be turned into lumber.

The scientists had to calculate all of the costs and revenues. To estimate hauling cost, for example, they had to multiply the number of miles driven times the per mile cost of owning and operating a truck, including the fuel used. To calculate revenue, they had to estimate the number of tons of woodchips cut from each area, and multiply the number of tons by how much money they would get from each ton.

When the scientists had all of the numbers they needed, they entered the numbers into a computer program. The computer program compared burning small trees with cutting and hauling woodchips from the study areas in the forest. The computer program also contained the equation that would subtract the costs and add the revenues for each of the four options.

Reflection Section

- Whenever people make a choice to do one thing rather than something else, there are costs and benefits to each choice. Think about a choice you recently made. Identify the costs and benefits of that choice, compared with another choice you could have made instead. Remember that costs involve more than just money. For example, time, or even the loss of a friendship, can be considered a cost.
- In this study, there is one cost in particular that continues to rise. What is that cost? How do you think this cost might affect the scientists' results if they did this study next year?

Findings

The scientists discovered the distance woodchips were hauled was the most important variable to consider when choosing between burning small trees and cutting woodchips. The farther the distance between where the trees were cut and the thermal energy facility, the more costly it was to cut woodchips for thermal energy. When woodchips could be hauled to either Darby or Frenchtown, the *net revenues* were higher. When all chips had to be sent to Darby, there was still net revenue, but not as much. When all chips had to be sent to Frenchtown, the cost went up and net revenue went down. This was because Frenchtown was not as centrally located as Darby to the forested areas (**figure 5**). In this case, it made more sense *economically* to burn more of the small trees at the forested sites.

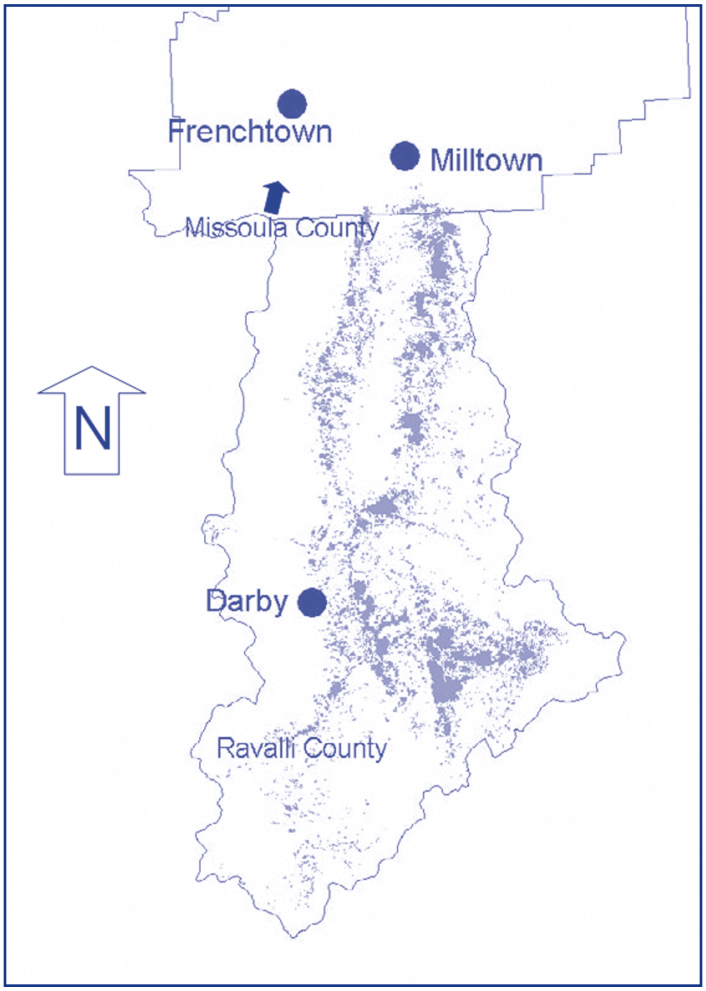


Figure 5. Darby was more centrally located within the forested area.

Figure 6 shows the *average* cost and revenue per acre for each step in the process. Costs involve cutting small and large trees, burning small trees or cutting them into woodchips, and hauling the trees and woodchips. Revenues are gained from selling the woodchips and selling the larger trees.

