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Date Aug. 22, 1985

COST OF PRODUCING AND MARKETING A SHADE TREE: THE RED MAPLE

A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee, Knoxville

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ABSTRACT

The primary objective of this research was to study the cost-price relationship of producing and marketing the red maple as a representative shade tree. Average production costs were estimated and compared with estimated average prices for 1984.

A literature review was made to describe the economic issues of pricing in the nursery industry and also the results of past cost of production studies of ornamental species. A study was made of the growth requirements of the red maple. From interviews with nurserymen in Middle Tennessee, a production system was synthesized and modeled to grow red maples. Method 1 grew the trees from seed up to five years and harvested half of them selectively in each of the last two years. Method 2 grew the trees from seed up to six years and harvested about one-third of them selectively in each of the last three years. All the trees were balled and burlapped at harvest. The costs of production were estimated with an enterprise budget using a model small nursery. The nursery was assumed to have 50 acres and the capacity to grow the red maples and various other species of ornamentals on 40 acres of field space. The assumption was made that the model represented conditions of nurseries in Tennessee and USDA Climatic Zones 7 and 8 in 1984.

The average cost of production for all the trees harvested from an acre was the lowest, and the average net returns per tree were the highest for Method 1, the shorter production system. Average prices per tree were estimated to be higher than the average cost per tree for all sizes of trees grown by either method. The difference between the

average price per tree and the average cost per tree was the highest for the 10' - 12' trees grown by Method 2, and the lowest for the 12'-14' trees grown by Method 2. The cost-price differential decreased for the larger trees due to higher harvest costs and to fewer trees remaining in the field.

Limitations on the results of this study were recognized. The large amount of soil removed from a field with a balled and burlapped harvest represents a cost of production which was not accounted for. Variations in the number of trees selectively harvested from a field each year greatly affects the average cost per tree for each tree size. The model harvest schedule used in this study is just one of many possible systems. It is difficult to know how the assumptions of the model nursery and production system used in this study actually compare with the average for all small nurseries growing red maples in the South.

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CHAPTER I

INTRODUCTION

Statement of Problem

Ornamental horticulture has become an important industry in the South and yet cost of production information for this industry is not available for many types of ornamentals. The Southern Regional Research Project, S-103, "Economics of Producing and Marketing Woody Ornamentals in the South" has been developing cost of production research for several species. This cooperative effort by nine Southern State Agricultural Experiment Stations has three primary objectives:

1. to develop estimates of cost-price relationships of producing and marketing selected woody ornamental plants;
2. to estimate optimum market schedules for selected woody ornamentals based on input costs and product price relationships;
3. to ascertain patterns of geographical distribution and exchange of woody ornamental plants from production units to the point of final sales and analyze the product flow of nursery products consumed in the Southern Region.

One of the results of the research project was a publication on the costs of producing and marketing the pin oak as a representative shade tree (5). The current study is an extension of this research designed to develop an estimate of the cost-price relationship of producing and marketing another shade tree. The red maple was chosen as a representative fast growing shade tree commonly grown in the South.

Overview of Nursery Industry

Red maple (Acer rubrum L.) is one of many species of ornamental shade trees grown by nurseries in the South. Shade trees are classified as "woody perennials" or "woody ornamentals" and in turn are members of a larger classification of plants included in "ornamental horticulture." Because ornamentals are not grown for food or fiber they have often been excluded from agricultural surveys so that data for this industry are not nearly as abundant or accurate as data for the other sectors of agriculture. As Raleigh, an agricultural economist has observed, "there is probably no segment of agriculutre that knows less about itself than the ornamental segment" (75, p.1).

Data for the nursery industry come from federal and state censuses, and from independent surveys by nursery business associations and land-grant universities. The data are not always consistent among the various sources, but one source used alone can be useful for determining trends within an area over time or for comparisons between different regions. Confusion and inaccuracy of the data for the nursery industry is due in part to the enormous diversity of plant species grown by nurseries and also to the diverse market channels by which they are sold. The problem is not only the difficulty of collecting the information but also the need to categorize it.

The Tennessee Crop Reporting Service (70) reports the gross wholesale value of "greenhouse and nursery products" in its annual reports. The United States (U.S.) Census of Agriculture (76) about every 10 years also provides data for "greenhouse and nursery products"

but demonstrates what this classification includes by subdividing the data into "bedding plants, bulbs, cut flowers and cut florist greens, foliage and flowering plants, mushrooms, nursery products, sod harvested, vegetable and flower seeds, greenhouse vegetables, and other nursery and greenhouse products." The annual statistical report of the United States Department of Agriculture (USDA) gave no production data for ornamental horticulture in 1984 (77).

The category of "nursery products" is a sub-group of "greenhouse and nursery products" and itself includes a large number of different ornamentals. Detailed production data for the nursery industry has been gathered through the U.S. Bureau of the Census only five times from 1890 to 1970 in the "Special Census of Horticultural Specialty Crops" (75). These bulletins report production data for 10 kinds of cut flowers, six kinds of potted plants, but more inclusively, eight categories of ornamentals under "nursery products." One category is called "deciduous shade and flowering tree." The last of these special bulletins reported that in 1970 the total wholesale value of all "ornamentals" sold was about $824 million which was about 2% of all agricultural products sold that year. "Ornamentals" in these bulletins correspond to the category of "greenhouse and nursery products" except that after 1969 it did not include mushrooms and vegetables grown under glass. Ornamental production showed an average annual growth of sales of 7% since 1949 which was greater than the growth in the other segments of agriculture during this period. The group of ornamentals with by far the greatest growth in sales was the "deciduous shade and flowering trees" with sales of $45 million and an increase of 870% from 1949 to 1970 or an average of about 40% annually.

The U.S. Bureau of the Census has continued to give information on the nursery industry although not in as much detail as with the special censuses. According to the latest U.S. Census of Agriculture report (76), the wholesale value of all "nursery and greenhouse products" climbed to $3,821 million in 1982 which was an increase of about 364% in 12 years or about 30% annually since 1970. About one-third of the total sales in 1982 were of "nursery products" with a wholesale value of $1,155 million. There is no way of knowing what percentage of these sales were of "deciduous shade and flowering trees."

The Horticultural Research Institute estimates the value of retail sales as at least three times the wholesale value (36). Thus, "nursery products" could have generated close to $3,400 million in retail sales in 1982. The large amount of employment in wholesale production, the large and diversified garden center and retail business, the landscaping business, and the production of inputs for the industry all combine to make this an important sector of the economy.

The nursery industry which is largely decentralized has become concentrated in several highly productive regions due to climatic and other regional advantages. Tennessee has become one of the more important producers of nursery products in the South. Although research on the marketing of nursery products has not been abundant, the Southern Regional Research Project, SM-33, a cooperative effort of nine Southern land-grant universities has published some important market studies. In a 1965 study (32, 67) it was found that Tennessee was the largest producer of narrowleaf evergreens, ornamental trees, and deciduous

plants in the South. Tennessee's greatest production was in deciduous plants but the state grew about 75% of all the ornamental trees produced in the South. Of the 22 different kinds of trees reported, maples were the second most produced behind dogwoods but more nurseries grew maples. It was estimated then that 72% of wholesale nursery sales in the South occurred within a 25 mile radius of the nursery. This is a remarkable contrast to a later study by the same committee in 1981 (4) which estimated that only 13.5% of the gross sales were within the state. Evidently the expansion of the industry since 1965 has relied on shipping of products outside of the region. The 1981 study estimated that Tennessee nurseries sold 43.3% of their product to the North with the largest percentage going to the East North Central Region (Illinois, Indiana, Michigan, Ohio, and Wisconsin). This illustrates the significance of the link between the economic conditions of the Northern industrial belt to the prosperity of the nursery industry in the South. A 1976 study in North Carolina (17) suggested an even stronger linkage with 85% - 90% of all semi-truck loads of native ornamentals reported to be destined for the Northeast and New England.

The Nursery Business magazine has conducted surveys of the industry using data from state agencies and from nursery associations. They ranked Tennessee as the fifth largest nursery producer in the nation in 1984 up from the ninth place the year before (49). Their survey covered 661 nurseries on 12,000 acres in Tennessee with gross sales of $125 million. The Tennessee Department of Agriculture that same year certified 764 nurseries on 25,168 acres (72).

In 1983 the Tennessee Crop Reporting Service (70) ranked

"greenhouse and nursery products" as the fifth most important agricultural output in the state with sales of $145 million. This placed the nursery sector behind cattle, dairy, tobacco, and soybeans but above hogs, cotton, chickens, eggs, wheat, and corn all for the first time. This reporting service had revised the data however. In 1981 they had reported the wholesale value of nursery crops in Tennessee to be $33.9 million (69) while in the 1984 bulletin this figure for 1981 was revised to $142 million (70). This significant change moved the nursery sector from eleventh place to sixth place in Tennessee agriculture. It appears that the category of "greenhouse and nursery products" previously had been reporting the sales of "nursery products" alone when the data are compared with U.S. Census of Agriculture data for Tennessee. The U.S. Census of Agriculture of 1982 reported a wholesale value of $56.9 million for "nursery and greenhouse products" in Tennessee of which "nursery products" was the most significant product with $34.6 million (76). Whatever the true value of nursery sales in Tennessee or the nation may be, it seems clear that the nursery industry is significantly large and is showing very healthy growth. It is also clear that much more effort by state and federal agencies is both needed and justified to monitor the nursery industry.

There has been a general trend in agriculture towards fewer but larger farms. The Special Census of Horticultural Crops reported a sharp decline nationally in number of nurseries and a moderate increase in total acres from 1949 to 1969 which fit this national trend (75). The number of nurseries certified in Tennessee was also declining into the 1970s but then this trend reversed and both number of nurseries and

total acerage increased from 1980 to 1982 (71,72). While many nurseries began and still remain as small backyard or hobby farms, others have grown to have over two thousand acres with sales counted in the millions (49). According to the Special Census of Horticultural Crops, the national average size of a small nursery ($25,000 - $100,000 in gross sales) in 1970 was 45 acres. A large nursery ($1 million+ in gross sales) averaged 700 acres in 1970.

Most woody ornamentals grown in nurseries take more than a year and can even take up to seven years to grow to market size. It is difficult to forecast either macroeconomic conditions or consumer preferences over such a long period and so there is a considerable risk in taking on such relatively long-term investments in a crop. Besides problems of market demand are the usual problems inherent to agriculture such as droughts, winter freezes, and insect infestations.

In 1982, the American Nurseryman magazine reported a gloomy market situation for growers in the South (26). Most nurserymen blamed the economic recession and the decline of the heavy industry and manufacturing sector of the North. In February of 1985, this same magazine surveyed nurserymen (64) and reported that three-fourths of them said that sales were now up and that the picture was one of an optimistic and healthy industry. About one-half of them credited the change of affairs to the national economy. It is interesting that many reported a problem of keeping up with demand for large landscape plants, especially shade trees. Three years before, when there had been a glut of containerized stock, there had been a swing back to large landscape plants so that this sector had experienced no decline in prices or

demand. Those that weren't selling their trees were growing them longer in anticipation of an upturn and as a security against the price swings of their other stock.

Although there were concerns in the above surveys about prices that fell below the cost of production in tough times, many nurserymen felt that quality and variety were more important for sales than competitive prices. Researchers have referred to the problem of pricing policy with the implication that it is a "seller's market" in which the producer has to decide on a price to set. The market potential for some deciduous trees and shrubs is said to be constrained only by the productive capacity of the nursery industry (60).

One of the unique characteristics of the nursery industry is that wholesale growers send out calalogs with price lists for their products in advance of the normal harvest period from fall to spring. Nurserymen initially publish prices which are consistent with prices in the previous year, which are a response to the advanced orders they may have received, and which correspond fairly closely with the prices which other nurseries quote. Some researchers have referred to the practice of the larger nurseries acting as "price leaders" for the other nurseries (55) and the "stickiness" of prices from year to year due to the reluctance of nurseries to change their prices (53). This practice of setting prices is inconsistent with the theoretical economic basis of free competition in which price is set not by the firm but by competitive bidding in the open market.

With most agricultural products, knowledge of the quantity produced that year and the willingness and ability of consumers to

purchase this quantity will determine the market price of the product. If a single producer asks for a higher than market price, the consumer will presumably prefer to purchase somewhere else where the price is lower. The producer who accepts the lowest price will sell the most product but if the price is too low, eventually the firm will fail. In the long-run, the price will be adjusted by market forces to equal the minimum average total cost of production. The producer in a competitive market is a "price taker," not a "price maker."

The assumptions behind this economic model for free competition are that there are a large number of independent sellers, the product is standardized, no firm is large enough to influence the market price, and there are no obstacles preventing firms from entering or leaving the industry. It is also assumed that there is "perfect knowledge." In other words, prices will not be competed down if the buyers aren't aware that lower prices are available somewhere else.

If prices are indeed being "set" above the cost of production by nurseries and remain high, some degree of monopoly power in the industry is indicated. This may occur when a nursery sells a unique product such as a patented cultivar of a shade tree. Or when there is some natural advantage such as a deep fertile top soil necessary for balled and burlapped trees, other firms without this kind of soil cannot enter production to capture some of the profits occurring. There are also advantages of being already established in an industry which act as a barrier to new firms entering. A large established nursery may be able to produce at lower costs than a new nursery.

These factors which impede competition may or may not apply to

the nursery industry to some degree. But even without them, prices may be higher than the average cost of production for a limited amount of time for a plant type if there is a temporary shortage of that type of plant. Presumably however, the profits will attract other nurseries to expand or enter production of that type of plant and eventually the quantity produced in the market will match the quantity demanded so that prices will fall. For instance, if prices for smaller trees are low due to an abundance of these trees available in the market while prices for larger trees are high, many nurseries may decide to keep their trees in the field longer to take advantage of the more favorable prices of the larger trees.

