PB 1880

FIREWOOD HARVESTING AS A FOREST MANAGEMENT TOOL

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Introduction

Firewood is the major use of all wood harvested globally, predominantly for household heat and cooking. Tennessee, a state with 14 million acres of forestland, has an abundance of excellent potential firewood. Burning firewood has many benefits. For some, it's simply the cozy ambiance of a wood fire. However, it also can be a less expensive form of heating than gas or electricity. Firewood is local and often considered *carbon neutral*.[1] Finally, as will be explained in this publication, harvesting firewood can help make a forest healthy and more productive.

Many forest stands in Tennessee have historically been mismanaged by repetitive improper harvesting of only high-value trees, leaving low-value trees as residuals. Without intervention, such high-graded stands will continue to perpetuate the growth of mainly poor-quality trees. Yet, often hidden within these degraded stands are younger and healthier trees that, if given sufficient growing space, could become the top-value crop trees that are in demand by the wood industry. The removal of undesirable trees for use as firewood can provide growing space for crop trees and help restore degraded stands to healthier, more productive and higher-value forests.

This publication outlines the process of improving forest stands by removing trees for firewood and also addresses wide-ranging firewood information, including:

- Timber stand improvement,
- General tree felling safety,
- Firewood properties,
- Units of firewood measurement,
- Firewood preparation and storage and
- Business considerations.

[1] Carbon neutrality refers to the release of carbon dioxide gas to the environment from burning wood being balanced by the absorption of that gas by the living tree during photosynthesis. Carbon dioxide (from fossil fuel burning) is the major driver of climate change. Some people debate whether burning wood can be considered carbon neutral.

Improving Forest Stands Through Firewood Removal

Timber stand improvement (TSI) is a cultural practice applied to a forest to improve the composition, stocking and growth. TSI helps ensure that desirable trees are not only retained in the forest, but that they increase growth and maintain a healthy condition. Firewood removal, when implemented properly, is a form of TSI that benefits forests. Desirable future crop trees are first identified, then less desirable trees that are in direct competition with crop trees are removed for firewood. The goal is a crown-touching release on three to four sides of the crop trees. In other words, identify the crop trees, then remove as firewood those trees whose crowns are crowding the crowns of the crop trees.

Crop tree release is typically conducted in younger stands that are 15-30 years old with trees averaging 3 to 8 inches in diameter. These trees are good candidates to be felled by nonprofessionals and require less splitting prior to being burned. But crop tree release can be applied to more advanced stands, too, whereby culls or unacceptable trees are removed to lightly release larger crop trees.

As crop trees are released, growth increases to the roots first, followed by branch expansion, ending with enlarged trunk diameter, as can be seen by observing annual growth rings (Figure 2). Growth response of fully released crop trees varies from 25 to 70 percent (adapted from Perkey and Wilkins 2001). Table 1 provides a summary. Note that, in general, oak trees respond favorably to crown-touching release.

Figure 1a, ***left.*** *Depiction of crop tree release by removing firewood trees.*

Figure 1b, ***right.*** *Walnut crop tree (right) and elm tree (left). Harvesting the elm tree as firewood will release the walnut tree for faster growth.*

Table 1. *Ten-Year Diameter Growth Rate (inches) on Average Appalachian Sites per Species*

Species	Unreleased Growth Rate	Released Growth Rate	% Increase in Growth Rate
Red Oak	2.0	3.4	70%
White Oak	1.2	2.0	67%
Yellow Poplar	2.5	3.8	52%
Sugar Maple	1.4	2.0	50%
Black Oak	1.8	2.7	50%
Chesnut Oak	1.6	2.3	44%
Scarlet Oak	1.7	2.3	35%
Black Cherry	2.4	3.0	25%
Average	1.8	2.7	50%

Figure 2. *Growth rings on an oak tree show where crown release occurred and increased growth response resulted (note the wider growth rings).*

What constitutes a preferred crop tree? Three criteria are important: species, form and grade. A preferred crop tree is a high-value *species*, having *good form* (i.e., straight) and *grade* (i.e., with few defects). All three are ideal, as these attributes will produce high-value timber. For example, a white oak (financially a highly preferred species) **may not** qualify as a desirable crop tree if it is crooked (poor form) or with many knots or is hollow (poor grade). The financial potential for such trees would be limited. In contrast, a tulip poplar (financially a moderately preferred species) **may** qualify as a desirable crop tree if it has superior form (i.e., very straight and with few knots). Figures 3-6 show examples of preferred crop trees versus less preferred ones.

