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To the Graduate Council:

I am submitting herewith a thesis written by Billy Gene Hicks entitled "Utilization of Low-Quality Hardwood in the Production of Charcoal." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Agricultural Economics.

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UTILIZATION OF LOW-QUALITY HARDWOOD IN THE PRODUCTION OF CHARCOAL

A Thesis

Presented to

the Graduate Council of

The University of Tennessee

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

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by

Billy Gene Hicks

June 1961

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CHAPTER I

A REVIEW OF OPPORTUNITIES FOR UTILIZATION OF LOW-QUALITY HARDWOODS AND THE PROBLEM

More than 12 million acres of land in Tennessee are covered with commercial forest, nearly one-half of the State's over-all area.[1] Some 1.1 million acres of this forest land are publicly owned, another 5 million acres are in farms, and the remainder are held by numerous industrial and other private owners.[2] From this vast area of woodland comes nearly a billion board feet of sawtimber,[3] and more than one-third million cords of pulpwood annually.[4] In 1950, the value of timber products represented about 6 per cent of the total income payments in Tennessee, or about $190 million.[5]

But if we show only the magnitude of forestry in Tennessee, we tend to mask problems of great significance. The State forests have a much greater potential than that shown above. It has been estimated

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[1]U. S. Department of Agriculture, Tennessee's Timber Economy, Forest Resource Report No. 9 (Washington: Government Printing Office, 1955), p. 14.

[2]Ibid., p. 45.

[3]U. S. Department of Agriculture, Timber Resources for America's Future, Forest Resource Report No. 14 (Washington: Government Printing Office, 1958), p. 528.

[4]J. F. Christopher and M. E. Nelson, Southern Pulpwood Production, 1958, Forest Service Release 82 (New Orleans: Southern Forest Experiment Station, 1959), p. 1.

[5]U. S. Department of Agriculture, Tennessee's Timber Economy, op. cit., p. 1.

that a reasonable growth goal for Tennessee forests would be approximately double our present average growth rate, which is 23 cubic feet per acre annually for growing stock and 71 board feet for sawtimber.[6]

A problem that is associated with the low growth rate is the area in our forests that is taken up by cull trees, virtually all hardwoods. Some 9.3 million acres, or almost 75 per cent of the commercial forest area, are of hardwood and hardwood-pine species.[7] Of the 13.2 billion board feet of hardwood sawtimber in Tennessee, about 70 per cent is of quality below that generally preferred by sawmills - that is, logs that will not grade no. 1 and 2.[8] It has been estimated that about 17 per cent of the forested area of the State (the equivalent of more than two million acres) is taken up by low-quality hardwoods.[9]

Forest management studies have shown that the removal of cull hardwoods for the purpose of stand improvement may be achieved economically by several methods, which one to be used depends upon conditions found in that particular area. The most common methods recommended include girdling, chemical killing, or controlled burning. So far none of these or any other method has been greatly used by forest land owners in the State. Under conditions approaching that of pure competition, theoretically, these methods would be adopted if they tended to maximize the net returns to the forest land owners. The assumption here is that increased net returns are most important to these individuals. The recommendation to use these methods is based upon the economic gains

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[6] Ibid., p. 31. [7] Ibid., p. 45.

[8] Ibid., p. 18. [9] Ibid., p. 1.

from replacing low-quality trees with higher quality ones and assumes that there is no economic loss in destroying the low-quality timber. However, this assumption is not true if there is a market for the wood which would return to the owner a price greater than the difference between the cost of harvest and the cost of destroying the timber.

I. REVIEW OF OPPORTUNITIES FOR UTILIZATION OF LOW-QUALITY HARDWOOD

Some of this wood is being used, primarily for fuel, fence posts, cross-ties, and pulpwood; but the annual volume going into various uses does not equal its annual rate of growth. According to the Government Forest Resource Report, in 1949 the net growth of all merchantable trees totaled 286 million cubic feet. Logging removed about 252 million cubic feet of the total. Therefore, growth on all merchantable timber thus exceeded the total cut by 13 per cent. However, sawtimber-size trees have been removed at a rate that outstrips growth on trees of this size.[10]

A great variety of marketable products can be produced economically from Tennessee forests. And perhaps most important to this study, many of these products can be made from low-grade, small-sized timber. Existing plants and equipment with little modification can be used in manufacturing some of the products. However, investment in plant and equipment for other products may be necessary and could be quite high.

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[10] Ibid.

Promising Enterprises

Charcoal production. There has been great interest in charcoal production from low-quality hardwood in Tennessee as a small rural enterprise. So far, these ventures in Tennessee have largely met with failure, mostly because the supply to customers has not been of a uniform quality and of adequate quantity at a specified time.

Nevertheless, charcoal production will be considered in this study because it not only utilizes low-quality trees and mill waste, but also because it is an enterprise which can be established with a relatively small amount of capital. Tennessee, with its underemployed labor, large supply of wood resources, and proximity to markets, should be able to compete with other states in charcoal production.

Wooden pallets. In Tennessee the wooden pallet industry is potentially an important outlet for low-quality hardwood logs and lumber. Several advantages present themselves in the manufacture of pallets over most wooden articles: the use of lower grades of lumber assures the availability of adequate raw material at an economical price, operating efficiency is not greatly affected by the size of the operation, and production can often be integrated with sawmilling or other wood processing plants. Thus, pallet manufacturing can be started with a small amount of capital. All of this incidates ease of entry into this business and is probably the reason for relatively small profits and keen competition.[11]

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[11]U. S. Department of Agriculture, Forest Industry Opportunities in Rural Development, Forest Service, Agriculture Information Bulletin No. 222 (Washington: Government Printing Office, March, 1960), p. 15.

Pulpwood. As pointed out earlier, the State produces pulpwood annually in excess of one-third million cords - almost one-third of this comes from hardwood species.[12] The utilization of hardwood in Tennessee pulp production may be expected to increase with expansion of the industry, reduction of the pine pulpwood supply in the State, and as certain new processes gain wider use.[13]

The volume of paper and other products made from pulp is enormous and is continuing to increase steadily. The applicability of new pulping methods such as the semi-chemical process are especially well adapted to hardwood species. Although softwood species are of major importance to the pulping industry, hardwood pulps have some highly desirable characteristics, including high yield, good sheet formation, bulk, and smooth surface. In addition to the quantity and quality of labor and wood resources, Tennessee has adequate water supplies for the pulping industry.

Fiberboard. Both hardboard and insulating board belong to a type of fiberboard which is sheet material largely manufactured from fibers of wood with natural adhesive properties bonded together by heat. However, some binding agents or other materials may be added during manufacture in order to increase strength or other properties. Hardboard with its greater density and rigidity, harder surface, and greater resistance to impact is thus distinguished from insulating board.

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[12]Christopher and Nelson, op. cit., p. 9.

[13]J. A. Hall, "Opportunities and Problems in Utilizing Wood Products," Proceedings, Society of American Foresters, Memphis, Tennessee, 1956, p. 9.

These boards are used for many purposes, including insulation core for furniture and wall panels. Therefore, the market for fiberboards gives promise of continuing expansion, and, with some of the largest manufacturers of hardboard using hardwoods, there should also be a continuing increase in the utilization of low-quality hardwoods.

Furniture, small dimension, turned and shaped goods. Many species of trees found in the State's forest are favored in furniture manufacturing. According to the Census of Manufacturing, the furniture industry in Tennessee grew from a $26 million industry in 1947 to one of $43 million in 1954. Tennessee, with its wood resources, ample labor, and proximity to markets, is well suited for this industry.

Small dimension stock is a group classification for a number of parts or blanks processed to a point where a maximum amount of waste is left at the producing mill and a maximum of usable wood is delivered to a great variety of fabricators of wooden articles. This stock is ordinarily remanufactured into a number of finished products, furniture being the most common. Other items such as blanks for ball bats, handles, dowels, toys, and other items can be made from poor quality logs and waste materials.

Turned and shaped goods can be made on lathes from square or rectangular pieces of wood. Furniture parts, handles, toys, novelties, utensils, and other items can be made from hardwood.

Good design, ability to deliver the quantity and quality of goods demanded by customers at specified dates with efficient manufacture and handling of articles are critical factors in this business. However, if

these conditions are met, opportunities are present for thus increasing the utilization of our labor and wood resources.

Flooring. Modern, high-grade sectional, square, or rectangular flooring can be manufactured from Tennessee's timber. Not only is this a valuable product but its manufacture provides an excellent outlet for the State's low-quality lumber and short stock material. This industry is by no means unknown to Tennessee, but by using nearby raw materials, attractive yet simple designs, and by possibly integrating with the manufacture of other products such as molding or paneling, possibilities exist for additional production.

Paneling. The trend in modern homes is definitely toward the use of more wood paneling. Home owners believe that wood paneling improves the appearance of a room, and most of them would include paneling in a new or remodeled home. Home builders, decorators, architects, and retailers have done a great deal to promote the charm and beauty of wood in this form. The demand is particularly good for wall paneling made of hardwood with a natural or clear finish that allows the distinctive character of the wood to show through.[14]

Almost all species of hardwoods have distinctive grain patterns that can be utilized to produce attractive paneling. Low grades of lumber can be used if it is properly machined and finished. Discolorations, streaks, pin holes, worm holes, knots, and other small defects

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[14]Richard C. Smith, Lee K. Paulsell, Lawrence Leney, Oak Paneling Its Processing and Marketing, Bulletin No. 737 (University of Missouri Agricultural Experiment Station, July, 1959), p. 1 and pp. 8-12.

and irregularities add to the character and variety of the panels.[15]

A most attractive assortment of paneling is being made from low-quality hardwood by at least one manufacturer in Tennessee. Several million board feet of hardwood paneling would probably be used to replace inferior knotty pine and other paneling and building materials if proper processing and merchandizing were carried out.

Paper-overlaid lumber. By covering low-grade lumber with resin-impregnated paper, satisfactory panels and boards for interior or exterior use can be manufactured. Panels are made by gluing boards together edge to edge and covering. The boards may then be sawed to the desired width and generally handled like ordinary lumber. Although this product is now only emerging from the experimental stages, it appears to have an excellent future.

Miscellaneous products. Quite an array of other articles, like mine ties and timbers, cross-ties, fence posts, and similar products, can be made from a variety of the State's hardwood species. Lower quality hardwood trees and waste material can be used for additional items, such as soil conditioners, roofing felt, and chemical derivatives. The field of wood chemistry, pioneered at the Forest Products Laboratory, offers a host of products such as sugars, molasses, alcohol , furfural, etc., made from wood. However, economical production remains to be worked out.

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[15]U. S. Department of Agriculture, Forest Industry Opportunities in Rural Development, op. cit., p. 17.

II. THE PROBLEM

After several years of national prosperity, some areas are still plagued with low incomes. Tennessee has its share of such areas. Therefore, increasing employment and returns in these marginal areas are of primary importance. This can be done by developing our wood-using industries and by increasing the productivity of our forests - two aspects which are more than just casually related. By improving the quantity and quality of our timber resources, Tennessee wood-processing and wood-using industries are sure to increase in importance. Yet it may be necessary to develop our forest industries more fully in order to realize anything approaching optimum conditions in the State's forests. This situation exists because past utilization of hardwood trees has led to what is pretty largely a high-grading operation, creating a major problem in the management of forests in Tennessee. Removal of low-quality hardwood trees is needed to provide more growing space for thrifty merchantable timber. Generally, the improvement of forests solely for the production of lumber has not provided the necessary incentive.

Therefore, the problem evolves into one of developing mass utilization outlets for low-quality hardwoods that will make economically practical the re-establishment of good pine stands on hardwood-infested lands that are best suited for pine production and improve the quality and productivity of the State's hardwood forests where such species are best suited. This problematical relationship is based on the assumption that competition exists in the production of forest products, so that forest owners will endeavor to adopt practices that will increase the

spread between costs and returns. Usually, competition among producers is in the nature of cost competition because the producer has no control over the price received for his products. However, producers will seek the most profitable alternative markets for their products under competitive conditions. Forest owners will seek to maximize net returns both by reducing costs and by using the more profitable marketing alternatives.

If a sizeable increase in hardwood utilization can be developed, this will not only serve as positive encouragement for forest stand and species improvement and for a higher level of management, but will also bring in more income from this resource. Moreover, "cull hardwoods," which are now a liability, would become a base for productive employment in low-income areas of the State.

Purpose. The purpose of this study was to investigate the economic feasibility of utilizing low-quality hardwoods in the production of charcoal as an alternative to destroying them and as a means of providing employment alternatives for some of the State's underemployed. In order for charcoaling to provide an alternative to destroying the timber, it might appear that the stumpage must have positive value after payment of all other costs. However, from the standpoint of forest improvement, the stumpage value may be negative, but the returns to labor and other inputs must be comparable to those that could be received in other employment opportunities. Thus, if charcoaling does not return a profit but is less costly than destroying the timber, it is economically feasible from the forest management viewpoint.

The specific objectives may be stated as follows: (1) to estimate

the future production possibilities by analyzing the supply and demand for charcoal; (2) to investigate Tennessee's competitive position in the conversion of low-quality hardwoods into charcoal in terms of location with respect to markets, source of raw materials, labor supply and other factors affecting cost of production and marketing; (3) To establish estimates of the stumpage value of low-grade hardwoods based on the market value of charcoal and/or briquettes less harvesting, conversion and marketing costs, or to determine if the difference between production and marketing costs and the sales value of the charcoal and/or briquettes is less than the cost of destroying the timber.