Perhaps the most significant factor which may keep the nursery industry from fitting the model of "perfect competition" is the availability of information. With nurseries growing so many kinds of plants to many different sizes, it may not be clear which products are yielding profits. It could be that some plants are sold below the cost of production but the firm stays in business because others are priced above the average cost of production. Studies of the average cost of production of individual plants may indicate high returns while total returns for the entire nursery operation may be normal.

Without readily available market information on the quantity supplied, resulting market prices may not reflect competitive pricing. Retailers in the North for instance, may be purchasing trees locally because they are not aware that the same trees could be purchased for less from the South. With quoted prices at different wholesale nurseries remaining very similar, there may be more of an incentive to

shop for quality and convenience of sales than to compare prices. This factor of non-price competition is evidenced by the large amount of advertising involved in the nursery industry.

This is not to say that prices are not important. The final decision on price is made by the consumer. Landscapers concerned about their own profits will have an advantage if they switch their loyalties from their usual reliable producer to a lower priced producer. Retailers must respond to the preferences of homeowners by supplying not only the type and quality of ornamentals desired, but also at a price which will move the product. Therefore, if nurserymen "set" prices, the prices set are not what the nurseryman wants as much as what the consumers want and are willing to pay.

The difference between the price of a product and the minimum average cost of production of that product indicates the degree of competition in the market. This study investigates the cost-price relationship of balled and burlapped shade trees grown in the South using the red maple tree as an example. Enterprise budgeting was used to find the average cost of production on a model nursery with a model production system. The results are limited to the assumptions of the models so may not be an accurate estimation of the average cost of production for all nurseries growing red maples in the South. However, the models are approximations of conditions in the South and the results are intended as a guide for estimating the cost of production for this important shade tree.

Objectives

The specific objectives of this study were to:

1. study the requirements for growth of the red maple tree;
2. synthesize a model production system which was consistent with known production requirements and with successful commercial cultural practices;
3. estimate the costs of producing red maples with the model production system on a model nursery;
4. analyze the relationship of the costs of production developed by the model production system with the estimated expected price per tree;
5. estimate transportation costs per tree to various markets.

CHAPTER II

LITERATURE REVIEW

Cost of Production

Information on the costs of production of ornamental nursery crops is important for studying the economics of the nursery industry. In an address to the International Shade Tree Conference in 1973 on the "Status of Research in the Shade Tree Industry," Anderson remarked that "An understanding of the actual and theoretical economic systems that govern the industry is still in the definition stage. We are at point Alpha" (2, p. 12). He described accurate statistics as "poor to non-existent," but also, that even worse, was a lack of coordination and information exchange with other professions, along with a lack of vital research commitment.

One area of research which is lacking is cost of production information for different plant species. Calculating production costs for each type of plant grown on a nursery however is a costly and complicated task when so many different plants are produced and marketed in so many different ways. A shade tree can have as many as eleven different prices quoted for different sizes from seedling up to 2" caliper size. How are these prices derived?

Commonly, the larger nurseries publish prices based on production cost studies and serve as "price leaders" for the rest of the industry. This method has its pitfalls for the small producer. In a study by Perkins and Levins (55), a comparison of nursery trade magazine

published prices showed a decline in prices for some items from 1971 to 1974 even though nearly all costs had increased in that time. A nursery that had not lowered average fixed costs by expanding production, or lowered variable costs with the latest technologies, might not be able to survive with the prices set by the larger nurseries. They also pointed out the problem of the popular pricing policy of increasing prices for all the plants by the same percentage periodically when costs for different operations may vary differently. They developed an example of calculating costs for a five acre nursery producing container stock and emphasized the need to calculate indirect, overhead, or fixed costs as well as the usual variable "out-of-pocket" or direct costs which are usually easier to compute. Direct costs vary depending on the type of plant grown and include those inputs such as labor, fertilizer, equipment use, and materials that can be directly allocated to that type of plant. Indirect costs are those that cannot be attributed to any specific plant produced and include such things as advertising, insurance, depreciation on buildings and equipment, electricity, interest costs and any other cost which may be included in general overhead. Since the indirect costs are the same regardless of the amount of production, a larger nursery producing a greater amount of material will reduce the average indirect cost per plant, and so will have a competitive advantage over a nursery with less production.

Aylesworth and Gartner (3) have defined seven different costs from economic theory which are important to ornamental production. They emphasized that in the short-run, a firm must receive prices which at least cover the average variable costs, but that eventually returns must

also cover the fixed costs for the nursery to stay in business in the long-run. If accurate cost of production information were available, the marginal cost concept could also be used. This is based on crop response to the variation of one input with the other inputs and prices remaining constant. With this concept, input use is expanded to the point that the cost of the additional input use is less than or equal to the additional revenue which would be expected from using the input. Unfortunately, plant response studies have not been common for nursery crops. Also, with shade tree production, marginal analysis would be difficult since the prices are evaluated for sizes which range in height by two feet rather than by prices per pound as with most agricultural crops. For instance, irrigation may increase the growth rate of a tree by 10% in a year but the additional growth may not be enough to change the tree to a higher price category for that year.

There have been more studies published on costs of production for the nursery container crops than for nursery field crops. As mentioned earlier, the larger nurseries such as Cartwright Nurseries (94) and Monrovia Nursery (41) periodically undertake such studies. These usually have been not for specific plants but for type of plant material such as for "liner production." Crafton et al. (19) developed budgets for specific plants produced by different methods with containers. In the early 1960s, cost of production studies were made by Padgett and Frazier (53) in Georgia which suggested that prices for container stock were too low to cover marketing, production, and climatic risks. The study suggested that producers if made aware of the problem would realize the need for higher prices, but that prices were too rigid or

"sticky" to be adjusted to changes in the industry. The suggestion was made that prices would not be likely to change without collective agreement by many nurseries. But the year after the study, a winter freeze damaged millions of dollars worth of container stock and the resulting upward adjustment of container prices illustrated the importance of the earlier conclusion that prices were low, and it also illustrated that prices do adjust to the quantity supplied in the market.

A few years later, Padgett (54) also published research on the production costs of field-grown stock. Padgett pointed out that costs could be very different for different nurseries and type of plant, but with the supposition that some information is better than none, he developed costs for a 100 acre model nursery from information assembled on nurseries in Georgia producing mostly broadleafed evergreens and conifers. The average investment in one acre after one year was estimated along with the additional costs for each additional year up to three more years. The conclusion was that the larger plants were the profit makers and that the younger plants were underpriced.

A more comprehensive study was made in North Carolina by Coutu and Cohen (17) to analyze not only the costs of production but also the market potential for field-grown native woody ornamentals. Three different types of production systems were modeled for growing mountain laurel and rhododendrons in the field. The production costs of these systems were compared, the relative profitabilities were estimated, and a comparison was made of the internal rate of return to capital when two acres were planted every year for six years rather than planting the entire 12 acres the first year. Consumer preferences of buyers

in the Northeast were also surveyed and cost comparisons of producing these plants in the Northeast were made. It was found that there was one plant with the most risk free opportunity for expansion (mountain laurel) and one method of production with the most favorable returns. The study illustrated the importance of not only accurate information on costs of production for more than one general production system, but also of knowledge of consumer preferences and producer conditions in the Northeast when analyzing market potential for Southern growers.

Unfortunately, cost of production studies in the Northeast are not available for comparisons. Of some interest is a report of operating costs of municipally owned tree nurseries in the Northeast in 1983 (66). In the belief that it was to the advantage of cities to grow their own trees for their own landscaping and maintenance needs, 24 municipalities were buying bare root trees from commercial nurseries and growing them out for an average of three more years. Maples were the only species that 100% of the nurseries grew. At 1980 prices, the nurseries purchased bare root trees at $12.50 and spent $18.05 on the average to grow and harvest them at 1½" - 1 3/4" caliper size for a value of $30.55 per tree on the average. This cost was close to $10 higher than wholesale prices in the South for that size of tree. The authors emphasized that costs were not the only concern of municipal nurseries, and that availability of trees at the right time and other considerations would continue to be an important role in determining whether they would continue. Although these costs cannot be compared to the costs of commercial nurseries, it is useful for Southern growers to know the kind and price of trees Northern buyers are willing to purchase.

Recognizing increased demands for and shortages of shade tree nursery stock, particularly in the Mid-Atlantic and Northeastern states, an economic study of the costs of establishment and the expected returns for a shade tree nursery was made in Virginia in 1973 by Smeal et al. (62). The native red maple was selected as a representative or average shade tree and a production system was modeled. Seedlings were assumed to be purchased from outside the nursery and 10 acres a year were assumed to be planted for six years at 4'x4' spacing with every third row omitted for truck aisles. Land was assumed to be fallow for one year so after the sixth year the nursery operation required 70 acres. Loses of 20% were assumed so that 1,452 trees per acre were harvested selectively at 10%, 40%, 40%, and 10%, successively, in the fourth through the seventh years. Harvest was contracted and was accomplished with a crew of five men and a mechanical digger. The trees ranged up to 3" caliper size after the seventh year. Fixed costs were estimated assuming only one kind of crop was produced on the nursery with used machinery, old buildings, land at $400 per acre, and interest rates at 8%. Variable costs included a manager, a laborer for the length of the production and another laborer beginning in the third year. A cash flow model was used. When the operation was fully established after the seventh year, returns were estimated to run about 30% annually on the investment, but the break-even came during the sixth year. From the data can be calculated total costs of about $4.05 per tree excluding harvest and sale costs ($52,171 annual variable costs + $6,644 annual fixed costs divided by 14,520 trees per year). The trees were estimated to be sold at an average net worth (before harvest and

sale) of $12.80 per tree. The returns "look especially inviting as compared to other farming operations," but the authors emphasized that "one must consider the high risk of investing a large amount of capital and leaving it for long periods of time" plus the weather, diseases and uncertainty about demand in the "distant future" (62, p. 4).

Several methods of determining costs of production in the nursery business have been proposed. Philipps (57) demonstrated the use of data from Internal Revenue Service income tax forms to calculate annual fixed costs combined with estimates of variable costs developed from enterprise budgets to arrive at total costs. An accounting form for calculating both known variable costs and estimated indirect fixed costs for each plant species grown has been developed by Oregon State University and was modified for Middle Tennessee growers by Dickerson (23). Gunter and Otte (33) suggested using existing records that a nursery manager would ordinarily keep to calculate both direct and indirect costs.

A method that does not require accounting of actual expenditures for estimating costs is enterprise budgeting. This method can use a priori capital requirements to calculate annual fixed costs, and step-by-step labor and equipment requirements for production of a particular plant species to estimate annual variable costs. The production systems modeled can be adjusted easily to different nursery conditions and production systems.

Research developed from Southern Regional Research Project, S-103 has used enterprise budgeting to estimate production costs for Pfitzer juniper (7), Kurume azalea (9), pin oak (5), dogwood (6,31),

Juniperus chinensis 'Pfitzeriana' (8), Burford holly (18), and forsythia (unpublished). One of the interests of this project was to compare production systems and costs between regions to determine if there were any regional economic advantages. To allow comparisons, an effort was made to standardize the assumptions and budgeting techniques employed. Standardized model nurseries were developed so that capital requirements were similar for different studies. Also, basic assumptions about variable inputs were agreed upon so that differences of input prices and the resulting effects on production costs could be analyzed.

The present study of shade tree production is an extension of the 1980 report by Badenhop and Wright (5) called Cost of Producing and Marketing a Shade Tree: The Pin Oak. In this study, pin oaks were grown on a model small nursery (50 acres) by two different methods using 1978 prices. For the first method, costs were estimated for growing one year old seedlings for three years in the field in 54" rows with 24" between plants in the row. The seedlings were cut back to 2" above the ground during the second year in the field. Survival loss was assumed to be 15%. Harvest was 70% as bare root 5' - 6' tall trees (with 5.5% extra loss due to grading), 20% as balled and burlapped (B&B) 6' - 8' trees, and 10% as 8' - 10' B&B trees. The second method started with 5' - 6' bare root trees transplanted 8' apart in rows 5' apart and grown up to four more years. Survival loss was assumed to be 10%. Harvest was all B&B with 10%, 40%, 40%, and 10%, consecutively, in the first through the fourth years.

The average total cost for the trees in the first method was $4.29. The average wholesale price of these trees was $6.72 or 57%

higher than the average total costs. The average total costs for the trees in the second method which grew the trees up to an additional four more years was $28.13. The average wholesale price of these trees was $34.10 or 21% higher than the average total costs. The largest effect on the costs of production occurred with variations on the assumptions of loss rates. Changes in the assumed loss rates by 15% effected costs in the first method by 76¢ per tree and by $5.65 in the second method.

Transfer costs were estimated to ship plants by semi-tractor trailer to Northern markets. The costs were low at about 12¢ per tree for bare root trees from Nashville, Tennessee to New York City. Transportation costs for the same distance were much higher for B&B trees at about $8.45 per tree for 20" diameter balls stacked two deep.

A cash flow estimate was made which showed the net present value of the total investment at an interest rate of 10% to be $4,595 for the first model and $5,957 for the second model method. Estimated internal rates of return were 39% and 41%, respectively, for the two methods. The results from this model indicate high returns by either method of production. The measures of profitability suggest higher returns from growing the larger trees with the second method even though the cost-price differential is greater with the first method which is of shorter duration. A model combining the two methods so that the trees were grown to B&B size from seedlings in one operation showed the lowest internal rate of return at 29%.