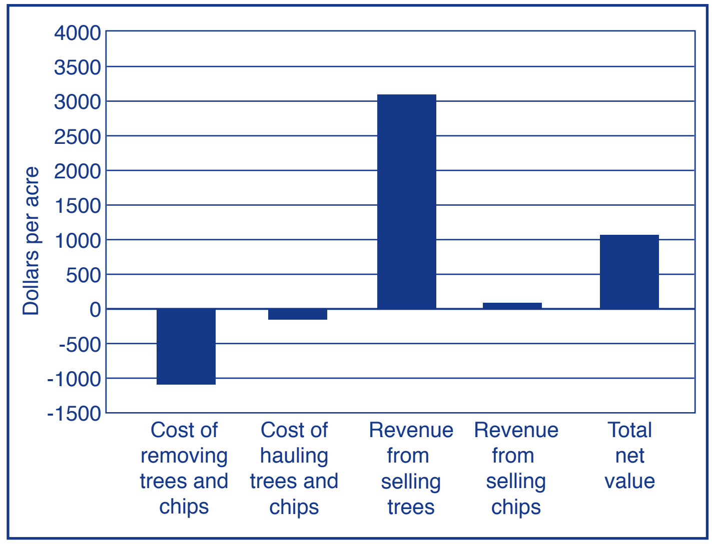


Figure 6. Costs, benefits, and resulting value for an average acre of forested land.

Reflection Section

- Look at **figure 6**. Where does most of the revenue come from in this situation?
- It makes sense to cut trees into woodchips when facilities that can use woodchips are located close by. However, few of these facilities currently exist. As fuel costs rise, in what ways might this situation change?

Discussion

Removing small trees from western forests can help reduce the risk of future wildfires. Such cutting also helps return the forest to a more natural condition, in which fires occasionally remove small trees by burning. Removing small trees, therefore, can help restore the health of a forest.

This research showed that cutting small trees into woodchips for energy produces revenue when there is a woodchip facility nearby. This research also showed the distance between the forest area and the facility was important. The further the distance between them, the less revenue was gained.

The scientists observed that to gain enough revenue from woodchips, more woodchip facilities will be needed close to forested areas. They noted, however, that as small trees are removed from western forests, forest health is improved. As forest health improves, fewer small trees will grow. This will reduce the future supply of small trees for woodchip facilities.

Reflection Section

- The scientists pointed out a dilemma that could be faced in the future. What is that dilemma?

Adapted from: Silverstein, R. P., Loeffler, D., Jones, J. G., Calkin, D. E., Zuuring, H. R., and Twer, M. (2006). Biomass utlization modeling on the Bitterroot National Forest, In: Andrews, P. L. and Butler, B. W., compilers. *Fuels management—How to measure success*. Conference Proceedings, 28-30 March 2006; Portland, Oregon, Proceedings RMRS-P-41. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. http://www.fs.fed.us/rm/pubs/rmrs_p041/rmrs_p041_673_688.pdf

FACTivity

In this FACTivity, you will answer the question: "Do rising fuel prices affect the choices we make?"

The method you will use to answer this question is:

Divide your class into groups of four students. Each group is given an imaginary $100 to spend on a Saturday, or $25 per student. If your group overspends, the money has to come out of your pockets equally. If your group under-spends, you can evenly split and keep the left-over money. All expenses are shared equally.

One of your options is to go to an amusement park. The amusement park is 60 miles away one way, and your group is riding in a vehicle that gets 30 miles to the gallon. The group must pay for the fuel. The admission price per student is $15. You will have to eat lunch and buy whatever drinks and snacks you want once you get into the park. You estimate that this will cost each of you $10. On the day you plan to go, a nationally famous hip-hop band will be giving a concert, and your admission price includes admission to the concert. This is a concert that everyone you know will be at.

An alternative activity for your group on that same day is a concert featuring a local college rock band. This is not one of your group's favorite bands, but the music is okay. The band is playing just 15 miles away one way, and the admission price is $5 per student. You would be riding in the same vehicle as before, and you have to pay for the fuel. Lunch will be available at a cost of $8 each.

Now, you will consider all of your options and make a decision about which activity you will do as a group. You will consider the options under four different situations. In these situations, everything is the same except the price of fuel.