III. METHOD OF STUDY

This study began with a review of the literature to bring to light those hardwood products with the most promising future with respect to total demand and expected expansion. A prime consideration in the selection of the production of charcoal for study was its use of relatively large quantities of low-quality hardwoods and its adaptability to Tennessee. The information upon which this study was based was obtained mostly from secondary sources. Production, consumption, and other pertinent economic data were procured to establish trend and outlook information to estimate the future production possibilities of charcoal.

An estimate of the price received by kiln operators in the State for lump charcoal in bags was derived from information obtained by interviewing eight members of the Charcoal Producers Association located

in Van Buren County. Bulk charcoal prices used in this thesis are the same as those paid by the briquetting plant in Cookeville, Tennessee. The plant at Huntsville, Tennessee, was reportedly paying the same prices before being destroyed by fire. Unless otherwise specified the prices are quoted f.o.b. kiln. Transportation costs incurred in delivering the end product to the consumer are reflected in the price paid for charcoal. Thus, transportation costs were not deducted as an item of cost in producing lump charcoal.

An estimate of the price briquettors could expect to receive for their product was made by subtracting all costs incurred in getting the end product to the final consumer from the retail sales value of the product. Retailer and jobber mark-up was estimated to be 20 per cent each. Freight rates for transporting briquettes to several points in the East were obtained. From these an estimate was made of the average transportation cost per ton of briquettes.

Perhaps the most critical phase of this study was the estimation of stumpage value of low-grade hardwoods. An attempt was made to determine from equipment manufacturers and published sources technical coefficients or input-output relationships for the various charcoal and briquetting operations used in this study. An estimate of local charcoaling and briquetting costs was made by applying costs applicable to Tennessee to these technical coefficients. The estimates were made by using the budgeting technique. The stumpage value for low-quality hardwood was estimated as the residual of the value of the end product, minus costs of harvesting, conversion and marketing the charcoal. Tennessee's

competitive position is determined by the cost of producing and marketing the charcoal and/or briquettes relative to prevailing prices received for the product.

The development of mass utilization outlets for low-quality hardwoods as well as the answer to our forest management problem may very well hinge on the value of "cull hardwoods" going into the various uses. The major premise of this study is that the forest land owners will be interested in improving their timber only when there is positive evidence of profits - only then will there be incentive strong enough to give relief to our low-quality hardwood situation. Furthermore, if positive evidence is produced to show that labor and capital can be profitably employed in utilizing this wood, there will still need to be an effective educational program developed to channel this information to the people in the forestry industry.

CHAPTER II

PROSPECTIVE SUPPLY AND DEMAND FOR CHARCOAL

The future possibilities of charcoal production will be examined in this chapter. A brief history of the charcoal industry is given to indicate trends and production techniques used. An estimation of future production is made from the industry trends and from supply and demand analysis.

History of the Charcoal Industry

The charcoal industry has gone through three distinct phases in the United States. Behive kilns were the main production method through the late nineteenth century. Most of the charcoal, the sole product produced in these kilns, was used principally for smelting iron ore.

A new reason for carbonizing wood began in the 1830's, overlapping the era of charcoal use in the iron furnaces: expensive and elaborate plants were built primarily for the purpose of converting wood vapors and tars into chemicals for industrial uses. Charcoal was a joint product of this process and was only of secondary importance. More than 100 plants were in operation around 1920, accounting for most of our charcoal production.[1] Many commercial and industrial uses of charcoal were developed, based on an abundant and low cost supply; "domestic" con-

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[1]John R. Warner and William B. Lord, The Market for Domestic Charcoal in Wisconsin, U. S. Department of Agriculture Forest Service, Lake States Forest Experiment Station, Station Paper Number 46, June, 1957, p. 4.

sumption was a small percentage of the total.[2]

The discovery of cheaper methods of obtaining many of these chemicals synthetically resulted in a rapid decline of the wood distillation industry. Charcoal again emerged as the chief product, being used primarily at this time as low-income house fuel in larger cities and for limited industrial uses. Only .3 per cent of all pig iron output involved the use of charcoal in 1929.[3] By 1932 half of the hardwood distillation plants had closed,[4] and by 1947 the total number had shrunk to 15.[5] Today there are a number of wood chemical plants producing charcoal and they produce a substantial amount of our total supply, but only four or five plants attempt to recover chemicals and these are operating under unusually favorable conditions.[6] New investments in such plants are prohibitive for charcoal production alone.

Just prior to or a short time after World War II, the industry began the third and current phase. Over the past 15 years there has been a steady decline in the industrial demand for charcoal but more

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[2]Domestic consumption has been defined in this thesis as that portion of the total charcoal and briquette demand used for such purposes as backyard or patio cooking. Charcoal and briquette consumption was further divided into commercial and industrial demand. See page 27 for items included in these two subdivisions of the total demand.

[3]Ronald Beazley, "Charcoal Marketing in the United States, Description and Analysis," The Northeastern Logger, February, 1958, p. 34.

[4]Warner and Lord, loc. cit.

[5]Beazley, loc. cit.

[6]Charcoal Survey, University of Arkansas, College of Business Administration, Industrial Research and Extension Center, Little Rock, November, 1956, p. 36.

than making up for this has been the steadily increasing domestic demand. Today indications are that less than half of the charcoal produced is being consumed for industrial purposes. The remainder is used chiefly by middle-income groups for outdoor cooking and by dining cars and restaurants. During this time, with charcoal the only product obtained from carbonizing wood, the kiln has again emerged as an important producing unit.

Production and Consumption of Charcoal in the United States and Indicated Trends

Production. Charcoal production in the United States reached a peak of over one-half million tons in 1909. As can be seen from Table I, there has been no decided trend in charcoal production. Yet, present production is considerably below that of the early 1900's. Production in 1956 of 264,990 tons, a post-war peak, was less than half that of 1909. Of this amount the seven state area of Tennessee, Alabama, Mississippi, Arkansas, Louisiana, Oklahoma and Texas, produced 74,260 tons or about 28 per cent of the total.[7]

Eight large plants accounted for 69 per cent of the 1956 production. The remaining 31 per cent was produced by 232 small producers. Over half of these coaled less than 100 tons of charcoal each. Three of the large plants are located in the seven state area mentioned above, one in Arkansas and two in Tennessee. In 1956 there were 29 producers

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[7]U. S. Department of Agriculture, Charcoal Production in the United States, Forest Service, Division of Forest Economics Research, July, 1957, pp. 2-3.

TABLE I

CHARCOAL PRODUCTION IN THE UNITED STATES,
SELECTED YEARS 1899-1956 [a]

Year	Production	Year	Production
	Tons		Tons
1899	171,543	1939	250,780
1905	266,701	1944	306,192
1909	554,785	1947	213,660
1914	448,278	1952	251,784
1921	227,033	1954	214,481
1925	438,358	1955	237,770
1929	453,550	1956	264,990
1935	328,014	1958	234,404

[a]Source: All years prior to 1955 - Bureau of the Census, U. S. Department of Commerce; 1955 and 1956, Forest Service, U. S. Department of Agriculture, as given in Charcoal Production in the United States, U. S. Department of Agriculture Forest Service, July, 1957; 1958, Census of Manufacturing, Bureau of the Census.

in the previously mentioned seven state area along with only 12 in the Lake region, accounting for less than one-sixth of all producers but 65 per cent of the charcoal. In the Southeast (Virginia, North Carolina, South Carolina, Georgia, and Florida) there were 46 producers or just under one-fifth of the total, accounting for only an estimated 10 per cent of the charcoal.[8]

A large part of the charcoal being produced today is being converted into briquettes. Total briquette production amounted to 125,000 tons in 1956. This represents an average per capita use of about 1.5 pounds of briquettes. There has been considerable interest in charcoal production over the past few years and as a result several charcoal and briquette plants have been erected. Less than 50 per cent of the 1956 charcoal production was converted into briquettes and this was approximately 25 per cent more than the year before.[9] There are no reliable data on recent briquette production, but it is generally conceded that considerably more than half of today's charcoal is briquetted. Almost all of the charcoal used for fuel is briquetted.

According to the 1958 Census of Manufacturing, charcoal production from the softwood and hardwood distillation industry, including a "small amount produced in kilns" was down to 234,404 tons. The data from this census for the years 1947, 1954 and 1958 are the same as those given in Table I. Whether these data include all of the charcoal produced in

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[8]Ibid., p. 3.

[9]Ibid.

kilns is not known, but there are indications that they do not. According to the Charcoal Survey, the 1955 production amounted to 300,000 tons.[10] In fact, unpublished data of the U. S. Forest Service, Forest Products Laboratory, at Madison, Wisconsin, estimated the national charcoal production in the mid-1950's to be nearly 375,000 tons.[11] It is estimated that 65 per cent of the charcoal was produced in large distillation plants.[12] However, if the census data does not include all of the charcoal produced (and it does not make such a claim), the 1958 census data would indicate that the wood distillation industry is declining further. But the issue is clouded by the fact that 1958 was a recession year. Industrial production was below normal; therefore, the demand for charcoal for such purposes was cut. Also, charcoal for domestic use is basically a "luxury" item and consumption may have been curtailed for that reason. However, charcoal makes up a very small fraction of the family budget and it is doubtful if charcoal use was significantly reduced on that account, and in addition, charcoal imports suffered most during the recession as they were cut almost in half.

Future production. Due to the obsolesence of wood distillation plants which formerly produced charcoal as a by-product, charcoal production has been declining over the years. Thus room has again been made for the kiln as a producing unit.

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[10]Charcoal Survey, op. cit., p. 82.

[11]As given in Warner and Lord, op. cit., p. 4.

[12]Ibid.

In addition to the many kinds and sizes of kilns in use today, there are perhaps just as many different kinds and sizes of retorts.[13] Retorts are described in the literature ranging in price from less than $1000 to 100 times that amount, just as there are brick beehive kilns with capacities of 10 to 100 cords and cinder-block kilns with capacities ranging from one to 40 cords. Which one of these kilns or retorts proves to be most economical depends on the situation. Wood and labor costs are two major items involved. The economics of charcoal production will be examined more fully in the next chapter. However, one thing is almost certain: production of charcoal from either kiln or retort will increase in the future. Furthermore, briquette production will increase, which may improve the outlet for charcoal from the small retorts and kilns.

The Quaker Oats Company is producing charcoal briquettes from cobs and hulls after extracting furfural. Their briquettes are relatively small and are "cog" shaped. They are packed in an attractive bag and may possess some novelty appeal. There will probably be some consumer discrimination against them because of the absence of "Made from hickory wood" on the label. However, some consumers seem to prefer them and the briquettes are being sold in this State and others in competition with Tennessee briquettes. It is difficult to predict what influence this product will have on Tennessee's future production.

The exact amount of charcoal produced and consumed in Tennessee

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[13]A charcoal kiln is a type furnace that allows the wood to carbonize through incomplete combustion. A retort differs from a kiln in that the furnace or chamber is heated in the absence of oxygen. Thus, it is not necessary for the wood to burn partially to produce charcoal in a retort.

is not known, but there is more produced in the State than is consumed. Charcoal consumption in Tennessee would amount to only about 5,600 tons, assuming per capita consumption to be 3.2 pounds - the 1956 National average. Two of the oldest charcoal producers in the State each produce approximately this amount, and one of the plants produces enough briquettes to supply the entire domestic needs of the State. The only other major charcoaling operation in the State was destroyed by fire during the time this thesis was being prepared. It is now known whether or not the plant will be rebuilt. A new plant is under construction elsewhere in the State and will offset this loss of production. Total charcoal production for Tennessee would be somewhere around 12,000 to 15,000 tons per year. Therefore, it is reasonable to conclude that additional production must go into markets outside the State. However, the Southeast is a deficit producing area along with other states in the South; Georgia and Texas are examples. The Far West and the Northeast also consume more charcoal than is produced in these respective areas. At the present time, producers in the North and South are marketing charcoal in all the States. Any new producer is not going to corner a very large segment of the market. It will be necessary to compete over a wide area. Plants in Tennessee are competing at the present and the next chapter will provide further insights into the competitive situation.

Demand. Several sources indicate that the demand for charcoal during the mid-1950's was strong with respect to the available supply, especially during summer, the peak demand season. The briquette demand for backyard cooking and similar uses, such as in restaurants, is probably

inelastic and has been increasing over the past few years. Since charcoal cost is minor compared to the total cost of a "cook-out" and there is no good substitute for charcoal, a small change in price will have only a slight effect on total sales on an industry-wide basis.[14] However, the demand for charcoal from the industrial sector is probably not so inelastic and has been decreasing. There are other substitutes for charcoal as industrial fuel, and as the other fuel costs come down or as technology permits, the market for charcoal here is reduced.

The combination of increasing domestic demand and reduced production from the distillation plants gives the impression of a rapidly increasing total charcoal demand. While the distillation plants in existence during the mid-1950's have failed to decline further, charcoaling and briquetting facilities have been expanded via kilns and not-too-expensive retorts to change the producing structure of the charcoal industry. Indications are that charcoal demand is continuing to increase but perhaps not at the same rate as for the years 1954-1957. The increase in U. S. imports of charcoal beginning in 1954 is typical of the overall increasing demand for charcoal, especially during 1956-1957, and again in 1959 (Table II). The net imports of charcoal would be enough to sustain two good-sized charcoal and briquetting operations if producers in the United States could capture this segment of the market.

As indicated previously, there are no reliable data on the total amount of charcoal being produced in this country or just what the

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[14]Beazley, op. cit., p. 36.