Red Maple Production

The first objective of this study was to investigate the requirements for growth of the red maple so that a model production method could be developed. The production method was synthesized from both interviews with nurserymen and from a literature review. Some of the information gathered was specific to maple trees or to red maples, but it can also be applied to other fast growing shade trees with the same growth requirements. The information was gathered in Tennessee but it was assumed that the conditions apply to the USDA Climatic Zones 7 and 8 (Figure 1).

Shade tree production is an important sector of the woody ornamental industry in Tennessee and the South. One of the most popular selling shade trees is the maple. Of the 170 species of maples in the world, 25 are native to North America (50) and eight are commercially important to the nursery business (29). Imported varities such as the Japanese maple are also becoming popular.

The red maple (Acer rubrum L.) sometimes called "soft," "swamp," "scarlet," or "white" maple is a common woodland tree which has some value as sawtimber (79). In the forest it is considered to be an inferior pioneer or sub-climax species but it has been cultivated since as early as 1656 (80) as a landscape tree for its thick shade, handsome shape, and bright fall foliage. The largest known specimen is 125' tall with a 108' crown spread (1) but the normal height at maturity is 70' (79). It is native to North America from Newfoundland to Florida and east of Texas and Minnesota, but the range where it has its best development is in the mountains of central Appalachia (38). It

HARDINESS ZONE MAP OF THE EASTERN UNITED STATES

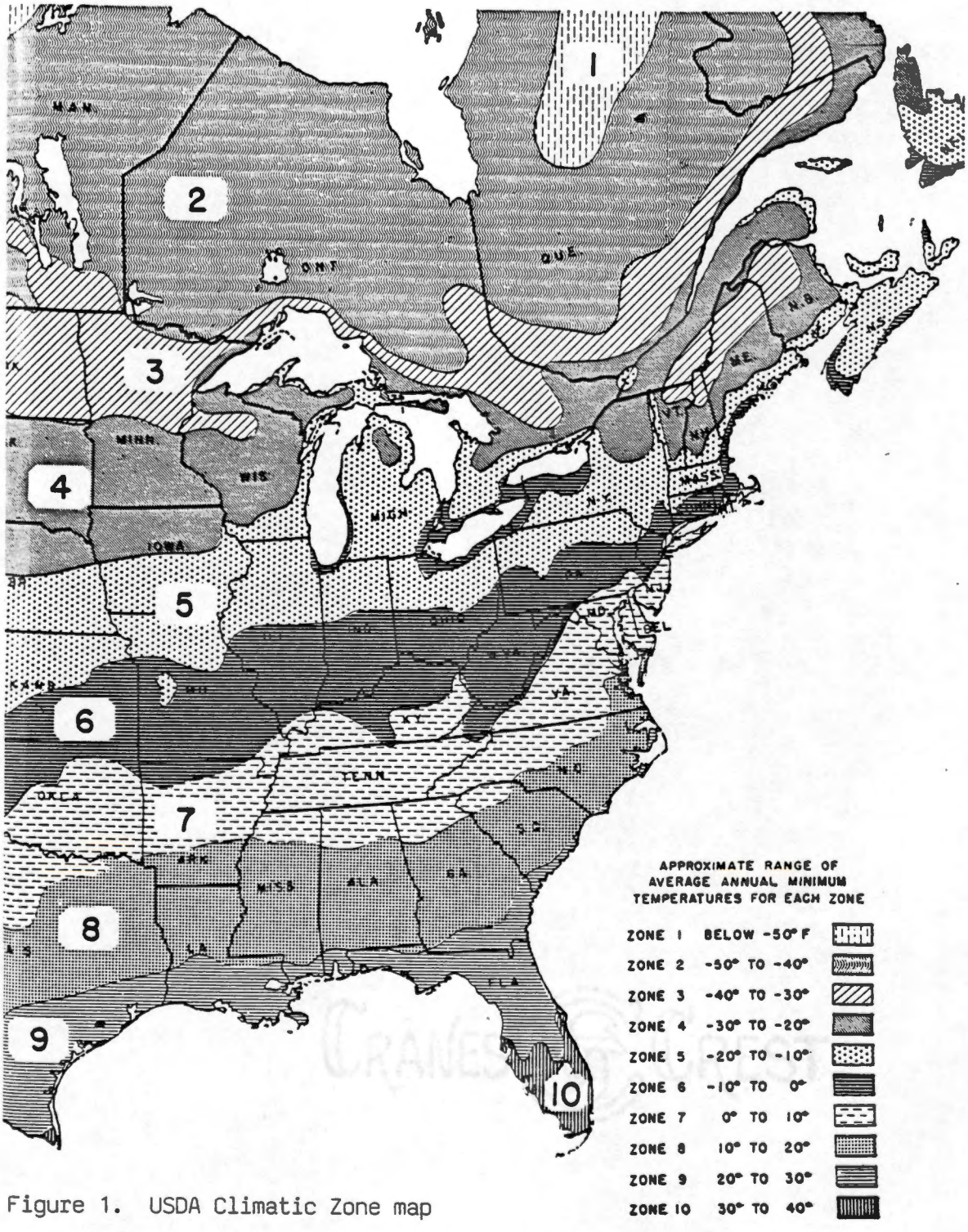


Figure 1. USDA Climatic Zone map

is extremely adaptable to different soil conditions, but is comparitively susceptible to snow and ice damage and is especially sensitive to trunk wounding (38).

Propagation

Nurserymen interviewed for this study used various methods for growing red maples. There were some consistent practices however. Most of the commercially successful nurseries started the trees from seed rather than by purchasing seedlings. Native red maple as in most wild species has the disadvantage when propagated from seed of displaying a wide range of shape, vitality, and color. This variability can be reduced only a little by using seeds from selected choice specimens. Maple seeds are sown ¼" - 1" deep by broadcasting in a seed bed at a density of 15 to 30 seeds per square foot (80). The inferior seedlings can be detected after the first year or two and be eliminated.

With many plants, the variations in propagated plants can be reduced entirely by rooting cuttings from selected trees. This had been considered difficult to do with red maples (38, 50) but methods have been developed that allow commercially acceptable survival rates (52). A common and increasingly popular practice is to graft buds of a particular choice tree to the root stocks of other trees of the same species to produce a uniform variety or cultivar of the chosen specimen tree. In 1982 the U.S. National Arboretum registered 37 valid cultivars of red maple, many of which were patented (61). The budding of cultivars or the rooting of cuttings are specialized and labor intensive methods. These methods deserve further research, but for this

study, propagation from seed was assumed for the model production system.

Red maple seed has the two wings or "samaras" characteristic of all maples, but unlike any other maple except boxelder (Acer negundo L.), matures on the tree in the early spring and will germinate later in the same spring. A pound of dewinged or "cleaned" seeds will have on the average 22,800 seeds with about 85% of commercially purchased seeds being viable (80). It has been claimed that red maple is one of the least difficult of all forest trees to germinate (38).

It has been reported sometimes that red maple seeds are not dormant at dispersal in the spring but a study made in East Tennessee found that about 50% of collected seeds were dormant (27). Dormancy was more likely with seeds from higher elevations, with warm incubation periods, and from particular trees. Apparently, red maples in Tennessee (which is in the central portion of red maple's range) have adapted to uncertainty of weather conditions by allowing seeds to germinate over two seasons whereas seeds from the northern and southern ends of the range are not dormant at dispersal in the spring.

Seed dormancy is not the only genetic variation found in red maples of different origins. The USDA was interested enough in this important shade tree to investigate the genetic variations of the red maple (74). Seeds were collected from throughout the natural range of red maple and grown on plantations in North Central states. There was a great amount of variation found between regions, within regions, and even from the same tree, but generally, the trees grown from seeds from the most northern sources were superior in earliest and brightest

autumn color, straightest stem form, earliest defoliation and fall dormancy, and least winter injury. But because these trees had slower growth rates, seeds from North Central sources were considered to be the best choice. This would also be a good choice for Southern nurseries considering how many trees grown in the South are sold in the North. Red maple seeds from the North are also best for root stocks of cultivars to be sold in the North (51).

Root System

Aside from the genetic characteristics of the tree, the most important factor affecting the quality of a nursery grown shade tree is the root system. Seedlings and young trees can be removed from the soil with much of their root systems intact, sold bare root, and be transplanted with success. A mature tree however, when dug out of the field loses most of its roots. The American Standards for Nursery Stock minimum root ball size for a 2" caliper tree is only two feet in diameter giving only 12" of root on each side of the tree (34). It was estimated that the tree loses 80% of its roots at harvesting (84) or even 98% (87). A root ball twice as big would have about 50% of the roots (14) but would be prohibitively heavy for large scale harvest of nursery trees.

Extensive research has been conducted on the root systems of red maples (43, 44, 90). Several (5 to 8) woody roots radiate horizontally in the top 25 cm (10") of the soil branching as they grow with short-lived non-woody root fans growing up near the ends to collect moisture and nutrients from the top 2 - 8 cm (3") of the soil. In a sapling, most of the root fans would be located beyond about 12' from the base

of the tree. There is a tap root but it doesn't grow deeply and usually turns to grow horizontally along with the lateral woody roots which grow from its base. The roots may grow 20 mm (0.9") a day during the regular growing season with an average of about 80 cm (31.5") a year (from 40 cm to 220 cm) so that the roots may be 1½ to 2 times longer than the stem of the tree if they are not disturbed or damaged. Even in nursery conditions red maple root density is higher in the top five inches and rapidly decreases below 15 inches (87). Root growth is greater in moist aeriated soil and warm conditions so that except for the coldest months, there may be root growth during the winter in the South (44).

Van de Werken (84) has estimated that about 50% of all trees sold die because of inadequate roots and the rest have three years of shock or reduced growth. "Rests" following root damage may be even longer than that for some trees, but Wilson (90) did not find this to be true of red maple. Older red maples or ones with damaged roots vigorously produce adventitious roots from the base of the stem and root collar, and re-occupy the zone at the base of the tree with root fans. Cultivation of the top three inches of the soil encourages deeper rooting and an abundance of roots at the base of the tree (14).

The ground surface around a tree has an affect on tree growth. A study of root growth in orchard trees (15) with cultivation, white clover, bare surface, and straw mulch soil management treatments showed that straw mulch and bare surface resulted in the greatest root length and weight for two species of fruit trees. Interestingly, white clover planted between the trees resulted in the lowest root weight of any of

the practices. Whitcomb (89) affirms this problem of root competition by estimating that weeds and grasses can reduce the growth of some trees and shrubs by up to 50% to 70%. The nursery practice of growing a ground cover to keep down unwanted weeds and to hold soil moisture appears to not be clealy justified unless there is a problem with soil erosion on sloping land. Whitcomb recommended a herbicide method which was used for the model production sytem in this study and is described in Chapter IV, Results and Discussion.

Experimental methods are being tested to accomplish the goal of producing a dense root ball in nursery trees for improved transplantation success. Container production which is becoming so popular in the nursery industry has been tried with trees, but it has been found to be inefficient and uneconomical for trees over two years old and with containers over five gallons in size (88). Another method called "air root pruning" involves bottomless containers set on raised wire frames so that the tip of the tap root as it encounters the air dies back which encourages branching of the primary and secondary roots to produce a dense, fiborous root system. But this method has the drawback of exposing the root system to the extremes of temperature which have proved costly to all container production (88). An alternative is being tested which allows the tree to be grown in the ground but with the root system confined by a synthetic fiber bag so that the entire root system is sold with the tree (59). This has also been suggested as a way to confine the roots of trees which have been dug, but will not be planted for some time (86). Although this is a promising approach, it has not been adapted for use on nurseries yet.

There has been research on the beaded rootlets of red maple. It had been believed that one explanation was mycorrhizal infection of the roots, but this has been found to be false (12) and it now seems that they may be genetically inherent to red maples (48). However, it has been shown that red maple root systems infected with endomycorrhizae significantly enhanced the growth of the trees in conditions of low fertility such as in sand and in anthracite (soil from strip coal mines) (20). Earlier it had been found that red maples did not perform well on coal mine reclamation (22), but innoculations of the tree at the nursery or adding the endophytes to the spoil material increases the uptake of atmospheric nitrogen and soil nutrients. Just as certified virus free fruit tree cultivars are an important development with fruit trees, it would be possible for nurseries to exploit endomycorrhizal infected trees (20).

Stem Growth

Although the root system of the tree is the most important factor assuring the success and quality of a nursery tree, the selling points are the height, caliper, straightness of the stem, and the shape of the crown. It is to the advantage of the nursery grower to facilitate as rapid a growth as possible without producing a weak tree. One common method to accomplish this is to cut back the young seedling at one or two years old to stimulate sprouting. Red maple is one of the most vigorous stump sprouters of any forest tree (65). The sprouts develop from dormant buds on the side of the stem in the spring (about mid-May) and grow so rapidly that within a growing season they will have

overtaken the height of a normal seedling. For the first two or three years they will grow faster than seedlings and it is not until about 40 years later that seedling trees finally match the height of sprout trees (42). The accelerated growth of the sprout can be explained by the larger root system, and slows down when the stem is large enough to fully utilize the excess food supply in the roots (42). The larger the stem is, the more sprouts that will develop. These extra sprouts have to be removed initially but eventually, if one sprout has been selected it will inhibit further sprouting as it grows taller (91). It is best to use stakes to keep the young fragile sprouts from being knocked or blown down in the first year or two. There is a pronounced sweep where the sprout attaches to the stem, but eventually the swelling of the stem reduces it. The sprout takes over the root system completely and the stub of the old stem is callused over so there is no problem with trunk rot as there is with older stems (42).

