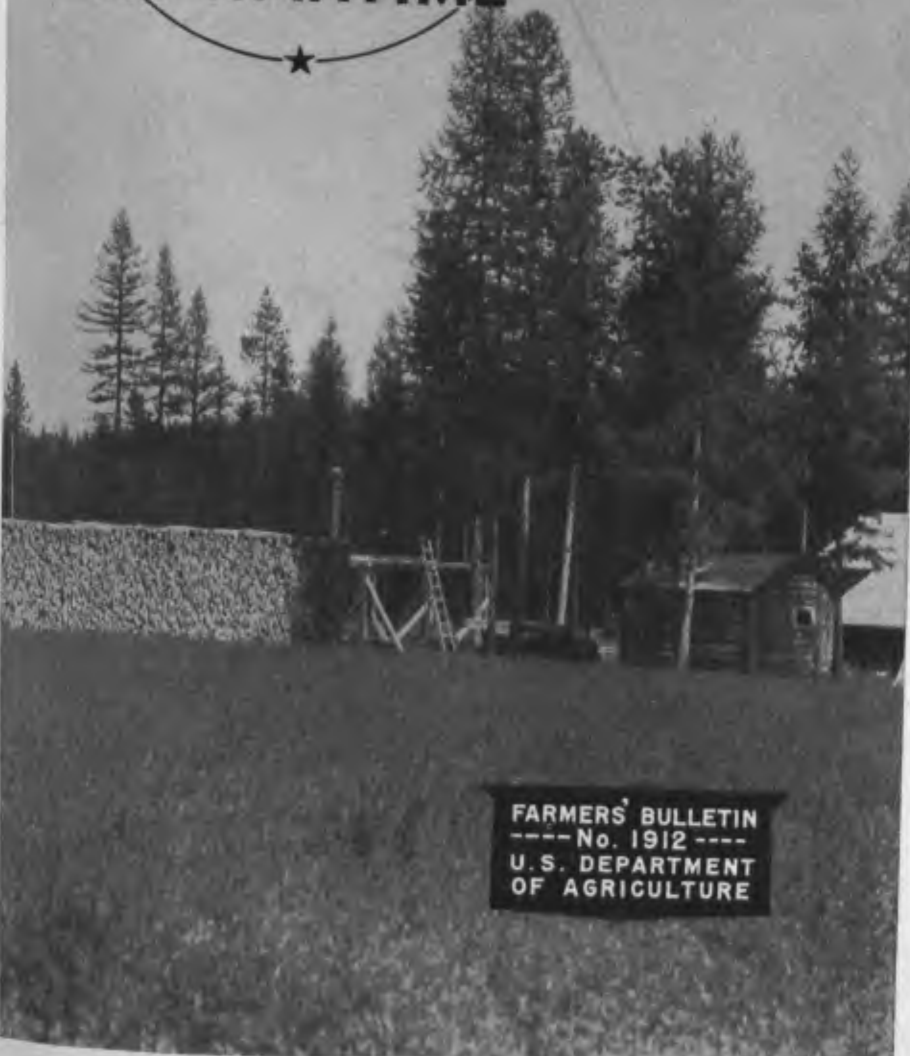
WOOD FUEL IN WARTIME



FARMERS' BULLETIN
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TO MAKE A TON of steel for a cannon, a warship, or a tank, requires more than a ton of coal. Transportation of fuel and raw materials for war industries, of food, clothing, and equipment for soldiers' and sailors is vitally important and tremendously difficult. To supply homes and businesses with the quantities and kinds of fuel used in peacetime adds to the difficulty. Coal, for example, makes up about one-third of the total freight normally carried by railroads, and increasing amounts of fuel must now be delivered to munitions factories and power plants. If domestic consumers will use wood obtained nearby, instead of coal and oil brought from mines and wells hundreds of miles away, then ships and rail-road cars can be released for hauling war materials.

There is a growing popular demand in small communities for information on the fuel value of wood, how to cut cordwood without damage to the forest property, how to produce and market it more economically, and how to operate heating equipment when burning wood. Since most fuel wood is much improved by seasoning for a few months, action should be taken to provide a supply well in advance of the winter when the fuel will be needed.

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COVER PHOTO.—FUEL WOOD SEASONING ON A WESTERN MONTANA RANCH. F 413715

WOOD FUEL IN WARTIME

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WOOD FUEL AND NATION-WIDE PRODUCTION FOR VICTORY

TO PROVIDE POWER for manufacturing and transporting the munitions and materials necessary to defeat the enemies of the United States and at the same time to keep homes, schools, office buildings, and thousands of new factories warm enough for health, the requirements for fuel will soon be the largest in our history. Though industrial production was then greater than ever before, the President announced in January 1942 that the armament program would be at least doubled. This calls for more and more raw materials, power and heat to process them, and fuels to generate the power and heat.

Railroads and shipping must carry an enormous additional traffic. Troops and their supplies must be moved, as well as lend-lease shipments, raw materials, and fuels. A large part of the total tonnage to be carried is fuel. Fortunately, pipe lines now transport large quantities of certain fuels—natural gas, oils, and gasoline—relieving the burden on railroad and maritime traffic to that extent. But coal is still the major source of energy for generating electricity and steam. The increased demands for power are suggested by the fact that consumption of bituminous coal by electric utilities was a third more in the fall of 1941 than in the fall of 1940.

Other factors further complicate the problem of supplying fuel to homes. The railroads and the tanker fleet are already operating at near the capacity of their equipment. Because of the shortage of iron and steel, it appears doubtful that enough gondola and coal cars and locomotives will be built to fill the needs of expanding rail traffic, nor are many additional pipe lines likely to be constructed during the war. Instead of transporting coal for ordinary domestic use, more and more trains and boats will be hauling coal to new blast furnaces, for example, besides additional quantities of ores and metals. Wartime strain on shipping is at least as severe as that on railroads.

During the first World War the railroads soon became overburdened with traffic and it became difficult and sometimes impossible to obtain deliveries of coal in some sections of the country. Some factories in New England were forced to burn cordwood instead, and local fuel committees, State foresters, and the United States Fuel Administration urged the public to substitute wood fuel for coal. The situation today is not entirely the same, because oil and gas are in more general use, and there are means of delivering greater quantities of fuels than was possible 20 years ago. On the other hand, the emergency requirements during the present war will be far greater, and there is a limit to the tonnage the railroads can handle. Hauling capacity must be devoted first of all to war materials and services for the armed forces. The domestic consumer may have to take care of himself as best he can.