Calculate your group's fixed costs first. Those are the costs that will not change, such as the price of admission and of lunch. You can complete the chart on the next page.

	Admission price per student	Admission price for group	Lunch price per student	Lunch price for group	Subtotal cost for group	Number of gallons of fuel for round trip
Amusement park and hip-hop concert						
Rock concert						

Now, complete the next two charts.

	Fuel: $2.00/gal	Fuel: $2.75/gal	Fuel: $4.20/gal	Fuel: $4.50/gal
Cost of fuel for round trip to amusement park and hip-hop concert				
Cost of fuel for round trip to rock concert				

	Fuel: $2.00/gal	Fuel: $2.75/gal	Fuel: $4.20/gal	Fuel: $4.50/gal
Subtotal cost for group—Amusement park (from first chart, same value for all columns)				
Cost of fuel for round trip to amusement park (from second chart)				
Total cost for amusement park trip				
Subtotal cost for group—Rock concert (from first chart, same value for all columns)				
Cost of fuel for round trip to rock concert (from second chart)				
Total cost for rock concert trip				

As a group, decide which activity you would choose under the four different prices of fuel. If the amusement park was 20 miles away, would your decision change? What if it were 100 miles away?

How has your discussion changed as a result of increasing fuel prices? Has your decision changed as a result of increasing fuel prices? If so, why? If not, why not?

Hold a class discussion about your group's decisions. Now discuss whether you or and your family are making any changes as a result of changing fuel prices. What changes are being made, if any? What are some advantages and disadvantages of having to make these changes?

How were your options like the simulated options presented in this article? How were they different?

Additional information for your classroom:

The title of this article is "Chip and Truck." This title is a take-off on the phrase "Nip and Tuck." The phrase, "Nip and Tuck" was first used in the 19th century. It means "a close result in a race or contest." You might ask your students to compare and contrast the phrase "Nip and Tuck" with the results of the article, "Chip and Truck" (http://www.phrases.org.uk/).

PLT®

If you are a Project Learning Tree-trained educator, you may use Activity # 53: "On the Move" or Activity #82: "Resource-Go-Round" or Activity #51: "Make Your Own Paper."

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.

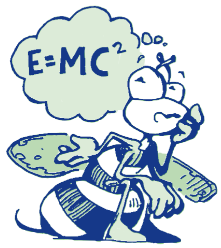
forest managers (**för** est **mä** ni jürz): Skilled individuals who takes care of natural resources.

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**).

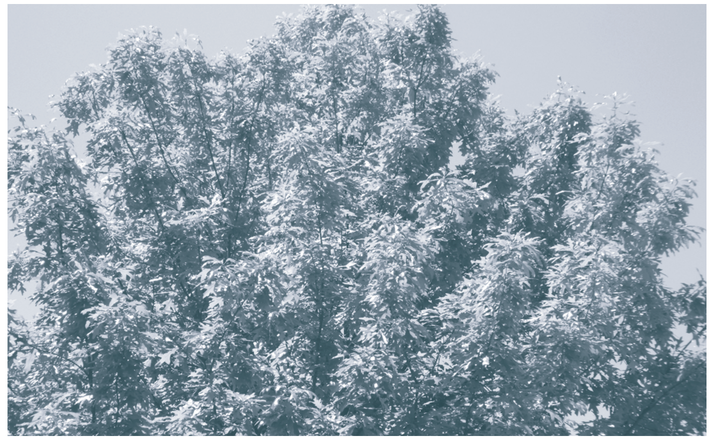


Figure 1. A tree crown.

Figure 2. Tree crowns piled together are called slash.