For a more thorough understanding of TSI and the concept of releasing crop trees, see a professional forester. Also, these University of Tennessee Extension publications offer further explanation:

Crop Tree Release in Precommercial Hardwood Stands
extension.tennessee.edu/publications/Documents/SP559.pdf

Technical Guide to Crop Tree Release in Hardwood Forests
extension.tennessee.edu/publications/Documents/PB1774.pdf

Treatments for Improving Degraded Hardwood Stands
extension.tennessee.edu/publications/Documents/SP680.pdf

Figure 3, ***top left.*** *Tulip poplar tree (left) and red oak tree (right) are examples of desirable crop trees having both good form and grade. The tree in the center has poor form and could be removed for firewood.*

Figure 4, ***top right.*** *When grown on the proper site, black cherry can be a valuable crop tree. This young black cherry tree is growing on a northern slope, has been fully released and has good form and grade. It can be retained as a crop tree.*

Figure 5, ***bottom right.*** *White oak is considered a highly desired crop tree; however, one with poor grade (note the excessive branches) may be better if harvested as firewood.*

Figure 6, ***bottom left.*** *A white oak with very poor form will not make a valuable crop tree but is excellent firewood.*

Tree Felling and Safety

Prior to cutting firewood trees, fellers must know their personal and mechanical limitations. Broad highlights that should be considered are detailed below (Jepson 2018).

Chainsaw safety — Know your saw and make sure that it is equipped with safety features; do not work alone; stay off ladders; be aware of chainsaw fatigue; and always use a sharp saw.

Protective equipment — Should include safety helmet with head, face and ear protection; leg chaps; gloves; and work boots.

Tree and site hazards — Be aware of loose, hanging or dead limbs overhead (widow makers); identify hollow trunks or those that have decayed centers indicated by swollen bases, exterior wounds or fungus; watch for hornet/bees' nests; ensure good footing especially on steep terrain or slick surfaces; do not cut during periods of high wind; and once felled, be careful when cutting limbs and tree tops that might be bent, leaning and/or under pressure.

Determine tree lean and crown weight — Tree lean is any deviation from vertical, and crown weight is where branches are concentrated. Both affect the inherent direction that a tree will fall. Cutting trees with severe lean or crown imbalance can be dangerous and may cause a tree to snap and/or collapse on top of the feller.

Have an escape route — Prior to felling, create a clear path to retreat once the tree begins to fall by removing ground debris, small shrubs, sapling and other obstructions.

Carefully execute felling cuts — Correctly place notch on the trunk, paying attention to proper size and depth of the notch. Make a back cut and leave a hinge.

Units of Firewood Measurement

Firewood is bought and sold using a variety of measurements. The only officially recognized measurement is the cord — a stack of firewood 4 feet high, 4 feet deep and 8 feet wide — or an equivalent volume (128 ft³). "Rick" is an informal measurement that usually represents 1/3 of a cord, or that same stack but only 16 inches deep — a common length for a stick of firewood.