TABLE II

IMPORTS AND EXPORTS OF CHARCOAL, 1952-1959[a]

Year	Imports (tons)	Exports (tons)	Net imports (tons)
1952	3,290	b	-
1953	3,328	b	-
1954	5,806	b	-
1955	6,521	2,665	3,856
1956	13,522	2,216	11,306
1957	13,082	2,486	10,596
1958	7,013	2,379	4,634
1959	11,338	2,891	8,447

[a]Source: Bureau of the Census, U. S. Department of Commerce, U. S. Imports of Merchandise for Consumption and U. S. Exports of Domestic and Foreign Merchandise, Annual Reports.

[b]Not reported.

capacity is, but we do know that several charcoal producing plants have been built in response to the increasing domestic demand. But even so, the price paid by the consumers for charcoal has remained about the same. Wholesale prices for charcoal have fallen since 1956; however, a New York source has been quoting approximately the same prices over the past three or four years. One of the weekly quotations is listed below.[15]

Charcoal, hardwood, lump, bulk, c.l., f.o.b. plant ton	$ 55.00
Briquettes, bulk, c.l., f.o.b. plant ton	80.00
5-lb. paper bags, c.l. same basis ton	106.00
20-lb. paper bags, c.l., f.o.b. plant ton	90.00
40-lb. paper bags, c.l. same basis ton	86.00

The prices quoted should not be interpreted as the price Tennessee producers could expect to receive for their charcoal if it went to the New York - New England points. There is a considerable difference in transportation charges for charcoal produced and consumed in New York and charcoal produced in Tennessee and consumed in New York. Minimum freight rates from Tennessee to New York are around $20 per ton; therefore, the price of charcoal f.o.b. plant in Tennessee would be lower than in New York. But the quoted prices can be used as an indication of the general price level and the relative stability of industry prices. There is considerable variation in the delivered price in different consuming centers because some centers are located near surplus-producing areas and others are located in deficit-producing areas. However, due to the high-cost facilities that produce over 50 per cent of the charcoal and are reportedly operating near the break-even point, it is difficult to

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[15] Oil, Paint and Drug Reporter, March 6, 1961 (Weekly Publication) Vol. 179, No. 9, 30 Church St., New York, New York.

conceive of any further significant reduction in charcoal prices.

Demand for charcoal can be broken down into three principal classifications; industrial, commercial and domestic. Most of the charcoal can be diverted to domestic use, which retails mostly as briquettes, for seldom less than $135 per ton, but usually around $160 per ton. Most all of the total growth in charcoal sales over the past few years has been due to the increasing domestic market. The chief factor that has given impetus to this trend is the increasing popularity of backyard cooking in small portable grills or in barbecue pits. A rapidly increasing population along with the addition of more people to the middle-income groups will continue to add to domestic charcoal sales. The climate in the South as well as in other parts of the United States permits outdoor cooking during most of the year. But even in a state like Wisconsin the use of charcoal has increased dramatically in the past few years. Due to the rising popularity of outdoor cooking, retail sales increased nearly four times between 1954 and 1957.[16] In 1957 sales were up to 3 pounds per person in Wisconsin; about one-third above the national average. In Texas sales of charcoal jumped from about 2 pounds per person in 1955 to over 3 pounds in 1957.[17] Even at the 1956 domestic consumption level of around 2 pounds per person, today's domestic charcoal

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[16]Warner and Lord, op. cit., p. 1.

[17]Bill R. Shelton and James R. Brodley, The Marketing and Production of Charcoal in Texas, 1955 and 1956, Research Report 58, Texas Engineering Experiment Station, March 1957, p. 2; and Bill R. Shelton, Developments in the Texas Charcoal Industry Since 1956 (Supplement No. 1 to the above), April, 1958, p. 2.

consumption would be up around 180,000 tons. And if domestic consumption increases, as many expect, to three or four pounds per person, then total domestic consumption will be around 270,000-360,000 tons. Of course, many families today use 40 to 50 pounds of charcoal each year while many others never cook out.

Perhaps it might be well to point out that the rapid rise in domestic demand is associated with what might be regarded as a "fad." Usually we think of a fad as something that is here today and gone tomorrow. Outside cooking has been popular for eight to ten years now, and there are no signs of its diminishing. But the most important point to be gleaned from this is that it is too hazardous to predict future demand entirely from the assumption that the fad will increase in popularity. The portable charcoal grill has done wonders for the charcoal-briquette industry. With a plentiful supply of charcoal there can be stock piling, new consumers, new uses and sales expansion of present uses. Greater efforts in promoting, merchandizing and salesmanship of complementary items such as the portable grills and other efforts to encourage middle-class conformity would do much in expanding charcoal consumption. There is considerable room for increased charcoal consumption for domestic purposes.

The commercial classification is composed mainly of restaurants, steak and barbecue houses and railroad dining cars that use charcoal for cooking meats. This market demands charcoal of high quality because uniform heat with a minimum of smoke are a must to assure quality cooking. The importance of this market is felt not so much by its total demand but for the relatively steady demand throughout the year as contrasted

to the domestic demand.

Commercial demand like the domestic demand is also growing. Charcoal broiling and barbecuing are a specialty business and in many cases signify a quality eating establishment. Facilities for this type of cooking are being added to many of the older restaurants as well as to the new ones. This, however, is not just a fad; barbecuing has long been practiced in the South. Charcoaling meats is not new by any means, but it is a growing custom, representing even more of a luxury than cooking out.

The industrial market differs from the other markets because of the various needs of the buyers. Ordering by specification is not at all uncommon, as the charcoal use may vary from that of a highly specialized fuel to that of a catalyst or to that of "fines" for nursery soils. This market usually buys in bulk at a lower price, since bagging costs are lowered or eliminated. This segment of the market seems to offer the poorest opportunity for expansion. In fact, industrial sales have been declining and show little prospect for increasing.

The overall demand picture for charcoal appears to be strong and will no doubt continue to be so if the present conditions are not altered too seriously. Whether the market will continue to improve is not the vital question; rather, it is in terms of just how the market will be supplied. Will most of the future charcoal market be supplied from the large distillation plants, with or without the recovery of chemicals, or will other cellulose materials such as corn cobs come in for a larger share of the market? Will the kiln and retort producers contribute most

to charcoal production by using mill residues, or will the producers be able to use low-quality hardwoods direct from the woods? These questions will be pursued in the following chapters.

Charcoaling as a Means of Utilizing Low-Quality Trees

One thing is certain - charcoal is one of the uses for which low-quality hardwoods and other cull materials are admirably suited. It takes about 2.2 cords of hardwood to make one ton of charcoal. Thus about 573,700 cords of wood were used in charcoal manufacture in 1956.[18] Hardwood - chiefly oak, hickory, birch, beech, and maple - accounted for 92 per cent of the wood consumed. Roundwood use amounted to 74 per cent of the total; the remainder being residues.[19] However, even if charcoal consumption should increase to 500,000 tons, which would be an all-time record, and if wood were the only raw material, only about one million cords of wood would be consumed. Hardwood pulpwood is already being used in excess of six times this rate. But the charcoal industry is an excellent scavenger and possibilities exist to improve the timber industry by producing charcoal. If there is truly an interest in forest improvement, even the smallest opportunity should not be overlooked.

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[18] Charcoal Production in the United States, op. cit., p. 6.

[19] Ibid.

CHAPTER III

THE ECONOMICS OF CHARCOALING

This chapter is devoted to that portion of the problem dealing with the economics of converting wood into charcoal and briquettes. The purpose of this phase of the investigation was to estimate the value of low-quality hardwoods when used in this manner. In those situations where the stumpage has a negative value, a comparison was made between the cost of destroying the timber and the net loss incurred in the charcoaling operation. The loss involved in converting wood into charcoal is a justifiable forest management cost only if it is less than the least cost method of destroying the timber. Included also is the premise set forth in the first chapter that the least cost method of destroying the trees will return a profit. The stumpage value of the low-quality hardwoods was estimated to be the residual of the value of the end product minus all other costs of production and marketing.

Several budgets on charcoal and briquette production are presented, ranging from a single two-and-one-half-cord kiln operation to a battery of kilns or retorts integrated with a briquetting plant. From these budgets and from the budgets estimating the cost of getting wood cut and delivered to the kiln, an estimate of the residual value of the low-quality hardwood stumpage was obtained. The maximum value of the stumpage, or really the amount that can be paid for the stumpage going into each operation, is conditioned by several factors. Two of the important variables are the amount received for the charcoal and the labor cost.

Several stumpage values are estimated from each of the operations by assuming different values for these two variables. Variables that are more of a technical nature, such as the skill of the kiln operators and the moisture content and density of the wood, are assumed to be constant in this study. The ovendry weight of a cord of hardwood was assumed to be 2,670 pounds. This is admittedly low especially when compared with the weight used by Tennessee pulpmills in purchasing hardwood. Although straight, neatly trim bolts are desirable, such bolt characteristics are not critical for charcoaling. An ovendry weight of 2,670 pounds per cord would probably not be too low for the crooked and defective trees of all species that would be burned from a timber-stand-improvement cutting. Charcoal yields were calculated at 30 per cent of the ovendry weight when produced in kilns and 34 per cent when produced in retorts. These are not exceptionally high yield rates and if conversion of seasoned hardwood is much below these rates, it would indicate very inefficient equipment operation. The potential producer must become familiar with these variables and control them to obtain high yields and favorable results.

The budgets were prepared by applying per unit costs to the input-output data gathered from published sources and from equipment manufacturers. The $1.25 per hour wage rate is perhaps more applicable to the larger integrated operations, but by using the same rate in all of the budgets, the per ton cost of production can be compared for the different output volumes and techniques of production.

The first three budgets were prepared for a small two-and-one-half-cord, a seven-cord and a battery of six five-cord kilns. These budgets

have two main parts. The first is an estimation of charcoaling costs or the cost of producing bulk, lump charcoal to be sold f.o.b. kiln. The second part is an estimation of the cost of producing and bagging lump charcoal in four-pound bags also to be sold f.o.b. kiln. The cost of bags increases sharply as the bag size declines. In order to keep the calculations simple, only four-pound bags were used in the budgets.

From these budgets and from the budget in the appendix on the cost of wood procurement, equations were derived to estimate the maximum amount that could be paid for a cord of stumpage. Several estimates were made by using a combination of charcoal prices and wage rates.

About the same procedure as above was used to arrive at the estimated charcoaling cost minus wood cost and returns to capital for the integrated charcoal-briquette operations. This cost was carried over into the budget estimating briquetting costs to give the total integrated cost of producing briquettes. A somewhat different procedure was used to estimate the stumpage value of low-quality hardwoods going into these operations. The retail market price for briquettes was assumed to be 69 cents for 10-pound bags or $138 per ton. Here again, for the purpose of simplicity, only 10-pound bags were used in the calculations. Jobbers' and retailers' profits were assumed to be 20 per cent each. It was further assumed that transportation costs to the wholesaler or jobber would be an average of $12 per ton for a yearly production of 4,000 tons and $10 per ton for an output of 2,500 tons. The above-mentioned mark-up and transportation costs, along with the cost of producing the charcoal, and 15 per cent return on the fixed investment and operating capital were

deducted from the retail sales price of briquettes. The remainder was the amount that could be applied toward the cost of the wood. Wood harvesting and delivery costs were subtracted from the remainder, leaving only that portion of the revenue that could be paid for the stumpage.

Production costs were calculated using both $1 and $1.25 per hour wage rates. Thus there were two estimates of the maximum amount that could be paid for wood. Wood harvesting and delivery costs were also calculated using wage rates of 50 cents, 75 cents, $1, and $1.25 per hour. Each of the wood harvesting and delivery cost estimates were deducted from the amounts that could be paid for wood. This gave eight estimates of the residual value of the stumpage, using the above combination of labor costs.

Actual costs and returns will vary with the managerial ability and ingenuity of the producer as well as with the prevailing cost of inputs in a given area and the price received for the end product. Furthermore, it is not possible to make precise calculations due to the many variables of a charcoaling operation and data for large, efficiently operated kilns are not available. For these reasons, interpretations of the cost estimates and other calculations of this study should be made with caution. However, the budgets should provide helpful guides for planning future charcoaling operations.

I. COST OF DESTROYING HARDWOODS

To be economically feasible, total revenue from any charcoaling operation using cull hardwoods must cover all costs with the exception of that portion of the total cost that can be attributed to forest

management. The maximum limit of total cost over total revenue is set by the minimum cost of destroying the cull hardwood trees. A typical cost estimate of destroying hardwoods is presented in Table III. It is not claimed that this is the least cost method of destroying trees. It is doubtful if the job could be done for less than $6 per acre where there are numerous hardwoods to be killed. Input data compatible with that in Table III can be found in Data for Planning Woodland Opportunities on West Tennessee Farms.[1]

There are costs involved in forest improvement in addition to cull tree removal, such as applying chemicals to the stump to keep down sprouting. The $3.70 per acre cost of axe girdling was used as the maximum portion of the charcoaling cost that could be charged to forest improvement since axe girdling accomplishes essentially the same results as removing the tree. The average number of cords of cull hardwood per acre in hardwood and hardwood-pine forests over the State has been estimated to be 2.77 cords.[2] If converting wood into charcoal is to be economically feasible, a loss of not more than $1.34 per cord on the average could be charged to forest management. This loss would be borne by the owner in the form of harvesting cost, i.e., the value of the wood would not cover the cost of harvesting; however, the loss in this instance

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[1]Solon L. Baraclough and Alfred Pleasanton, Data for Planning Woodland Opportunities on West Tennessee Farms, Bulletin No.276 (University of Tennessee Agricultural Experiment Station in cooperation with Southern Forest Experiment Station, U. S. Department of Agriculture, November, 1957), pp. 14-18.

[2]U. S. Department of Agriculture, Forest Statistics for Tennessee, Forest Survey Release 70 (New Orleans: Southern Forest Experiment Station, June, 1952), pp. 18 and 22.