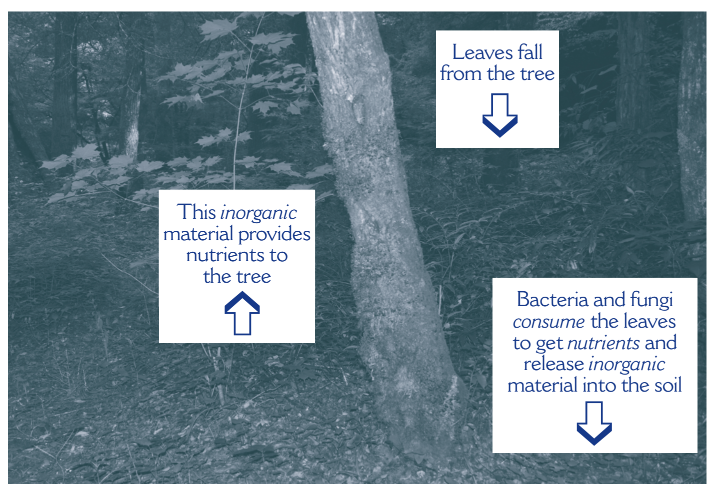


Figure 3. The movement of nutrients from trees to the soil. Most of the nutrients in a tree are stored in the crown. After a tree is cut or burned, the leafy crown and branch material is returned to the soil as it decays. The inorganic material comes from minerals.

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.

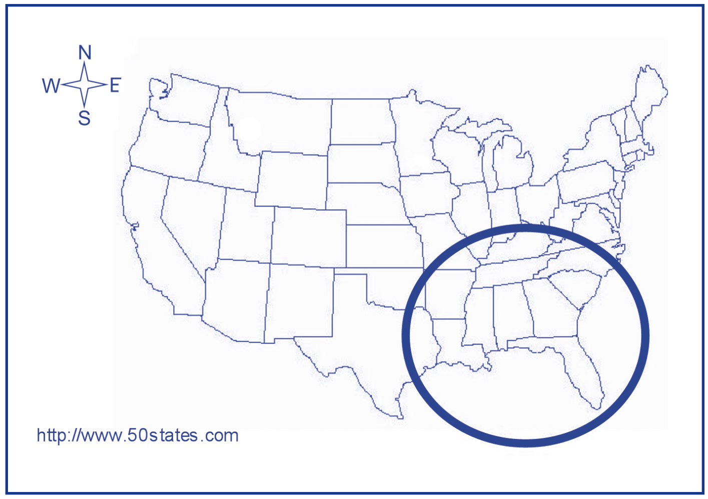


Figure 4. The Southeastern United States.

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.

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.)

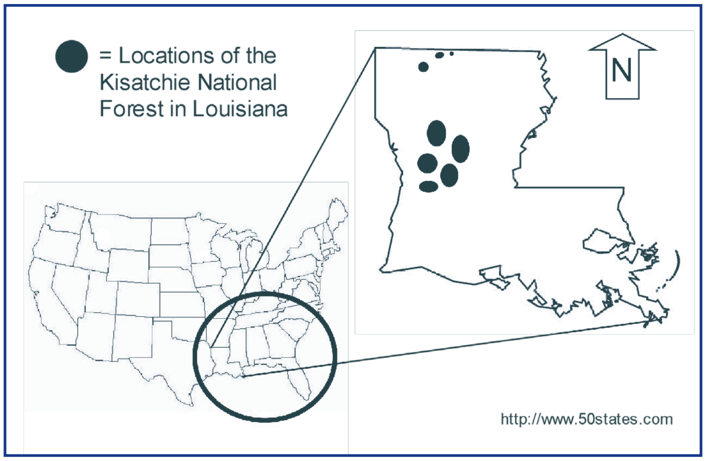


Figure 6. Locations of the Kisatchie National Forest in Louisiana.

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.

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.

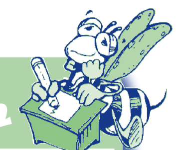
Reflection Section

- 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

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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/)

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* is written at the 7th grade level, but students from grade 5 upward have found the articles useful. The *Natural Inquirer* contains articles describing environmental and natural resource research conducted by the Forest Service scientists and their research 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.

The Format of a Natural Inquirer Article

Each *Natural Inquirer* article follows the same format. *Natural Inquirer* articles are written directly from a published science article. All rewritten articles have been reviewed by the scientists for accuracy. Each article contains the following sections, which you may introduce to your students as they read:

Meet the scientists: Introduces students to the scientists who did the research. Can be used in a discussion of careers in science.

Glossary: Introduces possibly new scientific or other terms to students. The first occurrence of a glossary word is italicized in the text.

Thinking About Science: Introduces something new about the scientific process, such as a scientific habit of mind or procedures used in scientific studies.

Thinking About the Environment: Introduces the environmental topic being addressed in the research.

Introduction: Introduces the problem or question being addressed by the research.

Method: Describes the method used by the scientists to collect and analyze their data.