Unlike the people of Europe, Americans are not likely to suffer from lack of heat in their homes. In many parts of the country there is an

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FIGURE 1.—Picking up limb wood and tops for fuel, after a harvest cutting. These farmers were permitted to take the wood free of charge; removing it increased property values.

ample reserve of fuel in the form of wood in the forests. Although the volume of high-grade timber is decreasing year by year, inferior and waste wood is so plentiful that there is more than enough for most fuel purposes (fig. 1). Since coal and oil shortages appear likely in some sections, householders and public authorities may well consider a return to the use of wood. In any case, it is wise to lay in some emergency fuel. Many families can make an important cash saving, besides, by cutting a few cords of firewood for their own use.

In view of the expanding need for power and heat, even a large-scale substitution of wood is not likely to bring about any decrease in the total consumption of coal and oil. Production of mineral fuels, however, is concentrated in relatively small areas; these fuels must usually be transported hundreds of miles to consumers by rail, ship, or pipe line. The difficulty in supplying coal, for example, is not in production at the mines, but transportation to the consumers. Fuel wood, on the other hand, is available in most sections of the United States and requires hauling only very short distances. With reasonable cooperation on the part of the public, more of our coal and other industrial fuels can be allotted to war purposes and the deficiency made up by use of wood fuel.

Delivering coal to consumers on farms and in the smaller towns is in general comparatively wasteful of railroad and truck service. If such consumers would temporarily abandon or reduce their use of coal and burn wood from nearby timberlands delivered in light trucks or wagons, it is clear that a considerable number of railroad cars and heavy, long-distance trucks could be released for war-production service. This bulletin, prepared in collaboration with the Northeastern and Lake States Forest Experiment Stations and the Forest Products Laboratory, is intended to point out the best sources of wood fuel, its heating value, and some recently developed techniques in producing, transporting, and utilizing fuel wood.

INCREASING THE USE OF WOOD FUELS

SOURCES OF SUPPLY

Several classes of material make up the potential supply of fuel wood. Because of the widespread practice of leaving poor trees uncut, there has accumulated in American forests a vast number of culls unfit for sawlog use either now or later. On an average, an acre of forest land bears at least a cord of cull material good only for fuel.

In logging and in milling forest products, a large volume of wood is cast aside, in such forms as tops, limbs, slabs, edgings, and ends. Much of the debris from milling operations is already being utilized, for many mills either burn this material in their own power plants or sell it as a byproduct. Little of the waste in the forest, however, is now recovered. Removing and utilizing this wood not only is economical (fig. 2), but will reduce forest-fire hazards.

Not all of our timber crop reaches maturity. Each year more than 2 billion cubic feet of timber is killed by such destructive agencies as fire, insects, and disease. A high proportion of these trees would make excellent fuel wood if used before decay advanced very far. In the section of the Northeast where a hurricane struck in 1938, many thousands of cords of usable seasoned wood remain on the ground, awaiting salvage.

Another excellent way to obtain fuel wood is to weed the undesirable trees from the woodlands and thin out the overdense stands. Inferior species and suppressed trees are often entirely satisfactory as fuel. The better trees that are left after these improvement cuttings and thinnings are made will grow faster, produce more useful timber, and earn higher profits for the owner.

Production of fuel wood can therefore be made to yield twofold returns in connection with the good forestry practices of making improvement cuttings and thinnings and salvaging dead and down trees promptly. Properly carried out, these operations would do more to conserve the values in American forests as a whole than any other measure except fire protection. Similarly, the use of mill waste as fuel not only increases opportunities for immediate profit but tends to conserve natural resources.

The regions of the country that have the highest fuel-consumption rates and are probably in the most danger of rail traffic difficulties are those that are most highly industrialized and to which orders for the largest volumes of war production have been allocated—namely, the Central and Lake States, New England, and the Middle Atlantic States. It is in these areas that the substitution of wood for other fuels can be of greatest help. Fortunately, stands of timber containing the best species for fuel are concentrated in these regions, as well as in the Southeast. About one-fourth of our total volume of hardwoods is in the northeastern section of the country, comprising New England and the Middle Atlantic States. The Lake States,

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FIGURE 2.—Taking sawlogs and fuel wood from the forest at the same time, after a selective cut in a pine-oak stand near Westville, N. Y.

Michigan, Wisconsin, and Minnesota, together contain nearly 12 percent of the hardwood volume, and five Central States—Ohio, Indiana, Illinois, Iowa, and Missouri—have 8 percent. Thus these three regions, where fuel consumption is heavy, have more than 44 percent of the total hardwood stands of the Nation.

WHO CAN USE WOOD FUEL

When other fuels are obtainable and moderately priced, regular use of wood fuel is rarely feasible if it must be transported more than about 20 miles to the consumer by motortruck. To bring wood more than 20 miles in sufficient quantities for consumers in the larger cities could easily cause serious traffic congestion. Wood is bulky in proportion to its heating value and takes relatively more shipping space than other solid fuels. If, however, there are sawmills or woodworking plants within a radius of a few miles or accessible by barge line, local use of wood waste from such plants tends to be more economical of the Nation's transportation facilities than the use of coal. The people who are nearest the source of supply can render a service to the war effort, and perhaps also to themselves, by preparing to use more wood fuel during the emergency. Many who live in the smaller towns and on farms will find that fuel wood can be cut almost at their very doorsteps.

Users of wood fuels may be grouped mainly in three classes. First are the householders who can burn wood for heating and cooking, or in fireplaces for supplementary heat. Many schools, churches, and businesses such as processors of farm products fire their furnaces with wood, or could do so. In the third class are the larger plants, which supply heat and power for large buildings, for wood-products mills, or for generating electricity; these plants usually have apparatus for automatic stoking of sawdust or other waste wood, sometimes in combination with pulverized coal. Ordinary household use, nevertheless, accounts for at least two-thirds of our present consumption of wood fuels. Householders have the best opportunities to substitute wood for other fuels in wartime; accordingly this bulletin is devoted mainly to wood fuel for domestic use.

ADVANTAGES IN USE OF WOOD

Wood has certain advantages as a fuel, which many people nowadays have not considered. Wood is clean and free from disagreeable dust; it produces little smoke or soot when properly burned. A cord of hardwood leaves only 60 pounds of ashes, while a ton of hard coal will make 200 to 300 pounds. The wood ashes, moreover, have fertilizing value. Wood begins to burn at a comparatively low temperature, so that a wood fire is easy to start and can be maintained at a lower ebb than a coal fire, when only a small output of heat is needed. For cooking, a wood fire need not be kept burning so long as a coal fire and is less likely to overheat the kitchen in warm weather.

For churches, community halls, summer cottages, and other buildings where heat is required only occasionally, wood is more satisfactory than coal for providing a large volume of heat quickly. There is considerable economy in using wood in stoves and hot-air furnaces during the more variable spring and fall weather, or when a fire is needed only to remove the chill of evening and early morning. Wood burned part of the time is cheaper than coal burned all the time. Finally, most people appreciate the pleasant aspect of a few logs glowing in a fireplace, which can have a practical value in warming a living room on mild days or in supplying extra heat in colder weather.