Fertilization

The fertility of the soil has an affect on the growth of a nursery tree. According to one study (12), applying nitrogen to greenhouse grown red maple seedlings can increase height growth 20 times over non-fertilized seedlings. Increasing the nitrogen rate improves the growth performance up to 200 ppm but declines with 400 ppm. Another study (58) showed that apparently after the first year, the amount of nitrogen applied has little affect on height and caliper growth, but a rate of 180 pounds of nitrogen per acre can give the greatest primary root growth. In a study (85) of the current state of the art of

fertilization of shade trees, it was found that an application of 150 pounds of nitrogen per acre of surface broadcast Osmocote or slow-release fertilizer gives the greatest caliper, height, and canopy growth after eight years. This method was superior to the same fertilizer and three others being placed in drilled holes at the base of the tree. It has also been concluded that 150 pounds of nitrogen per acre was optimal in another study (93) since any more had no effect on growth response and was even harmful in the case of maples at 300 pounds per acre.

Application of nitrogen fertilizer has an important affect on timing of fall color, defoliation, and onset of dormancy. Higher levels of nitrogen which would be present with a slow-release fertilizer in the fall will cause prolongation of growth. Before harvesting it is best to reduce the nitrogen level to assure normal dormancy (30). Some nurserymen interviewed apply this fertilizer in the winter when the ground is still frozen. The slow-release fertilizer with a nine month formulation would then be diluted early the next fall so that the problem of delayed dormancy is avoided.

Irrigation

Of even greater importance to red maple growth than fertilization rate according to some research is the amount of water available (58). Trickle irrigation used on field grown red maple at a rate of one and one-third gallons per day produced more height and caliper growth in trees as compared to non-irrigated trees. However, a rate of two-thirds of a gallon per day resulted in the best overall primary and fiborous root growth. Nurserymen using irrigation claimed that as a

rule-of-thumb, irrigation of field grown trees reduced the time to grow to a market size by one year.

Red maple seems to be able to survive in both wet and dry conditions which makes it such a good landscape tree. In one study (37), red maples survived 60 days of inundation. Growth was inhibited, but inundation stimulated vigorous growth of adventitious roots. This ability plus the shallow root system are advantageous in residential plantings where there is often a high clay and poorly drained soil condition (46).

Field Spacing

The pros and cons of different field spacings for nursery tree crops, although of great economic importance, has not received much attention by horticultural researchers to the knowledge of this researcher. However, the forest industry which is concerned with maximizing woody growth has studied this issue to find at what field density competition becomes a factor (11, 47). It is possible for competition to stimulate height growth and reduce caliper, but as one researcher remarked, "Growth in a biological sense is not much affected by variation in common densities but in an economic or business sense it is profoundly so affected" (10, p. 97). Spacing of nursery trees is more often determined by estimating at what distance the crowns will start competing at the end of the time planned for that spacing, by what size machinery needs to move between the rows, and by economy of space in the interest of maximizing returns to land as an input given the first two constraints (21). Commonly, the tree is transplanted several times to wider spacings as the tree grows.

Growth Rate

Although red maples are commonly found shaded by the top canopy of a forest, the lack of sunlight inhibits their growth and they are much more successful as one of the first hardwoods in the reforestation of open areas (16). In Northern climates, 90% of red maple height growth occurs in a four week period from May to June with the peak in early June and almost no growth after July (39, 40). Apparently, maple growth is slowed by high temperatures. The early growth rate could be a genetic adaptation to competition for light in the forest since growing maples in well-watered soils with plenty of sunlight does not seem to effect the growth pattern in the South (25).

The height and caliper of a tree at the time of harvest determines the price category of the tree. The growth rate of red maples was estimated and is shown in Figure 2. The top curve is the expected height with good nursery practices and fertilization. The heights up to the third year on this curve are measured heights from the study of irrigation effects on red maple in Alabama by Ponder et al. (58) in which year old bare root seedlings were grown for two years. The heights after the third year were averaged and extrapolated from a study in Tennessee by van de Werken (85) which measured maples about 25' tall after eight years with the best fertilization and cultural practices starting with 6' - 8' bare root whips.

The lower curve is a baseline from studies of red maple in the forest without nursery culture. It assumes about one foot of growth the first year, two feet the next few years, and eventually a rate of one and a half feet per year (28).

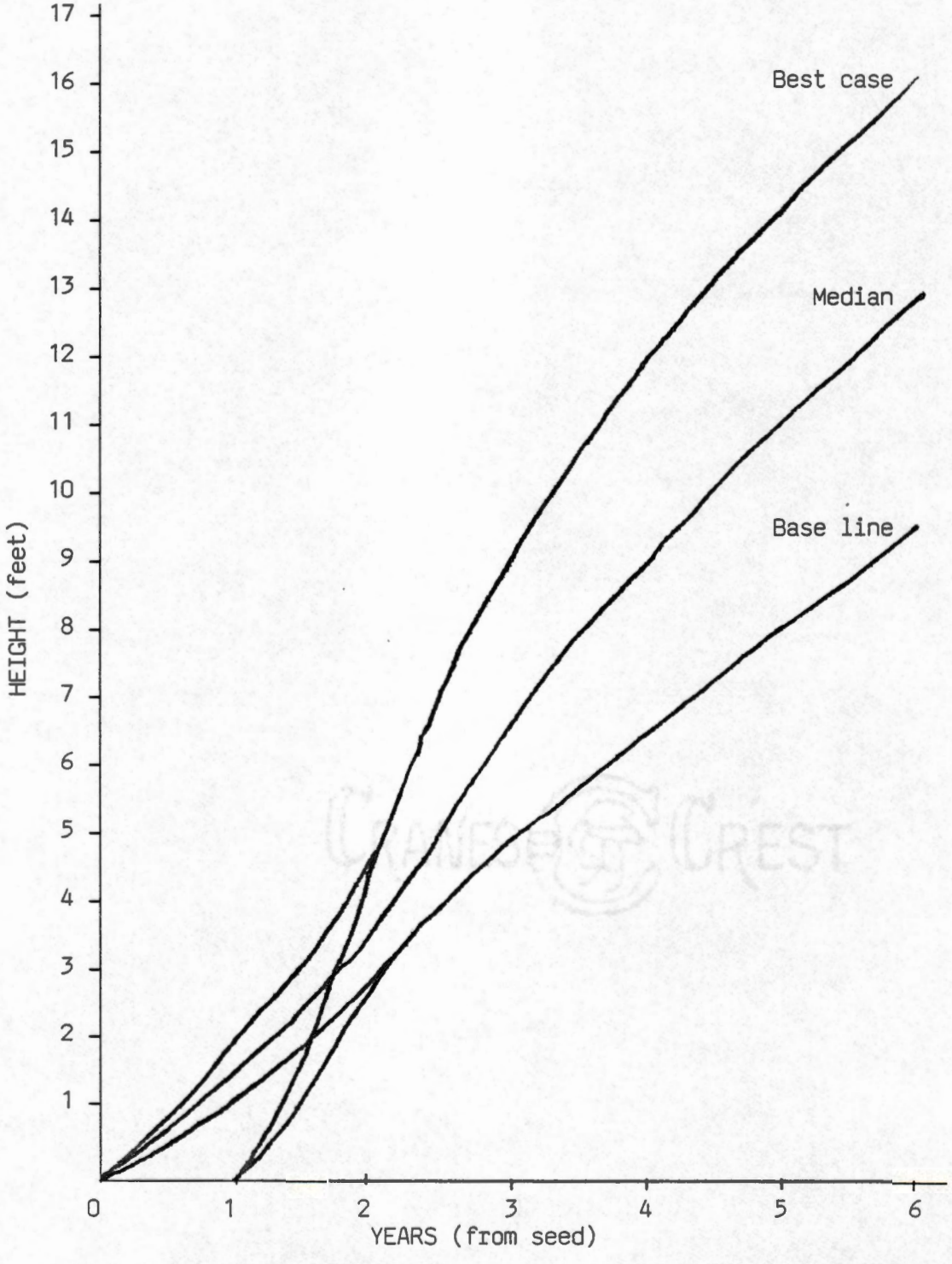


Figure 2. Estimated expected height growth of red maple

The middle curve approximates a midpoint between the baseline and the best case top curve. About one foot above and below the middle curve gives the range of size to be expected for each year.

It is assumed that after cutting back the seedling, the sprout at least recovers the height the seedling would have reached. Soloman and Blum (65), Wilson (91), Leffelman (42) and others have indicated that the sprout will overtake the normal growth rate, but to be conservative, it was shown to match the normal growth rate after the first season of growth.

Because red maples are so adaptable to different soil and environmental conditions, its vigor gives it the reputation of being able to grow like a weed which makes it such a popular nursery tree. The nursery grower must be competitive with the quality as well as the price. From the literature review and from interviews with nurserymen growing red maples, a model production system was synthesized and is described in Chapter IV, Results and Discussion.

CHAPTER III

METHODOLOGY

The primary objective of this study was to estimate the cost-price relationship of producing and marketing the red maple as a balled and burlapped ornamental shade tree. A production system (Method 1) was modeled which grew the trees up to five years from seed and which harvested half of the trees in each of the last two years. An alternative system (Method 2) was modeled which grew the trees an additional year and which harvested about one-third of the trees in each of the last three years. The production systems were synthesized from conditions and cultural practices in Tennessee but are assumed to apply to USDA Climatic Zones 7 and 8. From the model production systems, variable costs per year to grow an acre of trees were estimated. To these were added annual fixed costs per acre on a model nursery to arrive at an estimated total cost per acre and per tree harvested.

Model Nursery

Since it would be unusual for an actual nursery to grow only one kind of tree, a model nursery was used for this study which was equipped to grow different types of woody ornamentals. The red maple was considered to be the representative species of shade tree on the nursery.

The characteristics of the model nursery used in this study are not the outcome of a specific research study to find the typical or

average characteristics of a small nursery in Tennessee or the South. However, the characteristics were developed and synthesized from years of research and familiarity with the nursery industry by members of the Technical Committee of the Southern Regional Research Project, S-103 and are assumed to be fairly consistent with known conditions. The members of this committee represent nine Southern State Agricultural Experiment Stations and include professionals in ornamental production and agricultural economics.

The nursery was modeled to represent the average size of a small nursery which averages about 45 acres (75). This model nursery consisted of 50 acres of which 40 acres were allocated for field production and 10 acres for seed beds, propagation areas, polyhouses, roads, buildings, and other uses.

Capital Requirements

The capital requirements for the model nursery are shown in Table 1. Land was valued at $2,000 per acre which is intended to represent productive land in the fertile nursery area of Middle Tennessee. The expected useful life of machinery and buildings, the initial costs, and the salvage values were estimated by the Agricultural Extension Service of the University of Tennessee for planning farm budgets (82). The costs are assumed to represent 1984 prices. Where information was not available for capital requirements specific to the nursery industry, the necessary data was estimated by members of the Technical Committee of the S-103 research project.

Most of the machinery was common farm equipment except for an articulated four-wheel drive front-end loader which can be fitted with

Table 1. Capital requirements for a small field nursery, USDA Climatic Zones 7 and 8, 1984

Item	Description	Unit	Useful life (years)	Quantity	Cost per unit	Total initial cost	Salvage value
					----------dollars----------		
Land and improvements	Unimproved land	acre	--	50	2,000	100,000	---
	Grading, road construction, gravel	---	20	---	---	25,530	---
Subtotal						125,530	
Buildings:							
Office and restrooms	20' x 40'	sq.ft.	20	800	25	20,000	---
Plant and supply storage	40' x 50'	sq.ft.	20	2,000	18	36,000	---
Machinery storage and shop	40' x 100'	sq.ft.	30	4,000	3	12,000	---
Polyhouse, no heat	24' x 96'	each	10	3	1,250	3,750	---
Polyhouse, with heat	24' x 96'	each	10	2	2,150	4,300	---
Subtotal						76,050	
Machinery and equipment:							
Tractor, 60 Hp	60 Hp, gas	each	10	1	19,380	19,380	4,250
Tractor, 35 Hp	35 Hp, gas	each	10	1	11,791	11,791	3,500
Tractor, 19 Hp	19 Hp, diesel, "Kubota"	each	10	1	7,695	7,695	2,600
Articulated front-end loader	"Swinger 320"	each	10	1	38,000	38,000	4,000
Forks	For loader	each	10	2	1,100	2,200	200
Tree spade	"CT20 3P"	each	4	1	4,695	4,695	450
Flatbed truck	1½ T, 24' bed	each	10	1	15,200	15,200	2,000
Plow	3-14" plows	each	10	1	1,600	1,600	160
Disk	8' wide, tandem	each	10	1	2,800	2,800	280
Harrow	10' wide	each	10	1	266	266	25

Table 1. (continued)

Item	Description	Unit	Useful life (years)	Quantity	Cost per unit	Total initial cost	Salvage value
					----------dollars----------		
Cultimulcher	10' wide	each	10	1	3,550	3,550	350
Rotovator	"Howard", 60"	each	10	1	2,300	2,300	230
Sprayer	100 gal. tank with booms	each	7	1	695	695	60
Sprayer	Solo backpack	each	10	1	115	115	---
Transplanter, 2-row	For 42"-48" rows	each	10	1	965	965	100
Transplanter, 2-row	For 20" rows	each	10	1	975	975	100
Transplanter, 1-row	For tree plants	each	10	1	475	475	50
Airblast sprayer	300 gal., trailer	each	7	1	3,600	3,600	514
Rotary tiller	8 Hp, reartine	each	10	1	1,150	1,150	100
Undercutter	50" blade	each	7	1	250	250	25
U blade	18" blade	each	7	1	250	250	25
Fertilizer sidedresser	2-row	each	10	1	860	860	85
Cultivator	2-row	each	7	1	625	625	50
Rotary mower	5' wide	each	8	1	925	925	100
Wagon	4 wheel	each	10	2	950	1,900	200
Truck	½ T, pickup	each	7	1	8,700	8,700	850
Package machine	For small plants	each	10	1	4,100	4,100	500
Pallets	Wooden	each	2	50	20	1,000	100
Shears	Electric	each	5	1	69	69	---
Cyclone seeder	Hand operated	each	20	1	25	25	---
Hand service tools	Miscellaneous	---	5	--	---	2,000	200
Irrigation system	Pumps, controls, pipes, nozzles-for drip system	---	20	1	8,000	8,000	500
	Mist system for propagation	each	10	2	500	1,000	100
Subtotal						147,156	
TOTAL						348,736	

hydraulic spades to dig large trees and with loading forks to lift heavy pallets. Two sizes of U blades were also included which are mounted behind regular tractors for undercutting nursery stock. This nursery was modeled with a drip irrigation system for field propagation and with polyhouses for propagation of cuttings with mist irrigation. A package machine was included for sleeve packing small plants.