Findings: Describes the results of the analysis.

Discussion: Discusses the findings and places them into the context of the original problem or question.

Reflection Section: Questions to promote critical thinking about science.

Citation: Gives the original article citation, and a Web site address to access the original scientific article.

FACTivity: A hands-on activity that reinforces an aspect of the research.

Science Education Standards and Evaluations

In the back of the journal, you will find a list that allows you to identify articles by the national science education standards they address. You and your students may also complete evaluation forms online by visiting http://www.naturalinquirer.org.

If you have any questions or comments, please contact:

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Athens, GA 30602-2044
706.559.4224
bmcdonald@fs.fed.us
(Please put "Educator Feedback" in the subject line)

Educator Resources

Visit the *Natural Inquirer* Web site at http://www.naturalinquirer.org. 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. You can also view and download a year-long lesson plan aimed at helping your students learn about the scientific process.

Lesson Plan

This is a generic lesson plan that can be used with any *Natural Inquirer* article, including all of the articles in this journal. You may also visit http://www.naturalinquirer.org and view or download "FACE Look!" or "Worming Their Way In" for more generic lesson plans, which are located at the back of each monograph.

This lesson plan is an adaptation of the "Questions Only" Reading Strategy. The goal is to help students identify key concepts and develop their own interpretations of what they read. This is especially important as a foundation for developing critical thinking skills in science.

This lesson plan is based on a typology of thinking called Bloom's Taxonomy, developed in 1956. It identifies six categories of thinking: Knowledge, Comprehension, Application, Analysis, Synthesis, and Evaluation. For more information, search the Web for Bloom's Taxonomy.

Time Required

1 class period (2 class periods with optional "hands-on" activity)

Materials

Natural Inquirer article, question strips (see p. 51), one sheet of lined paper and pencil per student

Procedures

In advance:

Make a copy of the 42 questions on page 51 and cut them into strips (one strip for each question). Fold the strips in half and put them into a box or hat.

In class (3 minutes):

Have students write the following headings on their lined paper. Students should leave three blank spaces in between each heading.

- Meet the Scientists
- Science
- Environment
- Introduction
- Methods
- Findings
- Discussion

Pass the box or hat around the room and have each student pull out one strip of paper.

30 minutes:

Read each of the seven sections of the *Natural Inquirer* article aloud in class. Ask for student volunteers to read one paragraph each. Skip the "Reflection Sections" and "Number Crunches," but examine any illustrations, charts, or graphs. At the conclusion of each section, students should complete the question they have pulled, based on information in the section. They should write their question in the correct section of their lined paper. Be sure to give students a few moments to formulate their question, and encourage them to reflect on the section before writing their question.

Now, have students pass their question (on the paper strip) to the student next to them. Repeat the process with each section. At the end, students should have formulated a different question for each of the seven sections.

5 minutes:

Quickly review the article by holding a class discussion using the following questions:

1. What was the problem the scientists wanted to address? (From the "Introduction" Section)
2. What was the question the scientists wanted to answer? (From the "Introduction" Section)
3. What did the scientists do to answer the question? (From the "Methods" Section)
4. What did the scientists discover? (From the "Findings" Section)
5. What was the key point of the "Discussion" section?

10 minutes:

Now, review each article section by having students share their questions. See if anyone in the class can come up with an answer to the questions. Encourage students to use logic to develop answers. In some cases, answers will be pure speculation. This is okay. The exercise is intended to have students identify questions that will help them think about their reading, and to consider potential answers to these questions.

Remind students that as they read, they should always be asking questions about the content. When they read science, they should ask critical questions, such as questions beginning with who, what, when, where, why, and how.

Optional (2nd day)

1 class period:

Quickly review the article from the previous day. Do the FACTivity associated with the article. The FACTivity can be found at the end of each article.

Who......

What.....

Where else.....

What if......

When will.....

How.....

What would happen if.....

How would you test.....

How would you apply.....

What does.....

How would you compare.....

Do you think.....

Why did....

What else.....

How did.....

How would you change.....

How is ____ like......

Who else.....

What is.....

What did.....

Where.....

Why do.....

When did.....

When would.....

Why was it better to.....

Can you connect ___ with....

Where have I heard about....

Do you think.....

Why.....

What is one.....

