Firewood: From Woodlot to Woodpile

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Contents

1 Lesson 1: Wood as a Fuel
5 Lesson 2: Firewood Sources
9 Lesson 3: Safety and Tools for Preparing Firewood
15 Lesson 4: Felling Trees
19 Lesson 5: Limbing and Bucking
22 Lesson 6: Transporting the Wood
23 Lesson 7: Splitting and Seasoning Firewood
27 Lesson 8: Selling Firewood
27 Lesson 9: Systems
30 Burning the Wood
32 Appendix 1. Firewood Use in Developing Countries
33 Appendix 2. Hydraulic Wood Splitter
34 Appendix 3. Packaged Fireplace Wood
35 Glossary
36 General References
Firewood: From Woodlot to Woodpile

Think back to the smell of wood smoke in the air, the crunch of leaves underfoot, and the chill of autumn on pink cheeks. Or, imagine yourself relaxing in a big, cozy chair in front of a glowing fire on a blustery winter’s night. These can be some of the more pleasant, richer parts of life. Many people are enjoying such moments as they convert part or all of their home heating systems to wood stoves. Because the demand for firewood is increasing, inexperienced people are going out into the woods to prepare firewood for themselves or for sale. Accidents and injuries are unnecessarily common and sometimes fatal. They are often caused by lack of skill and experience, lack of safety awareness and practices, and just plain foolishness.

This firewood preparation bulletin is designed to help young people develop a background knowledge of the use of wood as a fuel, understand how firewood removal can be effectively combined with forest management, learn how to prepare firewood safely and efficiently, and become skillful at maintaining and safely operating the tools required to prepare firewood.

Lesson 1: Wood as a Fuel

Objectives
To help youth
1. Develop background knowledge about the use of wood as a fuel,
2. Understand positive and negative aspects of burning wood,
3. Understand the quality of wood fuels,
4. Learn how to measure firewood.

Materials
- Seasoned and unseasoned wood samples of different kinds of trees (include some conifer samples)
- Axe — to test splitting ability
- Matches
- Hand saws, sandpaper, screws, pieces of plywood to make wood sample board
- Poster paper, colored markers

Throughout civilization, wood has been one of the most important fuels available to humans for cooking and heating. As late as the mid-nineteenth century, wood met about 90 percent of the fuel needs of the United States; even now, nine-tenths of the people in developing nations depend on firewood as their chief fuel. The development of coal, petroleum, gas, and electricity resources caused people in the U.S. to turn away from using wood. By the 1940s most U.S. homes were heated by oil, gas, or electricity because these fuels were more convenient, required less work than using wood, and were relatively inexpensive. Now, as prices for fossil fuels and electricity are rapidly increasing, many people are again finding wood to be a desirable alternative for heating their homes.

The use of wood has several advantages. Not only is it a renewable resource, but the sensible, selective harvesting of firewood from our forestlands can help to improve the quality of the remaining forest. The smoke from burning wood does not contain as much nitrogen oxides or sulfur as oil and coal. Nitrogen oxides and sulfur, the major components of air pollution today, make up 13 percent of the smoke from burning oil and coal compared with .01 – .05 percent of the smoke from wood. However, a substantial amount of particles and unburned compounds, which may be potentially hazardous to health, can be emitted from wood stoves that do not burn efficiently. Unfortunately, wood smoke has not been studied much, and its effects on air quality are largely unknown.

Wood can be an economically competitive fuel if it is prepared
properly and burned efficiently. Preparing your own firewood can be as psychologically rewarding as the enjoyment of sitting around the fire. It also provides good physical exercise. As Thoreau once wrote, “Wood heats you twice, once when you cut it and again when you burn it.”

The disadvantages of wood as a heating fuel, however, should not be ignored. Simply, the use of wood fuel requires more work than alternative fuels. Cutting, hauling, and stacking your own supply is hard and potentially dangerous work. Someone must always be around to tend the fire. Stoves, stove pipes, and chimneys must periodically be cleaned to remove ashes, soot, and creosote, which can build up and cause chimney fires. Wood is relatively bulky for the amount of heat it produces and is more difficult to transport and store than alternative fuels.

The decision to use wood for heating and even cooking means a real change in lifestyle. For some people this change is positive, and they derive great enjoyment from the new patterns in their lives. For others who find that the disadvantages outweigh the advantages, the conversion to firewood heat is not possible or desirable.

Wood as an Energy Resource

Wood is essentially a solid form of solar energy produced by the tree “factory”. Leaves enable the tree to convert the sun’s energy into chemical form by the process of photosynthesis. As the tree grows, energy is stored in the fiber of the tree. In nature when the tree dies and as the wood decays, this solar energy is slowly released as heat. Burning wood in a stove speeds up this process. The heat is released in a much shorter time and at a more intense level.

All wood will burn, but different woods burn at different rates. Two main factors contributing to wood’s heat value are the dryness and the density of the wood. Green wood, that is, wood that has not been seasoned (allowed to dry to 25 percent moisture content), contains much water, which makes it difficult to light and keep burning. Once it does catch fire, it puts out less useful heat because some of the wood’s energy must be used to boil off the excess water before the rest of the wood can burn. This lack of air and lack of heat caused by moisture produces a lot of smoke and can create a creosote buildup in the chimney.

Pound for pound, all seasoned wood will give off about the same amount of heat when burned. Each tree species, however, builds its wood differently. Thus the densities of woods vary, and equal volumes of different kinds of wood will have different weights and different heat outputs. For example, a solid cubic foot of dry black locust weighs about 43 pounds, whereas the same volume of dry Douglas fir weighs about 30 pounds. The black locust, being more dense than the Douglas fir, has 13 more pounds worth of energy to burn (fig. 1). As a denser wood, it burns longer, produces more coals, and requires fewer trips to the woodbox. (It is worthy to note that individual trees of the same species may vary in specific density, the differences depending on rate of growth.)

Another factor affecting the amount of heat a piece of wood gives off is its oil or resin content. This factor applies mainly to softwoods because hardwoods are not resinous. Any resin or oil that is present causes the wood to burn rapidly and with a high, hot flame. These woods are usually easy to ignite.

Generally speaking, softwoods are not as dense as hardwoods. Being resinous, softwoods are easy to ignite, produce a quick flame and a lot of heat, burn out quickly, and require frequent attention. Hardwoods are generally more difficult to ignite and burn less vigorously with a shorter flame, but last longer and produce more coals than softwoods. An ideal fire can be started with resinous softwood and kept at a slow, heat-producing burn with dense hardwood.

Other characteristics of wood that affect its desirability as firewood include ease of splitting, ease of ignition and burning, extent of smoking, aroma of the smoke, extent of sparking, and coalizing qualities. These characteristics are determined by the structure of the wood. Wood with straight grain splits easily; wood with interlocking grain is next to impossible to split. The presence of moisture pockets in a piece of wood decreases the heat value. Wood from a particular pine tree that is more resinous than normal
for that species will have a higher than normal heat output. Some wood, such as decaying wood, light-weight wood, or any other wood that you can stick your thumbnail into, is most likely not worth preparing for the amount of heat returned (see table 1).

**Measurement Units of Fuelwood**

Fuelwood is measured in various ways. The traditional unit of measure is a *standard cord*, which is a well-stacked pile of logs 4 feet (1.22 m) wide, 4 feet (1.22 m) high, and 8 feet (2.44 m) long. Including air, the content is 128 cubic feet (3.58 cu m), although the volume of solid wood is only about 80 cubic feet (2.24 cu m), the amount depending on the size and crookedness of the wood pieces. If a cord is cut into shorter lengths and restacked, it will occupy less space because many of the crooks are eliminated. A tree with a base 12–14 inches (30.5–35.6 cm) in diameter will yield about one-half cord.

Wood may be sold by the standard cord or by the face cord. A *face cord* appears the same as

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**Table 1. Some Commonly Burned Woods**

<table>
<thead>
<tr>
<th>Species</th>
<th>Ease to split</th>
<th>Ease to start</th>
<th>Heavy smoke</th>
<th>Sparks</th>
<th>Heat value rating</th>
<th>Coaling qualities</th>
<th>Other characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apple</td>
<td>Tough</td>
<td>Poor</td>
<td>No</td>
<td>Few</td>
<td>Best</td>
<td>Excellent</td>
<td>Good aroma</td>
</tr>
<tr>
<td>Beech</td>
<td>Tough</td>
<td>Poor</td>
<td>No</td>
<td>Few</td>
<td>Best</td>
<td>Good</td>
<td>Seasons readily when split</td>
</tr>
<tr>
<td>Hickory</td>
<td>Fair to tough</td>
<td>Fair</td>
<td>No</td>
<td>Few</td>
<td>Best</td>
<td>Excellent</td>
<td>Green hickory good for smoking meats</td>
</tr>
<tr>
<td>Ironwood</td>
<td>Tough, make sure it's green</td>
<td>Poor</td>
<td>No</td>
<td>Few</td>
<td>Best</td>
<td>Excellent</td>
<td></td>
</tr>
<tr>
<td>White Oak</td>
<td>Tough</td>
<td>Fair</td>
<td>No</td>
<td>Few</td>
<td>Best</td>
<td>Good</td>
<td>Makes good fence posts</td>
</tr>
<tr>
<td>Black Locust</td>
<td>Tough</td>
<td>Poor</td>
<td>No</td>
<td>Few</td>
<td>Best</td>
<td>Excellent</td>
<td></td>
</tr>
</tbody>
</table>

1 cord = about 1 ton of anthracite coal

<table>
<thead>
<tr>
<th>Species</th>
<th>Ease to split</th>
<th>Ease to start</th>
<th>Heavy smoke</th>
<th>Sparks</th>
<th>Heat value rating</th>
<th>Coaling qualities</th>
<th>Other characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ash</td>
<td>Easy</td>
<td>Fair</td>
<td>No</td>
<td>Few</td>
<td>Average</td>
<td>Good</td>
<td>Best of all wood to burn green</td>
</tr>
<tr>
<td>White Birch</td>
<td>Fair</td>
<td>Good</td>
<td>No</td>
<td>Moderate</td>
<td>Average</td>
<td>Good</td>
<td>Must be split to avoid spoilage</td>
</tr>
<tr>
<td>Yellow Birch</td>
<td>Fair</td>
<td>Good</td>
<td>No</td>
<td>Moderate</td>
<td>Average</td>
<td>Good</td>
<td></td>
</tr>
<tr>
<td>Sugar Maple</td>
<td>Fair</td>
<td>Poor</td>
<td>No</td>
<td>Few</td>
<td>Best</td>
<td>Excellent</td>
<td>Excellent fuel; sap used for sirup</td>
</tr>
<tr>
<td>Red Oak</td>
<td>Fair</td>
<td>Poor</td>
<td>No</td>
<td>Few</td>
<td>Best</td>
<td>Excellent</td>
<td></td>
</tr>
</tbody>
</table>

1 cord = about 9/10 ton of anthracite coal

<table>
<thead>
<tr>
<th>Species</th>
<th>Ease to split</th>
<th>Ease to start</th>
<th>Heavy smoke</th>
<th>Sparks</th>
<th>Heat value rating</th>
<th>Coaling qualities</th>
<th>Other characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red Maple</td>
<td>Fair</td>
<td>Fair</td>
<td>No</td>
<td>Few</td>
<td>Average</td>
<td>Excellent</td>
<td></td>
</tr>
<tr>
<td>Tamarack</td>
<td>Easy</td>
<td>Good</td>
<td>Medium</td>
<td>Few</td>
<td>Average</td>
<td>Good</td>
<td></td>
</tr>
<tr>
<td>Willow</td>
<td>Easy</td>
<td>Fair</td>
<td>No</td>
<td>Few</td>
<td>Average</td>
<td>Poor</td>
<td>Burns quick and hot</td>
</tr>
<tr>
<td>Aspen</td>
<td>Easy</td>
<td>Excellent</td>
<td>No</td>
<td>Many</td>
<td>Poor</td>
<td>Poor</td>
<td>Good kindling</td>
</tr>
<tr>
<td>White Pine</td>
<td>Easy</td>
<td>Excellent</td>
<td>Medium</td>
<td>Many</td>
<td>Poor</td>
<td>Poor</td>
<td></td>
</tr>
<tr>
<td>Norway Spruce</td>
<td>Tough</td>
<td>Good</td>
<td>Yes</td>
<td>Moderate</td>
<td>Poor</td>
<td>Poor</td>
<td></td>
</tr>
</tbody>
</table>
a standard cord — it is 4 feet (1.22 m) high and 8 feet (2.44 m) long, but the log length can be anywhere from 2 feet to 12 inches (0.6–0.3 meters). When sold, the length of the wood must be specified. Approximately 155 pieces of wood are in a face cord. A unit of wood is approximately 1/24 of a standard cord and will fit into a car trunk or a station wagon (fig. 2).