HEATING VALUE OF WOOD

Wood that is well seasoned, or thoroughly air-dry, contains about 15 or 20 percent moisture by total weight. A pound of such wood, from most species of trees, has a little more than half the heat value of a pound of good coal. A cord of one of the heavier hardwoods

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weighs about 2 tons and has approximately the same heating value as a short ton of coal of high quality, or 200 gallons of domestic fuel oil (table 1).

TABLE 1.—*Woods classified by number of cords of wood*[1] *required to equal heat value of 1 short ton of anthracite*[2]

1 cord	*1.5 cords*	*2 cords*
Hickory.	Shortleaf pine.	"Cedar."
Oak.	Sweetgum (redgum).	Redwood.
Beech.	Douglas-fir.	Poplar.
Sweet birch.	Sycamore.	Catalpa.
Hard maple.	Soft maple.	Cypress.
Rock elm.	Slippery elm.	Basswood.
Locust.	Black cherry.	Spruce.
Longleaf pine.	Tamarack.	White pine.

[1] A cord of stacked wood 4 by 4 by 8 feet is assumed to contain 80 cubic feet of solid wood, with 15 to 20 percent moisture by total weight.
[2] Adapted from Technical Note 98, Forest Products Laboratory, Madison, Wis. Slightly altered. For a few species, the quantities stated are somewhat high; compare with table 2.

Stacked wood occupying 128 cubic feet of space makes up 1 cord, usually considered as a pile 4 by 4 by 8 feet. The content of solid wood in a cord varies considerably, depending on the length, size, and form of the individual sticks as well as the care exercised in fitting them together, but a fair average is 80 cubic feet of solid wood to the cord, which is used as the basis for table 1. In some parts of the country wood is sold in "stovewood," "face," or "running" cords, "runs," or "ricks" composed of 12-, 16-, or 24-inch pieces in piles 4 feet high and 8 feet long. Three such piles of 16-inch wood actually contain somewhat more than one pile of 4-foot wood.

The presence of considerable quantities of resins or oils, as in longleaf pine and eucalyptus, tends to raise the heating value of wood, but causes it to be consumed faster. Pound for pound, resin gives about twice as much heat as wood; it also produces more smoke. Resinous woods named in table 1 are considered as containing 15 percent, or an average amount of resin. The bark of some species, such as birch, Douglas-fir, ponderosa pine, and shagbark hickory, has a higher heat value than the wood, but the bark of some other trees, such as the "cedars" or junipers, has low fuel value and leaves much ash. Generally the softwoods (from cone-bearing trees) burn more readily than the hardwoods, and the lighter hardwoods are consumed faster than the heavier species. The pines, for example, make a quicker, hotter fire and last a shorter time than birch, but birch gives a more intense flame than oak. Oak and hickory burn more slowly and give a steady heat.

American beech has long been a favorite fuel wood in the northeastern and central regions of the country, having heating value nearly equal to that of the best oaks. Eastern hophornbeam, sometimes called ironwood, is also very heavy and yields much heat per cord. Red mulberry and hawthorn, though small trees, are highly esteemed as fuel. Of about the same fuel value as sycamore is black tupelo (known also as "sour gum" and "blackgum"), which is widely distributed in the Eastern States. For open fires, chestnut, butternut, tamarack, and spruce are not generally in favor, because they throw off sparks.

Moisture in the wood is the most important factor in the heating value. When wood is burned, the water in it must be raised to the boiling point, converted into steam, and finally superheated to the temperature of the flue gases. Hence the heat required to drive off the moisture does not serve to warm the stove or furnace. Generally from 25 to 45 percent of the weight of green wood is water, and in such species as cottonwood and willow it may be even 55 or 60 percent. By drying out much of this water, the heating value of the wood is considerably increased. For example, green shagbark hickory weighs about 800 pounds more per cord than air-dried wood of the same species, the difference representing mostly water. This extra moisture reduces the heat value about one-sixth, as shown in table 2.

TABLE 2.—*Approximate weight and heating value per cord* [1] *of different woods, green and air-dry* [2]

[Data supplied by Forest Products Laboratory, Madison, Wis.]

Species	Weight		Available heat [3]		Equivalent in coal [4]	
	Green	Air-dry	Green	Air-dry	Green	Air-dry
	Pounds	*Pounds*	*Million B. t. u.*	*Million B. t. u.*	*Tons*	*Tons*
Ash	3,840	3,440	16.5	20.0	0.75	0.91
Aspen	3,440	2,160	10.3	12.5	.47	.57
Beech, American	4,320	3,760	17.3	21.8	.79	.99
Birch, yellow	4,560	3,680	17.3	21.3	.79	.97
Elm, American	4,320	2,960	14.3	17.2	.65	.78
Hickory, shagbark	5,040	4,240	20.7	24.6	.94	1.12
Maple, red	4,000	3,200	15.0	18.6	.68	.85
Maple, sugar	4,480	3,680	18.4	21.3	.84	.97
Oak, red	5,120	3,680	17.9	21.3	.81	.97
Oak, white	5,040	3,920	19.2	22.7	.87	1.04
Pine, eastern white	2,880	2,080	12.1	13.3	.55	.60

[1] Containing 80 cubic feet of solid wood.
[2] Air-dry means with 20 percent moisture in terms of oven-dry weight, or 16.7 percent in terms of total air-dry weight.
[3] 1 B. t. u. (British thermal unit) is the amount of heat required to raise the temperature of 1 pound of water 1° F. Available heat equals calorific value, minus loss due to moisture, minus loss due to water vapor formed, minus loss in heat carried away in dry chimney gas. Flue temperature 450° F.; no excess air.
[4] Heat value of coal under similar conditions taken as 11,000 B. t. u. This would require a good coal with a calorific value of about 14,000 B. t. u. per pound of dry coal. Tons of 2,000 pounds.

Drying the wood for a short time is much better than not drying it at all; if air is allowed to circulate freely about the wood (fig. 3) for 3 months in reasonably dry weather, seasoning will be about half complete, and the fuel value will then be about 90 percent of that of thoroughly air-dried wood. Dry wood kindles much more readily than wet wood, and in a stove or domestic furnace a fire of dry wood is generally easier to tend and regulate. It is said, however, that some species such as gray birch and aspen given better results if not too dry, being consumed less rapidly.

DOMESTIC USE OF STOVE AND FURNACE WOOD

How to Burn Wood

When wood is used as fuel, certain rules should be applied in adapting and operating the heating equipment. To do this will be of benefit in getting as much heating value from the wood as possible and will make its use generally more satisfactory.

1. Stove wood and furnace wood must be cut short enough to lie flat in the fuel chamber. If the firebox is rounded or oval in shape,

it is best to have the pieces somewhat shorter than its inside length. Several sticks should be packed in closely, side by side, with only very narrow air spaces between them, if a hot fire is wanted. The heat reflected from one to the other aids in driving off moisture and maintaining the proper rate of burning.