TABLE III

APPROXIMATE COST OF DEADENING OR CONTROLLING HARDWOODS[a]

Item of cost	Cost per acre
Labor	
Axe girdling (3.7 man-hours @ $1 per hour)	$3.70
Applying chemical (1.2 man-hours @ $1 per hour)	1.20
Chemicals (2.5 gallons, 3 per cent solution of 2, 4, 5-T in fuel oil @ 43 cents per gallon)	1.08
Total	$5.98

[a]Source: Prepared by Ernest B. Hoskins, Tennessee River Pulp and Paper Company, Counce, Tennessee, and Carl B. Dalton, Southern Plywood Conservation Association, Montgomery, Alabama, for use in a future publication for Tennessee Teachers of Vocational Agriculture.

would be less than the cost of girdling the timber.

II. LUMP CHARCOAL PRODUCTION

The Two-and-one-half-cord Kiln

The kiln and technique of production upon which the budget in Table IV was based is similar to those in operation on the Cumberland Plateau. While this kiln is known by several names, it is generally referred to in literature as "The Connecticut Charcoal Kiln."

The budget in Table IV shows charcoaling cost per ton to be $28.75 and cost of producing bagged charcoal to be $46.25, plus any consideration for wood cost and with wages at $1.25 per hour. Witherow and Smith found labor costs to be $24.05 and depreciation on the kiln to be $3.44 per ton of charcoal when produced in an experimental two-cord kiln.[3] Nevertheless, labor inputs for the two-and-one-half-cord kiln may seem a bit high when compared with the other budgets. However, high labor inputs are required for a small, nonmechanized, single unit. A lower range of wage rates is probably justifiable for the smaller operations due to the willingness of rural laborers to accept lower wages and also a large portion of the tasks may be performed by excess family labor, such as youngsters, in bagging, and elders or physically handicapped in tending the kiln. Therefore, a range of wage rates from 50 cents to $1.25 per hour was used to estimate the maximum allowable

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[3]Boyd M. Witherow and Walton R. Smith, Cost of Operation for Three Types of Charcoal Kilns, Southeastern Forest Experiment Station, Paper Number 79, p. 15.

TABLE IV

ESTIMATED COST OF PRODUCING A TON OF CHARCOAL IN A 2 1/2-CORD CINDER-BLOCK KILN (NO MECHANIZATION)

Item	Cost per ton
Bulk sale f.o.b. kiln	
Labor @ $1.25 per hour	
Loading (6 man-hours)	$ 7.50
Burning and cooling (5 man-hours)	6.25
Unloading (7 man-hours)	8.75
Depreciation on kiln ($500 ÷ 100 burns; producing 1 ton of charcoal per burn)	5.00
Miscellaneous supplies (oil, mortar, sand, and re-usable bags)	.50
Returns on investment ($500 x .06 ÷ 40 burns per year)	.75
Charcoaling Cost	$28.75
For sale f.o.b. kiln in 4-pound bags	
Weighing and bagging cost (labor - 6 man-hours)	7.50
Bags (4 pound brown-paper bags @ $.02 each)	10.00
Total Charcoaling and Bagging Cost	$46.25

stumpage cost in order to break even.

Both of the cost figures of Table IV are of interest to a charcoal producer, but for the problem at hand, the maximum allowable stumpage cost estimates in Tables V and VI are more appropriate. Wage rates for the kiln operation and wood procurement were varied and a range of prices received for the charcoal were used to make the estimates.

In order to break even from the sale of charcoal produced in the two-and-one-half-cord kiln, a producer could not have more invested in the stumpage than that shown in Tables V and VI. Of course, some of the stumpage values are negative. The maximum allowable cost of wood on the stump ranges from a low of -$10.16 per cord with wages at $1.25 per hour and bulk charcoal prices of $30 per ton to a high of $6.56 per cord with wages at 50 cents per hour and bulk charcoal prices of $45 per ton (Table V). For charcoal marketed in four pound bags the maximum allowable stumpage costs range from -$13.15 per cord with wages at $1.25 per hour and the price of charcoal at $40 per ton to $7.36 per cord with wages at 50 cents per hour and charcoal priced at $60 per ton (Table VI). Only at the lower wage rates and/or relatively high prices for the product would the production of charcoal provide positive incentive for forest improvement. With wages just under 70 cents per hour and the price of bulk charcoal at $35 per ton f.o.b. kiln, a break even point is attained, but there is no residual revenue for the stumpage. At present, the price being paid for charcoal in this form is from $30 to $35 in Tennessee. Assuming the value of stumpage to be zero, the returns to labor must be around 55 to 70 cents per hour if the charcoal operation

TABLE V

MAXIMUM AMOUNT THAT CAN BE PAID FOR A CORD OF STUMPAGE WITH VARYING WAGES AND PRICES RECEIVED FOR BULK CHARCOAL F.O.B. 2 1/2-CORD KILN

Price received for bulk charcoal f.o.b. 2 1/2-cord kiln	Wage rates			
	$ .50	$ .75	$1.00	$1.25
	Maximum allowable stumpage cost[a]			
$30.00	$0.56	-$2.91	-$6.58	-$10.16
35.00	2.56	-0.91	-4.58	-8.16
40.00	4.56	1.09	-2.58	-6.16
45.00	6.56	3.09	-0.58	-4.16

[a]Equation used: $C = aP - bX - cY - Z$

$C = .4(P) - 7.2(X) - 7.09\ (Y) - 4.29$

C = Maximum allowable stumpage cost

P = Price received for a ton of charcoal

X = Per hour labor cost in charcoaling

Y = Per hour labor cost in wood procurement (See Appendix for estimated wood harvesting cost)

Z = Cost other than labor

TABLE VI

MAXIMUM AMOUNT THAT CAN BE PAID FOR A CORD OF STUMPAGE WITH VARYING WAGES AND PRICES RECEIVED FOR CHARCOAL IN FOUR-POUND BAGS F.O.B. 2 1/2-CORD KILN

Price received for bagged charcoal f.o.b. 2 1/2-cord kiln	Wage rates			
	$ .50	$ .75	$1.00	$1.25
	Maximum allowable stumpage cost[a]			
$40.00	-$0.64	-$4.81	-$8.98	-$13.15
45.00	1.36	-2.81	-6.98	-11.15
50.00	3.36	-0.81	-4.98	-9.15
55.00	5.36	1.19	-2.98	-7.15
60.00	7.36	3.19	-0.98	-5.15

[a]Equation used: $C = .4(P) - 9.6(X) - 7.09(Y) - 8.29$ (See Table V for definitions of variables).

is to be self-sustaining (Table V).

The price being paid for bagged charcoal at the kiln is around $50 per ton, or $40 if the bags are furnished by the purchaser. Returns to labor would be 70 cents per hour at this price if the operation is to break even, assuming the stumpage cost to be zero (Table VI).

If the producer bags and sells the charcoal to retailers, assuming the marketing cost to be $10 per ton and the wholesale value of charcoal to be $70 per ton, and with wages at $1 per hour, harvesting, marketing and conversion costs would still absorb all revenue from the sales and each cord of stumpage would have a negative value of 98 cents. With wages at 75 cents per hour, the allowable stumpage cost would be $3.19 (Not shown in the tables - equation used: $C = .4(P) - 9.6(X) - 7.09(Y) - 12.29$, or just read $10 less for the price of charcoal in Table VI).

The market for lump charcoal, regardless of the marketing channel, is extremely limited to the small producers in Tennessee. Until the demand for lump charcoal is strengthened, charcoal production in the small kiln will be no more than a marginal operation. Chances for an increased demand for lump charcoal are remote. The establishment of additional briquetting plants in the State would increase the demand for charcoal, but the briquettors would offer very little more for lump charcoal than the cost that would be incurred if they attempted to produce their own. The budgets for the one-ton and the two-ton per hour integrated charcoal-briquetting operations show the cost of producing charcoal to be from $17 to $19 per ton plus the cost of wood and returns to capital. Total cost of producing charcoal in such plants would be

around $30-$35 per ton, so one could not expect the price of lump charcoal to increase greatly even with competition among the buyers.

But what about charcoaling in the small kiln as a tool of forest management? With the price of lump charcoal in bulk at $35 per ton and $50 per ton in four-pound bags, the wage rate could be no more than 78 cents per hour if charcoaling is to be economically feasible, i.e., if the loss is to be less than the cost of girdling the timber.

The Seven-cord Kiln

The type of kiln for which the budget in Table VII was prepared is similar to the two-and-one-half-cord kiln previously discussed. It is larger, of course, and would probably be constructed with wide metal doors that would allow a tractor and scoop or fork lift to enter and back out. Instructions for building this sort of kiln (no metal doors) is given in Production of Charcoal in a Masonry Block Kiln: Structure and Operation.[4]

The budget in Table VII shows charcoaling cost per ton to be $25.05 and cost of producing bagged charcoal to be $42.55 per ton without any consideration of wood cost and with wages at $1.25 per hour. The average cost of producing charcoal in a seven-cord kiln for 14 experimental burns was found to be $27.44 by researchers of the Lake States

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[4]U. S. Department of Agriculture, Production of Charcoal in a Masonry Block Kiln: Structure and Operation, Forest Service Report No. 2084 (Madison: Forest Products Laboratory, 1957).

TABLE VII

ESTIMATED COST OF PRODUCING CHARCOAL IN A 7-CORD MASONRY BLOCK KILN

Item	Cost per ton
Bulk sale f.o.b. kiln	
Labor @ $1.25 per hour	
Loading (5.5 man-hours)	$ 6.88
Burning and cooling (4.5 man-hours)	5.63
Unloading (2.0 man-hours)	2.50
Depreciation on kiln ($1,250 ÷ 100 burns; producing 2.8 tons per burn)	4.46
Tractor operating cost (used for approximately .5 of an hour per ton for unloading and 1.9 hours per ton for loading)	
2.4 tractor hours @ $1.10 per hour	2.64
Miscellaneous supplies (oil, mortar, sand, etc.)	0.40
Returns on fixed investment (kiln - $1,250) + (tractor - $2,500) + (other improvements - $1,000); $4,750 x .06 ÷ 112 tons per year	2.54
Charcoaling Cost	$25.05
For sale f.o.b. kiln in 4-pound bags	
Weighing and bagging cost (6.0 man-hours)	7.50
Bags (4-pound brown-paper bags @ $.02 each)	10.00
Total Charcoaling and Bagging Cost	$42.55

Forest Experiment Station.[5] Wages of approximately $1.47 per hour were paid out in the experimental operation. If the difference in wages were eliminated, the experimental cost figure would not be greatly different from the estimated charcoaling cost presented here.

The maximum allowable cost of wood on the stump ranges from a low of -$8.67 per cord with wages at $1.25 per hour and bulk charcoal priced at $30 per ton to a high of $6.24 per cord with wages at 50 cents per hour and bulk charcoal priced at $45 per ton (Table VIII). For charcoal marketed in four-pound bags the maximum allowable stumpage costs range from -$11.67 per cord with wages at $1.25 per hour and the price of charcoal at $40 per ton to $7.04 per cord with wages at 50 cents per hour and charcoal priced at $60 per ton (Table IX).

The maximum allowable stumpage cost estimates for wood converted into charcoal via the seven-cord kiln are very similar to those for the smaller kiln. In fact, about the same general interpretation could be made of the estimates in Tables VIII and IX as was made for the previous operation. However, there is at least one difference: the labor input is of less importance in operating the seven-cord kiln than in the two-and-one-half-cord kiln due to the use of a tractor in loading and unloading. At the higher wage rates, the negative stumpage value is less for wood converted in the larger kiln. The small kiln appears to have the advantage at the lower wage rates. The difference between the maximum allowable stumpage cost on the lower wage scale for the two kilns is

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[5] C. E. Boldt and Carl Abbogast, Jr., "Charcoal Kiln Operation for Improved Timber Stands," Forest Products Journal, January, 1960, p. 44.

TABLE VIII

MAXIMUM AMOUNT THAT CAN BE PAID FOR A CORD OF STUMPAGE WITH VARYING WAGES AND PRICES RECEIVED FOR BULK CHARCOAL F.O.B. 7-CORD KILN

Price received for bulk charcoal f.o.b. 7-cord kiln	Wage rates			
	$ .50	$ .75	$1.00	$1.25
	Maximum allowable stumpage cost[a]			
$30.00	$0.24	-$2.73	-$5.70	-$8.67
35.00	2.24	-0.73	-3.70	-6.67
40.00	4.24	1.27	-1.70	-4.67
45.00	6.24	3.27	-0.30	-2.67

[a]Equation used: C = .4(P) - 4.8(X) - 7.09(Y) - 5.81 (See Table V for definition of the variables).

TABLE IX

MAXIMUM AMOUNT THAT CAN BE PAID FOR A CORD OF STUMPAGE WITH VARYING WAGES AND PRICES RECEIVED FOR CHARCOAL IN FOUR-POUND BAGS F.O.B. 7-CORD KILN

Price received for bagged charcoal f.o.b. 7-cord kiln	Wage rates			
	$ .50	$ .75	$1.00	$1.25
	Maximum allowable stumpage cost[a]			
$40.00	-$0.96	-$4.53	-$8.10	-$11.67
45.00	1.04	-2.53	-6.10	-9.67
50.00	3.04	-0.53	-4.10	-7.67
55.00	5.04	1.47	-2.10	-5.67
60.00	7.04	3.47	-0.10	-3.67

[a]Equation used: C = .4(P) - 7.2(X) - 7.09(Y) - 9.81 (See Table V for definition of the variables.

small compared to that of the upper wage scale.