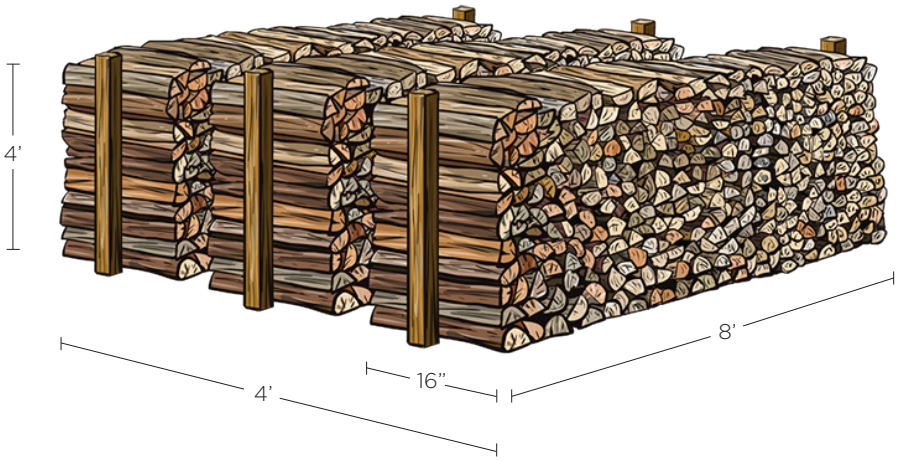

Figure 7. *Cord of firewood.*

Some use other definitions of a rick, or speak of "face-cords" to mean essentially the same; again, these are not official volumes. Firewood is often sold by the "truck full," which of course depends on the size of the truck!

Less Desirable Trees in Your Forest = Great Potential Firewood When Cut

The trees removed during a TSI operation have the potential to make great firewood. As is explained below, any species can make useful firewood. Similarly, some of the defects that detract from a crop tree's potential lumber value (poor form, damage, disease, small size and slow growth) do not prevent the tree from making good firewood. Finally, these less desirable trees can provide considerable amount of desirable firewood, as shown in Table 2. This table shows average data. The form of the individual trees can influence these values.

Table 2. *Number of Trees Needed to Make a Cord of Firewood, by Size*[2]

DBH (inches)	Total tree height (feet)	Trees needed per cord of firewood (cut down to 4" top)
5	40	90.9
6	40	40.0
7	50	20.8
8	60	12.2
9	60	9.3
10	70	6.1
11	70	5.0
12	70	4.0
13	70	3.4
14	70	2.9
15	70	2.5
16	70	2.2
17	70	1.9
18	70	1.7
19	70	1.5
20	70	1.4
21	80	1.1
22	80	1.0

[2] Data from Gevorkiantz, Suren Rubenian, and Lucille P. Olsen. 1955. Composite volume tables for timber and their application in the Lake States. Tech. Bulletin No. 1104. Washington, DC: US Department of Agriculture, Forest Service. 51 p.

Which Species Make the Best Firewood? The DRY Ones!

The wood from any tree species can be good firewood. The most important requirement for firewood is that it be dry. All wood from living trees starts out quite wet (often referred to as "green wood"). If water isn't removed prior to use as firewood, the wood will be difficult to burn, will burn with considerable smoke (smolder), and will provide less heat. Some wood starts out wetter than others, and some wood is easier to dry than others; however, all species will eventually dry out to make perfectly acceptable firewood.

Because of the large amount of energy required to heat and evaporate water from green wood, it will deliver less than half the heat than dry wood. Energy content of firewood can be expressed in various units, including British thermal units (BTUs). A BTU is defined as the heat energy needed to raise a pound of water by 1 F.[3] Table 3 reveals that for an average cord of mixed hardwood firewood, the yield of useful energy is greatly reduced in green wood.

The drier the wood, the more heat it can provide. Note that firewood can never be too dry. Drier wood will burn faster, but the best way to control the rate of combustion is by limiting the air flow, not by using green wood to slow the fire. Modern wood stoves allow for the precise control of the air supply. In open fireplaces and campfires where the air supply cannot be controlled, it is better to add less wood than to try to slow the fire down with green wood.

Table 3. *BTU Provided by Moisture Content of Wood*[4]

	Moisture content (wet basis)	Net heat provided (million BTU/cord)
Green wood	60%	5.9
	50%	8.2
	40%	10.5
Semi-dry	30%	13.0
Air dry	20%	15.3

[3] The metric system expresses energy in joules; one BTU = 1,055 joules.

[4] Data from USDS Forest Service, Fuel Value Calculator, 2004.