The total initial cost for all capital requirements for this model 50 acre nursery was $348,736. This represents $125,530 (36% of the total) for the land and improvements, $76,050 (22% of the total) for the buildings, and $147,156 (42% of the total) for the machinery and equipment.

Annual Fixed Costs

From the capital requirements for the model nursery were estimated the annual fixed costs which are shown in Table 2. The annual fixed costs for the capital requirements include depreciation costs, interest costs, and insurance and taxes.

Depreciation costs represent the anticipated cost of replacement of the buildings and equipment after they are no longer useful. They were estimated by dividing the initial cost minus the salvage value by the expected years of useful life to arrive at an annual cost.

Interest cost for the land was estimated by multiplying the initial value by the annual interest rate. The annual interest costs for the other capital requirements were estimated by compounding the interest for the expected life of the machine, subtracting the future salvage value, and averaging the cost over the expected life of the machine.

Table 2. Annual fixed costs for a small field nursery[a], USDA Climatic Zones 7 and 8, 1984

Item	Description	Depreciation[b]	Interest[c]	Insurance and taxes[d]	Total
		dollars			
Land and improvements	Unimproved land	---	5,000	500	5,500
	Grading, road construction, graveling	1,277	2,110	128	3,515
Subtotal		1,277	7,110	628	9,015
Buildings:					
Office and restrooms	20' x 40'	1,000	1,653	400	3,053
Plant and supply storage	40' x 50'	1,800	2,976	720	5,496
Machinery storage and shop	40' x 100'	400	1,329	240	1,969
Polyhouse structure, no heat	24' x 96'	375	236	75	686
Polyhouse structure, with heat	24' x 96'	430	270	86	786
Subtotal		4,005	6,464	1,521	11,990
Machinery and equipment:					
Tractor, 60 Hp	60 Hp, gas	1,513	794	388	2,695
Tractor, 35 Hp	35 Hp, gas	829	392	236	1,457
Tractor, 19 Hp	19 Hp, diesel, "Kubota"	510	224	154	888
Articulated front-end loader	"Swinger 320"	3,400	1,990	760	6,150
Tree spade	hydraulic	1,061	140	94	1,295
Forks	For front-end loader	200	118	44	362
Flatbed truck	1½ T, 24' bed	1,320	756	304	2,380
Plow	3-14" plows	144	85	32	261
Disk	8' wide, tandem	252	148	56	456
Harrow	10' wide	24	14	5	43
Cultimulcher	10' wide	320	188	71	579
Rotovator	"Howard", 60"	207	122	46	375
Sprayer	100 gal. tank with booms	91	32	14	137
Sprayer	Solo backpack	12	7	2	21
Transplanter, 2-row	For 42"-48" rows	87	51	19	157
Transplanter, 2-row	For 20" rows	88	51	20	159

Table 2. (continued)

Item	Description	Depreciation	Interest	Insurance and taxes	Total
		dollars			
Transplanter, 1-row	For tree plants	43	25	10	78
Airblast sprayer	300 gal. on trailer	441	137	72	650
Rotary tiller	8 Hp, reartine	105	62	23	190
Undercutter	50" blade	32	11	5	48
U blade	18" blade	32	11	5	48
Fertilizer sidedresser	2-row	78	46	17	141
Cultivator	2-row	82	29	13	124
Rotary mower	5' wide	103	43	19	165
Wagon	4 wheel	170	99	38	307
Truck	½ T, pickup	1,121	385	174	1,680
Package machine	For small plants	360	208	82	650
Pallets	Wooden	450	1	--	451
Shears	Electric	14	4	1	19
Cyclone seeder	Hand operated	1	2	1	4
Hand and service tools	Miscellaneous	360	71	40	471
Irrigation system	Drip system	375	636	160	1,171
	Mist system	90	53	20	163
Subtotal		13,915	6,935	2,925	23,775
General overhead:					
Utilities	Telephone, elect., gas				4,250
General repairs and maintenance	Buildings and grounds				4,000
Licenses and bonds					325
Advertising and printing					1,200
Insurance, personnel	Workman"s comp., FICA, health, unemployment, etc.				7,488
Travel and entertainment					1,500
Professional fees					125
Administrative and management	Clerical, operators, and supervisory labor salaries				52,000

Table 2. (continued)

Item	Description	Depreciation	Interest	Insurance and taxes	Total
		dollars			
Miscellaneous	Office supplies				1,000
Subtotal					71,888
Interest on general overhead insurance, and taxes	Compounded at 5% per annum for 6 months				1,797
Total annual fixed cost					118,465

[a]Model small nursery: 50 total acres, 40 acres for field production, 10 acres for production facilities, holding area, propagation areas, roads, etc.

[b]Depreciation was estimated by dividing initial cost adjusted for salvage value by the years of useful life.

[c]Interest cost for land was estimated by multiplying the initial value of the land by the interest rate per annum, 5%. Interest cost on the buildings, land improvements, machinery and equipment was estimated by compounding the interest at 5% for the expected useful life, subtracting the future salvage value, and dividing by the years of useful life.

[d]Insurance and taxes: on the land and improvements, only taxes were assessed. Taxes were estimated at the rate of 2% per year of the assessed value which was 25% of the market value. For buildings and equipment, insurance and taxes were estimated at 2% of the initial cost.

The interest cost represents the opportunity cost of investment capital over the life of the machine. The interest cost of a loan would be less if less than 100% of the needed funds were borrowed.

Annual taxes on the land and improvements were computed as 2% of one-fourth of the initial value. The annual taxes plus insurance were estimated for the buildings and equipment at 2% of the initial value.

Also included in the annual fixed costs for the model nursery were the general overhead costs which included utility costs, general repair and maintenance costs, licences and bonds, advertising and printing, personnel insurance, travel and entertainment costs, professional fees, administrative and management salaries, and miscellaneous costs which included office supplies. The largest item in the general overhead costs was the administrative and management salaries which totaled to $52,000 per year. It was assumed for the model nursery that the owner would need to hire a secretary, an operation supervisor, and a manager.

Some general overhead costs would occur at the beginning of the year, some at the end of the year, and others would occur monthly throughout the year. Therefore, to estimate the annual interest cost for these funds the total annual general overhead cost was divided by two and multiplied by the interest rate to give an average cost.

Interest rates. Interest on money can be considered to be the cost of using that money or the rental charge of investment funds. If funds are borrowed, interest costs are real expenses when the loans are repayed. But if all the capital for a project is owned, interest costs are measured by the returns foregone by committing funds to a project

rather than investing them in the next best alternative use. Thus, the interest cost of capital over time is valued as the "opportunity cost."

The correct cost of capital to be used in an analysis is always debatable. Basically, it should be the rate of return on a project that will leave the market price of the firm's capital assets unchanged (35, p. 440). However, different firms with different debt ratios and debt limits will have different financing costs over time. The cost of equity capital ideally should be related to the expected rate of return on all assets in the entire economy. A weighted-average cost of capital for an individual firm is realistic but complex, and beyond the scope of this study. A simpler approach is to estimate the real interest rate by averaging the difference between the nominal interest rate and the inflation rate over a time period. Rather than define the "correct" real rate of interest for this study, several different rates were used which may approximate the real interest rate.

The summary of the annual fixed costs are shown in Table 3 for three different interest rates. Interest costs range from 12% of the total annual fixed costs with a real interest rate of 3%, to 25% of the total with a real interest rate of 7%. In all three cases, the management cost of $52,000 per year was the highest percentage of the total annual fixed costs ranging from 40% to 47% for the three rates.

Fixed costs per acre. The fixed costs on a nursery occur annually regardless of the amount of production which occurs during the year. They are considered to be indirect costs since they cannot be directly allocated to any particular operation on a nursery. Rather than divide

Table 3. Summary of annual fixed costs for a small field nursery using three different interest rates, USDA Climatic Zones 7 and 8, 1984

Item	Depre-ciation	Interest	Insurance & taxes	General overhead	Manage-ment	Total	Percentage
			Interest Rate at 5%				
Land & improvements	1,277	7,110	628	---	---	9,015	8
Buildings	4,005	6,464	1,521	---	---	11,990	10
Machinery & equipment	13,915	6,935	2,925	---	---	23,775	20
General overhead	---	1,797	---	19,888	52,000	73,685	62
Total	19,197	22,306	5,074	19,888	52,000	118,465	
Percentage of total	16	19	4	17	44		
Annual fixed costs per field production acre (40 acres)						2,962	
			Interest Rate at 3%				
Land & improvements	1,277	4,266	628	---	---	6,171	6
Buildings	4,005	3,878	1,521	---	---	9,404	8
Machinery & equipment	13,915	4,161	2,925	---	---	21,001	19
General overhead	---	1,078	---	19,888	52,000	72,966	67
Total	19,197	13,383	5,074	19,888	52,000	109,542	
Peecentage of total	18	12	5	18	47		
Annual fixed costs per field production acre (40 acres)						2,739	
			Interest Rate at 7%				
Land & improvements	1,277	9,954	628	---	---	11,859	9
Buildings	4,005	9,050	1,521	---	---	14,576	11
Machinery & equipment	13,915	9,709	2,925	---	---	26,549	21
General overhead	---	2,516	---	19,888	52,000	74,404	59
Total	19,197	31,229	5,074	19,888	52,000	127,388	
Percentage of total	15	25	4	16	40		
Annual fixed costs per field production acre (40 acres)						3,185	

the total annual fixed costs equally among all the plants grown, for this study the annual fixed costs were allocated equally among the 40 field production acres.

There were 10 acres on the model small nursery which were not involved directly with field production and so essentially added to the total costs occurring for field crops. The budget for growing red maples was estimated for growing one acre of trees. Other plants grown on the model nursery could also be budgeted per acre of field use. If only one acre of trees and nothing else was grown on the nursery, the entire annual fixed costs would be allocated to that acre. For this study, it was assumed that all 40 acres were in use at any one time so that each acre was allocated one-fortieth of the total annual fixed cost.

Model Production System

To estimate the costs of producing an acre of red maples, labor and equipment requirements were estimated for a production system. The production system was synthesized from a literature review and from interviews at 11 nurseries during the summer of 1984 in the McMinnville and Winchester areas of Middle Tennessee. Further discussion of this model production system can be found in Chapter IV, Results and Discussion.

The system created was a model or representative system and does not represent the practice of any one particular nursery. Each of the nurseries interviewed practiced different methods and used different machinery. For this study, a "high level management" system was assumed

so that the best practices and equipment were used. In several cases, the nurserymen interviewed reported doing one thing while knowing that another way was preferable or the "right way." In other cases, where it was not clear what the "right way" might be, information from literature was relied upon. Generally however, the method selected was representative of what is actually practiced by successful commercial field nurseries in Middle Tennessee and the equipment required was common to most of these nurseries. It was assumed that the model production system would also apply to any nursery in USDA Climatic Zones 7 and 8.

Once the production system was defined, each step in the process was described. The machine and manhours required for eacn step were then estimated. Time and motion studies were made to estimate the hours required for each operation. For operations which required self-propelled machinery, the time required to move through the field was estimated at: 3 miles per hour (mph) for plowing, cultivating, and undercutting; 5 mph for spraying; and 6 mph for disking and harrowing. To this was added 15 seconds for each turn-around in the field and 10 minutes to move the equipment to and from the field. The manhours amounted to the machine hours plus 15 minutes to prepare the machine before the operation, and to clean or disassemble after the operation. The times used were close to or slightly above the machine and manhours used for similar field operations in the Farm Planning Manual (81).

The manhours required for operations which were largely accomplished by hand were estimated by the time it should take to prepare, move through the field, and accomplish the task for each tree times the number of trees. These estimates in some cases were highly judgemental.

In all cases the times were rounded up so that some efficient workers may actually be able to accomplish them sooner, but others may take longer. It is very difficult to account for every task in production. At the end of the year, 20% of the total time required was added to cover unplanned activities.

A pickup truck is frequently used on a nursery. Rather than allocate transportation time for each trip to and from the field for carrying workers and materials, 10 hours of pickup use and 11 manhours of driving and loading time were allocated for each year after the seed bed stage. On a small nursery with 50 acres, assuming the acres are contiguous, the distances traveled would not be great. The hours allocated were assumed to be sufficient for one crop but would not cover trips to town or other general uses.

Annual Variable Costs

Once the machine and manhours were estimated for each operation, the costs for each operation were calculated. Data for estimating the cost per hour of use of machinery and equipment are shown in Table 4. The data were estimated by the University of Tennessee Agricultural Extension Service (81). Gasoline was at $1.25 per gallon and diesel fuel was $1.20 per gallon. Equipment without engines had an hourly cost based on expected repairs necessary after a year of use divided by the estimated number of hours of annual use. The estimated number of hours of use were approximations made by members of the S-103 Technical Committee. Hourly variable costs for machinery with engines included not only repair costs but also fuel and lubrication costs.