If charcoaling in the seven-cord kiln is to provide an alternative to destroying the cull trees, the wage rate in operating the kiln and in wood procurement cannot exceed 63 cents per hour with bulk charcoal priced at $30 per ton. The stumpage still has a negative value of 73 cents per cord if the bulk price is $35 per ton and wages are 75 cents per hour. With wage rates around 75 cents per hour, a price of $50 per ton for charcoal in bags is comparable to $35 for bulk charcoal.

The Battery of Six Five-cord Kilns

Over the country, perhaps no two kiln installations have the same number of kilns or kilns with like capacities. The kiln sizes range from two-cord capacity up to 40 cords. There is a tendency to increase the size of the kiln instead of the number for the larger charcoal outputs. About the only other difference in kiln installations is the amount of labor-saving equipment for which provision is made.

The budget in this section represents cost estimates for charcoal produced in a battery of six five-cord kilns. Individually, the kilns are similar to those previously budgeted. Capital requirements for the kilns, storage shed, tractor and other improvements would be about $12,000 to produce bulk charcoal. If the charcoal is to be bagged, an additional $6,000 would be needed.

The battery of six five-cord kilns is not to be interpreted as the optimum combination of number and size of kiln for the most efficient production, but the budget does indicate that economies of scale are

present in producing charcoal.

Assuming it takes an average of six days to complete one full cycle (loading, coaling, cooling and unloading), one kiln would need to be unloaded and recharged each day of a six-day work week. Thus, one five-cord kiln would yield approximately two tons of charcoal per week. To yield 500 tons of charcoal per year, the battery of kilns would need to be operated for around 290 days, allowing for Sundays or a more lengthy cycle.

The cost of labor to produce a ton of bulk charcoal at $1.25 per hour was estimated to be $10.64. Bagging labor cost amounted to $3.44, for a total estimated labor cost of $14.08 per ton of bagged charcoal produced. This cost was separated from the main budget, and is shown in Table X.

Charcoaling costs were estimated to be $22.33 per ton and the cost of producing bagged charcoal to be $39.01. Both estimates are considerably below those of the preceding budgets.[6] The total yearly cost of producing 500 tons of bulk charcoal in this battery of kilns was estimated to be $11,165, and of bagged charcoal to be $19,505 (Table XI).

The per ton cost of producing charcoal in the battery of kilns

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[6]If the cost of wood is eliminated from Shelton's estimated cost of producing bagged charcoal, the upper cost range would be around $28 per ton, excluding taxes and insurance. It was necessary to assume a rate of conversion of wood into charcoal to arrive at this figure. The assumed rate was two and one-half cords of wood per ton of charcoal - the same rate that was used in all the kiln budgets in this thesis. In addition to the above noted exclusion from Shelton's cost estimate, cost of tending the kiln, a major item, and repair and maintenance are also omitted. Perhaps this explains some of the $11 differential between Shelton's estimate and the one used here. Shelton, op. cit., p. 5.

TABLE X

ESTIMATED LABOR COST IN OPERATING A BATTERY OF 6 5-CORD KILNS PRODUCING TWO TONS OF CHARCOAL PER DAY, LABOR @ $1.25 PER HOUR

Operation	Labor cost per ton
Tractor operation (used to bring wood inside the kiln from the stacks and to unload the charcoal; 4 man-hours per day)	$ 2.50
Arranging wood in the kiln (5 man-hours per day)	3.13
Unloading (3 man-hours per day of extra labor to aid the tractor-scoop operator in unloading)	1.88
Kiln operation (5 man-hours)	3.13
Charcoaling Labor Cost	$10.64
Bagging (5.5 man-hours per day)	3.44
Total Labor Cost[a]	$14.08

[a]Allowance is not made here for additional or miscellaneous labor cost as in the budgets for larger installations because this operation does not include Sundays, and by adjusting the working hours of the three laborers, the kiln may be tended for 12-15 hours each day. The air inlets may be adjusted to minimize tending needs during the remainder of the day.

TABLE XI

ESTIMATED PER TON AND YEARLY COST OF PRODUCING 500 TONS OF CHARCOAL IN A BATTERY OF 6 5-CORD CINDER-BLOCK KILNS

Item	Cost Per ton	Cost Yearly
Bulk sale f.o.b. kiln		
Labor @ $1.25 per hour	$10.64	$ 5,320
Depreciation on the kilns: Assume the kilns to cost $1,000 each with a minimum life of 100 burns; thus each of the 6 kilns would be used for about 42 burns each year in producing 500 tons of charcoal, lasting 2.4 years. ($1,000 ÷ 2.4 years = $416.67 per year; 42 burns x 2 tons per burn = 84 tons per kiln per year.) $416.67 ÷ 84	4.96	2,480
Tractor operating cost (used for approximately 4 hours per day @ $1.10 per hour - including fixed and variable costs) $4.40 ÷ 2 tons	2.20	1,100
Repair and maintenance on kiln and other equipment ($100 per year ÷ 500 tons per year)	.20	100
Taxes and insurance (2.0 % of fixed investment	.48	240
Miscellaneous	.25	125
Returns on fixed investment (kilns - $6,000) + (tractor and equipment - $3,000) + (shed and land improvements - $3,000) = $12,000. $12,000 x .15 ÷ 500 tons	3.60	1,800
Charcoaling Cost	$22.33	$11,165
For sale f.o.b. kiln in 4-pound bags		
Depreciation on other processing and bagging equipment (cost $6,000, lasting 10 years = $600 per year or $600 ÷ 500 tons)	1.20	600
Returns on fixed investment ($6,000 x .15 ÷ 500 tons) -	1.80	900
Insurance and taxes (2.0 per cent of fixed investment -	.24	120
Bagging labor cost	3.44	1,720
Bags (4-pound brown-paper bags @ $.02 each)	10.00	5,000
Total Charcoaling and Bagging Cost	$39.01	$19,505

would appear to be much less costly than charcoal produced in the single units. The cost spread between the budgets of Tables IV, VII, and XI is probably representative of the difference in costs between the multiple and single unit installations with wages at $1.25 per hour. However, at medium to low wage rates, the cost advantage of the battery of kilns is not so apparent, because the battery operation is more efficient in the use of labor.

The estimated amount of labor required to produce one ton of charcoal is less for the battery of kilns than for the seven-cord-kiln and considerably less than for the two-and-one-half-cord kiln. Therefore, as the wage rate declines, cost of production declines more rapidly when charcoal is produced in the single than when produced in the multiple units. At the relatively low wage of 50 cents per hour, there would be little difference in the maximum allowable stumpage cost per cord of wood to be converted into charcoal via the two-and-one-half-cord, the seven-cord, and the battery of six five-cord kilns. Assuming the price of bulk charcoal to be $30 per ton and wages at 50 cents per hour, the stumpage values were estimated to be 56 cents for the two-and-one-half-cord kiln, 24 cents for the seven-cord kiln, and 28 cents per cord for the multiple kiln operation (Tables V, VIII, and XII). However, for wages of around 60 cents per hour and above, the battery of kilns would have the advantage.

For the battery of kilns, the maximum allowable cost of wood on the stump ranges from a low of -$7.58 per cord with wages at $1.25 per hour and bulk charcoal priced at $30 per ton to a high of $6.28 per cord

with wages at 50 cents per hour and bulk charcoal priced at $45 per ton (Table XII). If the charcoal is to be marketed in four-pound bags, the maximum allowable stumpage costs range from a low of -$10.26 per cord with wages at $1.25 per hour and the price of charcoal at $40 per ton to a high of $8.43 per cord with wages at 50 cents per hour and charcoal priced at $60 per ton (Table XIII). An additional 86 cents to $1.15 could be applied toward stumpage costs, depending upon the method of marketing the charcoal, if the multiple unit producers were willing to accept six per cent returns to capital instead of the indicated 15 per cent.

Prices of $35 per ton for bulk charcoal and $50 per ton for bagged charcoal would allow a producer operating the battery of kilns to pay around 70 cents per hour for labor and still break even. In breaking even the operation would be returning 15 per cent on the fixed investment, but the stumpage value would be zero.

At the above charcoal prices and with wages of about 83 cents per hour, the stumpage would have a negative value of approximately $1.34 per cord. This is assumed to be the maximum cost that could be attributed to forest improvement. Thus, if wages exceed this level or if other costs are higher than those assumed here, then it would most likely be cheaper for the forest land owner to girdle the timber rather than harvest for stand improvement.

III. BRIQUETTE PRODUCTION

Perhaps at one time in the not-too-distant past, the charcoal industry offered an opportunity to earn relatively high profits with a

TABLE XII

MAXIMUM AMOUNT THAT CAN BE PAID FOR A CORD OF STUMPAGE WITH VARYING WAGES AND PRICES RECEIVED FOR BULK CHARCOAL F.O.B. BATTERY OF KILNS[a]

Price received for bulk charcoal f.o.b. battery of kilns	Wage rates			
	$ .50	$ .75	$1.00	$1.25
	Maximum allowable stumpage cost[b]			
$30.00	$0.28	-$2.34	-$4.96	-$7.58
35.00	2.28	-0.34	-2.96	-5.58
40.00	4.28	1.66	-0.96	-3.58
45.00	6.28	3.66	1.04	-1.58

[a]An additional $0.86 per cord could be paid for the stumpage if the producers were willing to accept 6 per cent returns on their investment instead of 15 per cent.

[b]Equation used: $C = .4(P) - 3.4(X) - 7.09(Y) - 6.47$ (See Table V for definition of variables).

TABLE XIII

MAXIMUM AMOUNT THAT CAN BE PAID FOR A CORD OF STUMPAGE WITH VARYING WAGES AND PRICES RECEIVED FOR CHARCOAL IN FOUR-POUND BAGS F.O.B. BATTERY OF KILNS[a]

Price received for bagged charcoal f.o.b. battery of kilns	Wage rates			
	$ .50	$ .75	$1.00	$1.25
	Maximum allowable stumpage cost[b]			
$40.00	-$1.57	-$4.46	-$7.36	-$10.26
45.00	0.43	-2.46	-5.36	-8.26
50.00	2.43	-0.46	-3.36	-6.26
55.00	4.43	1.54	-1.36	-4.26
60.00	6.43	3.54	0.64	-2.26
65.00	8.43	5.54	2.64	-0.26

[a]An additional $1.15 per cord could be paid for the stumpage if the producers were willing to accept 6 per cent returns on their investment instead of 15 per cent.

[b]Equation used: $C = .4(P) - 4.5(X) - 7.09(Y) - 11.77$ (See Table V for definition of variables).

small investment by converting low-quality wood into lump charcoal. Today, however, the demand for briquettes has largely replaced the demand for lump charcoal as a source of fuel. An additional $75,000 to $100,000 investment is the minimum requirement to give the consumer this extra service. The total investment for an integrated plant may run up to $250,000.

Three integrated charcoal-briquette plants were budgeted in this section. The first was a briquetting plant with a capacity of one ton per hour and the second had a capacity of two tons per hour. Both of these plants had a supporting number of nine-cord kilns. Total yearly production was assumed to be 2,500 and 4,000 tons respectively for the two plants. The third plant had a capacity of two tons per hour, supported by six retorts.

All of the budgets were designed to estimate the maximum amount that could be paid for stumpage. The cost of labor was assumed to be $1.25 in budgeting these operations, but $1 per hour was also used in estimating the maximum allowable stumpage cost. Wood harvesting wage rates were allowed to range from 50 cents to $1.25 per hour in combination with the two wage rates of the charcoal-briquette plants to make the stumpage estimates.

The output for the briquetting plants does not approach the maximum. During the peak demand season the plants may double their daily output, but during the winter months, especially, the industry can send few briquettes to market. Due to the storage problem, most of the briquettors cease production during the lowest demand period. Each of the budgets were prepared on a one-shift basis only. The plants would

operate from 250 to 300 days per year. The budgets were put together in sections so that, if it were desirable, the cost of producing charcoal or the cost of briquetting could be easily determined.

Integrated Charcoal-briquette Plant with an Output of 2,500 Tons per Year

To furnish 2,500 tons of charcoal per year, a battery of 18 kilns of nine-cord capacity would be needed. Assuming it takes approximately seven and one-half days to complete one full cycle, an average of 2.4 kilns would be unloaded and recharged each day. At the conversion rate of 800 pounds of charcoal per cord of wood, the kilns would yield 17,280 pounds or 8.64 tons of charcoal each day. The kilns would need to be operated for approximately 290 days on a continuous basis.

An estimation of labor cost for the battery of kilns is presented in Table XIV. Ten per cent was added to the cost of producing each ton of charcoal because of the anticipated increased cost of labor for week-end work. Total labor cost per ton of charcoal was estimated to be $10.19. Van Geuns assumed that a labor cost of $15 per ton for charcoal produced in a 30 kiln battery "would likely not be too low."[7] To justify this cost, reference was made to three sources. However, none of the operations for which cost data was given by the sources would compare with the size of operation under discussion.[8] The labor cost in Table XIV

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[7]Robert E. Van Geuns, Charcoal Briquettes: A Manufacturing Opportunity in Georgia (Georgia Institute of Technology Engineering Experiment Station Industrial Development Branch, Prepared for the Georgia Department of Commerce, August, 1958), pp. 11-12.

[8]Furthermore, it would be difficult to obtain a $15 labor cost figure from the budget in Charcoal Survey (one of the references) with

TABLE XIV

ESTIMATED LABOR COST IN OPERATING THE BATTERY OF 18 KILNS WITH AN AVERAGE DAILY OUTPUT OF 8.64 TONS AND WAGE RATES AT $1.25 PER HOUR

Item	Cost per ton
Tending the wood yard (8 man-hours per day)	$ 1.16
Tractor, forklift and truck operator (8 man-hours per day)	1.16
Arranging wood inside the kilns (20 man-hours per day)	2.89
Unloading (12 man-hours per day in addition to the tractor-scoop operator)	1.74
Kiln operation (16 man-hours per day)	2.31
Charcoaling Labor Cost	$ 9.26
Miscellaneous labor costs (10 per cent of above)	.93
Total Cost	$10.19

should not be too low for a large, efficiently run battery of kilns.