2. The simplest and most effective way of using wood in a coal furnace is to combine it with coal. A layer of good-sized sticks of wood should be placed in the firebox; then a layer of coal should be added, filling most of the crevices between chunks of wood but leaving an open flame burning in at least one place. From 25 to 50 percent of the coal normally used can be saved in this way, but refueling will be required slightly more often. Seasoned wood will have less tendency than green wood to cause deposits of creosote in the flues.

3. If wood alone is to be burned in a coal furnace, a few minor changes in the equipment are desirable. Openings in a coal grate are larger than necessary for wood, but it is not difficult to remedy this; simply keeping a layer of ashes on the grate helps considerably. For temporary conversion about two-thirds of the coal grate may be covered with a piece of sheet iron or flattened gallon-size cans, perforated if desired. Many stoves and furnaces are provided with duplex grates, which need only reversing in order to burn wood. In other cases a special wood grate can be obtained from dealers. Even a furnace that has been converted into an oil burner can in an emergency be adapted for wood by removing the oil-injecting mechanism. If the former grates have not been kept available, a wood fire can be built on the floor of the furnace, which may be insulated with firebrick. The furnace thus becomes a "Wilson heater," one of the more efficient wood burning devices.

4. Because wood burns with a long flame and intense heat, various measures should be taken to keep flames from going up the pipe and wasting the heat. Fuel should not be piled up near the level of the smoke outlet. With dry wood, the problem is to hold down the rate of release of combustible gas from the wood and at the same time to admit enough oxygen to burn all the gas that is released. The draft from below the grate should therefore be restricted carefully, while about four-fifths of the air is admitted around and above the fuel, usually through slots in the fuel door. Some wood-burning stoves of conventional design are provided with special tubes to admit air at the top of the fuel level. For the sake of efficiency a check damper in the smoke pipe should be used; wood does not need as much chimney draft as coal.

5. Holding a wood fire overnight requires extra fueling with the largest chunks, preferably of heavy hardwood, and special attention to closing the draft dampers tightly.

6. In managing a fireplace, the ashes should be kept to the level of the andirons, forming a bed for the accumulation of glowing charcoal. This yields steady heat and aids in igniting fresh fuel as it is added. To check the fire, cover the burning logs lightly with ashes. Since a banked fire will keep 10 or 12 hours, the fireplace can be used continuously if desired. If a fireplace supplements an automatic heating system, the thermostat regulating the latter should not be placed so that the fireplace radiates heat upon it. An ordinary fireplace takes nearly 10 times as much wood as a stove to heat a room equally well. More efficiency is gained by an arrangement that permits the warming

of outside air that enters the room to replace the air drawn up the chimney. The fresh air is routed behind a metal shield at the rear of the fireplace and may then be led through ducts and discharged into any room. These devices have been described in Farmers' Bulletin 1889, Fireplaces and Chimneys.

7. Wood requires about two-thirds more burning space and one-third more grate surface than coal, to provide the same amount of heat. The same stove or furnace fired with wood therefore cannot yield the maximum heat of which it is capable when coal is used. In steam boilers, it is sometimes possible to overcome this difference in part by removing the grate and maintaining a wood fire on the ash-pit floor or on a layer of firebrick, as suggested previously. The ash-pit

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FIGURE 3.—Piling fuel wood for rapid seasoning, near Durham, N. C.

casing may be insulated with firebrick also. With an arrangement of this kind, the ash-pit door is kept tightly closed, and all air is admitted through the damper in the fuel door. Such a conversion is somewhat similar to that for use of domestic gravity-feed sawdust burners. For a hot-water heating system, the use of wood is not recommended. At low temperatures in the boiler, large deposits of creosote are likely to result, necessitating frequent cleaning.

8. In stoves and furnaces, green wood should not be used in a slow fire, because it will tend to cause deposits of soot, creosote, and acetic acid in the smoke pipe and flue. Burn the green wood in a hot fire and save well-seasoned sticks for use in starting the fire or maintaining it at a low rate. A small hot fire is better than a large smoldering one.

Improved Wood-Burning Stoves

Modern devices can add much to the efficiency and convenience of wood-burning equipment. Slow-combustion stoves and furnaces have been developed with considerable success in Europe, and various improved heating stoves of American design are being tested in this country. The principle generally used is to direct the burning gas from the wood downward and then by a roundabout route through the stove, so that it can be well mixed with preheated air. In this way combustion can be made nearly complete, and little of the heat is wasted. With a fairly large fuel magazine, a stove of this type may need refilling only every 8 to 24 hours. The rate of burning is quite even, and damper settings do not require frequent changing.

One stove being tried out is designed to heat a four- to five-room house and use either hogged fuel or wood in the form of small blocks. Other improved stoves have been placed on the market, with such features as downdrafts and thermostatic damper controls to keep room temperatures more constant and save fuel (fig. 4). County agents or

FIGURE 4.—An improved wood stove. A unit like this, equipped with downdraft and thermostatic control, reduces the number of refills per day, provides an even flow of heat, and uses less fuel. (Courtesy Ashley Automatic Wood Stove Co.)

extension foresters may be able to supply a partial list of these new stoves, or inquiries may be addressed to the Division of State and Private Forestry, Forest Service, Washington, D. C. Under present conditions, the availability of such equipment is likely to be uncertain.

A farmer may find it best to construct his own wood-burning furnace of brick, using little new metal material except pipes for smoke outlets and air ducts. One or more large oil drums can serve as the firebox, and other parts can be made from discarded articles. A home-made furnace of this type is shown in figure 5. Circulating by means of inlet and outlet pipes, the air is heated in the enclosed space around the oil drum. Another type of home-designed furnace is described and illustrated in the pamphlet, How to Burn Wood, fourth revised edition (September 1941), publication No. 33 of the Connecticut Forest and Park Association, 215 Church Street, New Haven, Conn.