Wood of all species has more or less the same energy content per pound: about 8,600 BTU per pound of dry hardwood.[5] Thus, the second-most important consideration in firewood is the density of the wood — the number of pounds in a given volume of wood. Wood species vary substantially in their density (Table 4). For example, basswood has half the density of dogwood on average, thus dogwood has the capacity to provide twice the heat per cord burned (44 million BTU versus 22 million). Remember that energy content is the potential energy; the actual heat provided will be less due to inefficiencies in the burning process and, most importantly, the amount of water in the wood. Even completely air-dried wood has some water in it.

While denser woods provide more heat per piece, low-density woods can be better for kindling (the small pieces of wood used to get a fire started). Low-density (and dry) wood is easier to heat initially and ignite when starting a fire. Furthermore, some of the low-density softwoods such as pine and spruce naturally contain resins that are especially flammable, making the wood particularly useful for kindling.

Another consideration for firewood is the ease of splitting. Firewood must be cut to length and split in order to speed the drying process and to provide pieces of a convenient size for burning. Most species will split reasonably easily *if the wood grain is straight*. The grain will deviate around branches and knots, so splitting wood chunks with these features will be more difficult. Some species also naturally have *interlocked grain*, meaning the wood cells alternate their orientation periodically during growth. Species where this trait is common include sweetgum, elm and hackberry. These woods can be very difficult to split. Contemporary use of mechanical splitters has mitigated this issue when compared to historic hand-splitting.

[5] Surprisingly, softwoods such as pine actually have more energy per pound (~9000 BTU) than hardwoods such as oak. However, this difference is small compared with their difference in density.

Table 4. *Wood Density by Species*[6]

Species	Density (lb/ft³)
Hardwoods	
Ash, white	34
Basswood	20
Beech	35
Box elder	26
Cherry	29
Cottonwood	23
Dogwood	40
Elm, American	29
Sweetgum	29
Hackberry	31
Hickory/Pecan Locust,	39
black	41
Maple, red (soft)	29
Maples, sugar (hard)	31
Oaks, red	32
Oaks, white	37
Sycamore	29
Yellow poplar	25
Black walnut	32
Softwoods	
Hemlock	24
Redcedar	27
Southern (hard) pines	29
White (soft) pines	21

[6] Density data from Ross, R.J. 2010. Wood handbook: Wood as an engineering material. Gen. Tech. Rep. FPL-GTR-190. Madison, WI:US Department of Agriculture, Forest Service, Forest Products laboratory. 509 p.

Preparation of Firewood

Because dry firewood is important, the first consideration in the preparation of firewood is providing the opportunity for drying to occur. Wood will dry very slowly, and not thoroughly, if left in whole log form. Firewood should be cut to length for appreciable drying to occur because bark is a good moisture barrier and wood dries much faster on the end grain (the cut surface). By cutting the logs into 12-24-inch-long sections (or the desired length), the amount of exposed end-grain is greatly increased, thereby facilitating rapid drying. Splitting the sections also will expose more wood surface, thus increasing drying rate. Wood is also weaker, and usually easier to split, when it is wet. It is best to buck and split logs into firewood as soon as possible after felling to begin the drying process.

Figure 8, *left*, and 9, *right. It is best to buck and split firewood as soon as possible to begin the drying process. Here ash is highly desirable as firewood due to ease in splitting and relatively high energy content. Split wood dries faster than wood left in round form.*

The second consideration in firewood drying — or "seasoning" — is to allow adequate time for the water to evaporate. There are many variables affecting the drying rate, including species, temperature, humidity and rainfall, but as a general rule, wood cut and split in the spring or early summer will be dry enough for burning in autumn.[7] Although wood directly touching the ground may rot in wet conditions, the remaining stack above ground should dry satisfactorily. Stacking the wood on a surface that doesn't retain moisture is best. Sheltering a stack of firewood can prevent rewetting from rain, but good air flow is important. Drying is enhanced if firewood is not completely covered with a tarp.

Figure 10. *Firewood is best stored under a shelter but with some open sides for good air flow.*

[7] Firewood drying can be accelerated using specialized kilns to heat the wood, but this technology is beyond the scope of this publication.