The $10.19 labor cost was included in the chunk charcoal budget in Table XV along with other charcoaling costs to give a total cost of $19.37 to produce a ton of charcoal, and the yearly cost of producing 2,500 tons of charcoal would be $48,425. Cost of wood delivered to the kilns and returns to capital are not included.

The cost of producing charcoal was carried over into the briquetting portion of the budget. Although all known items of cost were included in the budget, ten per cent was added to cover any contingencies and to keep the estimate conservative. Total integrated cost minus the cost of wood and returns to capital amounted to $52.02 per ton or a yearly outlay of $130,050 (Table XVI).

After reducing the $138 per ton retail price for ten-pound bags of briquettes by the expected mark-up of jobbers and retailers and further by $10 per ton to cover transportation charges, the remainder was $85.83 (Table XVII). This can be considered the price manufacturers could expect to receive for their briquettes f.o.b. plant. Thirty-three dollars and 81 cents remain after subtracting the cost of producing briquettes. Fifteen per cent return on investment and operating capital

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wood hauling and bagging labor eliminated. Labor cost of about $11.50 would be more nearly correct. Labor cost would be no more than $13.33 including bagging labor in the battery of seven nine-cord kilns described by Simmons. If bagging labor cost were taken from this and the same wood to charcoal conversion rate applied as was used in this thesis, labor cost would be around $8. See the Charcoal Survey, op. cit., p. 87, and Fred C. Simmons, Guides to Manufacturing and Marketing Charcoal in the Northeastern States, Forest Service, United States Department of Agriculture, Northeastern Forest Experiment Station, Station Paper No. 95, 1957, p. 15.

TABLE XV

ESTIMATED PER TON AND YEARLY COST OF PRODUCING CHARCOAL IN AN INTEGRATED CHUNK CHARCOAL BRIQUETTE OPERATION

Producing 2,500 tons per year - 1-ton per hour briquetting capacity

Item	Cost Per ton	Cost Yearly
Labor	$10.19	$25,475
Amortization of kilns. Assume the kilns cost $1400 each with a minimum life of 100 burns; thus each of the 18 kilns would be used for 39 burns each year in producing 2,500 tons of charcoal, lasting 2.6 years. ($1,400 ÷ 2.6 years = 538.46 per year. 39 burns x 3.6 tons per burn = 140.4 tons per kiln per year.) 538.46 ÷ 140.4	3.84	9,600
Amortization of 1 truck, 1 forklift, 1 small tractor and scoop, buildings, land improvements, etc., over a 10-year period (18,000 ÷ 10 years = $1,800) $1,800 ÷ 2,500 tons per year	.72	1,800
Repair and maintenance on kilns, equipment and miscellaneous costs (oil, etc.)	.60	1,500
Operating (variable expense) for: tractor, truck, and forklift	1.82	4,550
Property taxes and insurance (2 per cent of fixed investment)	.35	875
Supervision @ $2.00 per hour	1.85	4,625
Total Cost (does not include wood cost and returns to capital)	$19.37	$48,425

TABLE XVI

ESTIMATED PER TON AND YEARLY COST OF PRODUCING BRIQUETTES IN THE 1-TON PER HOUR BRIQUETTING PLANT

Item	Cost	
	Per ton	Yearly
Chunk charcoal cost (does not include wood cost and returns to capital)	$19.37	$48,425
Starch	1.00	2,500
Paper bags (white with attractive lettering, 10-pound size @ $.03 each)	6.00	15,000
Amortization of briquetting plant and equipment ($110,000 over 10 years = $11,000 per year) $11,000 ÷ 2,500 tons per year	4.40	11,000
Wages and salaries		
5 men @ $1.25 per hour	6.25	15,625
1 foreman @ $2.00 per hour	1.85	4,625
1 administrative employee	1.44	3,600
1 manager-salesman-technician	3.60	9,000
Utilities	1.00	2,500
Repair and maintenance	1.20	3,000
Operating supplies	.30	750
Taxes and insurance (2 per cent of fixed investment)	.88	2,200
Subtotal	$47.29	$118,225
Miscellaneous costs (10 per cent of above)	4.73	11,825
Total Integrated Cost (does not include wood cost and returns to capital)	$52.02	$130,050

TABLE XVII

RETURNS TO THE WOOD FROM THE 18 KILN, 2,500 TON PER YEAR INTEGRATED BRIQUETTING OPERATION

Item	Per ton	Yearly
Remainder after deduction retailer's and jobber's mark-up[a]	$95.83	$239,575
Transportation costs, assuming producer to wholesaler average transportation costs would be	10.00	25,000
Remainder	$85.83	$214,575
Cost of production	52.02	130,050
Remainder	$33.81	$ 84,525
Returns to fixed investment (kilns = $25,200 + charcoaling buildings and equipment = $18,000 + briquetting plant = $110,000 = $153,000) $153,000 x .15 ÷ 2,500 tons	9.18	22,950
Remainder	$24.63	$ 61,575
Returns on operating capital $35,000 x .15 ÷ 2,500 tons	2.10	5,250
Remainder	$22.53	$ 56,325

[a]See the budget for the two-ton per hour briquetting operation on page 68, Table XXII.

further reduced the revenue to a residual of $22.53. It was assumed that income and other taxes would come from the 15 per cent. Then, $22.53 would be the maximum amount that could be paid for wood to produce one ton of briquettes.

Assuming it takes two and one-half cords of seasoned round hardwood to yield one ton of charcoal, the amount that could be paid for a cord of wood would be limited to $9.01. With wages at $1 per hour, instead of $1.25, the residual would be $26.15 per ton, and the amount that could be paid for a cord of wood would increase to $10.46 per cord.

The maximum amounts that could be paid for a cord of wood on the stump with plant wages varying from $1 to $1.25 per hour in combination with wood harvesting wages ranging from 50 cents to $1.25 per hour have been calculated (Table XVIII). With wood harvesting labor cost at 50 cents per hour and plant labor cost at $1 per hour, $3.26 could be paid for a cord of wood on the stump. An increase up to 75 cents per hour for wood harvesting labor would bring the residual left for stumpage down to $1.49 per cord. Even a low stumpage return of $1.49 per cord would provide incentive to remove heretofore unmerchantable timber.

Briquette production would still be economically feasible with plant labor at $1 and wood harvesting labor at $1 per hour. The negative stumpage value of -28 cents per cord would be less than the previously indicated maximum of $1.34 per cord that could economically be invested from the standpoint of forest management viz. - viz. girdling the timber. It would be difficult to justify wage rates higher than $1 per hour for wood harvesting or plant labor.

TABLE XVIII

MAXIMUM ALLOWABLE STUMPAGE COSTS PER CORD OF WOOD CHANNELED INTO A 2,500 TON PER YEAR INTEGRATED BRIQUETTING PLANT WITH VARIABLE WAGE RATES

Maximum amount left to pay for a cord of wood with plant wages of $1.00 and $1.25 per hour		If wood harvesting wage rates are:			
		$ .50	$ .75	$1.00	$1.25
		then cost of harvesting a cord of wood will be:			
		$7.20	$8.97	$10.74	$12.52
		and the maximum allowable stumpage cost would be:			
$1.00	$10.46	$3.26	$1.49	-$0.28	-$2.06
$1.25	$ 9.01	$1.81	-$0.04	-$1.73	-$3.51

Integrated Charcoal-briquette Plant with an Output of 4,000 Tons per Year

To supply 4,000 tons of charcoal per year, a battery of 30 kilns of nine-cord capacity would be needed. An average of four kilns would be unloaded and recharged each day, assuming it takes approximately 7.5 days to complete one full cycle. The kilns would yield around 14.4 tons of charcoal each day. To yield 4,000 tons of charcoal per year, the battery of kilns would need to be operated continuously for approximately 280 days. Cost of labor per ton of charcoal has been estimated to be $9.15 when produced in the battery of 30 nine-cord kilns (Table XIX).

Total cost of producing charcoal exclusive of wood cost and returns to capital was estimated to be $17.23 or a yearly outlay of $68,920 (Table XX). The lower per ton cost of producing charcoal in the 30 kiln over the 18 kiln battery was due primarily to more efficient use of labor and lower cost of supervision.

The total estimated cost of producing a ton of briquettes was $44.99 or a yearly outlay of $179,960 in producing 4,000 tons as shown in Table XXI. Briquettes are less costly to produce in the larger plant primarily because wage and salary costs are 17 per cent less per ton in the larger operation.

Assuming the retail price of briquettes in 10-pound bags to be 69 cents and with jobber and retailer mark-up at 20 per cent, it was estimated that the briquettor would receive $95.83 per ton or $383,320 yearly for delivered briquettes. It was further assumed that transportation costs would average $12 per ton - $2 higher than for the 2,500 ton operation since the latter need not reach out into the more distant

TABLE XIX

ESTIMATED LABOR COST OF OPERATING THE BATTERY OF 30 KILNS WITH AN AVERAGE DAILY OUTPUT OF 14.4 TONS AND WAGE RATES AT $1.25 PER HOUR

Item	Cost per ton
Tending the woodyard (8 man-hours per day) - - - - - - - -	$ .69
Fork lift operator (8 man-hours per day) - - - - - - - - -	.69
Arranging wood inside the kiln (32 man-hours per day) - -	2.78
Tractor and truck operation (8 man-hours per day) - - - -	.69
Unloading (16 man-hours per day in addition to the tractor scoop and truck operation) - - - - - - - - - - -	1.39
Kiln operation (24 man-hours per day) - - - - - - - - - - -	2.08
Charcoaling Labor Cost - - - - - - - - - - - - -	$8.32
Miscellaneous labor cost (10 per cent of above) - - - - -	.83
Total Cost -	$9.15

TABLE XX

ESTIMATED PER TON AND YEARLY COST OF PRODUCING CHARCOAL IN AN INTEGRATED CHUNK CHARCOAL BRIQUETTE OPERATION

Producing 4,000 tons per year - 2 tons per hour briquetting capacity

Item	Cost Per ton	Cost Yearly
Labor	$ 9.15	$36,600
Amortization of kilns Assume the kilns to cost $1,400 each with a minimum life of 100 burns; thus each of the 30 kilns would be used for 39 burns each year in producing 4,000 tons of charcoal, lasting 2.6 years. ($1,400 ÷ 2.6 years = $538.46 per year; 39 burns x 3.6 tons per burn = 140.4 tons per kiln per year). $538.46 ÷ 140.4	3.84	15,360
Amortization of 1 truck, 1 forklift, 1 small tractor and scoop, buildings, land improvements, etc., over a 10-year period. ($20,000 ÷ 10 years = $2,000) $2,000 ÷ 4,000 tons	.50	2,000
Repair and maintenance on kilns, equipment and miscellaneous costs (oil, etc.)	.50	2,000
Operating (variable expenses) for: tractor, forklift, and truck	1.82	7,280
Property taxes and insurance (2% of the fixed investment)	.31	1,240
Supervision @ $2 per hour	1.11	4,440
Total Cost (does not include wood cost and returns to capital)	$17.23	$68,920

TABLE XXI

ESTIMATED PER TON AND YEARLY COST OF PRODUCING BRIQUETTES IN THE 2-TON PER HOUR BRIQUETTING PLANT

Item	Cost Per ton	Cost Yearly
Chunk charcoal cost (minus wood cost and returns to capital)	$17.23	$ 68,920
Starch	1.00	4,000
Paper bags (white with attractive lettering, 10-pound size @ $.03 each)	6.00	24,000
Amortization of briquetting plant and equipment ($130,000 over 10 years = $13,000 per year) $13,000 ÷ 4,000 tons	3.25	13,000
Wages and salaries		
7 men @ $1.25 per hour	4.38	17,520
1 foreman @ $2 per hour	1.11	4,440
1 administrative employee	.90	3,600
1 manager-engineer	2.25	9,000
1 salesman	2.00	8,000
Utilities	.88	3,520
Repair and maintenance	1.00	4,000
Operating supplies	.25	1,000
Property tax and insurance (2% of fixed investment)	.65	2,600
Subtotal	$40.90	$163,600
Miscellaneous costs (10% above)	4.09	16,360
Total Integrated Cost (does not include wood cost and capital returns)	$44.99	$179,960

markets. After subtracting transportation costs, the residual as indicated in Table XXII was $83.83 per ton. There was $29.76 per ton remaining to pay for wood after subtracting cost of production and returns on investment and operating capital. This gave a figure of $11.90 per cord that could be paid for wood. With wages at $1 per hour instead of $1.25, $13.09 could be paid for a cord of wood.

The maximum amounts that could be paid for a cord of wood on the stump is shown in Table XXIII. Plant labor cost and wood harvesting labor cost were varied as indicated in the table in order to make the estimates. With plant wages at $1.25 per hour and wood harvesting wages at $1, about $1.16 would remain to pay for each cord of wood on the stump. At lower wage rates, the forest owner would have an even greater incentive to remove the low-quality timber. Even if both plant and wood harvesting labor were to cost $1.25 per hour, briquette production would still be economically feasible. The forest owner could afford to invest 62 cents per cord in forest improvement where low-quality hardwoods are a menace.