The heat value of a cord varies with the density and dryness of the wood; but, in general, a standard cord of several seasoned northeastern hardwood tree species has the same heating value as 1 ton of hard coal or 200 gallons of fuel oil. Such a cord, in other words, has approximately a gross value of 28,000,000 B.T.U. (B.T.U. = the amount of energy required to raise the temperature of 1 pound of water by 1 degree Fahrenheit) or 7,055,440 Kilocalories (1 Kilocalorie = the amount of energy required to raise the temperature of 1 kilogram of water by 1 degree Centigrade).

Activity Suggestions
1. Read about some countries that use mainly wood for fuel. Are their forests able to supply all the fuelwood needed? Are their forests being maintained as renewable or are they being destroyed? How does this apply to our country? If wood burning became very popular, do you think our forests could be overcut? How might this be prevented?
2. List some advantages of using wood as a fuel. What are some disadvantages?
3. Why do you wish to prepare firewood?
4. Do your own cost comparison of wood heat and other sources of heat. As you prepare firewood, make a list to keep track of all costs and the amount of time you spend. Also, keep a record during the winter months of type of

Figure 2. Measurement units of wood.
heating fuel, amount used, and heating costs for a house that does not use wood for heat. Use this information for the Wood Heat Cost exercise on page 28.

**HOW NOT TO SAVE BY BURNING WOOD**

Stove, pipe, installation, etc. .......... $1,000.00
Chain saw ($99 special) .................. 99.00
Chain saw repair (broke down after 24 hours use) ............... 13.00
New chain saw ....................... 250.00
Replacement chain (broke old chain on a rock when bucking on the ground) .... 50.00
Sawbuck .......................... 10.00
Gas and lubricating oil ................. 55.00
Doctor's fee for removing splinter from eye ........... 45.00
Safety glasses ........................ 8.00
Work gloves ......................... 8.00
Emergency room treatment (broken toes dropped log) .......... 120.00
Safety shoes .................... 50.00
Replacement bar for chain saw (pinched and warped old bar when bucking) ........ 29.00
Wedges .......................... 11.00
Broken leg (cutting branch under tension) ..................... 150.00
Head X-ray and overnight observation in hospital (because of concussion received from widowmaker) ............. 250.00
New hard hat to replace bump cap .......... 8.30

Total first year's costs: $2,156.30
Savings in "conventional" fuel-first year 500.00

Net cost of first year's woodburning .......... $1,656.30

5. List qualities of a kind of wood that make it a good fuel.
6. Compare characteristics of different kinds of wood:
a. Record the weight and volume of seasoned and unseasoned samples of different woods. Volume may be computed from measurements (length \times width \times height) or calculated using the water displacement method. Calculate density of each (wt/vol).
b. Burn samples of each wood. Note characteristics such as those listed in table 1. Which type of wood from those tested would make the best firewood?
7. Make a sample board of trees that make good firewood. Identify each sample with a card that states the species and lists its qualities as a fuelwood. Use 4-H Bulletin M-5-3a as a guide.
8. Draw a poster to illustrate the measurement units of firewood.

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**Lesson 2:**

**Firewood Sources**

**Objectives**

To help youth
1. Become aware of possible sources of firewood,
2. Develop the confidence to contact source people,
3. Learn to research topics of interest,
4. Realize that the forest produces many resources,
5. Develop the skill of choosing trees for firewood harvest.

**Materials**
- Cloth or plastic flagging or chalk
- Sand, flat boxes

To obtain wood for fuel, you do not necessarily need a woodlot in your backyard. Wood can be obtained from many sources. Local dumps and landfills can be an excellent source of firewood. Usable wood fiber makes up as much as 30 percent of the debris in some dumps and is generally free for the taking. Make sure to obtain official permission to do so.

From time to time, trees in cities need to be removed either because they are diseased, damaged, or dying or to make room for construction or road work. These trees are usually hauled to the dump. Check with utility companies and the local park or street department for a supply of free wood from these trees. Landscapers, nursery managers, and tree experts all remove wood and may be glad to give it away instead of disposing of it themselves. You can find these people in your phone book. Talk with people who are involved with demolition or construction of buildings and fences. They may be able to provide you with scrapwood.

Other potential sources of wood pieces include lumbermills and loading docks. When logs are sawed into boards, odd pieces invariably remain. Some mills burn this scrap to supply part of their own energy, but others give it away or sell it for a small fee. Another source is the cast-off wooden pallets used in truck and freight shipping and as base support when moving goods with a forklift. They are made of beech and oak of low timber value and make excellent firewood. In most cases, they are reused. Worn-out or used pallets, however, may be available at warehouses or at stores and businesses that receive goods shipped on pallets.

Forests and wooded areas are the most obvious sources of firewood. Downed trees and fallen limbs that have not rotted yet can provide an easy, quick supply of firewood. Trees that are not commercially valuable or are crowding out valuable timber may be felled and bucked. Branches from pruned trees can also make good wood for burning.

Some persons have immediate access to woodlands owned by themselves, their family, or friends. Others can obtain permis-
sion to cut on woodlots owned privately or on land controlled by federal or state agencies. Local farmers and woodlot owners may give you permission to thin and clean up their woods if you approach them in a friendly and courteous manner. On public lands, it is often possible to buy cutting and salvage rights. Many state and national forests have specially designated cutting areas for which the cutting fee, if any, is usually nominal. Some of these cuttings involve selected thinnings of woodlands; others are salvage operations in logged areas. In some cutting areas, the trees will have already been felled, and in others the trees will be standing and marked for you to do the fell-
ing.

When cutting on land other than your own, it is best to obtain written permission that specifies what and how much you are permitted to take and by what means, when, and from where you are permitted to take it. All lands and woods are owned; it is important to respect the property rights of others.

Firewood Harvest Plan

If your supply of firewood is in an area where the trees have not been marked for cutting, you should develop a plan for selecting which trees to harvest. Remember that your operation will influence the growth and composition of the future stand. Try to visualize how your cutting will affect the remaining stand of trees. Haphazard cutting can re-
duce the quality and value of other forest resources such as timber, wildlife, aesthetics, and recreation found in that particular stand. In the past, people have tended to cut the straight, well-
pruned trees for firewood because these trees split more easily than their crooked, limby neighbors. This practice of highgrading has left many wooded areas with a supply of poor quality commercial timber. The increased interest in wood fuel provides an opportunity to correct some of these past mistakes.

A plan for cutting is important to ensure that the stand is not overcut and to maintain the re-newability of our forest resource. The United States is fortunate to have a large amount of forested lands available for wood production, but that amount is limited and even decreasing in some areas. Cutting for firewood should be done in such a way as to en-
sure reproduction of desired tree species, continued growth of the forest, and minimal environ-
mental disturbance. If properly managed, most of our forested lands are capable of producing ½-1 standard cord of firewood per acre yearly forever.

In many other countries not so fortunate as ours, the search for fuelwood has been extreme and has led to destructive deforesta-
tion of large areas. When fuelwood is not available, people burn crop residues and animal wastes, which could be used instead to maintain agricultural productivity. The pro-
ductivity of their land is also lost through erosion caused by the lack of forest protection. Care-
ful planning can avert these extreme problems.

The key to a good firewood harvest plan is to keep in mind what resources the owner desires from his/her woodlot. As you re-
move trees, you will influence the species, the form, and the spatial arrangement of the remaining vegetation. Good management can enhance the production of such desired forest resources as timber, aesthetics, wildlife, and recreation.

Timber

Certain species of trees are commercially more valuable than others. For example, in the North-

east the most valuable species for log production include yellow birch, black cherry, red and white oaks, and hard maple. Black locust, an excellent firewood, may be worth more if sold instead as decay-resistant fence posts. These commercially valuable trees are the species to avoid cutting for firewood unless they are deformed or are crowding the forest.

Tree form affects commercial worth. Tall, clean-boled, straight trees make high-quality lumber and should be left to grow. Select
among those that are crooked, partially rotten, damaged, or insect-ridden to cut for firewood. Remember as you choose, however, that these trees may be of value in other ways. If they are providing homes and food for birds and other wildlife, or if they have an aesthetic appeal to the owner, you may not wish to remove all of them.

Trees need room to grow at their maximum rates. Northeastern forests are generally stocked with an overabundance of young trees. The results are stands of thin, slow-growing, low-value trees that compete for light, water, and nutrients. Many of these trees will eventually die as they get crowded out. Periodic thinning of young stands permits the more desirable trees to grow rapidly throughout their lives. A greater volume of wood will be produced on larger, high-quality trees in less time than if the stand were not thinned. Your firewood harvest can be the application of thinning (fig. 3).

When deciding which trees to cut for fuelwood, you should mark the trees to be left with flagging or chalk. A general rule of thumb is to select a timber crop tree every 4.5–6.1 meters (15–20 ft). The distance will depend upon the species composition of the forest. Check with your local forester for advice on spacing. The crop tree should be of a valuable species and of good form — straight and tall with relatively small branches. It should be a dominant or codominant tree. A dominant tree has its crown above most of the other trees in the stand. Codominant trees make up the general uppermost crown level of the stand.

For good growth, the crop tree needs 0.9–1.2 meters (3–4 ft) of open space on at least two sides of its crown. Remove for firewood those trees that are touching the crown of your crop tree. Walk through the stand in systematic parallel lines and mark trees as you go (fig. 4). Because ideal crop trees are not evenly spaced, you will end up with some holes and some areas of crowding. In cases where there are no ideal crop trees nearby, you will have to settle for a second or maybe even third best. An average 6-meter (20-ft) spacing will give you about 247 trees/hectare (100 trees/acre).

More information may be found in forestry books, Cooperative Extension publications, USFS bulletins such as "Improve Your Woodlot by Cutting Firewood" (see reference section), and the 4-H bulletin L-5-13, "Understanding Forest Ecosystems."

**Aesthetics**

Like beauty, aesthetic quality is in the eye of the beholder. General components of forest aesthetics include species composition, form, and spatial arrangement of vegetation.

Forests are composed of either a single tree species or of a mixture of tree species. The aesthetic appeal of a forest stand is influenced by the physical appearance of the particular tree species within it. For example, a forest of strictly redwoods or white pines may be breathtaking, whereas a forest of mixed hardwoods is pleasing in its diversity and is striking in the fall.
The form of trees individually or in a stand also has an influence on the aesthetic value of a forest. A massive, gnarled, multiforked wolf tree has a character that may be appealing to some people. Other people may find a stand of straight, tall, uniform trees pleasing to view.

Forests will vary as to how the vegetation is arranged within them. Some forests are even-aged, all the trees being of approximately the same height and size. Some forests are many layered, having trees of all sizes. Forest vegetation may be scattered about fairly evenly. More commonly, the vegetation will be grouped, some open spaces being left. Trees may be cut to complement a nice view or may be left to hide an offensive sight. The spatial arrangement of a forest's vegetation will influence the eye of the observer and will affect the aesthetic quality of the forest.

As you remove trees for firewood, you will change the species composition, form, and spatial arrangement of the remaining vegetation. You should, therefore, discuss with the landowner what characteristics make the land aesthetically pleasing to him or her. Your firewood harvest can be designed to enhance these specific qualities.

The neatness of your job also influences the visual beauty of the forest. Branches and other debris can be unsightly if not properly reduced and piled. Using heavy equipment or working on a wet soil can tear up the forest floor and leave an offensive sight. If the firewood operation is done neatly, you will leave a good impression with the landowner and will most likely be welcomed back next time.

Wildlife

The creation of diversity is perhaps the most important thing that can be done to enhance the wildlife resource of a forest. The tree species, the form of the trees present, and the pattern of cuts influence diversity (fig. 5).