Considerations for Firewood As a Business

The many considerations involved in operating a firewood business are beyond the scope of this publication. However, a few points are worth stressing:

1. All business ventures, including firewood, should begin with a solid business plan and understanding of direct marketing. For consultation on direct marketing, contact the Center for Profitable Agriculture at: ag.tennessee.edu/cpa
2. A firewood business involves much more than the firewood product itself. The service side of the business (e.g., custom sizing, delivery and stacking) is also important.
3. Due to concern about the spread of invasive exotic insects in or on firewood (like the emerald ash borer that has devastated ash trees throughout the region), many customers and locations (such as state parks and national forests) are requiring that firewood be heat treated. The phytosanitary regulations for firewood are located here: aphis.usda.gov/aphis/ourfocus/planthealth/import-information/firewood
4. Also, there are weights and measures regulations for packaged firewood. Details are found here: ag.tennessee.edu/cpa/Information%20Sheets/adc51.pdf

Conclusion

Firewood is a resource that has been used for millennium for household heating and cooking. It is natural, renewable and biodegradable, and the energy to produce firewood is free — a product of the sun's energy and photosynthesis. To many, the burning of firewood is considered carbon neutral because the carbon dioxide gases released are cycled back into trees when new wood is formed.

There are several hundred thousand forest landowners in Tennessee. For these landowners and those with whom they share their trees, the burning of firewood is a means to offset heating costs. Further, the proper selection of trees to use as firewood provides an opportunity to overcome past forestry mistakes and improve forest stand composition and growth. It's a concept much like weeding a garden, in that growing space and other resources are made available to a desired plant — in this case, preferred trees. However, the task lies in knowing which trees to cut and which to leave. Professional foresters are available to assist in meeting these challenges. A summary of professional foresters includes:

Area Foresters — Area foresters work for the Tennessee Division of Forestry. Their services are normally free, but are limited, and include developing woodland plans, administering conservation cost-share programs, and coordinating wildfire control. They are a helpful initial contact for general woodland advice, including determining harvesting feasibility. Area foresters cannot represent landowners during marketing or timber sale transactions. To locate an area forester in Tennessee, visit this website: state.tn.us/agriculture/forestry/directory.html

Consulting Foresters — Private consulting foresters offer a wide range of services, including timber marketing. Just as a realtor represents homeowners when selling a home, consulting foresters act as a liaison between landowners and the timber industry. The fee for their marketing services is often commission-based on the gross sale price. Landowners should not be skeptical of employing a consulting forester. Most landowners find that consultant fees are offset by higher sales revenue due to a consultant forester's knowledge of timber markets and experience in selling timber. In addition, using a consultant will give you a heightened assurance of a quality logging job and a resultant more productive woodland, as well as legal protection (with a sound timber contract). To locate a consulting forester in Tennessee, see the "State of Tennessee Cooperating Consultant Forester Program Directory" (TDA Forestry Division 2009): state.tn.us/agriculture/publications/forestry/cfdirectory.pdf

Industrial Foresters — Some forest industries employ professional foresters who manage company land and procure wood. These foresters may also offer timber marketing services. On occasion, forest industries offer incentives, such as free tree seedlings for reforestation.

Figure 11a, *above*, and 11b, *left.* *A hardwood stand prior to and following removal of firewood trees. Note the residual red oak and the increased growing space after firewood tree removal.*

References

Jepson, Jeff. 2009. To Fell a Tree. Beaver Tree Publishing. Longville, MN.

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This publication is funded in part by the Tennessee Department of Agriculture Forestry Division through the Tennessee Agricultural Enhancement Program (TAEP) and by the U.S. Department of Agriculture National Institute of Food and Agriculture Renewable Resources Extension Act.

PB 1880 05/20 20-0186 Programs in agriculture and natural resources, 4-H youth development, family and consumer sciences, and resource development. University of Tennessee Institute of Agriculture, U.S. Department of Agriculture and county governments cooperating. UT Extension provides equal opportunities in programs and employment.