All labor hours were valued at $4.50. Prices for materials and chemicals were average 1984 prices. Contract fees to hand-dig, ball and burlap trees were $1.50 for 20" diameter balls and $1.75 for 22" balls. At these prices it was assumed that the diggers supplied all the burlap, twine and nails required. The only other contracted work was a high clearance tractor to undercut the trees in the propagation plot. Due to the necessity of these contracted services, it was necessary to assume that the model nursery was located in an area with other nurseries nearby so that these services were likely to be available.

Once the variable costs were estimated, and the annual fixed costs were allocated to the field production acre, the total costs for growing an acre of red maples with the model system were computed. The results are described in Chaper IV, Results and Discussion.

Table 4. Data for estimated cost per hour of use of machinery and equipment for a small field nursery, 1984.

Item	New cost (dollars)	Expected life (years)	Estimated annual use (hours)	Repairs (% of new cost)	Variable costs per hour[a] (dollars)
Tractor, 60 Hp	19,380	10	600	90	6.08
Tractor, 35 Hp	11,791	10	600	90	4.82
Tractor, 19 Hp	7,695	10	600	90	3.75
Articulated 4-wheel drive loader	38,000	10	600	90	9.42
Forks	1,100	10	600	90	.70
Flatbed truck	15,200	10	300	90	11.99
Plow	1,600	10	100	80	1.28
Disk	2,800	10	120	65	1.52
Harrow	266	10	120	65	.14
Cultimulcher	3,550	10	70	65	3.30
Rotovator	2,300	10	60	65	1.08
Sprayer, boom	695	7	150	80	.74
Sprayer, Solo backpack	115	10	60	90	.14
Transplanter, 2-row, 42" row	965	10	60	75	1.21
Transplanter, 2-row, 20"	975	10	60	75	1.22
Transplanter, 1-row	475	10	60	75	.59
Tree spade	4,695	4	60	80	3.47
Airblast sprayer, 300 gal.	3,600	7	200	80	3.32
Rotary tiller	1,150	10	400	65	.37
Undercutter (50")	250	7	60	75	.15
U blade (18")	250	10	60	75	.20
Fertilizer sidedresser, 2-row	860	10	90	65	.62
Cultivator, 2-row	625	7	120	85	.63
Rotary mower	925	8	125	180	2.67
Wagon, 4-wheel	950	10	525	40	.29
Cultivator, 4-row	2,650	7	120	85	1.68
Truck, ½ T pickup	8,700	7	535	90	6.50

Tabler 4. (continued)

Item	New cost (dollars)	Expected life (years)	Estimated annual use (hours)	Repairs (% of new cost)	Variable costs per hour[a] (dollars)
Package machine	4,100	10	60	65	2.48
Shears, electric	69	5	60	40	.10
Cyclone seeder	25	20	40	25	.02
Irrigation system	8,000	20	300	40	.75
Mist system	500	10	300	40	.25

[a]Includes fuel, lubrication cost and repairs. See: Planning Budgets for Fruits and Vegetables: A Supplement to the Farm Planning Manual, Agricultural Extension Service, The University of Tennessee, EC 890 (Revised), January, 1984.

CHAPTER IV

RESULTS AND DISCUSSION

Model Production System

A production system to grow red maples was modeled and is shown in Table 5. Method 1 grew the trees up to five years from seed and harvested half of the trees in each of the last two years. An alternative method (Method 2) was modeled which grew the trees an additional year but harvested about one-third of the trees in each of the last three years.

Loss Rates

It was assumed that 85% of the seeds planted germinated and were acceptable (80). Of the 3,202 seedlings planted in the propagation plot it was assumed that 85% successfully sprouted into acceptable liners. Of the 2,722 liners transplanted into the field it was assumed that 2,586 trees (95%) survived to be acceptable for marketing during the production period. The total loss rate after the seedling stage was thus assumed to be 20% which is consistent with previous studies (62) and with estimates made by nurserymen interviewed. By having a propagation plot for two years most of the below grade trees can be eliminated before going to the field which conserves the field space.

Seed Bed Stage

To start the model production system it was assumed that native red maple seeds which had just matured on the tree were purchased in

Table 5. Labor and equipment requirements for one acre of red maples (2,586 trees, B&B), USDA Climatic Zones 7 and 8, 1984

Time	Description	Equipment	Hours per 2,586 salable trees	
			Machine	Man
	METHOD 1 and METHOD 2			
Year 1 - Seed Bed Stage				
March	Land preparation for seed bed (seed bed 3'x90', 0.006 ac.) (3,767 seeds planted, 85% survival)			
	Rototill - 2 times (x)	Rotary tiller	0.50	0.75
	Rake	Hand	----	0.75
	Install mist irrigation lines	Hand	----	0.50
April	Plant seeds (as soon as available)	Hand broadcast	----	0.50
	Rake to cover seeds	Hand	----	0.75
April-October	Irrigate (as necessary for 16 wks. at 4 hrs./wk.)	Mist irrigation system		
	Fertilize (surface broadcast Osmocote[a] 18-6-12 at 1,000 lbs./ac.)	Hand	----	0.50
	Apply herbicide (Ronstar at 125 lbs./ac.)	Hand	----	0.50
	Apply insecticide (Malathion at 4 pts./ac. at 2 different times)	Backpack sprayer	0.50	1.00
	Pull weeds - throughout season	Hand	----	2.00
September	Land preparation for propagation plot (propagation plot consists of 0.5 ac., 32 rows 150' long with 4' between rows and 18" between plants in the row) (of 3,202 plants, 85% or 2,722 are transplanted to the field)			
	Plow	Tractor, 60 Hp/plow	0.60	0.85
	Disk - 2x	Tractor, 60 Hp/disk	0.75	1.00
	Harrow	Tractor, 60 Hp/harrow	0.45	0.70

Table 5. (continued)

Time	Description	Equipment	Hours per 2,586 salable trees Machine	Man
		METHOD 1 and METHOD 2		
November	Remove irrigation lines from seed bed	Hand	----	0.50
	Dig up seedlings	Tractor, 60 Hp/undercutter	0.50	0.75
	Collect and load seedlings	Hand	----	6.00
	Transport to holding area and unload	Tractor, 35 Hp/trailer	0.50	1.50
	Prune roots, grade, bundle	Hand	----	8.00
	Lay out propagation plot	Hand	----	2.00
	Load and transplant to propagation plot	Tractor, 35 Hp/trailer	0.50	1.50
	Plant seedlings	Tractor, 60 Hp/transplanter (1-row)	3.00	9.00
	Lay out drip irrigation lines	Hand	----	3.00
Year 2 - Propagation Stage				
January	Fertilize (surface broadcast Osmocote 18-6-12 at 1,000 lbs./ac.)	Cyclone seeder	1.00	1.25
May	Prune (cut back to 2" above the ground)	Hand	----	9.00
June	Stake new shoots and remove excess	Hand, stakes, tie tabs	----	13.50
April-October	Irrigate (as necessary for about 16 wks. at 4 hrs./wk.)	Drip irrigation system		
	Cultivate - 3 different times	Tractor, 19 Hp/cultivator	1.80	2.55
	Apply insecticide (Malathion at 4 pts./ac. at 2 different times)	Tractor, 19 Hp/airblast sprayer	1.00	1.50
	Apply herbicide (Ronstar at 125 lbs./ac. at 2 different times)	Cyclone seeder	1.00	1.25
	Prune - throughout season	Hand	----	34.00
	Weed - throughout season	Hand	----	8.00

Table 5. (continued)

Time	Description	Equipment	Hours per 2,586 salable trees Machine	Man
		METHOD 1 and METHOD 2		
Year 3 - Propagation Stage (cont.)				
January	Fertilize (surface broadcast Osmocote 18-6-12 at1,000 lbs./ac.)	Cyclone seeder	1.00	1.25
April-October	Irrigate (as necessary for about 16 wks. at 4 hrs./wk.)	Mist irrigation system		
	Cultivate - 3 different times	Tractor, 19 Hp/cultivator	1.80	2.55
	Apply insecticide (Malathion at 4 pts./ac. at 2 different times)	Tractor, 19 Hp/airblast sprayer	1.00	1.50
	Apply herbicide (Ronstar at 125 lbs./ac. at 2 different times)	Cyclone seeder	1.00	1.25
	Prune - throughout season	Hand	---	34.00
	Weed - throughout season	Hand	----	8.00
September	Prepare field for planting, plow in cover crop (field is one acre, 40 rows 272' long, 4' between rows and 4' between trees in the row) (of 2,722 trees planted, 95% or 2,586 are marketed)			
	Plow - 2x	Tractor, 60 Hp/plow	1.00	1.25
	Disk - 2x	Tractor, 60 Hp/disk	0.75	1.00
	Harrow - 2x	Tractor, 60 Hp/harrow	0.75	1.00
November	Transplant liners into field			
	Collect stakes and remove irrigation lines from propagation plot	Hand	----	12.00
	Dig up liners in propagation plot	Contracted high clearance tractor with U blade	1.00	----
	Collect and load liners	Hand.	----	24.00

Table 5. (continued)

Time	Description	Equipment	Hours per 2,586 salable trees Machine	Man
		METHOD 1 and METHOD 2		
	Transport liners to holding area	Flatbed truck/trailer	0.50	2.00
	Prune roots, grade, bundle	Hand	----	26.00
	Lay out field	Hand	----	3.00
	Load and transport liners	Flatbed truck/trailer	0.50	2.00
	Plant bare root liners	Tractor, 60 Hp/transplanter (1-row)	4.50	16.00
	"Firm up"	Hand	----	12.00
	Prepare propagaion plot for cover crop			
	Plow	Tractor, 60 Hp/plow	0.60	0.85
	Disk - 2x	Tractor, 60 Hp/disk	0.75	1.00
	Harrow	Tractor, 60 Hp/harrow	0.45	0.70
Year 4 - Field Stage				
January	Fertilize (surface broadcast Osmocote 18-6-12 at 830 lbs./ac.)	Cyclone seeder	2.00	2.25
April-October	Cultivate - 3 different	Tractor, 19 Hp/cultivator	3.60	4.35
	Apply insecticide (Malathion at 4 pts./ac. at 2 different times)	Tractor, 19 Hp/airblast sprayer	1.50	2.00
	Apply herbicide			
	Goal at 1,5 gal./ac.	Tractor, 19Hp/boom sprayer	0.75	1.00
	Roundup at 1 gal./ac.	Tractor, 19 Hp/boom sprayer	0.75	1.00
	Surflan at 2.5 qts./ac.			
	Prune and weed - throughout season	Hand	----	30.00
November	Harvest 50% of trees (1,293), 1¼"-1½" cal. with 20" dia. root balls)	Custom hand-dug, B&B at $1.50/tree		
	Take pallets to the field	Pickup truck	3.00	9.00

Table 5. (continued)

Time	Description	Equipment	Hours per 2,586 salable trees Machine	Man
		METHOD 1 and METHOD 2		
	Load trees onto pallets in the field	Hand	----	32.00
	Load pallets onto trailer	Front-end loader/forks	6.00	24.00
	Transport to holding area	Tractor, 35 Hp/trailer	6.00	18.00
		Front-end loader	6.00	6.00
	Unload pallets from trailer	Front-end loader/forks	4.00	16.00
Year 5 - Field Stage (cont.)				
January	Fertilize (surface broadcast Osmocote 18-6-12 at 830 lbs./ac.)	Cyclone seeder	2.00	2.25
April-October	Cultivate - 3 different times	Tractor, 19 Hp/cultivator	3.60	4.35
	Apply insecticide (Malathion at 4 pts./ac. at 2 different times)	Tractor, 19 Hp/airblast sprayer	1.50	2.00
	Apply herbicide			
	Goal at 1.5 gal./ac.	Tractor, 19 Hp/boom sprayer	0.75	1.00
	Roundup at 1 gal./ac.	Tractor, 19 Hp/boom sprayer	0.75	1.00
	Surflan at 2.5 qts./ac.			
	Prune and weed - throughout season	Hand	----	30.00
November	Harvest 50% of trees (1,293), 1½"-1 3/4" caliper, 22" root balls	Custom hand-dug, B&B at $1.75/tree		
	Take pallets to field	Pickup truck	3.00	9.00
	Load trees onto pallets in field	Hand	----	32.00
	Load pallets onto truck/trailer	Front-end loader/forks	6.00	24.00
	Transport to holding area	Flatbed truck/trailer	3.00	9.00
		Front-end loader	3.00	3.00
	Unload pallets from truck/trailer	Front-end loader/forks	4.00	16.00

Table 5. (continued)

Time	Description	Equipment	Hours per 2,586 salable trees Machine	Man
	METHOD 1 and METHOD 2			
	Prepare field for cover crop			
	Plow - 2x	Tractor, 60 Hp/plow	1.50	1.75
	Disk - 2x	Tractor, 60 Hp/disk	0.75	1.00
	Harrow - 2x	Tractor, 60 Hp/harrow	0.75	1.00
Throughout 5-year cycle	Transport workers and materials	Pickup truck	40.00	44.00
	METHOD 2			
Year 6 - Field Stage (cont.)				
January	Fertilize (surface broadcast Osmocote 18-6-12 at 830 lbs./ac.)	Cyclone seeder	2.00	2.25
April-October	Cultivate - 3 different times	Tractor, 19 Hp/cultivator	3.60	4.35
	Apply insecticide (Malathion at 4 pts./ac. at 2 different times)	Tractor, 19 Hp/airblast sprayer	1.50	2.00
	Apply herbicide			
	Goal at 1.5 gal./ac.	Tractor, 19 Hp/boom sprayer	0.75	1.00
	Roundup at 1 gal./ac. Surflan at 2.5 qts./ac.	Tractor, 19 Hp/boom sprayer	0.75	1.00
	Prune and weed - throughout season	Hand	----	30.00
Throughout year	Transport workers and materials to field	Pickup truck	10.00	11.00