Another way to approach the problem of determining the value of the wood going into a charcoal-briquette operation is to use an appropriate f.o.b. price and subtract harvesting and processing costs. Eighty-five dollars per ton f.o.b. for briquettes in 10-pound bags is a reasonable price and is quite low compared to prices in some areas. However, allowance must be made for transportation costs. But at $85 per ton f.o.b. plant, there is room for 20 per cent mark-up by the wholesalers and 25 per cent mark-up by the retailers if charcoal is retailed at $140 per ton (70 cents for 10-pound bags - most chain grocery stores in Knoxville get slightly more), and there still remains $12.50 for transportation.

TABLE XXII

RETURNS TO THE WOOD FROM THE 30-KILN, 4,000 TON PER YEAR INTEGRATED BRIQUETTING OPERATION

Item	Per ton	Yearly
Retail sales @ $.69 for 10-pound bags	$138.00	$552,000
Retailer's mark-up (20%)	23.00	92,000
Remainder	$115.00	$460,000
Jobber's mark-up (20%)	19.17	76,680
Remainder	$ 95.83	$383,320
Transportation costs, assuming producer to wholesaler average transportation cost would be	12.00	48,000
Remainder	$ 83.83	$335,320
Cost of production	44.99	179,960
Remainder	$ 38.84	$155,360
Returns to fixed investment (kilns = $42,000 + charcoaling buildings and equipment = $20,000 + briquetting plant = $130,000 = $192,000) $192,000 x .15 ÷ 4,000 tons	7.20	28,800
Remainder	$ 31.64	$126,560
Returns to operating capital (say $50,000) x .15 ÷ 4,000 tons	1.88	7,520
Remainder	$ 29.76	$119,040

TABLE XXIII

MAXIMUM ALLOWABLE STUMPAGE COST PER CORD OF WOOD CHANNELED INTO A 4,000 TON PER YEAR INTEGRATED BRIQUETTING PLANT WITH VARIABLE WAGE RATES

Maximum amount left to pay for a cord of wood with plant wages of $1.00 and $1.25 per hour		If wood harvesting wage rates are:			
		$ .50	$ .75	$1.00	$1.25
		then cost of harvesting a cord of wood will be:			
		$7.20	$8.97	$10.74	$12.52
		and the maximum allowable stumpage cost would be:			
$1.00	$13.09	$5.89	$4.12	$2.35	$0.57
$1.25	$11.90	$4.70	$2.93	$1.16	-$0.62

To the briquette production cost of $54.07 (including 15 per cent returns to capital), one must add the wood harvesting and transporting cost before an estimate can be made as to the amount that could be paid for wood. With harvesting and transporting cost amounting to $10.74 per cord (wood harvesting wages at $1 per hour), the stumpage value of the wood would be $1.63 per cord. See the Appendix for cost of wood harvesting and transportation.

Four Thousand Ton per Year Briquetting Plant
Integrated with Six Charcoal Retorts

New types of retorts have been developed that are reportedly more efficient in converting wood into charcoal than previous methods of manufacture in relatively small units.[9] Apparently, the outside source of fuel used to bring the heat up to the optimum coaling temperature and maintaining it is a major factor contributing to the increased efficiency. It is not necessary to burn a portion of the carbon as in the kiln to coal the wood. Reported yields of 35 to 38 per cent of the oven-dry weight from seasoned hardwoods are not uncommon.[10] An increase in the conversion rate of four per cent means an additional 107 pound yield of charcoal from each cord of wood, or an increase in revenue of $1.60 per cord of wood coaled when the price of charcoal is $30 per ton f.o.b.

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[9]Fred C. Simmons, "Three New Charcoal Retorts," Forestry Equipment Notes, Food and Agriculture Organization of the United Nations, Rome, Italy, October, 1960.

[10]W. M. Pritchard, "A Simplified Charcoal Retort," Forest Products Journal, December, 1960, p. 641.

kiln.

The number of man-hours required to produce a ton of charcoal in retorts is very low in comparison to the kiln operations. In retorts, only about four man-hours are required to produce a ton of charcoal.[11] However, in order to approach this low labor requirement, the charcoaling operation must be mechanized. Amortization costs and the added cost of fuel boosts the cost of producing a ton of charcoal in retorts almost to a level equal to the production cost in a battery of kilns. Therefore, it would probably be difficult to justify the higher capital investment of the retorts solely on the basis of the small reduction in charcoaling cost. But for large, continuous operations the increased efficiency of wood conversion would give the retorts the advantage.

Charcoal retorts are sold and leased in the United States by both domestic and foreign manufacturers. If purchased from commercial manufacturers, even the small, simple retorts are quite expensive. Several sources indicate that the retort cost can be lowered considerably if a producer has ingenuity and is mechanically minded enough to develop his own retort.[12]

There are a number of basic differences in the production processes of these retorts. One type features a continuous process whereby wood is introduced through the top and charcoal is eliminated at the bottom. The

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[11]Simmons, loc. cit.

[12]Henry E. Steitz, "Ingenuity and Hard Work Go Into Rapidly Expanding Charcoal Business," Texas Forest News, April-May-June, 1959, Volume 38, p. 3; and Robert S. Aries, "Charcoal Manufacture in Small Continuous Retorts," Southern Lumberman, January, 1956, p. 39.

weight of the wood breaks the charcoal into pieces, forcing it out through discharge orifices into quenching drums. The hot drums must be stored for several hours before further processing. Some of the gases given off from the wood pass into a carburetor where they are mixed with a limited amount of air and burned. Sufficient heat is generated from the gases to carbonize the wood without an outside source of fuel.[13]

Another type of commercial retort recently put on the market operates on a batch basis. Because the retort does not operate continuously, an outside source of fuel is needed to bring the retort up to the optimum temperature and maintain it. The carburetor is designed with automatic controls to cut in gases from the wood upon their release. Quenching drums are also used with these retorts.

The retort upon which the budget in Table XXIV was based was similar to the above batch operation. However, the retorts were to be cycled only once about every 24 hours, eliminating the need for quenching drums and the extra labor involved. Preheating and coaling time would be around 6 to 8 hours, leaving 16 to 18 hours for the charcoal to cool.

Six retorts producing 2.5 tons of charcoal each day would need to be operated for approximately 267 days to produce 4,000 tons of charcoal. The wood would be placed on a conveyor and dumped into the retort. After coaling, the bottom of the retort would be opened, allowing the charcoal to fall onto a conveyor and be carried to a small storage bin. To reduce the fire hazard, the charcoal should remain in the small bins for several

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[13]Aries, Ibid.

TABLE XXIV

ESTIMATED COST OF PRODUCING BRIQUETTES IN AN INTEGRATED RETORT-BRIQUETTE OPERATION

Producing 4,000 tons per year - 2 ton per hour briquetting capacity

Item	Cost Per ton	Cost Yearly
Labor (two 3-man shifts @ $1.25 per hour)	$ 4.00	$ 16,000
Supervision and retort operation (@ $2 per hour)	2.13	8,520
Amortization of retorts (6 retorts @ $15,000 each over five years)[a]	4.50	18,000
Amortization of other building and equipment ($30,000 over 10 years)	.75	3,000
Fuel cost	3.25	13,000
Operating expenses for tractor and scoop	.75	3,000
Taxes and insurance (2% of fixed investment)	.60	2,400
Repair and maintenance (3% of fixed investment)	.90	3,600
Charcoaling Cost (not including wood costs and returns to capital)	$16.88	$ 67,520
Briquetting costs[b]	23.67	94,680
Subtotal	$40.55	$162,200
Miscellaneous costs (10% of above)	4.06	16,240
Total Integrated Cost (not including wood costs and returns to capital)	$44.61	$178,440

[a]This cost might possibly be reduced if the producer has ingenuity and is mechanically minded enough to develop his own retort. The retort cost used in this budget is near those of commercial manufacturers. The rate of depreciation and amount of maintenance is not known; however, they are in line with other estimates and can be compared with the 30-unit kiln operation.

[b]The briquetting cost is the same as in the two-ton per hour briquetting budget on page 66, Table XXI.

hours before being made into briquettes.

The cost of producing charcoal in the small retort was estimated to be $16.88 per ton, not including the cost of wood and returns to capital (Table XXIV). This compares favorably with the $17.28 per ton cost estimate for charcoal produced in the 30 kiln battery. Adding briquetting and miscellaneous costs to the cost of charcoaling gave a total integrated cost of $44.61 per ton without any consideration for wood cost and returns to capital, or a total yearly outlay of $178,440.

After subtracting production costs and 15 per cent returns on the fixed investment and operating capital, $27.96 remained to pay for the wood necessary to produce a ton of charcoal - or a total of $111,840 for the yearly production of 4,000 tons (Table XXV). Less revenue remains to pay for the total amount of wood going into the retorts to produce a ton of charcoal than if it were going into the kilns because of the higher capital charge on the increased investment and fuel costs. However, the amount of wood required to produce a ton of charcoal in the retort is sufficiently less than the kiln requirement so that more revenue remains to pay for each cord of wood.

Assuming it takes 2.2 cords of seasoned hardwood to yield one ton of charcoal, the maximum amount that could be paid per cord of wood to break even would be $12.71. With wages at $1 per hour instead of $1.25, the maximum allowable cost would be $13.55 per cord.

The maximum amounts that could be paid for a cord of wood on the stump with varying plant and wood harvesting wage rates have been estimated and are shown in Table XXVI. All of the stumpage estimates were

TABLE XXV

RETURNS TO WOOD FROM THE SIX-RETORT, 4,000 TON PER YEAR BRIQUETTING OPERATION

Item	Per ton	Yearly
Price received for the charcoal f.o.b. kiln[a]	$83.83	$335,320
Cost of production	44.61	178,440
Remainder	$39.22	$156,880
Returns to fixed investment ($250,000 x .15 ÷ 4,000 tons)	9.38	37,520
Remainder	$29.84	$119,360
Returns to operating capital ($50,000 x .15 ÷ 4,000 tons)	1.88	7,520
Remainder	$27.96	$111,840

[a]See the two-ton per hour briquetting budget on page 68, Table XXII. This is the remainder of the retail sales after deducting retailer and jobber mark-up and transportation costs.

TABLE XXVI

MAXIMUM ALLOWABLE STUMPAGE COST PER CORD OF WOOD CHANNELED INTO AN INTEGRATED RETORT-BRIQUETTING PLANT WITH VARIABLE WAGE RATES

Maximum amount left to pay for a cord of wood with plant wages of $1.00 and $1.25 per hour		If wood harvesting wage rates are:			
		$ .50	$ .75	$1.00	$1.25
		then cost of harvesting a cord of wood will be:			
		$7.20	$8.97	$10.74	$12.52
		and the maximum allowable stumpage cost would be:			
$1.00	$13.55	$6.35	$4.58	$2.81	$1.03
$1.25	$12.71	$5.51	$3.74	$1.97	$0.19

positive. With plant wages at $1.25 per hour and wood harvesting wages at $1, about $1.97 would remain to pay for each cord of wood on the stump. If the forest owners could receive this much for their low-quality hardwoods, there would be positive encouragement for forest improvement.

CHAPTER IV

SUMMARY AND CONCLUSIONS

Although the sale of timber products in Tennessee is of major importance, little effort has been made to improve or maintain the productivity of the State's forests. A continuous down-grading of the growing stock has been occurring for several generations, allowing a tremendous volume of low-quality hardwoods to build up in the State's once fine forests. Therefore, only about one-half of the productive potential is now being realized from the forests of Tennessee. And even though forest management studies have shown that stand improvement may be achieved by replacing the low-quality hardwoods with marketable timber, and done economically by several methods, none has been greatly used. Now if it can be shown that there is a way to turn the low-quality timber into a marketable product, the forest owners should be prompted into action by the greater gains to be earned in the process of improving their stands of timber.

This thesis was concerned with the utilization of low-quality hardwoods in the production of charcoal as an alternative to destroying them and as a means of providing employment alternatives for some of the State's underemployed. The criteria used to determine if charcoaling does provide an economic alternative to destroying the cull trees was the value of the stumpage when used in this manner. The stumpage value was estimated to be the value of the end product minus all other production and marketing costs. For charcoaling to be economically feasible, the stumpage value could be negative by no more than the least cost method of destroying the trees. A positive stumpage value for the low-quality

hardwoods would provide additional incentive for forest improvement. Returns to labor must also be comparable to other employment opportunities for charcoaling to provide job alternatives for some of the State's under-employed.

The information upon which this study was based came from a host of published sources and from equipment manufacturers. Production, consumption and similar economic data were procured to estimate the future production possibilities of charcoal. An estimate of local charcoal and briquette production costs were made for the different operations that were budgeted in this thesis by applying costs applicable in Tennessee to the technical coefficients obtained from the indicated sources. Production and marketing costs are also influenced by the availability of raw materials and location of the markets. Data on these factors were brought together to estimate the competitive position of charcoal producers in Tennessee relative to prevailing market prices.

Adjustments in charcoal supply and demand have been occurring for several years. Since chemicals formerly recovered from wood are now synthesized by cheaper methods, it is not economically practical to build the high-investment distillation plants solely for the production of charcoal. While these plants still produce the majority of the charcoal, room has been made for less expensive producing units such as the kiln and small retort.

Charcoal demand has been changing more in composition than in total. Industrial demand for charcoal has paralleled the declining distillation industry. Total demand has remained relatively steady, however, because of the increasing use of charcoal for such purposes as

cooking outdoors on portable or patio grills.

The increasing domestic demand and the declining production of the distillation industry has provided impetus for the construction of several briquetting plants in the East. While requiring a clean, uniform product of good-burning quality, the domestic market can be supplied with less difficulty than most of the remaining markets. It is probably easier for the relatively small charcoal producers to compete with the larger ones in the dispersed domestic market than in the industrial or commercial markets. Therefore, if potential producers in Tennessee can compete at the prevailing market prices, there should be little difficulty in marketing the product.