Forest wildlife rely on different tree species to meet their requirements for food. Oaks, beeches, maple, and other mast-producing trees provide food for animals such as turkeys and squirrels. Aspen buds are a favored food of ruffed grouse.

The form of trees also affects the wildlife population of a forest. A stand of trees that is uniform in height and size will attract only a small variety of animals. A multilayered forest will provide many more homes and feeding and singing stations for wildlife. Hole-nesting birds and denning animals find their homes in hollow trees and snags. These types of trees can be left as wildlife enhancement.

Size and pattern of cuts influence the number and types of wildlife to be found in a wooded area. A dark, dense forest is often zoologically poor. Cutting firewood in patches large enough to let sunlight onto the forest floor will encourage the growth of shrubs and forbs favored by deer, bear, and other wildlife.

A firewood-cutting operation can be planned to encourage the specific kinds of animals a woodlot owner may desire. By creating diversity with your harvest, you can increase the variety and numbers of the general wildlife population found in a woodlot.

Recreation

Firewood harvest can complement certain types of forest recreation on private properties. Trees for firewood can be removed to create a planned system of trails for hiking, skiing, or running. By cutting trees in a patch, you can provide an opening for a campsite, picnic, or game area. To provide access to these areas some trees may need to be removed. Be sure to consult with the property owner about the types of recreation she or he desires and the location for the activities on the land.

Private forest owners may desire other benefits. They may wish for their woodlot to produce several resources at the same time.
(multiple-use). Some resources are compatible — that is, they can be produced on the same piece of land at the same time. Aesthetics and wildlife may, in some circumstances, be considered compatible resources. The diversity that is aesthetically appealing to some persons can also attract a greater variety of birds and other wildlife to the area. On the other hand, some persons prefer the sight of uniform and pruned trees planted in rows. They may find the brush and dead trees left for wildlife to be unappealing. In this case, aesthetics and wildlife are incompatible.

Another incompatible combination might be timber production and wildlife. The multiforked, hollowed trees, which some animals may den in or make nests in, would be the first trees to be removed for strict commercial timber production. Sometimes, incompatible uses can become compatible if modifications are made. If a few snags and den trees are left and/or wooden nest boxes are provided for the wildlife, timber production can continue, though at a lower rate.

Discuss the compatibility of the resources the owner desires. Consider how you can enhance the production of those resources by a carefully planned firewood-cutting operation. Before cutting any wood, get a clear idea of what the owner wants from the woodlot and follow it. Likewise make sure she or he understands exactly when, where, and what you plan to do. A written agreement is always better than a verbal verification.

Activity Suggestions
1. Check out all possible sources of firewood in your community. Decide where you will get your supply of wood.
2. Why is it important to develop a firewood harvesting plan? What should you take into consideration in developing a harvest plan?
3. Pick a forest resource. Read outside materials on this resource. Discuss what is required for the resource to be produced. How can cutting firewood in the area harm or benefit the resource?
4. Arrange for a forester to talk with your group about firewood harvest and its affect on other forest resources. Do exercise #3 so you are prepared to ask questions.
5. Demonstrate in a forest how you would select the trees to remove for firewood. Mark the trees to leave with flagging or chalk. Discuss why you chose these particular trees. How would other forest resources be affected if you were to actually remove these trees?
6. If you are going to cut firewood from an unmarked forest, develop a harvest plan. Have a forester look at it to give you suggestions.

Lesson 3: Safety and Tools for Preparing Firewood

Objectives
To help youth
1. Be aware of the hazards involved in preparing firewood,
2. Learn how to maintain and safely handle the tools required to prepare firewood,
3. Understand the use of each tool,
4. Learn how to handle a chain saw.

Materials
- Axe
- Splitting maul
- Bow saw
- Chain saw
- Files for sharpening all of the above
- Screwdriver
- Peavy
- Fire extinguisher

Preparing firewood is hazardous. It is not a game and should be taken seriously. Trees are extremely heavy; falling branches can kill; and the tools used for preparing firewood have cutting edges. Accidents and injuries are common and result from carelessness, ignorance, gambling, and unprofessional operating techniques. It is important that you
wear proper clothing and protective devices as a second line of defense. Know what you are doing, how to avoid problems, and how to use the tools properly. Stay alert, and most important of all, make sure your actions follow what you know.

You should dress to protect your head, ears, feet, eyes, and hands. Wear trim-fitting, durable trousers, shirts, and jackets. Loose clothing can catch or snag. However, your clothing should not be so tight as to restrict freedom of movement. Chain saw chaps or knee pads help to prevent chain saw cuts. Light, tough, nonslip gloves protect your hands from abrasions, cuts, and splinters. Wear boots with grip soles to help prevent falls. High-top boots protect the lower legs, and toes are protected in boots with steel toes.

Safety goggles or eyeglasses with safety lenses should be worn to prevent injury from flying wood chips, sticks, or other debris such as metal spalls. Protect your head from falling branches or limbs by wearing a hard hat—a bump cap is not enough.

Chain saws produce noise at a level of 100 decibels or louder. This noise level causes permanent ear damage to the unprotected user who operates a saw for more than 1 hour. Earmuffs or earplugs should be worn. Many people are hesitant to wear them because they think it is too uncomfortable and they are afraid of not being able to hear important sounds. But comfortable ear protection can be found, and many plugs and muffs are designed to reduce only high frequency noise and allow normal, low frequency noise, such as conversation, to be heard (fig. 6).

When you work in the woods, you must be aware of all possible hazards at all times. Before you begin working, assess the situation. Plan your procedure—which trees to cut, where is the most convenient location to haul the wood for transport out of the forest, and so forth. Think ahead about what might happen as a result of your actions. Ask questions, such as: Where will that tree fall if I cut it here? Will it get hung up? Are any branches or dead trees likely to fall when the tree falls? How will I get out of the way when the tree falls? If it falls the wrong way, how will I escape? Which way will the log roll after it has been bucked?

Will this branch snap in my face if I cut it here? Will my chain saw get pinched?

As you work, take rest breaks. You will get tired without realizing it, and this fatigue breeds carelessness and accidents. Also, do not work too fast. If other people are in the area, make sure that they are in a safe spot and that you are, too. You can avoid accidents if you make the effort to be aware of potential hazards. Plan your response ahead of time in case a hazardous event should occur.

### Tools — Their Use and Maintenance

The axe and the splitting maul are two basic tools required for firewood preparation. The axe comes in handy for clearing slash and brush to make space to work safely. It is also used for lopping small limbs from a felled tree, for splitting kindling, and for
tapping — not hammering — a wedge into place for felling. The correct axe should be both comfortable and efficient. It should also be kept sharp. To sharpen the axe, secure the head in a vise and, with one hand on the file handle and the other at the file tip, stroke from heel to toe over the length of the blade. Be sure to make each stroke in the same plane and with uniform pressure on both ends of the file. Turn the axe after every six or seven passes, and concentrate on the entire blade instead of singling out gouges. Finish the edge with a whetstone so it has about a 25 degree angle. Do not use an electric grinder; it heats the axe edge and can spoil its temper.

The axe is a dangerous tool, but with safe work habits, accidents can be prevented. The safest way to carry an unshoathed axe is at the side of the body that is downhill; grip the axe at the point of balance near the head, cutting edge pointed out. If you stumble or slip, you can easily toss the axe aside as you fall (fig. 7). You should cover the head of an axe with a leather sheath when you are carrying it for distances or when you are not using it. Be sure to place your axe and maul out of the way so they will not be stumbled over when not in use.

The splitting maul is used for the heavy work of splitting stove-length pieces of wood into sections. The head is a flattened sledge on one end and a cutting blade on the other; the cutting edge should be kept sharp, although it need not be as sharp as an axe. Wedges and mauls are also sometimes used for splitting wood (fig. 8).

Be sure the axe or maul handle is free of defects that might cause it to split. It should be made of a knot-free hardwood with straight, uniform grain going the length of the handle. Hickory is a favorite wood. Avoid warped handles. Make sure the handle fits tightly into the head of the axe or maul and is secured by visible wooden or steel wedges.

The bow saw is one of the most efficient hand tools for sawing wood. While the chain saw does the work of felling and bucking, the bow saw is handy for limbing and other small jobs. It can be used when there is no room to swing an axe or when you cannot get the firm stance required for both the axe and the chain saw.

The bow saw is razor sharp and can fell a sapling or lop a limb in a few strokes. A bow saw can also cause serious wounds and must be handled carefully. The bow saw is usually carried to one side by the handle with the blade facing the ground (fig. 9). It can also be carried across the shoulder, the toothed edge of the blade facing back; the back handle should be removed to prevent its catching on anything. If you are with other people and are carrying a bow saw, it is best to walk in the rear and be sure no one is within sweep of the blade. When not in use, cover the teeth with a saw guard.

When sawing with a bow saw, use a rocking stroke so that the saw is always cutting on a corner; do not press down. When you are sawing pitchy woods, pitch will accumulate on the blade and make it hard to use. Frequent applications of kerosene on the blade dissolves the pitch (fig. 10). A dull bow saw blade is usually not filed to restore sharpness because
most bow saw blades are made of thin, highly tempered metal that requires special filing equipment most people do not have. Instead, dull blades are replaced with new ones, which are readily available. When inserting a new blade, make sure that no one is in front of the saw as the new blade may suddenly snap loose.

The chain saw is one of the most useful tools for preparing firewood. It is also one of the most dangerous. It is important that you learn how to maintain the saw and how to handle both it and yourself instinctively and safely before going out in the woods.

The chain saw is a mechanical device comprised of an engine, a guide bar, and a cutting chain (fig. 11). These saws are produced in many types, shapes, and sizes. They range from lightweight (less than 15 lb) to middleweight (general-purpose saws that weigh 15–20 lb) and heavy duty (used by professionals). For cutting firewood, you need a saw that is less than professional-sized, but that can run all day and handle big cuts without breaking down. At least a 3-cubic-inch engine has been recommended by dealers as the minimum power unit size for a chain saw that is used annually to produce 8 standard cords of wood. The length of the bar determines what size tree you can cut, but the longer the bar, the greater the weight and the more expensive the chain saw will be. The ideal length for most firewood cutters is 15 or 16 inches. Some chain saws have a “roller-nose” or “sprocket-tip” designed to reduce chain friction and to enable the saw to cut faster with less wear on the chain. Some persons prefer the roller-nose bars, yet others dislike them — it’s a matter of personal preference.

Optional features you may want for your chain saw include a kickback guard, a chain brake, a throttle safety catch, antivibration dampers, automatic oiling, and a heated handle bar for use during cold weather (fig. 12). The kickback guard is a safety device that forms a barrier between your forward hand and the chain. It protects your hand in case the nose of the bar hits something and causes the saw to kick back at you. The chain brake, another safety feature, completely stops the chain if kickback occurs. Located on the rear hand grip of the saw, the safety catch makes it difficult for the throttle to be opened accidentally. The hand grips on some chain saws are cushioned with rubber dampers, which lessen the amount of vibration transferred to your hands that otherwise causes fatigue and a tingling sensation. On older chain saws, the operator periodically lubricates the chain and bar while cutting by pushing a button near the throttle. The bar and chain of saws with automatic oiling are constantly oiled a measured amount by a small pump in the oil reservoir. This continual lubrication can add life to the chain and bar. Some saws have both manual and automatic lubricating devices. This feature is handy for jobs in which the automatic oiler does not supply enough oil.

Chain saws are more efficient and less dangerous if properly maintained. They will also last longer. As a chain saw operator, you should know basic maintenance skills, not only for in-the-field problems but also for regular care. Each of the many chain saws on the market has specific maintenance features. Be sure to read the owner’s manual thoroughly to become familiar with your particular saw, and consult the dealer if you have problems. Also, you should follow the manufacturer’s recommendations on which oils and fuel mixtures to use; your saw will run better and last longer. Basic maintenance procedures that apply to every saw include adjusting chain tension, cleaning, and filing.