How could.....

Where did.....

What is the most.....

Could.....

How could.....

Who was.....

How could you explain.....

What is most important.....

What difference....

Which do you.....

What do you think.....

What evidence…..

Reflection Section Answer Guide

Chip Off The Old Block

Introduction

- **What is the question the scientists wanted to answer?** *Would school districts save money if they used wood for heating instead of their usual way of heating schools using fossil fuels?*
- **What would the scientists have to do to answer their question?** *Although students may come up with many ideas, they should identify at least three things: Current heating costs at the schools must be understood, a new wood burning heating system would have to be built at the schools, and costs of the new system must be tracked.*

Method

- **Should the scientists include the following costs in their calculations: The cost of cutting trees, the cost of transporting cut trees to a mill for cutting into chips, and the cost of transporting the wood chips to the school? Why or why not?** *Yes, since these are real costs associated with biomass heating, they should be included in the scientists' calculations.*
- **Biomass heat, which comes from wood chips, is considered a renewable natural resource because trees can be replanted. What is one advantage of using biomass energy over a nonrenewable resource such as oil? What is one disadvantage?** *Renewable resources can be sustainable into the future, since trees and other biomass energy products can be replanted. In this case, the trees were being cut anyway, and this provides a way to use them for human benefit. A possible disadvantage is if too many trees are cut for biomass heat energy, there will be fewer trees to provide benefits such as carbon sequestration, wildlife habitat, and protection from soil erosion.*

Findings

- **Look at table 1. You can see the cost of oil had risen between 2003 and 2005, and, therefore, the cost savings rose over the 2 years. Based on what you know about oil prices now, do you think the cost savings for Darby Schools went up, down, or stayed the same during the last school year as compared with 2004–2005?** *Fuel prices have been rising annually, therefore, students should conclude that the cost savings associated with using biomass heat energy should be steadily climbing. The answer to this question, however, will depend on whether fuel prices are currently higher or lower than prices in 2004–2005.*
- **Do you think the cost savings would be the same for a school located in Kansas as in Montana? Why or why not?** *You may have to help your students think this through. There are not as many forests nearby in Kansas as there are in Montana. Therefore, wood chips would have to be transported to the school, raising the cost of biomass heating for Kansas' schools. While it is unknown whether there would be cost savings, it is clear that any costs savings would have to be less in Kansas than Montana.*

Discussion

- **Should the cost of replacing a conventional heating system with a new biomass system be considered when**

calculating cost savings? Why or why not? *Yes, because these costs are real.*

- **Should the cost of building a new biomass heating system at a new school be considered when calculating cost savings? Why or why not?** *Not necessarily. If total cost savings are to be calculated, one could compare the cost of building a conventional oil heating system with the cost of building a biomass system. Then, the operational costs could also be compared. Otherwise, it is probably okay just to compare estimated costs of heating with oil with actual costs of heating with biomass energy.*

Which Do You A-door?

Introduction

- **In your own words, state the question the scientists wanted to answer.** *Does the process up to and including the manufacture of a wood door strengthened with fiberglass or a steel door use more energy and create more waste?*
- **Where do people get the raw materials they need to manufacture products?** *From natural resources that came from Earth.*

Method

- **The scientists included the energy used and emissions produced when the raw materials were collected, as well as the manufacture of each door. Why do you think they included the gathering of raw materials in the life-cycle inventory?** *If the scientists wanted to compare the total amount of energy used and emissions produced in the manufacture of each door, they would have to include the energy used and emissions produced to harvest or mine the raw materials and transport them to a manufacturing plant.*
- **Do you think the scientists found it takes more energy to manufacture a wood door or a steel door? Why?** *Students will have to use their own critical thinking skills to determine which door they think is more environmentally sound in the manufacturing process. Whatever students report, they should support their conclusion with logically derived reasons.*

Findings

- **Examine tables 1–5. What conclusion can you make about the production of a steel door in comparison with the production of a wood door?** *Students should see that more energy is used and waste products produced in the manufacture of a steel door as compared with a wood door.*
- **Based on the findings you have just read, what would you predict about the environmental impact of manufacturing a steel table compared with manufacturing a wood table?** *Students should predict that the manufacture of a steel table would take more energy and produce more waste products than the manufacture of a wood table.*

