Chip and Truck

Comparing the Cost of Using Trees to Heat Buildings

Meet the Scientists

Dr. Silverstein, Landscape Ecologist: I enjoyed studying coyotes (k**i** **o**ts) 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** ch**u** 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 wildlfires.

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.**

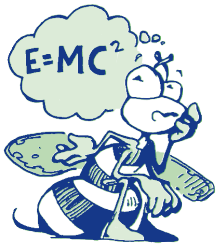
Glossary:

net revenues (net **reh** vuh n<u>oo</u>z): What is left of the revenue after costs are paid.

economically (e k<u>o</u> **nom** ik l<u>e</u>): 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.

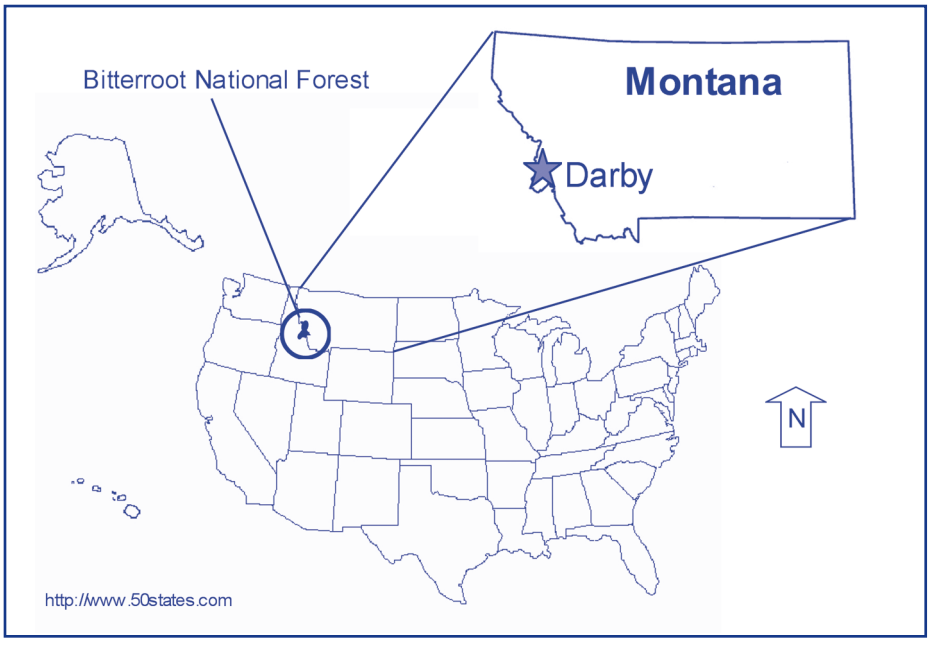


Figure 3. The Bitterroot National Forest in western Montana.

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.

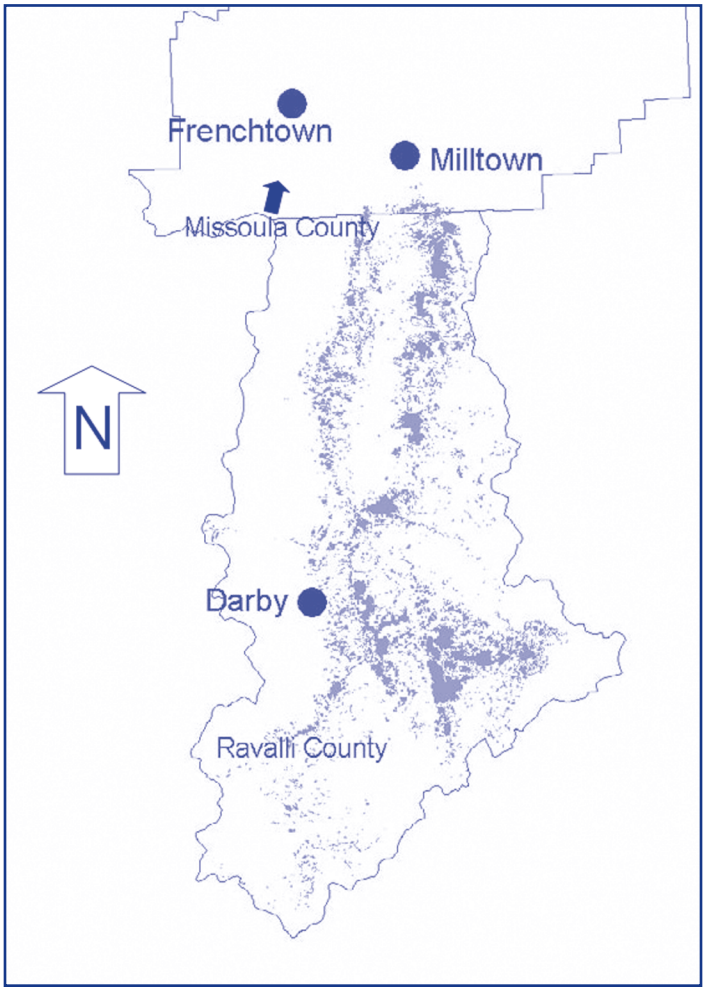


Figure 5. Darby was more centrally located within the forested area.

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.

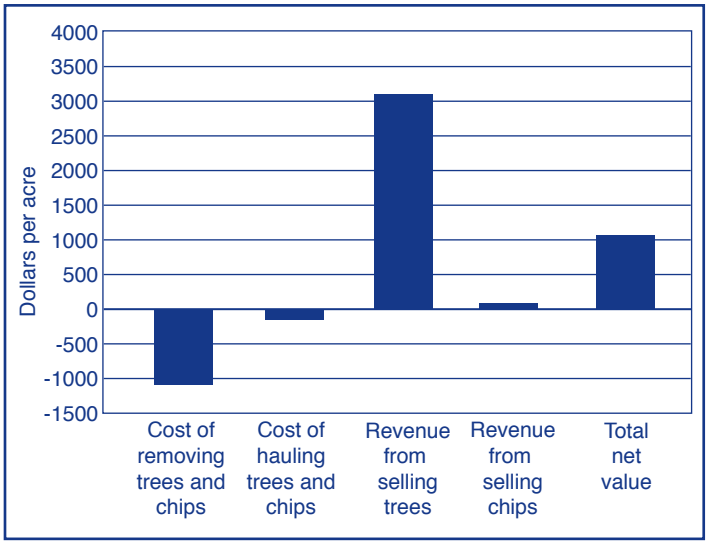


Figure 6. Costs, benefits, and resulting value for an average acre of forested land.

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/).

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."