OTHER FORMS OF WOOD-FUEL USE

If wood is cut to very small pieces, it can be moved more conveniently by means of shovels, chutes, or belt conveyors and becomes suitable for automatic firing. Hogged fuel is of this sort and is produced by a machine called a hog which reduces mill waste or other wood to chips and splinters; this fuel is often burned with sawdust and shav-

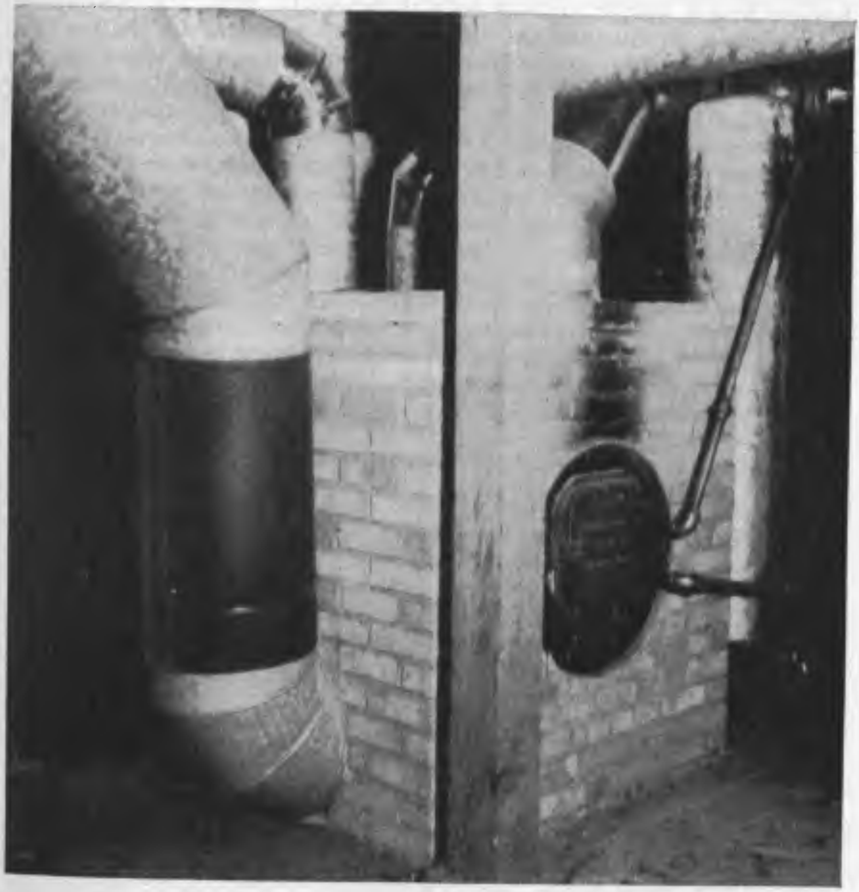

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FIGURE 5.—A home-made furnace with an 80-gallon oil drum as the firebox Air is heated in the brick-enclosed space surrounding it. The wood post is too close for complete safety.

ings in industrial boilers and large heating plants. Pacific Coast lumber mills, pulp and paper mills, and electric-power plants are the principal users.

These fuels are measured in units of 200 cubic feet, containing about the same quantity of material as a cord of 4-foot wood. Hogged fuel has 10 times the bulk of good coal, in proportion to its heating value, but, with mechanical stoking, efficiencies of 70 to 75 percent can be expected, at least equaling the efficiency obtained in burning steam coal. Where hogged fuel and sawdust are available locally, users have reported large savings, especially in regions that are remote from sources of other fuels. The Dutch-oven or reflecting-arch type of installation is commonly employed. In case of a shortage of the fuel formerly used, small industrial plants such as creameries can build Dutch ovens for burning wood fuel, if hand firing is feasible.

Sawdust has been used successfully also for domestic heating, particularly in the Pacific Northwest and in Maine. A unit with a large hopper and a simple gravity feed is generally used, the combustion taking place in the ashpit of a converted furnace, which has been lined with firebrick. As to economy, sawdust is said to compare very favorably with other fuels, and the use of sawdust burners became so popular in Portland, Oreg., a few years ago that the surplus of sawdust available has tended to disappear.

Another form of wood fuel is the sawdust and wood-waste briquet, which is very clean and convenient and ignites so readily that no kindling is required. Briquets are usually drier than ordinary wood and therefore have a slightly higher heat value per pound of material. They burn uniformly, free of soot and smoke, with little draft, and contain less than 1 percent ash. Only 40 cubic feet to the ton of wood briquets is needed for storage space, as compared with 35 to 45 cubic feet for coal. The briquets must be kept dry. On the basis of fuel value, a ton of them should be worth three-fourths as much as a ton of good coal.

HOW COOPERATIVE ACTION CAN REDUCE FUEL TRANSPORTATION

In wartime, increased use of wood fuel will be largely confined to the burning of ordinary stove and furnace wood to heat homes, apartment houses, and community buildings in the smaller centers of population and in the country. In the region east of the Plains States and north of the Ohio and Potomac Rivers, according to the 1940 census, there is a rural population of more than 23 million persons, living on farms and in towns of fewer than 2,500 people. This group of 19 States, although it is the most highly industrialized section and contains many of the largest cities in the Nation, has about 31 percent of its total population living in rural areas, and in most parts of the region the percentage is considerably higher. Well over half of our people live in these 19 States, and they account for two-thirds of the household consumption of coal. If one-fourth less coal is used on the farms and one-tenth less coal in the small towns of this region, through substituting wood, about 3 million tons of coal can be saved annually. This represents tens of thousands of carloads. Similarly, every shipload of coal and tanker load of oil saved is important in the war effort. Each person should do what he can to help.

In 1918, because of the failure of coal deliveries, the campaigns carried on by various public authorities to stimulate the use of wood to save coal, and the patriotic efforts of individuals, the national consumption of fuel wood increased about 25 million cords above normal. This represented a saving of perhaps 15 million short tons of coal, equivalent to more than 350,000 carloads. In hundreds of communities wood-fuel committees, "cut-a-cord" clubs, "cutting bees," or municipal woodyards were organized during the war, and many of them were very effective in expanding the local use of wood fuel. At present such a large total increase in fuel-wood consumption may not be possible, because of changes in types of heating equipment; nevertheless, very large additional amounts of wood can be used. Civic organizations, service clubs, and public agencies can help a great deal by distributing necessary information to the public and by promoting or organizing the marketing of wood fuels to make them more readily available to consumers.

PRODUCING, MARKETING, AND PURCHASING FUEL WOOD

The market for cordwood and stovewood has suffered in the recent past because of continued use of timeworn methods of production and delivery, requiring more hand labor than is strictly necessary. Lack of interest in more efficient methods, as well as the high cost of mechanized equipment if it is used on a single small operation, has frequently resulted in making fuel wood comparatively expensive to the consumer. If, however, woodland owners will club together or community fuel companies are organized, capital can be pooled to buy needed equipment; the use of the equipment can be scheduled to avoid having it idle; and interest and initiative in devising home-made rigs can be aroused.

In many areas there is no well-organized marketing procedure, so that a potential buyer has difficulty in finding a seller, and vice versa. An informal community fuel service could be developed to bring buyers and sellers together, or an existing consumers' cooperative organization could purchase fuel from producers, thus accumulating a supply ready for its members. Establishment of community forests, of which there are already about 1,500 in operation, mainly in the Northeastern and Lake States, offers another possibility for providing fuel wood, where the forest land bears suitable cull and low-value material.