**Chain Tension**

It is important that proper chain tension be maintained for the long life of the guide bar, chain, and sprocket. The chain will stretch with use. If the chain is loose, it damages the guide bar and sprocket and can wear down the side links on the chain itself. A loose chain may also jump off the bar. The need for a tight chain cannot be stressed enough. Tightening the chain tension requires only a wrench and a screwdriver;
consult your owner's manual for specific instructions and for information on how much to tighten the chain. Be sure to leave the amount of slack called for in the owner's manual, but keep in mind that 99 percent of the non-professionals leave too much slack. Although excess chain tension can lead to overheating of the nose of the guide bar and excessive wear on the drive links of the chain, it almost never happens.

Cleaning
A working chain saw will be oily and covered with sawdust, but it is important to clean certain parts of the saw frequently. Each day that you use the saw, check the air filter, the oiler outlet and sprocket area, and the groove in the bar; and clean them when sawdust has built up.

A clogged air filter restricts the flow of air to the carburetor. Remove and clean the filter by tapping it, by blowing on it, or by dunking it in gasoline if it is caked with dirt.

Remove the sprocket cover to clean around the oiler outlet. Scrape the oily sawdust out of the area.

A dirty chain wears faster, requires more power to pull it around the bar, and is more difficult to keep properly lubricated. Clean a dirty chain by soaking it in kerosene and scrubbing with a soft fiber brush. A freshly cleaned chain should be thoroughly dried and lubricated immediately to avoid rust. To remove built up debris in the groove of the guide bar, run a small screwdriver along it.

Filing
Keeping your chain saw sharp is the most important thing you can do to maintain its longevity. A dull saw strains the engine, leads to mechanical problems, and damages the bar. It also makes the job twice as hard and more dangerous. Chain sharpening is not difficult, but should be done whenever the chain gets dull, which may be frequent. You may even need to file your saw one or more times in one day if you are running it hard. The saw will dull if it is allowed to cut into earth, to strike a rock, or to touch metal. The chain is designed to chip the wood as it cuts. When it is dull, the saw grinds at the wood and produces fine chips and sawdust instead of the good-sized chips that it should. The blade also becomes very hot. Either of these signs should tell you that it is high time you filed the chain.

To sharpen your saw, follow the recommendations in the owner's manual. Purchase the appropriate gauges and files to help get the correct depth and angle on the cutting teeth. It is a good idea to have your dealer demonstrate how to properly file the chain. When sharpening the saw, you should wear a pair of gloves to protect your fingers from possible injury while the chain is being pulled around the bar.

Special care is necessary if you do not anticipate using the saw for a few days. Before you put the saw away oil the bar-cutter system, run the saw until it is out of fuel, and clean the general structure. To keep dust out, store your saw in its plastic carrying case, wrap it in clean newspapers, or keep it in a homemade plywood blade sheath. (The plywood sheath can also be used to protect the blade during transport.) Don't use a plastic bag because it seals in moisture and corrosives.

By checking the chain tension and by keeping the chain well lubricated and sharp, you will have a safe and efficient saw that will last for a long time.

Chain Saw Operation
Operating a chain saw is dangerous work if you do not know what you are doing. You must have an experienced person show you how to use a chain saw, and you must practice under his or her eye until you can handle the machine instinctively. Learn to find the saw's on/off switch, the chain brake, and the throttle trigger without looking. Always wear the proper attire, and treat the running saw with attentiveness, determination, and respect. Never touch or try to stop a moving chain with your hand — flesh is easier to cut than wood.
The following safety rules are simple and logical. They will quickly become habit and should be reviewed periodically.

1. Start the saw safely. Place it firmly on the ground with the bar and chain clear of branches and twigs. Anchor it with one hand on the front handlebar and with one foot on the rear hand guard, if the hand guard is large enough.

2. Stop the engine before carrying the saw between jobs. Carry the saw with the bar and chain behind you. It is a good idea to cover the chain with a guard during long transport.

3. While cutting, hold the saw firmly with both hands, and stand with feet well braced and body balanced. Keep elbows and knees slightly flexed for maximum control. Stand to the side of the saw when cutting so that it will not swing into you if it kicks back or cuts through the wood unexpectedly. Do not cut anything that requires you to hold the saw above your shoulders.

4. Cut with the lower side of the saw as much as possible. This way, gravity does part of the work. Do not twist the guide bar; let the saw do the cutting.

5. Kickback, that is, when the saw flies out of the cut and back towards the operator, is extremely dangerous (fig. 13). Because it happens so fast that one cannot stop it, the only way to deal with kickback is to prevent it from happening. Kickback is often caused when

- the chain at the tip of the bar nose comes in contact with a fixed object,
- the saw encounters an abrupt change of wood characteristics,
- the saw is run too slowly,
- damp sawdust builds up,
- the saw is twisted so the cutters grab the wood,
- the nose of the bar is used for cutting.

Some chain saws have safety features, such as a chain brake or a nose guard, to prevent kickback from occurring.

6. You may need to use wedges to prevent the saw from binding in the cut or as you fell a tree. Use only plastic, magnesium, or wooden wedges. The saw will be damaged if it comes into contact with a steel or iron wedge.

Using a chain saw out in the woods can start a fire. To help prevent fires you should follow these rules:

1. Use the correct gasoline–oil mixture to minimize carbon build-up. When carbon builds up in an engine, it produces sparks in the exhaust.

2. Handle fuel safely and avoid spilling it. Mix and carry the fuel in a safety container. Allow hot saws to cool before refueling. Refuel the saw in an area where there are no flammable materials.

3. Wipe the saw clean and move at least 10 feet away from filling area to start it.

4. If a fire should get started, be properly prepared to extinguish it — have some type of fire extinguisher available.

A peavy is a useful tool that can help you move a log about with ease. It is a heavy, hardwood handle shod at the lower end with a steel spike. A hinged "arm" attached to the spike wraps around the log. The handle gives the user good leverage to maneuver heavy logs. The peavy can also be used as a pry pole in lift-
ing logs to avoid pinching the saw when someone is cutting the log into lengths (fig. 14).

It is important to have an experienced person show you how to use all of these tools properly and watch you as you practice. Review the safety precautions, and heed them when you are in the woods. Be a responsible woodworker; keep alert, beware of potential accidents, and treat your tools with respect—they are not toys.

Activity Suggestions
1. Assemble your firewood preparation outfit. Discuss the value of each item.
2. Explain some of the dangers of working in the woods. List several ways to avoid accidents.
3. Draw a poster showing potential accident situations.
4. Learn what each tool is used for. Describe hazards of using the tools and how to handle them safely. Demonstrate the maintenance of each tool.
5. If you are going to use a chainsaw, take extra time to learn about its use, safety, and maintenance. Read additional information listed in the reference section. Demonstrate that you know how to adjust the chain tension, how to clean the saw, and how to keep it sharp. Review the safety rules. Make a poster of the rules to keep where you store your chainsaw.
6. Arrange to have a chainsaw dealer talk with your group about chainsaw selection, maintenance, and safety.
7. Describe how a chainsaw can start a fire and how to avoid it. Explain what you would do if a fire were to occur.
8. Practice starting and stopping a chainsaw until it becomes automatic. Have an experienced person show you how to cut with a chainsaw. Practice under a watchful eye until you develop a feel for the chain saw.

Lesson 4: Felling Trees

Objectives
To help youth
1. Learn how to fell trees properly and safely with a chainsaw and bow saw.
2. Be aware of the seriousness involved in felling a tree.

Materials
- Chain saw
- Bow saw
- Wedges — wooden, aluminum, magnesium, or plastic
- Maul

Felling trees is serious business. It is a skill that requires much practice. This text covers the basics, but by itself it will not provide the knowledge to do the job. Have an experienced person show you how to fell a tree; practice under his or her watchful eye. Be sure to wear a hard hat to protect your head from falling wood. There are plenty of woodworkers who proudly wear dented hard hats. They know that without their hat, they would either be permanently disabled or dead as a result of their close call.

Several things must be kept in mind when felling trees:
1. Assume nothing. Each tree is different. Anything from a differ-
ence in grain in the branches to a difference in the health of the tree could make it fall differently from another tree.

2. Trees can kill. Look up before you start to cut, and plan both the path of the tree fall and your escape route from the tree as it starts to go over. Your escape route should be about 130 degrees in a counterclockwise direction from the direction of the tree fall. Leave the tree as it begins to fall; it can split and jump 10 to 15 feet straight back off the stump (fig. 15).

3. Check the top of the tree for widowmakers — dead wood hung up in the tree — and for branches that may break off the tree as it falls. Be sure to wear your hard hat to deflect widowmakers if they fall on you.

4. Make sure other people are at a safe distance — at least 2½ times the height of the tree.

Once you have selected a tree, you must determine in which direction you want the tree to fall. This step is an important one, so take your time. A small tree can be dropped in any convenient direction. Ideally, you want the tree to fall in an area where it will not damage promising young trees, where it will not get hung up in the top of another tree, or where you can conveniently cut it into lengths and transport it out of the woods. If the tree is large, you may have little choice of direction; however, with experience and wedges you can sometimes change this direction by as much as 30 degrees. Trees with a lean should generally be felled toward the side with the branches. In both these cases, if you fell the trees in any other direction, you will have to make allowances to overcome the effects of gravity. As an inexperienced operator, you should attempt to fell trees only when it is highly certain which way the tree will fall.

If you are on a steep slope, you must take special care when felling straight uphill or downhill. When the tree hits the ground, the butt end could bounce and take an unexpected flip. The consequences could be disastrous. Be sure to quickly move uphill and well away from the falling tree. The best place to drop the tree is diagonally across the slope. Avoid felling a tree on an obstacle, such as a log or a rock, that can cause the tree to thrash around in unpredictable ways. Do not fell trees on windy days; the wind can deflect the tree from its intended line of fall and cause it to fall in an unexpected direction.

A tree is felled by making a series of cuts. The object is to leave a hinge of uncut wood in the tree. This hinge controls the line of fall, and depending upon how you shape it, enables you to aim the tree. After determining where best to fell the tree, the first cutting step is to make a notch or undercut on the side toward which it is to fall. First, make a horizontal cut at a right angle to the line of fall to a depth of one-third the diameter of the tree. To complete the notch, make another cut a few inches above the first cut angled down about 45 degrees to meet the back edge of the undercut. The back of the resultant notch should be at a right angle to the fall line. The direction of fall can be tested by placing an axe in the cut and sighting down the handle. It may be difficult at first to get the back edges of the two cuts to meet, but it is better to undershoot than to overshoot. By making the lower cut first, you prevent the chain from binding and being pinched by the wedge of wood from the top cut.

The backcut is the final cut and is made on the opposite side of the tree from the notch. It should be about 1 inch higher than the horizontal cut of the notch and parallel to it. Do not saw all the way through to the undercut. Leave an inch or two of uncut
wood to form the hinge. If you cut through the hinge, the tree could fall in any direction. It takes practice to place the backcut correctly. Don’t make the cut too low. If the cut is too high, it will probably fall generally where you want it to. If the cut is too low, however, the tree may fall over backwards (fig. 16).

Keep the guide bar of the chain saw in the middle of the cut so the cutters returning in the top groove do not recut the wood. Don’t twist the guide bar in the groove. Guide the saw into the tree — don’t force it. The rate of feed will depend on the size and type of timber.

Remove the saw from the cut and turn it off before the tree falls. The tree will begin to fall as the felling cut approaches the hinge fibers. Move to a safe spot away from the stump and look up for falling branches.

Before starting a cut that will require a long running period, it is a wise idea to check the fuel supply. Also, if you are tiring and the saw has not progressed to a near fall, remove the saw, shut it off, and rest until you are able to proceed with confidence. If there is any rotten wood in the tree base, it will not hold a hinge.

To be safe, make the undercut well above the rot.

**Wedges**

Although not absolutely essential, wedges come in handy for preventing or freeing a bound saw and for helping direct a tree along the desired line of fall. Use only wooden, aluminum, magnesium, or plastic wedges — not steel or iron — to prevent the wedge from damaging the chain and guide bar if they should come into contact.

To prevent your saw from getting stuck in the cut, place a wedge into the backcut as soon as there is room for it. Using a sledge, a mallet, or a stick cut for the purpose, tap the wedge until it is firmly in place. It should be pointed in the desired direction of fall. As you cut, periodically tap the wedge in further. Strike the wedge squarely with firm but not excessive blows. Careless blows may cause the wedge to pop out. For larger trees, you may need to use two or more wedges. If the tree does not fall after the backcut is completed, remove the saw and drive the wedge in further until the tree begins to fall. An inexperienced woodworker is wise to use wedges. They can give you more control over the tree and prevent problems with saw binding (fig. 17).