Table 5. (continued)

Time	Description	Equipment	Hours per 2,586 salable trees Machine	Man
	REVISED HARVEST SCHEDULE WITH METHOD 2			
Year 4	Harvest 35% of trees (905), 1¼"-1½" cal. with 20" root balls	Custom hand-dug, B&B at $1.50/tree		
	Take pallets to field	Pickup truck	2.00	6.00
	Load trees onto pallets in field	Hand	----	24.00
	Load pallets onto trailer	Front-end loader/forks	4.00	16.00
	Transport to holding area	Tractor, 35 Hp/trailer	4.00	12.00
		Front-end loader	4.00	4.00
	Unload pallets from trailer	Front-end loader/forks	3.00	12.00
Year 5	Harvest 35% of trees (905), 1½"- 1 3/4" caliper with 22" root balls	Custom hand-dug, B&B at $1.75/tree		
	Take pallets to field	Pickup truck	2.00	6.00
	Load trees onto pallets in field	Hand	----	24.00
	Load pallets onto truck/trailer	Front-end loader/forks	4.00	16.00
	Transport to holding area	Flatbed truck/trailer	2.00	6.00
		Front-end loader	2.00	2.00
	Unload pallets from truck/trailer	Front-end loader/forks	3.00	12.00
Year 6	Harvest 30% of trees (776), 1 3/4"-2" caliper with 24" root balls			
	Take pallets to dield	Pickup truck	2.00	6.00
	Machine dig trees and load onto pallets	Front-end loader/tree spade	78.00	234.00
	Load pallets onto truck/trailer	Front-end loader/forks	4.00	16.00
	Transport to holding area	Flatbed truck/trailer	2.00	6.00
		Front-end loader	2.00	2.00
	Unload pallets from truck/trailer	Front-end loader/forks	3.00	12.00

[a]Trade names which appear are intended as examples not as endorsements

the same spring from a Northern or North Central source. They were planted as soon as available in a 3' x 90' seed bed which had been rototilled and raked by hand. The seeds were broadcast by hand about 15 to 30 per square foot and were raked to cover with ¼" to 1" of soil. Mist irrigation was installed, and a few weeks after germination the seedlings were fertilized with a slow-release granular fertilizer at 180 pounds of nitrogen per acre. After the seedlings had gained some height, a granular pre-emergence herbicide was broadcast by hand. Before and after this treatment, weeds were pulled by hand when they developed. It was assumed that if the seed beds were used frequently, the problem with perennial weeds would not be great and bed sterilization would not be necessary. An insecticide was sprayed with a backpack sprayer twice in the season.

At the end of the season, it was assumed that the seedlings selected for transplanting were from 18" to 24" tall. The entire seed bed was undercut by a tractor straddling the bed pulling a U blade which cuts through the soil under the seedlings. With the soil loosened, the seedlings can be easily pulled out. The roots which were not cut by the U blade were pruned by hand when the seedlings were bundled and graded in preparation for transplanting to the propagation plot.

Propagation Stage

The propagation plots were one-half an acre in size. They were not part of the 40 acres of production area on the model nursery. The trees stayed in the propagation plot for two years and the plots were left fallow for one year. For continual production therefore, an acre of red maples required the use of a propagation plot for three years.

At least six weeks before planting, the cover crop on the propagation plot was turned over with a plow, disked twice, and harrowed. The seedlings were planted using a 1-row transplanter which breaks open a furrow in the soil and then pushs the soil back to close the furrow. Either one or two men can sit on the transplanter slipping the seedlings into the open furrow. Since the soil is still loose after the transplanting, men must follow to pack the soil around the plants with their feet to "firm-up" the seedlings.

The progagation plot was one-half an acre with 32 rows 150' long four feet apart. The seedlings were planted about 18" apart in the row in the fall as soon as possible after they had been removed from the seed bed. Drip irrigation lines were extended along each row. Normally, winters are wet enough that irrigation is not necessary except to assure an initial successful transplant. During about 16 weeks of the growing season water was assumed to be necessary. Even though most of the height growth of the tree occurs before July, root growth continues and stores energy for the following season.

In May, when the plants were well established the stems were pruned off, or cut back to about 2" above the soil. The best sprouts which developed were selected a few weeks later and tied to stakes to assure that they weren't knocked over. The excess sprouts were removed then and any time they appeared during the rest of the season until the dominant sprout inhibited further sprouting. Pruning and inspection of plants was a continual process throughout the year. For pruning, 34 manhours were allocated per year for the one-half acre plot. It was assumed that about three hours a month would be adequate to walk through

the plot for inspecting and pruning. This stage of the cycle needs more attention than the field stage which was allocated 30 manhours per year for pruning an acre of trees.

The maples were kept in the propagation plot for two years. The plot was fertilized with a slow-release fertilizer at 180 pounds of nitrogen per acre to assure maximum root growth. The fertilizer which had a slow-release formula for nine months was applied in January. This assured good growth of roots and sprouts in the early part of the first season. In the subsequent seasons it assured that the nitrogen level was not high in the fall causing delayed dormancy which would delay transplanting or harvesting.

A small tractor (40" wide) moved between the rows with a cultivator three times during the season. The cultivator removed weeds but more importantly, removed the maple root fans from the top three inches of soil which stimulated adventitious rooting to create a deeper and denser rootball.

Insecticide was applied twice in the season using an airblast sprayer pulled by a small tractor between the rows. Because the plants were small when transplanted to the propagation plot, and were under five feet tall at the beginning of the second season, a granular post-emergence herbicide was used. This was broadcast with a hand operated spreader. Several times during the season perennial or persistent weeds were removed from within the rows by hand or hoe. Pruning during these two years involved removing lower branches up to about four feet from the ground. This creates a long straight stem or "whip" and encourages more growth at the top of the tree.

At the end of the second season in the propagation plot, the whips were assumed to be six to eight feet tall. A special high clearance tractor straddling the rows moved over the trees and pulled a U blade which cut through the soil under the roots. The whips were easily removed from the loose soil and freed of earth so their roots were bare. The whips were transplanted from the propagation plot with a flatbed truck and trailer to a holding area. The trees which were below grade were culled and the select trees were bundled by size. Any long roots which had not been cut by the U blade were pruned by hand.

Field Production Stage

As soon as possible in the fall after the bare root whips were ready they were transplanted into the field. They were planted four feet apart in rows four feet apart with 2,722 trees per acre. A one-row transplanter was used with two men placing the whips into the open furrow before the transplanter pushed the soil back. Men also were needed to "firm-up" the whips by tamping with their feet.

Fertilization in the field was at a nitrogen rate of 150 pounds per acre. The fertilizer was applied with a hand operated spreader in January. There was no irrigation in the field.

Because the trees were over five feet tall, liquid herbicides were applied with boom sprayers pulled about 20" above the ground by a small tractor moving between the rows. A pre-emergence herbicide was applied early in the season. In mid-summer, another pre-emergence herbicide was applied in a tank mixture with a post-emergence herbicide for perennial or persistent weeds which may have appeared. A small tractor pulled a

cultivator between the rows three times in the season to remove weeds and to prune the maple roots. Insecticide was applied with an airblast sprayer pulled between the rows twice in the season.

Pruning in the field continued throughout the season. The goal at this stage was to shape the crown of the tree and to remove unsightly branches or sprouts. While in the field, the pruner can also easily pull any persistent weeds.

Harvest

Trees up to, but not including two inches in diameter were hand-dug, balled and burlapped. This operation was contracted at $1.50 per tree for the 20" diameter root balls and $1.75 per tree for the 22" balls. The custom diggers leave the B&B trees next to the hole in the field. A four man crew later brings wooden pallets to the field and loads the trees by hand onto the pallets. A loader, fitted with forks then lifted the pallets onto a trailer.

During the first harvest when the field was still filled with trees, a small tractor with a trailer was used to transport the loaded pallets to the holding area. After this harvest, since many trees had been removed from the field, a flatbed truck with trailer could move through the field to carry out the loaded pallets. With only one loader in this model, the loader had to follow the truck or tractor to the holding area to unload them there either for eventual sale or directly onto semi-truck trailers for shipment.

The trees with two inches or more in trunk diameter were harvested with 24" diameter root balls which required machinery. The front-end

loader fitted with a hydraulic tree spade was used to dig and lift the tree balls into wire baskets lined with burlap. It then lifted the trees onto pallets in the field. About 10 trees were assumed to be dug per hour. When the digging was finished, the tree spade was removed from the loader, loading forks were fitted on, and the loader returned to the field to load the pallets onto a flatbed truck and trailer. A three-man crew was necessary for the digging, and a four-man crew for the loading and transporting.

It was assumed that trees harvested were progressively larger each year. It was also assumed that grading of trees before transplanting into the field would allow trees of different size to be planted in rows so that harvest could remove an entire row. This allows truck aisles for removing the larger trees the following years. Method 1 assumed harvesting every other row. Method 2 assumed harvesting every third row at the first harvest and every other remaining row at the second harvest so that at the third harvest, there were 12' truck aisles beside the remaining rows.

Harvest Cost Per Tree

The total variable costs required to harvest trees by the different methods were calculated and are shown in Table 6. The costs per tree were indentical for the hand-dug trees for Method 1 and Method 2. The harvest variable cost for the 20" diameter balls was estimated to be $2.03, and for the 22" balls, $2.22 per tree.

The mechanical harvest in the third harvest of Method 2 was estimated to be $7.56 per tree. This high cost was due to not only the

Table 6. Harvest costs per tree

Cost	METHOD 1		METHOD 2			
	First harvest 1,293 trees	Second harvest 1,293 trees	First harvest 905 trees	Second harvest 905 trees	Third - 776 (mechanical w/ baskets)	Third - 776 (mechanical w/o baskets)
	dollars					
Equipment	207.88	185.80	141.96	127.24	1,132.66	1,132.66
Labor	472.50	418.50	333.00	297.00	1,242.00	1,593.00
Subtotal	680.38	604.30	474.96	424.24	2,374.66	2,725.66
Subtotal per tree	0.53	0.47	0.52	0.47	3.06	3.51
Custom digging per tree	1.50	1.75	1.50	1.75	----	----
Materials per tree	----	----	----	----	4.50	0.50
Total harvest variable costs per tree	2.03	2.22	2.02	2.22	7.56	4.01

large number of machine and manhours required, but also to the high cost of wire baskets and pre-sewn burlap liners. The wire baskets are preferred to secure the larger root balls, and the burlap liners with the baskets make balling and burlapping a quicker and easier task. It would be possible to use conventional burlap sheets pinned with nails and tied with twine. The extra work with this method was assumed to require at least another man to match the pace of the basket and liner method. Mechanical harvest without wire baskets and liners was estimated to be $4.01 per tree.

Price Per Tree

Average wholesale prices for trees were gathered from published nursery catalogs for 1984 and are shown in Table 7. There was a range of about $5 to $10 for most sizes except for the 10' -12' size which more often was very close to $25 per tree when sold 10 trees at a time. The ranges of prices varied the most after the two inch caliper size. Prices did not vary a great amount from 1982 to 1984.

Table 7. Expected height, caliper size, and average price of red maple trees, balled and burlapped, 1984

Year	Height (feet)	Caliper (inches)	Root ball diameter (inches)[a]	Price (dollars)
4	8-10	1¼-1½	20	15.00
5	10-12	1½-1 3/4	22	25.00
6	12-14	1 3/4- 2	24	30.00

[a]American Standards for Nursery Stock (34)

Ball Weight

Estimations of the weight of the soil removed with the root balls were made by calculating the volume of a cone of the appropriate size, and multiplying by a soil weight of 80 pounds per cubic foot. This soil weight is the average of the common estimation of from three to four million pounds of weight per acre foot of dry surface soil (13). The estimation for a root ball 20" in diameter was 97 pounds, for a 22" ball was 129 pounds, and for a 24" ball was 167 pounds. To these figures 10% of the weight was added for the weight of the tree and roots, so that the three sizes of trees were estimated to weigh 107 pounds, 142 pounds, and 184 pounds for the three sizes respectively. Trees weighing more than 150 pounds were assumed to be too difficult for men to handle without a machine.

Soil Loss and Cover Crop

Harvesting trees by balling and burlapping removes a large amount of soil from the field. The nursery is selling soil along with the tree. By the two harvest methods modeled, the loss of soil per acre would be 146 tons and 167 tons. This would amount to an estimated 73 tons of soil removed per year by Method 1 and about 56 tons of soil loss per year during the three harvest years in Method 2. There is clearly a need for some way of rebuilding the soil between harvests if continual production is expected. This is an important cost of production which needs to be considered and needs more research. Short of fallowing the land for an undetermined length of time or using green manure crops, the problem could be handled by hauling in fresh

topsoil. Since there was no clear indication from research or from interviews on how to best address this problem, for this model production system the land was merely left fallow with a cover crop for a year. This system would necessarily assume a sufficiently deep topsoil initially and would not be adequate for a long-run production system.

For the model, the nursery was assumed to be only responsible to plow and level the field after the last tree harvest. It may be necessary to grade the field to level it satisfactorily, but it was assumed that doubling the requirements for plowing, disking, and harrowing would accomplish the task or cover the additional cost if grading was required. Rather than estimate the cost of establishing a cover crop in the fallow years it was assumed that the land was leased to a farmer for a nominal fee to grow a hay crop. After the last harvest of hay, the nursery would then plow the field again in preparation for the next tree crop.