Three lump charcoal operations were budgeted in this study in order to estimate the value of low-quality hardwoods when used in this manner. The stumpage values reveal just how competitive one might expect producers in the State to be in the production of lump charcoal and briquettes. However, an estimated average loss on the forest improvement cuttings of $1.34 per cord could be charged to forest management if charcoaling is to merely provide an economic alternative to destroying the low-quality hardwoods. This loss would be borne by the forest land owner in the form of harvesting costs, and even though the owner should happen to be subjected to such a loss, it would not be greater than the cost of girdling the timber.

Budgets on the cost of producing bulk and bagged charcoal were prepared for a two-and-one-half-cord kiln, a seven-cord kiln and a battery of six five-cord kilns. From these budgets and from the budget on the

cost of wood procurement, equations were derived to estimate the maximum amount that could be paid for a cord of wood on the stump and still allow the operation to break even. The stumpage estimates for the different operations were summarized in Table XXVII. Only the most applicable labor costs and prices received for the charcoal were included in the table. In breaking even the single operations would be returning six per cent on the fixed investment. Both 6 and 15 per cent returns on the investment were used in making the stumpage estimates for the battery of kilns.

Only at the lower wage rates would the production of charcoal in the operations budgeted in this study provide incentive for forest improvement. Assuming the price of bulk charcoal to be $30 per ton and wages at 50 cents per hour, the per cord stumpage values were estimated to be 56 cents for the two-and-one-half-cord kiln, 24 cents for the 7-cord kiln and from 28 cents to $1.14 for the multiple-unit operation, depending upon the investment charge used. A price of $35 per ton for the charcoal and 50 cent wages would increase the maximum allowable stumpage costs by $2.00 per cord. With wages at 75 cents per hour and the price of charcoal at $30 per ton, the charcoaling operations budgeted here would not be economically feasible even as a tool of forest management. The $35 per ton charcoal price would allow the kilns to be used for stand improvement with wages of 75 cents per hour, since each of the negative stumpage values in this instance are less than the $1.34 loss per cord that could be charged to forest management.

With the $1.34 negative stumpage value charged to forest management

TABLE XXVII

COMPARISON OF THE MAXIMUM ALLOWABLE STUMPAGE COST ESTIMATES FOR THE THREE LUMP CHARCOAL OPERATIONS

Bulk sale f.o.b. kiln only

Type of operation	If wood procurement and kiln hourly wages were:					
	$.50		$.75		$1.00	
	and if the price of charcoal was:					
	$30	$35	$30	$35	$30	$35
	then the maximum allowable stumpage costs would be:					
One 2 1/2-cord kiln	$0.56	$2.56	-$2.91	-$0.91	-$6.58	-$4.58
One 7-cord kiln	$0.24	$2.24	-$2.73	-$0.73	-$5.70	-$3.70
Six 5-cord kiln[a]	$1.14	$3.14	-$1.48	$0.52	-$4.10	-$2.10
	$0.28	$2.28	-$2.34	-$0.34	-$4.96	-$2.96

[a]The two rows of stumpage estimates represent residuals values using 6 and 15 per cent return respectively on the fixed investment.

and with the price of bulk charcoal at $35 per ton f.o.b. kiln, the maximum wage rates that could be paid to produce the charcoal in the small kiln, the seven-cord kiln and in the multiple units would be 78, 80 and 83 cents, respectively. Higher wages could be paid by operators of the multiple units, but it is doubtful if a six per cent return on the comparatively high investment would be enough to attract the capital into the industry. Nevertheless, the battery of kilns would seem to have the advantage over the single units for the relevant wage rates.

For some areas in the State the charcoal kiln can be used as a tool of forest management and will, perhaps, provide additional employment for some of the underemployed areas. However, the unpleasant working conditions around most charcoal kilns coupled with the low wage rates makes charcoaling a poor alternative for the laborers.

The market for lump charcoal is extremely limited for the small producers in Tennessee. About the same maximum stumpage estimates were obtained regardless of the marketing channel, with the possible exception of direct sales to retailers, but this market for lump charcoal is limited even more than the others. However, the demand for charcoal briquettes is not nearly so limited, and possibilities exist for additional briquetting plants in the State.

Three integrated charcoal-briquette plants were also budgeted in this study in order to estimate the maximum amount that could be paid for the low-quality hardwoods when used in this manner. The first plant had an output capacity of one ton per hour and the second had a capacity of two tons per hour. Total yearly production was assumed to be 2,500

and 4,000 tons respectively. Both of the operations had a supporting number of nine-cord charcoal kilns. The third budget was for a two ton per hour briquetting plant supported by six retorts.

All costs incurred in producing and marketing the briquettes along with a retail and jobber mark-up of 20 per cent each, and a 15 per cent return of the fixed plant investment and operating capital were subtracted from the estimated retail sales price of $138 per ton in order to determine the maximum amount that could be paid for the low-quality hardwood. Production costs were calculated using both $1 and $1.25 per hour wage rates. Thus there were two estimates of the maximum amount that could be paid for the hardwood for each of the three operations. These estimates were further reduced by the cost of wood harvesting to give the residual amounts that could be paid for a cord of wood on the stump. In making the stumpage estimates, wood harvesting wage rates were varied from a low of 50 cents per hour, by 25 cent intervals, to a high of $1.25 per hour.

The stumpage estimates for the three briquetting operations, with plant wages of $1.00 per hour, were summarized in Table XXVIII. With wood harvesting wages at 75 cents per hour, all of the stumpage estimates were positive, and if the forest owner could receive the lowest of the values ($1.49 per cord), there would be positive incentive for forest improvement. Operators of the two larger plants could offer a sufficiently high price for a cord of wood to allow the forest owner to pay wood harvesting wages of $1.00 per hour and still receive positive returns for the stumpage. The $10.46 maximum amount that could be paid for a cord

TABLE XXVIII

COMPARISON OF THE MAXIMUM ALLOWABLE STUMPAGE COSTS PER CORD OF WOOD CHANNELED INTO EACH OF THE INTEGRATED BRIQUETTING PLANTS WITH PLANT WAGES AT $1.00 PER HOUR AND WITH VARIABLE WOOD HARVESTING WAGE RATES

Type of plant	Maximum amount left to pay for a cord of wood	If wood harvesting wage rates are: $.50 then cost of harvesting a cord of wood will be: $7.20 and the maximum allowable stumpage cost would be:	If wood harvesting wage rates are: $.75 then cost of harvesting a cord of wood will be: $8.97 and the maximum allowable stumpage cost would be:	If wood harvesting wage rates are: $1.00 then cost of harvesting a cord of wood will be: $10.74 and the maximum allowable stumpage cost would be:
18 kiln, 1 ton per hour briquetting plant	$10.46	$3.26	$1.49	-$0.28
30 kiln, 2 ton per hour briquetting plant	$13.09	$5.89	$4.12	$2.35
6 retort, 2 ton per hour briquetting plant	$13.55	$6.35	$4.58	$2.81

of wood to be converted into briquettes in the small plant would not allow the forest owner to harvest the wood and break even with harvesting wages of $1.00 per hour. However, the 28 cent loss per cord could be charged to forest management.

Stumpage estimates for the three briquetting operations using $1.25 per hour plant labor costs were summarized in Table XXIX. Operators of the two larger plants could again offer sufficiently high prices for a cord of wood to allow the forest owner to pay $1.00 per hour wood harvesting labor costs and still receive from $1.16 to $1.97 per cord for the stumpage. The small plant operator could pay only $9.01 for a cord of wood with plant wages at $1.25 per hour. It would not be economically feasible to harvest the low-quality hardwoods at this price if the forest owner must pay harvesting wages of $1.00 per hour, since the negative stumpage value of $1.73 is below the $1.34 maximum loss that could be charged to forest improvement. The forest owner would break even harvesting the wood for $9.01 per cord with wages at 75 cents per hour. Briquette production in the two largest plants would be economically feasible with both plant and wood harvesting labor costs at $1.25 per hour. In the retort briquetting plant the maximum amount left to pay for the wood was high enough for 19 cents to remain to pay for the stumpage after subtracting wood harvesting and delivery costs.

Briquettes were less costly to produce in the larger plants primarily because of the more efficient use of labor. To make the greatest profit, potential producers should consider the larger plant capacity where the demand warrants.

TABLE XXIX

COMPARISON OF THE MAXIMUM ALLOWABLE STUMPAGE COSTS PER CORD OF WOOD CHANNELED INTO EACH OF THE INTEGRATED BRIQUETTING PLANTS WITH PLANT WAGES AT $1.25 PER HOUR AND WITH VARIABLE WOOD HARVESTING WAGE RATES

Type of plant	Maximum amount left to pay for a cord of wood	If wood harvesting wage rates are: $.50	$.75	$1.00	$1.25
		then cost of harvesting a cord of wood will be: $7.29	$8.97	$10.74	$12.52
		and the maximum allowable stumpage cost would be:			
18 kiln, 1 ton per hour briquetting plant	$9.01	$1.81	-$0.04	-$1.73	-$3.51
30 kiln, 2 ton per hour briquetting plant	$11.90	$4.70	$2.93	$1.16	-$0.62
6 retort, 2 ton per hour briquetting plant	$12.71	$5.51	$3.74	$1.97	$0.19

While only low-quality timber was assumed to be used as raw material for conversion into charcoal, mill residues can and are being used. Where mill residues are plentiful and cheap, the integrated plant operators will probably find it advantageous to use them. However, the mill residues are usually dispersed over a wide area and would have to be collected and transported for several miles to support a large briquetting operation. More uses are being found for the residues and in the future they may not be plentiful; therefore, a plant would need cull hardwood reserves to rely on in case a shortage of residues did occur.

It is not necessary for the briquetting plants to be integrated with the charcoal kilns or retorts. Where the charcoal can be supplied by local producers at a price comparable to the cost of producing it in the integrated plant, the briquettor and the local charcoal producers would receive mutual benefits. The briquette manufacturer would not need the $40,000 to $50,000 for charcoaling equipment and local charcoal producers could use the kiln as a tool of forest management if wood harvesting wage rates were around 75 cents per hour.

It is doubtful if the local producers in this instance would use mill residues since the cost of harvesting the low-quality hardwoods minus the charge that could be made to forest management would be about equal to the cost of the residues delivered to the kiln. The incentive to produce the charcoal would come from forest improvement instead of profits.

Charcoal briquette production does offer a manufacturing opportunity

in Tennessee, and low-quality hardwoods can be supplied as the basic raw material at costs that are economical. In this way charcoaling and briquetting operations would upgrade otherwise almost worthless material and at the same time improve the forests of Tennessee.

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APPENDIX

TABLE XXX

ESTIMATED COST OF HARVESTING AND DELIVERING A CORD OF WOOD TO AN INTEGRATED CHARCOAL-BRIQUETTING PLANT[a]

Operation	Cost per cord
Felling, limbing, and bucking	
Labor (3.6 man-hours)	$ 4.50
Power saw	.54
Bunching	
Labor (.4 man-hours)	.50
Tractor-two plow (.4 machine hour @ $1.19 per hour)	.48
Cables, etc.	.03
Loading	
Labor (1.3 man-hours)	1.63
Hauling (Assuming: (1) the purchaser has mechanical means of unloading the truck, (2) a 2-ton truck hauling 2.77 cords of wood over 1 mile of woods road, 3 miles of gravel roads and 16 miles of paved road, and (3) a total operating cost per round trip mile per cord of 27 cents for woods road, 14 cents for gravel roads and 9 cents for paved roads)[b]	
Truck cost	2.13
Labor (.78 man-hour plus 10 per cent for stand by times = .86 man-hours)	1.08
Subtotal	$10.89
Profit and/or risk (15 per cent of above)	1.63
Total cost	$12.52

[a]Hourly wage costs of $1.25 were used in making the estimate.

[b]Truck operating costs were taken from Hardwood Logging Methods and Costs in the Tennessee Valley, Report No. 232-60, Division of Forestry Relation, Forestry Investigations Branch, Tennessee Valley Authority, Norris, Tennessee, Appendix Tables J and K.

TABLE XXXI

ESTIMATED COST OF HARVESTING AND DELIVERING A CORD OF WOOD TO A LOCAL CHARCOAL KILN[a]

Operation	Cost per cord
All costs from felling through loading are the same as those in preceding budget	$ 7.68
Hauling (Assuming: a 1 1/2 ton truck hauling 1.91 cords of wood over 2 miles of woods road, and a total operating cost per round trip mile per cord of 37 cents for woods road)[b]	
Truck cost	.74
Labor (1.08 man-hours plus 10 per cent for delay or standby - 1.19 man-hours at $1.25 per hour	1.49
Unloading labor (.6 man-hours)	.75
Total Cost	$10.66

[a]Hourly wages of $1.25 were used in making the estimates.

[b]Hardwood Logging Methods and Costs in the Tennessee Valley, Report No. 232-60, Division of Forestry Relations, Forestry Investigations Branch, Tennessee Valley Authority, Norris, Tennessee, Appendix Tables J and K.

TABLE XXXII

ESTIMATED WOOD HARVESTING COST WITH VARYING WAGE RATES DELIVERED TO A LOCAL KILN OPERATION AND TO AN INTEGRATED PLANT

Wage rates	Cost of wood delivered to a briquettor (stumpage cost not included)	Cost of wood delivered from the forest to a local kiln (stumpage cost not included)
$1.25	$12.52	$10.66
1.00	10.74	8.88
.75	8.97	7.11
.50	7.20	5.34