LABOR REQUIREMENTS IN CORDWOOD PRODUCTION

The commercial possibilities of producing cordwood from tops of hardwood sawlog trees, and from inferior hardwoods removed in improvement cuttings, have been studied at the Crossett Experimental Forest, Crossett, Ark. Results show that, with reasonably experienced labor, it takes about 5 to 8 man-hours per cord for the felling, bucking (sawing to cordwood length), and splitting. This does not include stacking or yarding the wood. Highly skilled professional woodsmen, in some parts of the country, can cut and split as much as 2 cords of 4-foot wood per day. The wages paid recently in New Hampshire for cutting and piling have varied, roughly, from $2.50 to $3.50 (sometimes more) per cord of hardwood, and the price of the 4-foot wood delivered in town has averaged about $6 to $10 per cord. In Connecticut, studies of the distribution of time expended in producing 4-foot cordwood at the roadside, with hand tools and under selective cutting, have shown the following relationships: Marking, 1 percent; felling, 11 percent; limbing, 14 percent; bucking, 26 percent; splitting, 7 percent; piling, 17 percent; and yarding, 24 percent.

Fuel-wood production can be carried on as a spare-time activity, as all farmers know. People in towns with forests nearby can try their

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hands at woodcutting, either individually or as a community undertaking. Almost any able-bodied man can do the work; great skill is not essential. The cost of the stumpage for fuel wood is usually low, averaging only $0.50 to $1.50 per cord. By organizing groups for "cutting bees," social enjoyment as well as recreation can be added to a useful task. At first, amateurs may find that half a cord per day is a good average. If begun moderately, the exercise will be healthful for those whose regular jobs keep them indoors. Another possibility, where shortage of materials has forced the curtailing or shutting down of industries, is for the town to give the displaced men temporary employment in cutting and hauling cordwood from nearby timberlands. This should not in any way hinder the transfer of such workers to war industries.

TOOLS AND EQUIPMENT

At every stage of production and transportation, the uneconomical use of hand labor, such as unnecessary stacking and repeated handling of the sticks, should be avoided. Improved tools should be utilized wherever possible, to make the work easier and more efficient. In the present situation there is no assurance, of course, that it will be possible in every locality to obtain new equipment. Repair parts will probably be available, however, for used tools and machines.

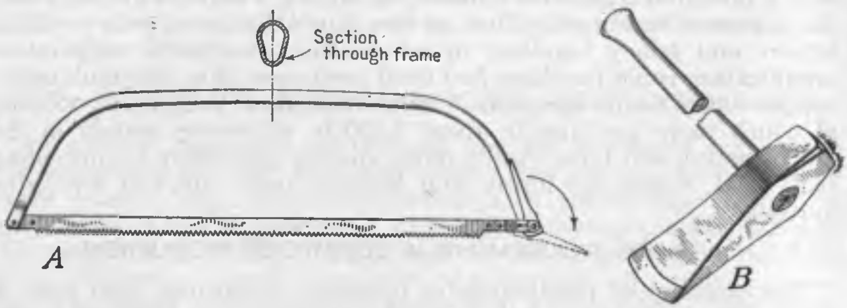

FIGURE 6.—*A*, A new-type saw, convenient and speedy for both felling and bucking fuel-wood trees; *B*, an Oregon-pattern splitting maul, suitable for splitting cordwood and driving wedges.

In the felling and bucking of trees up to 10 inches in diameter, one man can do almost the work of two by using the new "pulp saw," a bucksaw having a highly tapered blade held under great tension in a light tubular steel bow (fig. 6, *A*). The saws come in lengths of 42 and 48 inches, do not bind or chatter, and tire the hands much less than former designs. Handy for splitting cordwood is the Oregon-type splitting maul (fig. 6, *B*) with a heavy head combining sledge hammer and blade. For work in large timber various types of power saws offer means of speeding production. One of the newer developments is the power chain saw, operated by two men, which is suitable for felling and bucking both fuel-wood and sawlog trees. It is fairly expensive, but is adaptable to integrated cutting of saw timber and cordwood. The more familiar gasoline-powered dragsaw is cheaper; it is useful in bucking large-sized stems, particularly in case they are to be reduced to stove length immediately.

Yarding, or moving the wood to truck roadways, frequently consumes a large share of the total time expended. Cutting the sticks to 4-foot lengths before yarding has been customary, but it is not always necessary; savings can sometimes be made by hauling longer or tree lengths to a central point for bucking and splitting to stovewood size. Sleds can be drawn either by teams or by small tractors (fig. 7). A newer method is to transport the fuel wood in standard units: the wood is cut to a given length in the forest and placed in crates, which are skidded by sleds to the roadway and lifted by a portable hoist to the truck or trailer. The use of these crates or various means of packaging or baling stacked units of wood, to obviate the rehandling of individual sticks prior to delivery, is being investigated. (See How to Burn Wood, referred to on p. 10.) In hilly locations a further possibility for moving a large volume of material is the use of chutes.

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FIGURE 7.—Yarding cordwood by means of sled and crawler tractor. Two men with this equipment can handle 20 to 30 cords per day.

A buzz saw is the most necessary power tool, if the wood must be cut to stove length. Table saws for attachment to tractors having power take-offs are sold for about $30 plus freight. Many ingenious home-made devices have been constructed, with satisfactory results. The drive shaft or rear wheel of an old automobile can be fitted with a pulley and belt to operate the saw. Desirable features of such a rig are: (1) Portability; (2) ample power, usually not less than 5 horsepower; (3) saw rim speed of at least 6,500 feet per minute, to afford clean, quick cuts; and (4) adequate guards around both the drive and the saw to prevent accidents. For those having electricity available, full instructions for building a small electrically operated crosscut saw, using a ¼- or ⅓-horsepower motor to drive a dragsaw, may be obtained by writing to the United States Department of Agriculture, Bureau of Agricultural Chemistry and Engineering, Washington, D. C.

HAULING AND DELIVERING

A truck with a stake or similar body, capable of carrying 1 or 2 cords, will generally be the most adaptable for cordwood. Dump trucks such as those used for hauling earth and coal can be used in delivering stovewood lengths if the distance is short; they save one handling of the sticks. Another way to promote efficiency is to place the empty truck in a position near the buzz saw so that the short pieces may be tossed into the truck immediately after being cut. If the 16- or 12-inch lengths cut from a cord of 4-foot wood are thrown at random into a truck or wagon box (fig. 8), they will occupy as much as 150 cubic feet of space, while the same short wood carefully stacked measures little over 100 cubic feet; truck-body sizes should be considered accordingly. For hauling wood a truck need not be new, attractive in appearance, or

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FIGURE 8.—Working up Osageorange into stovewood with a buzz saw, near Hutchinson, Kans. Throwing the short lengths immediately into the wagon saves labor. The saw, belt pulley, and flywheel should be provided with safety guards.

in better than passable mechanical condition. An opportunity therefore exists for profitable utilization of many older trucks that might be discarded because they are outmoded or not dependable enough for more exacting use. Reports from one study indicate that the cost of hauling pine cordwood 5 miles under average conditions, carrying 2 cords to the load, is about 75 cents per cord, without adding a profit margin. Additional distances over good roads add about 10 cents a mile to the cost per cord.