Discussion

- **This life-cycle inventory showed that more energy is used and more waste produced in the manufacture of a steel door. What might be one advantage of using a steel door instead of a wood door in your home? Do you think this advantage of using a steel door outweighs the disadvantage of its greater environmental impact? Why or why not?** *One advantage of using a steel door might be its greater resistance to burglary. With added fiberglass, however, wood doors are made much stronger. Hold a class discussion about the relative importance of the advantages and disadvantages of steel and wood doors.*
- **If you were employed by a home improvement store in your community, what would you tell a homeowner who**

has come into your store wanting to buy a new door for his or her home? *Students will have to answer this question on their own. They should, however, be able to restate the findings of this research and integrate information from the class discussion held as a part of the reflection question above.*

Chip and Truck

Introduction

- **What question did the scientists want to answer?** *What are the costs, revenues, and benefits of using woodchips for thermal energy, and how does using woodchips compare with burning small trees on the forest?*
- **What are the sources of the two types of fuel being compared in this study? Which of these fuels is renewable?** *Diesel fuel to cut and haul the woodchips comes from oil; and thermal energy comes from woodchips cut from small trees. The woodchips are renewable because new trees can be grown.*

Method

- **Whenever people make a choice to do one thing rather than something else, there are costs and benefits to each choice. Think about a choice you recently made. Identify the costs and benefits of that choice, compared with another choice you could have made instead. Remember that costs involve more than just money. For example, time, or even the loss of a friendship, can be considered a cost.** *This is an individual question, and each student will have to answer for him or herself. The important point here is to emphasize how people analyze (or should analyze) costs and benefits before making a decision. You may want to use the example of risky behavior as something to be carefully analyzed before a decision is made.*
- **In this study, there is one cost in particular that continues to rise. What is that cost? How do you think this cost might affect the scientists' results if they did this study next year?** *Fuel costs continue to rise. Students should be encouraged to think beyond the costs of cutting trees and woodchips and hauling them. They should also consider the rising costs of conventional heating and how heating with thermal energy from woodchips may offset some of the rising fuel costs.*

Findings

- **Look at figure 6. Where does most of the revenue come from in this situation?** *Most of the revenue comes from selling the larger trees to a mill.*
- **It makes sense to cut trees into woodchips when facilities that can use woodchips are located close by. However, few of these facilities currently exist. As fuel costs rise, in what ways might this situation change?** *This is a good group or class discussion question. Students should realize that as fuel costs rise, hauling costs will rise. Heating oil costs will also rise, making woodchips more attractive. Some possibilities are that more woodchip facilities will be built in areas close to forests, making it more economically feasible. If hauling costs continue to rise and more facilities are not built close to forests, it may remain difficult to make woodchip heating feasible. Students should be encouraged to consider a number of options for the future in which woodchips might be a good option for some kinds of energy.*

Discussion

- **The scientists pointed out a dilemma that could be faced in the future. What is that dilemma?** *To make the use of woodchips for energy more economically* *feasible, more woodchip facilities need to be built near forested areas. As more small trees are cut and the forest regains its health, fewer small trees will be available to fuel the woodchip facilities. Thus, it is possible that, in the future, there will be a shrinking supply of small trees to cut into woodchips and use in the facilities.*

How Now Round Crown?

Introduction

- **What larger social issue does this research address? (Hint: it has to do with something we use everyday for just about everything we do.)** *This research addresses the energy issue. How does it address this issue? This research attempts to provide information about whether it is reasonable to use southern pine tree crowns as an energy resource.*
- **Describe the questions the scientists wanted to answer.** *This is a question that should help clarify whether students understand the research questions. Students should understand that the scientists were exploring how tree crowns might be used for energy and the effect of different ground treatments on future energy availability.*

Method

- **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 they should feel about this information?** *The scientists would need to check the accuracy of the information they were about to use. They must feel confident the information they were using was accurate. When you have not calculated the information yourself, you must be as certain as possible that it is accurate.* **In what ways do you or should you do the same thing when accessing information over the Internet?** *One should not consider information factual just because it was found on the Internet. Multiple sources should be compared and contrasted. Sites with extensions of .gov and .edu should be used if possible. These are governmental and educational institution sites.*
- **What three things were the scientists comparing in this study?** *The amount of extra energy available for use in 10-year old trees growing in three different situations. In the first situation, the tree crowns would not be available for use. In the second, the crowns would be available, but the ground had not been fertilized before planting. In the third, the crowns would be available and the ground had been fertilized before planting.*