Again, if at all possible, plan to fell the tree in the direction that gravity is likely to pull it — that is, toward the direction it is leaning or toward the side with heavy branches. If you have no other choice and the tree is leaning slightly in the wrong direction, you may be able to overcome the lean by “holding a corner”. Do not attempt this on your own; have an experienced person show you first. To hold a corner, you saw closer to the undercut on the side of the lean than you do on the side opposite the lean. The thicker side of the hinge holds the tree longer and pulls it to that side when it falls. As an extra precaution, you should drive wedges into the side of the backcut that the tree leans toward. The tree that leans heavily in the wrong direction should be left standing in the woods. A well-balanced tree may have to be wedged, pulled, or pushed in the desired fall direction.

A tree that leans heavily in the direction it is being felled is not the ideal tree. It tends to fall prematurely. As it falls, it puts stress on the back of the hinge, but because the grain of the tree is weaker than the hinge, the tree splits up the stem along the grain. To avoid this, make a cut in each side of the hinge after making the notch but before making the backcut. The depth of each of
these cuts should be 1-2 inches deep for a tree of about 10 inches in diameter. Make the cuts at a 30 degree angle to the undercut. (fig. 18).

The manipulation of fall control comes with experience. Approach complex falls with extreme caution. Do not neglect wind effects. Always keep the felling direction as simple as possible and avoid working on windy days. Once in a while you will end up with your tree lodging in the crown of another; it happens to even the most experienced loggers. First, cut the tree the rest of the way off its stump if it hasn’t completely fallen off. Be careful, though; the tree may spring back at you. If this does not do the job, you may be able to use a peavey to rock the tree free, if it is small. Jam the peavey between the ground and the end of the tree. Push up and back away from the holding tree, and the tree may slide backwards and come free. A tractor or winch may be necessary to pull out a more difficult tree. If the tree still won’t come free, cut chunks off the end of the hung up tree. Make the first cut 3 or 4 feet up from the butt, but to avoid pinching the saw, cut only a couple of inches into the top side and complete the cut from the underside. Keep your feet out of the way of the falling chunk. Continue successive cuts until the tree either falls out or until it is too high to cut safely (fig. 19). Never use a chain saw at a level above your shoulders because you do not have enough control over it. If all else fails, leave the tree. Do not cut the standing tree or climb either tree — it is too dangerous. Remember, you should not attempt to free a hung-up tree until you have enough skill and experience to feel comfortable with the saw and with felling trees. Watch an experienced person first before you attempt new maneuvers.

Whenever you are working in the woods, it is a good idea not to work alone. More than one person has been injured and has succumbed to exposure because no one was there to get help. Make sure someone knows where you are and when you expect to be back.

Activity Suggestions

IMPORTANT! Read the section on felling thoroughly. Look up additional information on felling, and read that also. Do not attempt to fell a tree without the aid of an experienced person.

1. What dangers are involved in felling a tree? How can you avoid them? Draw some posters that depict hazards and the right and wrong ways to fell a tree.
2. What determines the direction in which you fell a tree? How is felling on a steep slope different from felling on level ground?
3. Explain the importance of the cuts involved in felling a tree.
4. Describe the use of wedges. What kind of wedge should be used?
5. Discuss what is meant by "holding a corner". In what case would you use it?
6. How do you fell a tree that is leaning heavily in the correct direction? What must you be careful of?
7. Draw a diagram showing four ways to free a tree that is hung up. What dangers might you run into when trying to free a hung-up tree?

Proceed to limbing and bucking exercises. After you have used a chain saw for these sections and feel comfortable using one, you may do the following step.

8. Have an experienced person show you how to fell a tree using both a chain saw and a bow saw. Watch him or her fell several trees. Fell a small tree yourself as this person guides you. Appraise your job. Did you get the tree to fall where you wanted it to? How well are your cuts made? What should you do next time?
Lesson 5: Limbing and Bucking

Objectives
To help youth
1. Learn how to safely limb and buck a fallen tree,
2. Acquire more skills and experience with a chain saw.

Materials
- Chain saw
- Axe
- Flagging
- Hammer, nails, boards, posts—for making cutting crib
- Fallen trees to practice limbing
- Logs to practice bucking

Limbing
Once the tree is on the ground, the next step is to limb it. As you proceed, keep common sense and safety in mind. Many chain saw accidents occur during limbing. Be alert for movement of the tree and branches. Prevent kickback—do not let the nose of the saw's bar hit a branch or branch stub while cutting another branch with the center of the bar. Rest when your arms get tired.
Before limbing, assess the situation. Check the tree for stability. Determine if the trunk is resting on any limbs that are bent with great pressure. When cut, these limbs may spring violently at you or even cause the trunk to spring or roll at you. Save these limbs to do last. By removing the other limbs, the weight of the tree will lessen and perhaps free the pressure. If it does not, you can roll the tree over.

Start the limbing from the stump of the tree and gradually work your way up to the top (fig. 20). Cut the limbs on the top side of the trunk before removing those resting on the ground. Also, remove lesser branches that can impair vision, present obstacles, and cause kickback if twigs become lodged in the blade. Be especially careful with the small diameter limbs as they may catch in the saw and be whipped toward you. Cut the branches to desired lengths (stove lengths) by working from the tip to where the branch is attached to the trunk. Finally, cut the branch off flush with the trunk. Remember, anything down to 7.6 cm (3 in) in diameter can be used for burning. Branches make good kindling wood and quick, hot fires in a stove or fireplace to heat a cold room in winter. They can also be used to build short-duration fires during spring or fall to eliminate the chill in the house.

When limbing, use the tree as a barrier and stand on the side opposite the limb that you are cutting. If this is not possible, keep the saw to the side of the body so it will not swing into your legs or head. Avoid reaching with the saw, and always maintain good footing and balance. Do not limb with the nose of the guide bar because it will cause kickback (fig. 21).

As you saw branches, the tree may sag or roll. Watch out for your feet; if you are on a steep slope, work on the uphill side of the tree. Key branches that stabilize the tree should be left for last. You may even want to leave the final supporting branches on to make the bucking easier.

Limbing need not be done with a chain saw. With more effort and skill, a sharp axe may be used. In any event, an axe should be used when it is not safe to use a chain saw. Procedures for limbing with an axe are the same as with a chain saw. Always try to use the tree as a barrier between you and the axe, and swing away from yourself. Swing the axe parallel to the trunk and in the direction of growth — from trunk to top. Take time to clear your work area as you go, and avoid dangerous overhead swings.

**Bucking**

Bucking, or cutting the tree into desired lengths, is generally less hazardous than other sawing tasks. The main problems you may experience are kickback, unexpected roll of the log, and getting your saw pinched in the cut. Avoid letting the saw come into contact with soil or rocks, which cause your saw to dull quickly.

To buck the tree, first measure off the lengths to be cut. They may be stove sized or longer, depending upon the hauling distance to the road or vehicle and the hauling equipment you have. If you must haul the logs a long distance to where they are to be loaded, longer lengths require fewer trips. Of course, you must have the correct hauling equipment, such as a winch and tractor, to handle the logs. These long lengths can then be cut into smaller pieces either before loading or wherever it is most convenient. Beware of nails or other hardware that might be buried in the tree, especially in trees that are from a yard or a sugar bush or that line old roads or fences. Such metal can harm your saw or become dangerous flying debris.

As you buck the log, the tree may roll. You can prevent this by
blocking the tree. Always be sure to work on the uphill side of the tree, and keep firm footing.

The skill to good bucking is knowing how to cut off the lengths without binding the saw. The saw gets pinched in the wood when it cuts into the compressed wood of a log under tension. For example, a bridged log that is supported on either end and with the middle hanging free has compressed wood on top and wood under tension on the bottom. Sawing straight through from the top of the log — the compressed wood side — will cause the wood to bind the saw. Proceed by cutting one-third of the diameter from the top to prevent splintering. Finish the cut from the underside. This technique prevents the log from binding the saw. Be careful, however, because the log may suddenly collapse and move to the side. When a log is supported on one end only, cut one-third of the diameter from the underside. Make the second cut from the top through the tensioned side (fig. 22).

With logs lying on the ground, special care should be taken to keep the chain from coming into contact with the ground. Prop the log up with another piece of wood or with a rock. Another alternative is to make all of your cuts along the log but not completely through to the ground. Then roll the log over and finish the cuts. If the log is muddy on the underside be sure to clean it.
with a wire brush, or you will spend most of your time sharpening the saw.

When bucking a quantity of logs, some people use a sawbuck or a pallet rack. A sawbuck is a stand that holds the log firmly in place and off the ground at a comfortable level for sawing. Besides saving your back, the sawbuck keeps your saw from dulling by preventing contact with the ground. A pallet rack or cutting crib allows you to cut many logs at the same time. The vertical frame of the rack holds many logs piled side by side and on top of each other in the same direction. A single pass of the chain saw then “gang cuts” many pieces at the same time to the same length (fig. 23).

As you buck and limb, you will have to move limbs and sections of logs that can be quite heavy and unwieldy. To avoid straining your back or other muscles, use levers, sturdy poles, or bars as much as possible. Be sure to do all manual lifting with your legs, and keep your back straight.

Activity Suggestions
1. Have an experienced person demonstrate how to limb a tree. “Limb” your own tree, but do not use a saw. Instead, tie flagging or strips of cloth on the tree to show where you wish to make cuts. Point out problem spots, such as limbs that are under pressure. Discuss how you can safely handle them. Evaluate your limbing job, make any adjustments, and limb the tree with an axe or saw.
2. Review problems you might run into while bucking a log. How can you avoid them?
3. Practice bucking a log with a chain saw. Demonstrate how to avoid binding the saw.
4. When you prepare firewood, what length do you intend to cut the pieces? What should you take into consideration?
5. Construct a cutting crib.

Plan ahead how you are going to transport your wood out of the forest. There are three basic ways to transport wood.
- Logs can be dragged or skidded behind a horse, crawler tractor, or farm tractor.
- Logs or shorter lengths can be placed on a sled or cart pulled by a horse or tractor.
- Logs can be bucked into short lengths and carried by hand to where they can be loaded into a pickup truck.

The most efficient method is to haul long logs to the roadside where several logs can be bucked into smaller pieces at the same time in a cutting crib and then loaded into a pickup truck to be hauled to the place of storage. This method, of course, requires a tractor or horse and the proper rigs. If you have access to such equipment, you will be able to go deeper into the forest and farther away from the road to get your wood.

Lack of large equipment requires that you use the third and most time-consuming method. If you must haul pieces out by hand, plan your cutting operations close to a road to keep your hauling distances short. Regardless of your method of getting the wood to the roadside, you must have a proper vehicle to transport it to the storage location. The vehicle, most likely a truck, should be capable of carrying the heavy load of wood and also be able to travel over the
roads. Many forest roads are dirt or gravel and are poorly maintained.

When you haul wood and have heavy equipment in the forest, treat the forest with respect and avoid causing excessive damage. The trees that you leave standing may easily be wounded by logs or equipment that scrape against them. These open wounds can become a pathway for disease, rot, and insects. Avoid polluting bodies of water. Do not haul logs through waterways; build a bridge if necessary to cross a stream. Running equipment on wet ground can compact the soil and cause ruts and erosion. Review the state’s recommended forest practices. Be aware that if you do a sloppy, irresponsible job, you may be violating the law. Do not abuse the forest environment. Anyone who is not responsible enough to take certain precautions does not belong in the woods.

Hauling logs with tractors, horses, winches, and sleds can be difficult and dangerous. It is important to hitch only to the drawbar of a tractor when pulling a load. For safe hitching, the drawbar should be 33–43 cm (13–17 in) above the ground. A load hitched any higher can pull the tractor over backwards (fig. 24). The reference section at the back of this booklet has more information on using large equipment.

**Activity Suggestions**

1. Decide how you intend to transport the wood you are going to prepare. Go to the location where you plan to get wood to visualize the process. Do you need to change your source of firewood?
2. If you plan to use a tractor for hauling, read additional material from the reference section. Why should you hitch only to the drawbar? Set up a demonstration to make your point. Do not use a tractor for hauling unless an experienced person will haul for you or you have a great deal of experience yourself.
3. Look up your state’s rulings or recommendations on forestry practices. Write a summary of them so you will be sure to heed them.