The use of detachable trailers offers a method to prevent having the truck stand idle in the forest for considerable periods, during the process of loading. Practical devices have been developed for their application to logging work, and it is reported that five men with a truek and two trailers eould load and haul 23 eords of pine pulpwood in a day, where the distanee was 10 miles and two teams and wagons were used in yarding. (See Truek Logging with Detachable Trailers, by R. R. Reynolds, obtainable by writing the Southern Forest Experiment Station, New Orleans, La., for its Oeeasional Paper 85.)

Hauling the wood directly from the woods to the eonsumer is desirable wherever eonditions make it possible. The wood is first staeked beside the truek road for seasoning. After delivery to the eonsumer, it can be "buzzed" to the length he prefers. Sometimes it is best to saw the green wood to stove length in the forest and immediately haul it to a storage point or the buyer's yard to be seasoned.

SEASONING WOOD

For green wood freshly eut from the forest, from 6 months to a year is usually required for thorough seasoning. The rate of evaporation of the moisture will depend on sueh faetors as temperature, relative humidity of the air, exposure to rain or snow, and movement of air about the individual stieks. Splitting the pieees helps, and is almost indispensable with some speeies sueh as bireh and alder, whieh should also be plaeed in fairly dry loeations. Moreover, eottonwood, for example, is far easier to split when green. The wood should be stacked outdoors where it is exposed to the sun and wind, preferably on a hilltop. Skids or bed pieces may be used to keep the fuel wood off the ground, and for best results either some form of roof or eovering should be provided, or the top layer of stieks should be packed closely and slanted, to help prevent rain from reaehing the interior of the pile. In order to aeeelerate the seasoning proeess, the stieks may be piled erisseross. This provides for the maximum eireulation of air. If branehes of live trees felled during the summer are left intaet for 2 or 3 weeks, considerable moisture will be drawn out through the leaves.

Tree speeies vary eonsiderably in the proportions of moisture usually eontained in their wood at the time of felling, as table 2 indicates. For example, green Douglas-fir heartwood is so dry that it has very little more fuel value when seasoned. Near the opposite extreme are the eottonwoods, whieh contain a great deal of water. Under emergeney eonditions it may often be desirable to eut fuel wood for use within a very short time. In sueh eireumstanees, if the available woodland offers a ehoiee of several different speeies, it would be useful to know the kinds of trees from whieh satisfaetory fuel may be produced with only a minimum of seasoning. The following speeies are improved eomparatively little by drying:

Ash, biltmore.
Ash, blue.
Ash, Oregon.
Ash, white.
Beech, American.
Douglas-fir.
Fir, alpine.
Fir, noble.
Hickory, pignut.
Hickory, shagbark.
Locust, black.
Osageorange.
Pine, lodgepole.
Pine, red.
Spruce, red.
Spruce, white.
Tamarack (eastern larch).

Higher moisture content makes seasoning of the following woods more necessary:

Alder, red.
Ash, black.
Aspens.
Birch, paper.
Birch, river.
Cottonwoods.
Elm, American.
Fir, grand.
Fir, Pacific silver.
Fir, white (*Abies concolor*).
Hackberry.
Hickory, bitternut.
Hickory, nutmeg.
Hickory, water (bitter pecan).
Honeylocust.
Maples.
Oaks.
Pine, jack.
Pine, jeffrey.
Pine, loblolly.
Pine, pitch (*Pinus rigida*).
Pine, ponderosa.
Pine, shortleaf.
Pine, sugar.
Pine, Table Mountain.
Sugarberry.
Sweetgum (redgum).
Sycamore.
Tupelo, water.
Walnut, black.

GRADES AND SIZES OF FUEL WOOD

It has been pointed out that the value of a cord of wood as fuel may vary a great deal, depending on the species, moisture content, and form of the sticks. For use in the home, the length to which the sticks have been sawed is another important factor. Hiring men with a power saw to cut 4-foot cordwood to lengths of 16 or 12 inches, usually the most desirable for stove or furnace fuel, costs approximately $0.75 to $1.25 a cord, and there should be a corresponding difference in prices for the 4-foot and stove lengths. If these differences in values were more clearly recognized in the sale of fuel wood, the consumer would know much better what he was getting for his money. Dealers in coal do not sell merely in terms of weight or bulk, but specify the kind, source, size, and sometimes the heating value of the coal. Similar grading of fuel wood is desirable. Sale of wood by the ton rather than the cord or the load would provide a fairer measure of value if there could be assurance that all the wood offered was equally well seasoned. In most cases, however, it will be more practical to follow tradition and continue buying and selling wood by the cord, classified roughly as hardwood or softwood, well seasoned, partly seasoned, or green; slabwood, dry or green; and mill ends (softwoods). Mill ends or trimmings, useful as kindling, are usually sold simply by the truckload or unit, for it is not feasible to stack them in cords. If possible, there may be a further break-down according to the heat value of the species. (See tables 1 and 2.) Not many separate grades of fuel wood are likely to be required in any one community, and it should not be difficult to work out a practical grading system for local needs. Some States have laws regulating the measurement and sale of fuel wood, with which buyers and sellers should become familiar.

Fireplace wood should be of greater average diameter than stove or furnace wood, and the sticks may be longer. In some sections of the country a distinction between old-growth and second-growth wood is maintained, the former being considered better because it is easier to split, comes generally in larger pieces or chunks, and often has higher heat value. Split pieces from rather large stems are preferable to small round lengths and to limb wood. Moreover, a cord of split wood generally has a greater solid content than a cord of small round wood, if the length of the sticks is the same in both cases.

ENCOURAGING PRODUCTION

In places where the use of wood fuel is feasible and will, on the whole, tend to save transportation, effort should be made to interest local wood, coal, and lumber dealers in establishing or expanding the wood-fuel business. The possibility of utilizing waste from nearby sawmills and other wood-using plants should be looked into. Creating a demand and obtaining definite orders for fuel wood will do most to encourage farmers and others to provide a supply. It may be advisable in some instances to organize a wartime community fuel service such as those which proved helpful during the first World War. Action should be taken to get a supply on hand well before an actual fuel shortage can occur.

SELECTION OF MATERIAL TO CUT

The cutting of fuel wood may be done in such a way that the value of the woodland property is improved; if done unwisely, it may be destructive. Unfortunately, a good deal of the forest fuel wood is at present cut from sawlog material that should be reserved for lumber or similar uses. This represents a serious loss to the owner of the timber; from the viewpoint of the public, it is wasteful of a natural resource. Indiscriminate cutting of other classes of trees for fuel is also to be discouraged. Trees near the house that are valuable for shade or windbreaks should not be cut solely to obtain fuel wood. Stripping the woodland completely is not a good practice, except to clear the land for crops or pasture. The habit of cutting all trees large enough for fuel in immature second-growth stands is, in some regions, a greater evil than the misuse of saw timber.