Findings

- **Look at the last column. Why do you think the third plot shows a much higher energy potential than the second plot?** *Because the fertilization helped the trees to grow larger and, therefore, provide more biomass that can be used to create energy.*
- **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?** *Fertilizing the ground is important if you want to grow larger and healthier trees.*

Discussion

- **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?** *Students may have a variety of opinions about this. Whatever they say, they should have logical reasons for their position.*

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

	Which Do You A-door?	A Chip Off the Old Block	How Now Round Crown?	Chip and Truck
Science as Inquiry				
Abilities Necessary To Do Scientific Inquiry	✓	✓	✓	✓
Understanding About Scientific Inquiry	✓	✓	✓	✓
Life Science				
Regulation & Behavior		✓	✓	✓
Populations & Ecosystems		✓		✓
Diversity & Adaptations of Organisms		✓		✓
Science & Technology				
Understanding About Science & Technology	✓	✓	✓	✓
Science in Personal & Social Perspectives				
Risks & Benefits	✓	✓	✓	✓
Science & Technology in Society	✓	✓	✓	✓
History & Nature of Science				
Science as a Human Endeavor	✓	✓	✓	✓
Nature of Science	✓	✓	✓	✓

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

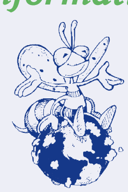
What Is the USDA Forest Service?

The Forest Service is a part of the United States Department of Agriculture (USDA). It is made up of thousands of employees who care for the Nation's forest land. The Forest Service manages more than 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 the 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 Forest Service are scientists, whose work is presented in the journal. 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 the Cradle of Forestry Interpretive Association?

The Cradle of Forestry in America Interpretive Association (CFIA), a 501c3 nonprofit organization, was founded in 1972 by a group of conservationists to help the Forest Service tell the story of forest conservation in America and to help people better understand both forests and the benefits of forest management.

Visit These Web Sites for More Information



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

The *Natural Inquirer*
http://www.naturalinquirer.org

Conservation Education
http://fs.usda.gov/conservationeducation

Cooperative State Research, Education, and Extension Service
http://www.csrees.usda.gov

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

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

Smokey Bear
http://www.smokeybear.com

Project Learning Tree
http://www.plt.org/

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

United States
Department
of Agriculture

Forest Service

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Visit These Web Sites for More Information About Bioenergy

Natural Inquirer
http://www.naturalinquirer.org

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

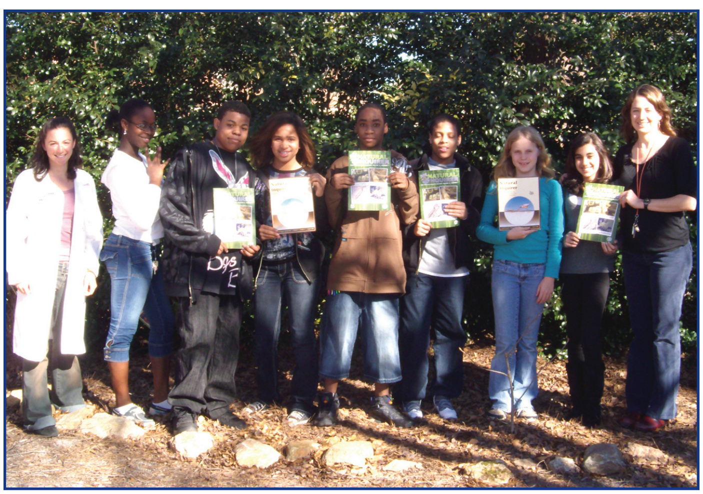
Forest Service Conservation Education
http://www.fs.usda.gov/conservationeducation

Kids.gov—Earth science for middle school
http://www.kids.gov/6_8/
6_8_science_environment.shtml

Energy Kids Page
(Energy Information Administration)
http://www.eia.doe.gov/kids/energyfacts/sources/
renewable/biomass.html

National Renewable Energy Laboratory
http://www.nrel.gov/learning/

Fuels for Schools
http://www.fuelsforschools.info/



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