**Lesson 7: Splitting and Seasoning Firewood**

**Objectives**

To help youth
1. Learn how to split wood properly,
2. Understand the necessity of seasoning wood.

**Materials**

Axe
Wood to split
Plastic, boards, nails, hammer to make solar dryer
Scale, chalk

**Splitting**

Though increased strength may be a side benefit, the main purpose of splitting wood is to shorten the seasoning period and to break down the wood into smaller, more easily managed pieces. As previously mentioned, green wood gives off less heat than wood that has been allowed to dry or season because part of the heat from burning is used to evaporate the excess water in green wood. In fact, water makes up about one-fourth to one-half of the weight of freshly cut stems from broadleaf trees. Wood that has been split has more surface area exposed to the air and is able to dry out faster than unsplit wood. It generally takes close to a year for wood that has been cut, split, and stacked in the open to dry.

Large pieces of wood are bulky, heavy, and difficult to carry. They must be burned in a large stove. Wood for fireplaces and smaller stoves should be split into pieces of the appropriate size. Also, consider who will be carrying the wood from the pile to the stove, and split the wood into pieces that they will be able to handle comfortably.

Tools used to split wood include an axe, a splitting maul, and a sledge hammer and wedges. Hydraulic splitters are also used and can greatly reduce the time and effort required to split large quantities of wood by hand. Such
splitters are relatively simple and consist of a stationary wedge and hydraulic ram powered by a small gasoline engine. They are available commercially to buy or rent, or they may be homemade from kits or your own ingenuity, but they are rather expensive.

To split wood by hand, use an axe for the smaller, more easily split material. A splitting maul will handle most of the remaining wood. Extra large or hard-to-split wood with dense, interlocking grain or many knots will most likely require the use of a sledge hammer and wedges. Balance the piece of wood to be split, commonly called a billet, either on the ground or on a chopping block. A stump or another piece of wood may be used as a chopping block to prevent the axe blade from hitting the ground and becoming dull. Hard-to-balance pieces can be steadied with other pieces of wood from the woodpile. Drive your axe, maul, or wedge into the face of the billet in line with any cracks or along an imaginary line through the center of the wood. Flex your knees as you swing and follow through. Continue striking the wood until you succeed in splitting it (fig. 25). To make splitting easier, remember the following tips:

- Split in line with checks. (Checks are cracks in the wood.)
- Split parallel to knots. Put your wedge in a place where the split will not go through or near any knots.
- Split parallel to spiral grain.
- Green or frozen wood splits easier than dry wood.

Make sure that you do not try to steady a billet by leaning it on the side opposite yourself to split it. If you hit the piece too high, it will fly up end over end and could hit you. Never steady the billet between your legs or with your foot as you strike it. Such foolish action can have you looking for a wooden leg (fig. 26).

The ease with which a wood splits is strongly influenced by its grain. Although grain varies from tree to tree depending upon how the tree grew, each tree species has a characteristic type of grain. Species can thus be categorized as to their ease of splitting (see table 1). Woods that have dense, close grain tend to be rather tough to split. Black locust, apple, beech, and many other broadleaf trees fall into this category. Some woods, such as American elm, have interlocking grain and are almost impossible to split. Many conifers and some broadleaf trees, on the other hand, split easily because their wood is more porous. The presence of crooked wood, spiral grain, or knots makes any wood difficult to split. Generally speaking, however, most species can be split without much difficulty, especially if they are green or frozen.

A general rule of thumb is to split logs 25.4 cm (10 in) or more in diameter into wedges. Split the tip off the wedge, and then split the wedge in half. Logs that are 20.3–25.4 cm (8–10 in) in diameter should be quartered and the smaller billets split in half (fig. 27). For wood lengths too small to split, you can run your axe lengthwise down the piece to open up the bark and hasten seasoning.
Seasoning Firewood

Several factors affect the seasoning rate of firewood. These include length of wood, the absence or presence of bark on wood, whether the exposed surface is split or is a debarked round surface, the species, whether the wood is heartwood or sapwood, and the humidity, temperature, and circulation of the air. The way in which you stack and shelter the wood influences these factors.

To speed up natural drying, stack the split wood in an area where it receives maximum exposure to sun and air movement. Try to locate the pile close enough for convenient use, yet out of the way for seasoning. Many woodpiles have been left to decay in the woods simply because it was too inconvenient to retrieve the wood. Shelter the stack against rewetting by rain with a roof of tarred paper, a tarp, or thick plastic. Make sure to weight the covering down so the winter winds do not undo your work. Wood stacked outside should be supported well off the ground to prevent contact with wet ground and decay of the lowermost logs.

Wood may be stacked in a freestanding pile, in a pile that is braced at either end, or in a roofed shelter. However you stack it, make sure the pile is stable. Test its stability with a gentle shake now and then as you work. Rebuild if necessary. A lost pile in January not only means lost work, but also slower drying of the wood if it is not restacked. A solid base is the key. Lay down two parallel rows of logs placed end to end. The rows should be less than billet-length apart and should be as long as the intended stack. For convenience, you can make the base the length and width of a cord. The base tier of logs is then placed at right angles to the bottom logs. The succeeding rows can be laid on top, either all in the same direction or with each layer at a right angle to the previous one. Alternate the layers for a more stable pile (fig. 28).

A pile that is braced on either end like a stack of books between book ends is quite stable. Begin by driving two pairs of stakes in the ground 8 feet apart. After the wood is stacked, you may wish to connect the stake with 8-foot-long poles notched at each end.

If you are serious about using firewood, it may be worth your while to build a roofed shelter. Figure 29 shows a design for a 4.9-meter (16-ft) × 7.3-meter (24-ft) roof supported 2.4 meters (8 ft) off the ground by square treated poles. Such a roof would cover about 20 standard cords of wood stacked 2.1 meters (7 ft) high. This amount is enough for a 2- to 3-year supply for most homes. Using such a system, you would be able to burn dry wood (that has seasoned a year) from one side while filling the other side with green wood.

There is a useful trick you can use to determine when the wood is seasoned. Mark a piece of wood from the pile. Weigh it and record it. Every couple of months, reweigh the piece. When the weight seems to be fairly constant over a period of time, it is seasoned, although it may gain or lose a couple of pounds depending upon the humidity of the air.

Seasoning time can be cut as much as three-quarters by build-
ing a solar dryer around the wood pile. In fact, it has been demonstrated that bolts 50.8 cm (20 in) long and split into pieces less than 20.3 cm (8 in) in diameter were bone dry after only 3½ months in a solar dryer during the summer and fall. To make your solar dryer, stack the wood in full sun. Then build a wooden frame around it as suggested in figure 30. Attach clear plastic sheeting to the frame to cover the stack. Avoid thin, easily torn plastic. For best results, use plastic that is at least 4 mil thick. In sunny weather, temperatures inside the covering will rise much higher than outside. This heat will cause moisture to evaporate from the warm wood. Be sure to provide ventilation so the water vapor may escape. Also, keep the plastic away from the wood to allow good air circulation and to avoid rewetting of the wood from any water that has condensed on the plastic. Before winter, a roof should be built over the wood pile to keep it dry; the plastic, after exposure to the sun, will be too deteriorated to provide adequate cover. An added advantage to using a solar dryer is that the high temperatures and fast drying help keep insects off the wood.

Whatever system you use to season your wood, it is a good idea to brush off the wood before you bring it indoors to burn. This way you won’t trail insects and sawdust into the house. Also, by keeping two days ahead of your indoor wood supply, you will give the wood a chance to warm up and allow surface moisture to evaporate.

4. Stack a woodpile. Test it for stability.
5. Take several different-sized pieces of wood that have different amounts of exposed surface area. Identify each piece with a mark, weigh the piece, and record the weight. Store the wood pieces in a covered seasoning pile that has good air circulation. Weigh each piece of wood once a month. How long does it take for each piece to season (reach the point at which it no longer loses more than a couple of pounds)? Write up a summary.
6. Construct a solar wood dryer.
7. Construct a roofed shelter for seasoning wood.
Lesson 8: Selling Firewood

Objectives
To help youth
1. Learn how to produce and market a product for sale to the public,
2. Gain confidence in dealing with people,
3. Take the responsibility to organize and perform in a business-like manner.

Materials
Wood, hammer, nails, screws, wheels, bolt, wire to build a jig

Selling firewood requires more than just preparing a pile of wood and labeling it with a “For sale” sign. Selling firewood means that you get the right product to the right person in the right package, at the right time and the right price. The customer may or may not want dry, seasoned wood. He or she may want it delivered in a nice stack or may be willing to pick it up. The customer may want wood only in a particular month of the year. A discount price offered for delivery of green wood in the spring could extend the selling season and provide a market for green wood, which could be used the following winter.

When you sell wood to the public, make sure that you follow any state or local laws that pertain to the sale of fuelwood. You can get copies of these laws by calling or writing to the state’s Bureau of Weights and Measures. Some laws require that most wood for fuel must be sold by volume but allow a few exceptions to be sold by weight (such as wood chips, quantities of wood over 1 cord, and logs). The weight of wood varies with species and amount of seasoning. For example, the same cord of wood that weighs between 2 and 3 tons when green can weigh 1½ to 2 tons when air dry. To get around this problem, some laws specify that the length of seasoning time be stated. Often a delivery ticket or sales invoice is required by law, but even if no law exists, it is a good way to protect yourself and keep track of your sales.

Activity Suggestions
1. If you have decided to prepare firewood to sell, you must plan carefully. Consider the following questions. Do you plan to sell wood just 1 year or more? Will your source provide you with enough wood to make a sale profitable? In what quantities will you sell wood? What are the legal units of sale in your state? Will you deliver it? What price will you charge? (You can find out the current price of firewood from your local forester.) Keep records of your sales. Do you need to pay any tax?

2. For those clubs that have decided to make this a group project, be sure to organize and involve all members. Set up a schedule to divide the work evenly.

3. Read the literature on packaging firewood. Build a jig to make the bundling of firewood easier (see appendix 3).

Lesson 9: Systems

Objectives
To help youth
1. Set up a plan and evaluation of their firewood preparation effort,
2. Gain an insight into costs of heating with firewood,
3. Learn how to conduct a rough economic analysis.

A person who is committed to preparing firewood for more than 1 year will find that a preparation system comes in handy. Such a system can help organize efforts to keep ahead of the game and make an efficient operation.

As you prepare firewood, make notes of things that you could have done to make it easier. Use them when you plan next year’s work. Talk with other people who have experience and pick up tips from them. If you are cutting your own trees, plan the areas you are going to cut over the next
couple of years. If you cut all the easy-to-get wood the first year, you may face difficulties the following years. Cut areas that are close together, if possible, to ease hauling problems.

Wood that is cut and split in the early spring may be dry enough by winter to burn well. Some people suggest leaving the leaves on a tree for 2 or more weeks after it has been felled. The idea is that the leaves will draw out excess moisture, and, thus, less time will be required to season the wood. Adopt a cycle of preparing wood. Leave a year’s supply to season in its original piles for use the following year. This will allow 12 to 15 months drying time. Remember that wood does decay, especially where it stays damp and is close to the ground, so you probably will not want to get too many years ahead of yourself.

With experience and by trial and error you will be able to develop a good system of firewood preparation that suits you individually. You can be proud of yourself; the woodpile you see in front of you represents hard work and sweat. It is an accomplishment.

As you work, take precautions, be safe, and, most of all, have fun.

Activity Suggestions
1. Lay out a plan to produce a quantity of firewood. Follow it through.
2. Write an evaluation of your work. Include:
   - Problems you had,
   - How to avoid these problems next time,
   - What worked particularly well,
   - What you will change for next year,
   - Any interesting things that happened,
   - How successful you were.
3. Wood Heat Costs
   The purpose of this exercise is to compare the cost of wood for heating with the cost of other heating fuels.
   a. Cost to heat a house with a fuel other than wood. Record heating bills during the months of highest use for a house that is heated with coal, fuel oil, electricity, or natural gas on the following chart.
      | Month | Amount of fuel (Y) | Cost of fuel (Z) |
      |-------|-------------------|----------------|

   b. Cost to produce wood fuel. Record on a summary sheet similar to the illustrated chart all costs paid to produce the quantity of firewood you prepared. Be sure to include costs for transporting wood and yourself (gasoline, vehicle operation costs, shock replacements) and cost for operation, fuel, and repair of tools. Most of the tools you use were either purchased previously or purchased specifically for your firewood project. Tools therefore have a built-in cost each time you use them that you must account for. Consider this cost as follows:

   Built-in cost = Depreciation + Interest on investment.