It must be remembered that among the various forest products, fuel wood is one of the lowest in value. In cutting for fuel wood, therefore, individual trees to be removed should be selected carefully, consideration being given to the local market for sawlogs, poles, piling mine timbers, fence posts, or pulpwood; if the operation takes the nature of an improvement cutting or a thinning, the profits of the owner will be increased. Timber is a renewable resource, but it cannot renew itself satisfactorily if the better trees are continually cut and the poorer ones left.

The removal of cull and inferior trees, if it can be made to pay returns, will go far toward solving one of the most difficult problems in building up the forest resources. It will provide an income to the timber owner during the period when the best trees are making their most valuable growth, and accelerate this growth by ending the excessive competition of inferior trees. In mixed stands of pines and hardwoods, pines are often taken because they split more easily. Generally the poorly formed hardwoods should be cut instead; their higher fuel value tends to offset the extra labor involved. The pines grow faster than the hardwoods and in most places can be sold at better prices for lumber, poles, or pulpwood. At a time when cordwood can be sold at good prices, the landowner has an excellent opportunity to put his timber stand in better growing condition.

A combined operation for the removal of fuel wood and other products from the forest will often be profitable, especially where the saw-timber or pulpwood material is so scattered that cutting for only one kind of product is uneconomical. Timber stands that have formerly been considered unmerchantable might be utilized if both fuel wood and a small volume of other products could be cut and marketed at the same time. Hardwood trees harvested for sawlogs usually contain much excellent fuel-wood material in their tops. Information on how to estimate the volume of cordwood and other products in standing timber may be obtained by writing to the United States Department of Agriculture for Farmers' Bulletin No. 1210, Measuring and Marketing Farm Timber.

Opportunities to obtain fuel from nearby logging or other woods operations should not be overlooked. Tops of trees, large limbs, and even rejected sawlogs are usually left on the ground. Sometimes trees are accidentally knocked down in the course of logging or cut to get them out of the way. At present, this material ordinarily goes to waste, but it can easily be worked up into cordwood. The timber owner, in most instances, will be glad to have it removed, to reduce the fire hazard. Cull trees and those of inferior species left standing by the loggers often have no value except as fuel.

Many stands of sapling size are so badly overcrowded that their growth is much retarded or has practically ceased. Thinning out the poorer individuals to make cordwood and leaving those with the straightest, cleanest stems and healthiest appearance will speed up the growth of the latter and increase the rate of interest earned by the timber capital. The thinning should not be too severe, however; enough trees should usually be left so that their crowns will come together again in about 5 years, to prevent the growth of undesirable branches along the lower and middle parts of the stems. In general, if two trees of equally valuable species stand so close together as to hinder each other's development, the slower-growing one should be cut.

Before the actual felling is started, it is a good plan to mark the trees to be cut. This takes but little time; better selection will be accomplished if other phases of the work are not claiming one's attention simultaneously; and inexperienced help may then be employed with less danger of having highly valuable trees felled by mistake. Figure 9 gives an example of the contrast between trees that should be cut immediately and those that should be left to grow because of their higher quality.

Technical advice applicable to local conditions may be obtained from the State extension service (extension forester or county agent), the State forestry department, or the United States Forest Service. In most woodlands a satisfactory improvement cutting or thinning can be made through the application of a few simple rules concerning what to cut. Figure 10 illustrates an improvement cutting. Although no set of rules will exactly fit every situation, the following are the most important classes of material that should be used for fuel wood:

1. Tops, large limbs, and other logging waste.
2. Dead trees, down or standing, that are sound enough for fuel.
3. Diseased or insect-infected trees and those likely to be attacked as a result of injury from fire or other causes; also species that are extremely susceptible to local epidemics.
4. Hardwoods of bushy form, with stems too short to make a clear sawlog.
5. Crooked or broken trees.

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FIGURE 9.—The tree in the left foreground is diseased; the one in the right foreground is deformed; both should be cut for fuel wood. The tree in the center should be left to grow until it can be cut for a more valuable product.

6. *Trees that* are seriously *overtopped and stunted by others*, so *that they* are unlikely to reach saw-timber size.
7. *"Wolf"* trees, *which have unusually large crowns of foliage and*, quality considered, occupy excessive space.
8. Trees of species not in demand for lumber, poles, ties, pulpwood, etc., especially if they are interfering with the growth of more valuable trees.

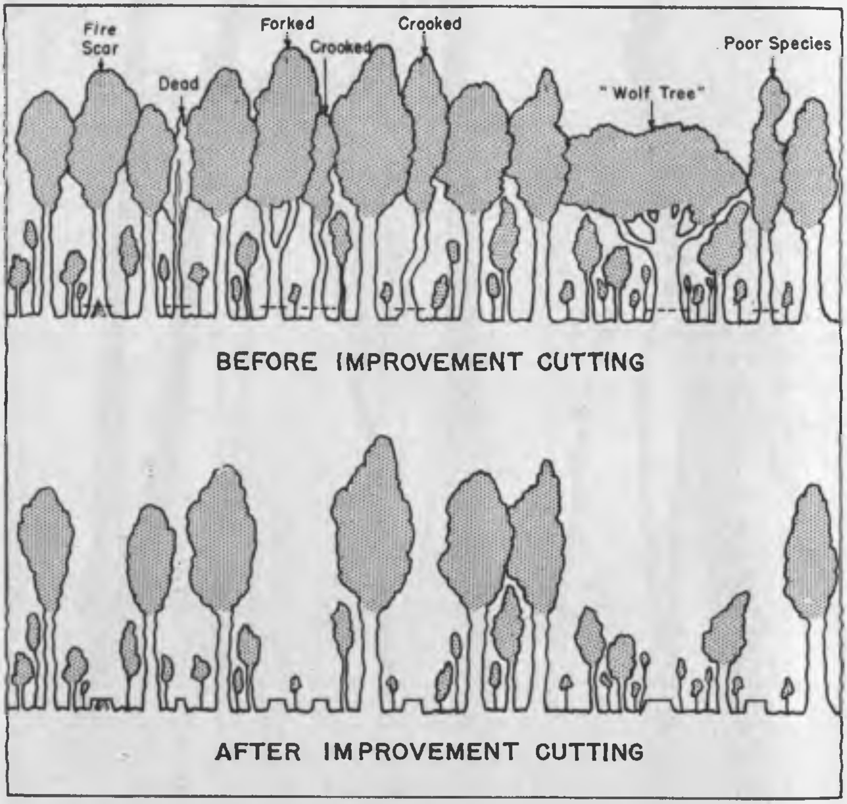

FIGURE 10.—How fuel-wood material can be cut with benefit to the remaining stand.

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