   (1) Depreciation: Each year after purchase the worth of a tool usually decreases.

   Depreciation =
   Purchase price - Salvage value / Number of years

   Because the salvage value, the amount of money someone would pay for the tool after many years, is not too important and only complicates things, for your purposes it can be ignored. Thus,

   Depreciation =
   Purchase price / Number of years

   (2) Interest on investment: There are many ways to spend your money, and one option is to put it in the bank to earn interest. When you spend money to buy a tool, you are cutting off that option. The “lost” interest can be viewed as a cost.

   Interest on investment
   = Purchase price / 2
   = Purchase price * 8%

   *The purchase price is divided by 2 to get an average between the price now and the price at the end of its life (which is $0).
   **Consider 8% to be an average interest. The actual interest earned by a savings account is less, but if you had to borrow the money to buy the tool, you’d be paying a much higher interest than 8%.

   The built-in cost figure is a yearly figure, so record it only once for each tool. For example: you bought a chainsaw for $250 that is expected to last 10 years.

   Built-in cost of saw = $250 / 10
   = $25

   x 8% = $25 + ($125 x .08)
   = $25 + $10 = $35

   (3) On the following charts, record the time you spent for each activity involved in producing firewood regardless of whether you spent any money or not.

   Complete the first three columns. Total the costs and the number of hours you have spent.

   Total cost (A) = A_1 + A_2 + A_3 +...
   Total time (B) = B_1 + B_2 + B_3 +...

   Determine the number of cords you produced (E). Calculate the total cost per cord and the total time spent per cord.
Table 2. Fuel Equivalents of Some Common Fuel Woods

<table>
<thead>
<tr>
<th></th>
<th>Equivalent of 1 cord of air-dry wood</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coal (tons)</td>
</tr>
<tr>
<td>Apple, Beech, Hickory, Rock</td>
<td>0.9</td>
</tr>
<tr>
<td>Elm, Ironwood, Black</td>
<td>(1.111)</td>
</tr>
<tr>
<td>Locust, White Oak</td>
<td>0.75</td>
</tr>
<tr>
<td>White Ash, Birch, Sugar</td>
<td>(1.333)</td>
</tr>
<tr>
<td>Maple, Red Oak, Black</td>
<td>0.6</td>
</tr>
<tr>
<td>Walnut</td>
<td>(1.667)</td>
</tr>
<tr>
<td>Black Ash, Green Ash, Black</td>
<td>0.5</td>
</tr>
<tr>
<td>Cherry, American Elm, Red Maple, Silver Maple, Pitch Pine, Red Pine, Tamarack</td>
<td>(2.000)</td>
</tr>
<tr>
<td>Aspen, Basswood, Butternut, Balsam Fir, Hemlock, White Pine, Spruce, Willow</td>
<td></td>
</tr>
</tbody>
</table>

Chart for recording costs of preparing firewood

<table>
<thead>
<tr>
<th>Activity, tool, item</th>
<th>Cost</th>
<th>Time</th>
<th>Cost/cord</th>
<th>Time/cord</th>
</tr>
</thead>
<tbody>
<tr>
<td>chainsaw purchase</td>
<td>$35.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(built-in cost)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>bucked logs – used 1/2 gal. of gas</td>
<td>.55</td>
<td>2 hours</td>
<td></td>
<td></td>
</tr>
<tr>
<td>filed saw</td>
<td>—</td>
<td>1/4 hour</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Activity, tool, item

<table>
<thead>
<tr>
<th>Activity, tool, item</th>
<th>Cost</th>
<th>Time</th>
<th>Cost/cord</th>
<th>Time/cord</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>$A_1$</td>
<td>$B_1$</td>
<td>$C_T$</td>
<td>$D_T$</td>
</tr>
<tr>
<td>2.</td>
<td>$A_2$</td>
<td>$B_2$</td>
<td>$C_2$</td>
<td>$D_2$</td>
</tr>
<tr>
<td>3.</td>
<td>$A_3$</td>
<td>$B_3$</td>
<td>$C_3$</td>
<td>$D_3$</td>
</tr>
<tr>
<td></td>
<td>$A_T$</td>
<td>$B_T$</td>
<td>$C_T$</td>
<td>$D_T$</td>
</tr>
</tbody>
</table>

Number of cords $= (E)

Total cost per cord $= C_T = A_T + E$

Total time spent per cord $= D_T = B_T + E$

If you are interested, determine the cost per cord and time spent per cord for each activity.

$A_1 + E = C_1$

You have recorded above the total price you paid to produce 1 cord of wood, but is it really the total cost? If your time has no value, it is the total cost. Actually, when you are making firewood, you could be spending your time to work at a paying job. In this sense your labor does have a fee. Consider that your time is worth $3/hour; what then is the cost to produce 1 cord of firewood?

$D_T \times \$3/hour = (F) (cost of time)$

$F + C_T = (G) (total cost to produce cord)$

c. Cost comparisons

To determine the cost of wood compared with other fuels, you need to determine how many cords of wood are required to replace the amount of alternate fuel that was used in the house you monitored.

Cords of wood $(W) = \text{Conversion factor} \times Y_T = (W)$

Use table 2 to determine the conversion factor. If you do not consider your time as a cost, the total cost to produce this amount of firewood is:

$W \times C_T = (H)$

If your time is worth $3/hour, the cost to produce this amount of firewood is:

$W \times G = (I)$

Now consider that this house does not have a woodburning stove. Therefore, in order to burn this wood, the household heating system must be converted. Conversion will increase the cost of using wood fuel and must be added to $H$ and $I$. Calculate the cost of conversion to a wood heating system as follows:

Cost of wood heating system = Depreciation + Interest on investment + Insurance + Increase in taxes

Add together the costs for stove, stovetop, tools, and accessories.

$J = (J)$

Depreciation = $J - \text{Salvage value} = (K)$

Number of years

Ask a dealer to estimate how much the stove and accessories will be worth in 10 years (the salvage value). Substitute 10 for the number of years.

You must also install your stove and heating system. Record how much this would cost. (If you do it yourself, consider your time at $3/hour.)

$L = (L)$

Divide this by the number of years the system is expected to last before parts must be replaced (such as when the stovepipe needs to be replaced). $= (M)$

29
Interest on investment: Sinking your money into a stove and installation fees means lost interest.

Interest investment = \( (J + L) \times 8\% = \) \((N)\)

Insurance rate: The household insurance will most likely increase because of the risk of fire. Ask an insurance agent how much the increase would be for the number of months that you monitored the fuel bills. \((O)\)

Taxes: Installation of a wood heating unit may be viewed as an improvement by the tax assessor. Call up your local assessor to find out how much taxes would increase for the number of months that you monitored the fuel bills. \((P)\)

Therefore, the cost of a wood heating system is:

\[ K + M + N + O + P = \] \((Q)\)

How much does it cost per season to convert to wood heat if your labor is free? \(H + Q = \) \((R)\)

How much does it cost per season to convert to wood heat if your labor is worth $3/hour? \(I + Q = \) \((S)\)

How much does it presently cost per season to heat the house?

Which is the best choice?

What other "costs" are involved?

4. This economic analysis is quite simplified. It is designed only to give you a ballpark figure. Many of the numbers used in calculations are estimates and are based on assumptions about the future. The final answer is as strong as the weakest part of the analysis. Which do you think are the weakest parts of the analysis?

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**Burning the Wood**

Burning the firewood you have prepared will give you a deep sense of satisfaction. It is important, therefore, to burn it safely in a stove that suits your desires. Because much literature has been written on these topics, it is not necessary to go into great detail here. A review of only the highlights is discussed. Be sure to consult the reference section for complete information.

**Creosote**

As wood burns, combustible gases are given off. Some of these gases are consumed in the burning process. The rest are carried through the stovepipe or chimney flue with the smoke, which is a visible, noncombustible gas, along with some combustibles. As these gases get farther from the fire, they cool and condense on surfaces that are below 250°F. This condensation forms creosote, the dark brown, ill-smelling, tarry substance, which is flammable. Dense smoke from a smoldering fire carries the most creosote. A hot fire burning in a creosote-lined flue system can ignite the creosote and cause a chimney fire.

Creosote buildup can be controlled by a system that keeps the chimney above 250°F. Unfortunately, a stove that allows that much heat to escape up the chimney is radiating less into the room and is not as efficient as other stove models.

Take the following precautions to reduce creosote buildup and the possible danger of chimney fire:

- Use only seasoned wood;
- Connect the stove to the chimney with a short length of pipe (but not directly);
- Line the chimney with tile;
- If the connecting pipe is long, use a double-walled pipe or insulate it;
- Use a chimney cap to provide better draft and to keep the chimney temperature higher;
- Deliberately have a hot fire for 15 to 30 minutes each day. The hot fire tends to burn up small amounts of creosote each day;
- Be sure to frequently inspect the chimney or stovepipe for creosote buildup. A pipe that makes a dull thud when tapped with a metal object indicates that a cleaning job is in order. Check a chimney with a mirror and flashlight;
Keep drafts of stove open so air is available to burn gases. Any time a chimney or pipe has excessive soot and creosote, it should be cleaned. A professional chimney sweep may be hired to do the job, or you may elect to do it yourself. References such as *Burning Wood* can provide you with more information.

**Stoves**

Many types of woodburning stoves are available for purchase. They range from free-standing fireplaces, box stoves, kitchen stoves, and potbellied stoves to airtight and double-chambered stoves. Stoves may be made of cast iron or steel. Decide what your heating needs are. Do you want a stove in the basement or garage for occasional quick heat? A lightweight, thin-walled stove may be the answer. If you want continuous heating, consider the ease of stove operation and efficiency. Consult stove dealers and friends and neighbors for advice in stove selection.

**Installation**

No matter what type of stove you have, it should be properly and safely installed. Make sure the stove has proper clearance distances between it, the wall, the floor, and the ceiling. Protect the floor beneath the stove with a board made of sheet metal and asbestos. The wall may need to be similarly protected if there is less than 3 feet between it and the stove. Install the stovepipe as recommended in *Burning Wood*. A check with the local fire department will help you meet all safety requirements in your installation (fig. 31).

**Safety**

A woodburning stove in your home greatly increases the chance of a house fire. Certain precautions and careful operation will help you avoid such a disaster.

- If you have a fireplace, use a metal screen to prevent damage from sparks.
- Use a noncombustible container for ashes. Do not use plastic. (Ashes can be used as a garden fertilizer, on icy sidewalks, or in soapmaking.)
- Keep flammable materials away from the stove.
- Keep an easily accessible fire extinguisher nearby.
- Have a fire escape plan for your house, and run through it enough times to make it an automatic reaction. Contact your local fire department for advice.
Appendix 1. Firewood Use in Developing Countries

Wood is a major energy source in many Asian, African, and Latin American countries. It is the principal cooking fuel as well as a major source of heat in the colder mountain regions of these continents. Electricity, solar, and oil-based fuels are not as commonly used because they are too expensive or are not available. More than one-third of the world’s population must daily find the wood to cook dinner.

Just one generation ago, the trip out to gather firewood took only one to two hours in places such as the once heavily forested Himalayan foothills of Nepal. Presently it can take a day or more to travel to and from a forested area because population growth has far exceeded tree regeneration and growth on deforested areas. Forests are rapidly receding in countries such as India, Pakistan, South Korea, and Ethiopia and in Latin American and African countries as people gather wood to provide for the basics of their lives. Forested land is also lost because of overgrazing and land clearing for agriculture.

The scarcity of available firewood has forced needy people to actions they would not ordinarily take. In India, for example, people cut trees in protected areas such as national forest reserves. Branches are stripped off trees, and in some Pakistani towns people remove the bark from live trees that line the streets. Poor city dwellers who cannot find trees must scrounge about town for twigs, garbage, or anything burnable. In the uplands of South Korea, needy people not only cut live trees, shrubs, seedlings, and grasses to burn, but they also rake the hillsides clean of leaves and litter. People in some parts of Nigeria uproot crop residues to use as fuel for lack of wood to burn. An increasing number of people in India, Pakistan, and Bangladesh have been forced to burn dried dung as an alternative to wood fuel.

All of these actions have destructive impacts on the environment. The simple removal of trees and vegetation leaves soil unprotected, and water is more likely to run off the surface than to be absorbed into the soil. The water carries with it the top fertile layer of the soil, and in steep, mountainous areas severe landslides and erosion result. This erosion leads to sitation and flooding of the lower flat lands. Tree regeneration and growth is slow on these denuded and eroded areas. When people are forced to use other alternatives for fuel, such as crop residues and dung, the fertility of the soil is further reduced. Decaying crop residues, dung, and leaf litter return to farmlands and forested areas the essential nutrients and organic matter that are required for fertility and good soil texture. If these materials are removed for burning, and if nutrients and organic matter are not replaced by other means, soil fertility and crop production suffers a loss. In parts of India, the following downward cycle has developed as a result of the firewood scarcity and lack of other cheaply available fuels. Because wood is scarce, farmers must burn more dung for heating and cooking. Therefore, they apply less to their fields, and food production decreases. The decreased food output requires that more forested land be cleared for farming, and since the accessible flatlands have already been cleared, only the steeper lands are left for clearing. These steeper lands tend to be low in productivity, and larger tracts must be cleared to produce the same amount of food. Erosion and landslide problems are intensified and, in turn, lead to sitation and flooding of lower lands. The problem can become irreversible.

Wood is a renewable resource, as long as the site has not been extremely degraded. These developing countries have tried to replant the deforested areas, but they have not been very successful because of social, political, and economic difficulties. Large-scale reforestation requires a period of years combined with strong political and local support.
Often the governments in these countries are less than stable, and the poor people who need the wood most are not the ones who will have access to the trees once they grow. In fact, in newly established but not closely guarded plantations, recently planted seedlings are uprooted for use as fuel or are eaten by passing herds of sheep and goats. This apparently willful destruction and degradation of forested lands may seem to be irresponsible to future generations. In reality, these people have no other practical choice under present circumstances. They are involved in a daily struggle to survive. They do not have a car in the garage to give up to conserve energy should a shortage occur. Too many days without fuel can mean death to the poorer people of these developing countries.

Appendix 2. Hydraulic Wood Splitter

E. W. Foss, professor, Dept. of Agricultural Engineering

New markets for pulpwood and fireplace wood of maximum diameters have created a renewed interest in mechanical wood splitters. Modern wood splitters use fluid or gas pressure from an outside source. Steam or air pressure with large cylinders are fairly common at mills. For field, farm, or woodlot, hydraulic units are more common. Because tractor hydraulic pressures are commonly above 1,000 psi, hydraulic cylinders do not need to be as large as cylinders using steam or air. One disadvantage, however, is the relatively slow movement of hydraulic cylinders (or rams). Use of aircraft accumulators (surplus) can secure a faster acting operation, but it involves some additional cost, piping, and weight.

Although tractor hydraulic power is most common, a separate engine and oil pump should be considered where a large volume of wood is to be split and where the tractor has other uses. The diameter and stroke of the ram (or hydraulic cylinder) will depend upon the length, diameter, and ease of splitting of the wood at hand. The length of stroke of the ram should equal ¼ to ½ the length of the wood. Actually, many rams of 24- to 30-inch stroke have been used. These rams have been obtained from discarded road graders, front end (tractor) loaders, and other hydraulically powered construction equipment. Cylinders at least 3 inches in diameter are suggested. For different lengths of wood, the frame (see diagram) can be constructed with several locations for the base “stop”. Commercial wood splitters of a similar design are available.
Appendix 3. Packaged Fireplace Wood

E. W. Foss
Department of Agricultural Engineering

By using either looped wire ties or coiled wire and a wiring machine along with a simple jig for packaging, woodlot owners can prepare a consumer package of fireplace logs. These packages should find ready sale near residential centers at roadside stands, lawn and garden stores, or other retail outlets.

Steel wire is the most economical as well as the most stable method of tying or binding. Other binders either cost too much or would not hold the bundle rigid. Either looped wire ties or coiled wire can be used. Looped wire ties are more expensive but require no machine. Large-volume users will prefer the machine that uses coiled wire, which costs approximately a penny per bundle. Binder twine placed across the two-wire ties makes a satisfactory handle.

The bundling jig permits the producer to make a round bundle and hold it in shape while tying the wire. Casters on the jig permit the bundle to be quickly rotated so that the wire can be applied to both ends of the bundle without difficulty.

The picture and plan of a jig for preparing the package is a suggestion only for devising a simple yet workable unit. Changes in the size of bundle, casters, length of wood, and other factors can easily be made. The jig shown prepares a 12-inch-diameter bundle of 16- or 18-inch wood weighing 25-35 pounds, the weight depending upon number of pieces and kind of wood. The owner of a sawmill who has edgings will please his customers by stuffing in a few pieces of this light wood for kindling.

Packaged fireplace wood must be handled quickly and as few times as possible to sell it at a price that the consumer considers reasonable and that returns a profit to both the retailer and the producer. Hardwood thinnings should be handled tree length to the buzz rig and the cut pieces loaded in a self-unloading wagon or truck. This green wood must be dried under cover for one season. After the wood has dried and during slack time, you can package the wood as shown, ready for shipping or hauling. Use a conveyor for both loading and unloading.

Different-sized bundles can be tried. Still another possibility is a bundle with sufficient tinder included so that the whole package can be placed in the fireplace ready for a match.
Glossary

aesthetics — visual beauty
billet — a section of wood the right size for splitting
bole — trunk section of a tree
bucking — the process of cutting a tree into specified log lengths
codominant tree — a tree that has its crown in the main canopy of tree crowns in the stand
commercially valuable — a tree that can be sold at a good price
cord — a stack of wood 4' x 4' x 8'; also called a standard cord
creosote — a dark brown, tar-like, unpleasant-smelling substance present in smoke
crop tree — a tree of good commercial form and health that will be cut at some time for sale
deforestation — the clearing of forested lands
diversity — the condition of having differences
dominant tree — a tree with a crown that rises above most all the other trees in a forest stand and gets nearly 360° exposure to sun
heartwood — the innermost part of a tree stem, which no longer contains living cells and tends to be darker in color than the sapwood
highgrading — the removal of all valuable trees, leaving only poor quality, low-grade trees to grow
kickback — when the tip of a chain saw strikes a solid object causing the saw blade to fly back at the operator
limbing — the removal of limbs from the trunk of a tree
mast — seeds, fruits, nuts that are produced in the forest and serve as food for wildlife
multiple use — the use of land for more than one product or benefit
photosynthesis — the process of using sunlight to make simple sugars and oxygen from carbon dioxide and water
resin — a flammable, sticky substance
sapwood — wood immediately inside the cambium of the living tree, composed of living cells; through it, most of the water is transported from the roots to the rest of the tree
skidding — the process of dragging logs from the woods to an area where they will be loaded for transport
slash — tops, branches, defective logs, and other wood debris left over from a logging operation
species composition — the relative abundance of the tree species in a forest
thinning — the removal of selected trees (usually of inferior quality or undesired species) in a stand to allow more growing space for the remaining trees
widowmaker — dead wood hung up overhead in the crown of a tree. It can kill if it falls onto the unprotected head of a person below
winch — an instrument for hauling or pulling
wolf tree — a limby, gnarly old tree with a large base
General References


Discusses use of an easily constructed plastic solar dryer to accelerate wood seasoning.


General coverage on wood as a fuel, fireplaces, stoves, furnaces, and installation. Includes appendix on cutting fuelwood with a chain saw.


_4-H projects in thinning, girdling, harvesting, logging, mapping, timber estimating, marketing, and milling._


Compares heating values of wood vs. coal, oil, and gas. Discusses woodburning units and problems with creosote.


Booklet of safety precautions; covers personal protection, chain saw, tree felling, limbing, and bucking.

_How to Select, Cut, and Season Good Firewood._ J. Vivian. FWB-1. 1977. 28 pp. Customer Service Department, Stihl Incorporated, P.O. Box 5514, Virginia Beach, VA 23455. ($1.00).

A concise, easy-reading book on finding and selecting firewood, cutting, transporting, limbing and bucking, stacking and seasoning, tree identification, safety, and chain saw selection.

"Improve Your Woodlot by Cutting Firewood." K. Lancaster and C. Hunt. 5 pp. USDA Forest Service, Northeastern Area, Upper Darby, PA 19082.

Pamphlet on cutting firewood as a means to improve a woodlot's timber value by thinning. Gives detailed instructions on how to thin and how to select crop trees.


Although somewhat outdated, much of the information is still useful. Covers farm equipment used for logging, hand tools, specialized logging equipment, layout of logging job, marketing, felling, limbing, bucking, skidding, loading, and hauling.


Written with the support and cooperation of the United Nations Environment program. Draws attention to negative worldwide ecological trends such as overgrazing, desert encroachment, deforestation, soil erosion, flood trends, and silting of irrigation reservoirs. Covers forestry, history of worldwide deforestation, and use of firewood for fuel in many countries and its effect on their forests.


General information on the advantages and disadvantages of using wood, how to burn wood efficiently, creosote problems, which trees to cut, fuelwood production, and chain saw safety rules.


Good, easy-reading "armchair" book written by a retired city man who became a woodlot owner. Discusses his experiences with and gives advice on thinning, felling, bucking, skidding, making firewood, logging contracting, planting, tools, and buying a woodlot.


Designed to assist the novice firewood producer to obtain firewood for personal use or for marketing. Gives advice on sources of wood, felling equipment, timber harvesting, preparing firewood, and marketing.

Collection of easy reading, amusing articles on furnaces, woodstove performance, chimneys, and sentimental values of a wood stove.


Provides general information on preparing firewood. Includes a design for a wood shelter. Is one section of a five part series: G2874 Wood as Fuel; G2875 Wood Burners and Chimneys; G2876 Heating Water; G2936 Safety and Wood Heating Systems; G2950 Measuring Firewood ... To Get Your Money's Worth.


Gives basic introduction to all aspects of heating with wood. Includes the science and history of wood heat, fireplaces, woodstoves, chimneys, cooking with wood, preparing firewood, and fringe benefits of wood heat.


Enjoyable, easy reading that discusses woodlot ownership in relation to forest ecology, management, and multiple use. Stresses environmental forestry for the owners of small woodlots.

Saws


Crosicut saw is viewed as a fast, efficient, and nonpolluting tool. Describes how and why a cross-cut saw works and how to sharpen one.


Complete guide to chain saw maintenance. Covers safety, chain parts maintenance, filing, chain repair, trouble shooting, installing a nose assembly, and cold-weather problems.

Power Chain Saws; Their Care and Use. W. W. Johnson. Special Circular 228. 12 pp. Pennsylvania State University, Cooperative Extension Service, University Park, PA.

A detailed look at chain saws. Includes parts, how they operate, chain sharpening, cleaning, and chain saw safety.

Transporting and Packaging Firewood


4-H Tractor Program covering safety, operation, and maintenance of tractors. Discusses hitches and pulling loads.


Discusses how the logging industry has changed from being labor-intensive to being increasingly mechanized. Describes chain saw and tractor use in woodlots.

Mechanize Your Farm Woodlot Safely. E. W. Foss and F. E. continued on back
Out of date but still some useful information. Gives general information on accidents in woodlots, cutting and felling trees, chain saws, bucking, skidding, and tractor safety.

Movies

Covers basic safety precautions to follow when felling, limbing, or bucking trees. Describes proper safety standards, maintenance, and cutting techniques. For ages 12 to adult.

"Do It Right." (15 min.) Cooperative Extension, Department of Natural Resources, Cornell University, Ithaca, NY 14853. (607) 256-2114.
Discusses many aspects of safe chain saw handling. For ages 12 to adult.

Discusses tips and precautions for safe and efficient heating with wood. Covers stove choice and installation, creosote problems, and buying, cutting, and storing wood. All ages.

Price per copy $2.00.
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