Transportation Cost Per Tree

Transportation costs to various market centers from Nashville, Tennessee were calculated and are shown in Table 8. Based on the estimated weight of the trees and the limit of 40,000 pounds for a load on a 5-axle truck, the number of trees per truckload were estimated. The cost per trip to several market centers from Nashville were estimated using distances from a Rand McNally atlas. In 1980, an informal survey indicated costs per mile for a 5-axle truck to range from $1.20 to $1.50 (18). For the current study an estimated average cost per mile of $1.50 was assumed. From the cost per trip and the number of trees per trip, the transportation cost per tree was estimated to various market centers.

Table 8. Transportation cost per tree from Nashville, Tennessee

-----TREES PER TRUCKLOAD-----			----COST PER TRIP FROM NASHVILLE, TN--			
Size of rootball diameter (inches)	Weight of tree (lbs.)	No. of trees per truckload[a]	Destination	Miles[b]	Cost per mile	Cost per trip
					-----dollars------	
20	107	373	Chicago	451	1.50	677
22	142	281	Pittsburg	559	1.50	839
24	184	217	New York	949	1.50	1,424
			Atlanta	252	1.50	378
			Wash., D.C.	600	1.50	900

TRANSPORTATION COST PER TREE FROM NASHVILLE, TENNESSEE

		20" rootball		22" rootball		24" rootball	
Destination	Cost/ trip($)	Trees/ trip	Cost/ tree($)	Trees/ trip	Cost/ tree($)	Trees/ trip	Cost/ tree($)
Chicago	677	373	1.82	281	2.41	217	3.12
Pittsburg	839	373	2.25	281	2.99	217	3.87
New York	1,424	373	3.82	281	5.07	217	6.56
Atlanta	378	373	1.01	281	1.35	217	1.74
Wash., D.C.	900	373	2.41	281	3.20	217	4.15

[a] 40,000 lbs./truckload (5-axle truck)

[b] distances from Rand McNally atlas

Cost of Production

Annual Variable Costs

Annual variable costs were estimated from the labor and equipment requirements for the model production system and are shown in Table 9. Method 1 grew the trees up to five years from seed. The model system allows for one year of growth for the seedling in the seed bed. An additional year in the seed bed would only add $43 to the budget. The total undiscounted variable costs with model production Method 1 was $13,117 for an acre of trees, or an average of $5.07 per tree for 2,586 salable trees.

With Method 2, the trees were assumed to be grown for an additional year with a different harvest schedule. The reduction of costs for Year 4 and Year 5 due to fewer trees being harvested in these two years were calculated and the additional costs of keeping some of the trees in the field for an additional year were estimated. The total undiscounted variable costs with Method 2 summed to $18,921 for an acre of trees, or an average cost per tree of $7.32.

Annual Total Costs and Returns Per Tree

Annual total costs were estimated by summing the annual variable costs and the annual fixed costs for each year, and are shown in Table 10. The annual fixed costs were allocated only to the years for which the field production acres were in use for that particular crop. Method 1 and Method 2 each assumed a year of fallow for the acerage. Thus the total production costs for Method 1 included three years of

Table 9. Estimated annual variable costs of producing one acre of red maples (2,586 salable trees, B&B) up to five years from seed (Method 1) and up to six years from seed (Method 2), USDA Climatic Zones 7 and 8, 1984

Description	Unit	Quantity	Price per unit	Total cost
			----dollars-------	
METHOD 1 and METHOD 2				
Year 1 - Seed Bed Stage				
Materials:				
Seeds (dewinged red maple)	lb.	0.17	5.80	0.99
Chemicals:				
Osmocote[a]	50 lb.	0.12	39.00	4.68
Ronstar	100 lb.	(0.75 lb.)	80.00	0.60
Malathion	gal.	0.024	18.66	0.45
Machinery and equipment:				
Mist irrigation	hr.	64.00	0.25	16.00
Rotary tiller	hr.	0.50	0.37	0.19
Backpack sprayer	hr.	0.50	0.14	0.07
Tractor, 60 Hp	hr.	2.30	6.08	13.98
Plow	hr.	0.60	1.28	0.77
Disk	hr.	o.75	1.52	1.14
Harrow	hr.	0.45	0.14	0.06
Tractor, 35 Hp	hr.	1.00	4.82	4.82
Undercutter, 50"	hr.	0.50	0.15	0.08
Trailer	hr.	1.00	0.29	0.29
Labor:				
Hired	hr.	42.05	4.50	189.23
Additional 20%	hr.	8.41	4.50	37.85
Subtotal				271.20
Interest on operating capital at 5% for six months				6.78
Total				277.98

Cost of keeping seedlings in seed bed an additional year:

Chemicals	$5.73
Machinery and equipment	16.07
Labor	21.60
Total	$43.40

Table 9. (continued)

Description	Unit	Quantity	Price per unit	Total cost
			-----dollars------	
METHOD 1 and METHOD 2				
Year 2 - Propagation Stage				
Chemicals:				
Osmocote	50 lb.	10.00	39.00	390.00
Ronstar	100 lb.	1.25	80.00	100.00
Malathion	gal.	0.50	18.66	9.33
Materials:				
Stakes	ea.	3,202.00	0.50	1,601.00
Tie tabs	cart.	1.00	4.75	4.75
Machinery and equipment:				
Drip irrigation	hr.	75.00	0.75	56.25
Cyclone seeder	hr.	2.00	0.02	0.04
Tractor, 19 Hp	hr.	2.80	3.75	10.50
Cultivator	hr.	1.80	1.08	1.94
Airblast sprayer	hr.	1.00	3.32	3.32
Pickup truck	hr.	10.00	6.50	65.00
Labor:				
Hired	hr.	82.05	4.50	369.23
Additional 20%	hr.	16.41	4.50	73.85
Subtotal				2,685.21
Interest on operating capital at 5% for six months				67.13
Total				2,752.34

Table 9. (continued)

Description	Unit	Quantity	Price per unit	Total cost
			-----dollars------	
METHOD 1 and METHOD 2				
Year 3 - Propagation Stage (cont.)				
Chemicals:				
Osmocote	50 lb.	10.00	39.00	390.00
Ronstar	100 lb.	1.25	80.00	100.00
Malathion	gal.	0.50	18.66	9.33
Machinery and equipment:				
Drip irrigation	hr.	75.00	0.75	56.25
Cyclone seeder	hr.	2.00	0.02	0.04
Tractor, 19 Hp	hr.	2.80	3.75	10.50
Cultivator	hr.	1.80	1.08	1.94
Airblast sprayer	hr.	1.00	3.32	3.32
Pickup truck	hr.	10.00	6.50	65.00
Tractor, 60 Hp	hr.	8.80	6.08	53.50
Plow	hr.	1.60	1.28	2.05
Disk	hr.	1.50	1.52	2.28
Harrow	hr.	1.20	0.14	0.17
Flatbed truck	hr.	1.00	11.99	11.99
Trailer	hr.	1.00	0.29	0.29
Transplanter (1-row)	hr.	4.50	0.59	2.66
Labor:				
Hired	hr.	162.35	4.50	730.58
Additional 20%	hr.	32.47	4.50	146.12
Contracted high clearance tractor	hr.	1.00	55.00	55.00
Subtotal				1,641.02
Interest on operating capital at 5% for six months				41.02
Total				1,682.04

Table 9. (continued)

Description	Unit	Quantity	Price per unit	Total cost
			-----dollars------	
	METHOD 1			
Year 4 - Field Stage				
Chemicals:				
Osmocote	50 lb.	16.60	39.00	647.40
Malathion	gal.	1.00	18.66	18.66
Goal	gal.	1.50	54.00	81.00
Roundup	gal.	1.00	84.00	84.00
Surflan	gal.	0.625	59.00	36.88
Machinery and equipment:				
Cyclone seeder	hr.	2.00	0.02	0.04
Tractor, 19 Hp	hr.	6.60	3.75	24.75
Cultivator	hr.	3.60	1.08	3.89
Airblast sprayer	hr.	1.50	3.32	4.98
Boom sprayer	hr.	1.50	0.74	1.11
Pickup truck	hr.	13.00	6.50	84.50
Articulated front-end loader	hr.	16.00	9.42	150.72
Tractor, 35 Hp	hr.	6.00	4.82	28.92
Loading forks	hr.	10.00	0.70	7.00
Trailer	hr.	6.00	0.29	1.74
Labor:				
Hired	hr.	156.60	4.50	704.70
Additional 20%	hr.	31.32	4.50	140.94
Custom B&B	tree	1,293.00	1.50	1,939.50
Subtotal				3,960.73
Interest on operating capital at 5% for six months				99.02
Total				4,059.75
	METHOD 2			
Reduction of costs with alternative harvest schedule (905 trees)				
Machinery and equipment		$65.92		
Labor		167.40		
Custom digging		582.00		
Total reduction		$815.32		
Subtotal Year 4				$3,960.73
Total reduction				-815.32
Revised subtotal Year 4				3,145.41
Interest on operating capital				78.64
Revised total Year 4				$3,224.05

Table 9. (continued)

Description	Unit	Quantity	Price per unit	Total cost
			-----dollars------	
METHOD 1				
Year 5 - Field Stage (cont.)				
Chemicals:				
Osmocote	50 lb.	16.60	39.00	647.40
Malathion	gal.	1.00	18.66	18.66
Goal	gal.	1.50	54.00	81.00
Roundup	gal.	1.00	84.00	84.00
Surflan	gal.	0.625	59.00	36.88
Machinery and equipment:				
Cyclone seeder	hr.	2.00	0.02	0.04
Tractor, 19 Hp	hr.	6.60	3.75	24.75
Cultivator	hr.	3.60	1.08	3.89
Airblast sprayer	hr.	1.50	3.32	4.98
Boom sprayer	hr.	1.50	0.74	1.11
Pickup truck	hr.	13.00	6.50	84.50
Articulated front-end loader	hr.	13.00	9.42	122.46
Loading forks	hr.	10.00	0.70	7.00
Flatbed truck	hr.	3.00	11.99	35.97
Trailer	hr.	3.00	0.29	0.87
Tractor, 60 Hp	hr.	3.00	6.08	18.24
Plow	hr.	1.50	1.28	1.92
Disk	hr.	0.75	1.52	1.14
Harrow	hr.	0.75	0.14	0.11
Labor:				
Hired	hr.	148.35	4.50	667.58
Additional 20%	hr.	29.67	4.50	133.52
Custom B&B	tree	1,293.00	1.75	2,262.75
Subtotal				4,238.77
Interest on operating capital at 5% for six months				105.97
Total				4,344.74

METHOD 2

Reduction of costs with alternative harvest schedule (905 trees) and with clearing of the field moved to the sixth year:		
Machinery and equipment	$79.97	
Labor	166.05	
Custom digging	679.00	
Total reduction	$925.02	
Subtotal Year 5		$4,238.77
Total reduction		-925.02
Revised subtotal Year 5		3,313.75
Interest on operating capital		82.84
Revised total Year 5		$3,396.59

Table 9. (continued)

Description	Unit	Quantity	Price per unit	Total cost
			-----dollars------	
	METHOD 2			
Year 6 - Field Stage (cont.)				
Chemicals:				
Osmocote	50 lb.	16.60	39.00	647.40
Malathion	gal.	1.00	18.66	18.66
Goal	gal.	1.50	54.00	81.00
Roundup	gal.	1.00	84.00	84.00
Surflan	gal.	0.625	59.00	36.88
Machinery and equipment:				
Cyclone seeder	hr.	2.00	0.02	0.04
Tractor, 19 Hp	hr.	6.60	3.75	24.75
Cultivator	hr.	3.60	1.08	3.89
Airblast sprayer	hr.	1.50	3.32	4.98
Boom sprayer	hr.	1.50	0.74	1.11
Pickup truck	hr.	12.00	6.50	78.00
Articulated front-end loader	hr.	87.00	9.42	819.54
Tree spade	hr.	78.00	3.47	270.66
Loading forks	hr.	7.00	0.70	4.90
Flatbed truck	hr.	2.00	11.99	23.98
Trailer	hr.	2.00	0.29	0.58
Tractor, 60 Hp	hr.	3.00	6.08	18.24
Plow	hr.	1.50	1.28	1.92
Harrow	hr.	0.75	1.52	1.14
Disk	hr.	0.75	0.14	0.11
Materials:				
Wire baskets	ea.	776.00	2.50	1,940.00
Burlap liners, twine	ea.	776.00	2.00	1,552.00
Labor:				
Hired	hr.	331.35	4.50	1,491.08
Additional 20%	hr.	66.27	4.50	298.22
Subtotal				7,403.08
Interest on operating capital at 5% for six months				185.08
Total				7,588.16

Table 9. (continued, summary)

Year	Chemicals	Materials	Machinery, Equipment	Labor	Contract Services	Total[b]
	dollars					
			METHOD 1			
1	5.73	0.99	37.40	227.08	----	271.20
2	499.33	1,605.75	137.05	443.08	----	2,685.21
3	499.33	----	209.99	876.70	55.00	1,641.02
4	867.94	----	307.65	845.64	1,939.50	3,960.73
5	867.94	----	306.98	801.10	2,262.75	4,238.77
Tot.	2,740.27	1,606.74	999.07	3,193.60	4,257.25	12,796.93
% of tot.	21.4	12.6	7.8	25	33.2	
			METHOD 2			
1	5.73	0.99	37.40	227.08	----	271.20
2	499.33	1,605.75	137.05	443.08	----	2,685.21
3	499.33	----	209.99	876.70	----	1,641.02
4	867.94	----	227.73	678.24	1,357.50	3,145.41
5	867.94	----	227.01	635.05	1,583.75	3,313.75
6	867.94	3,492.00	1,253.84	1,789.30	----	7,403.08
Total	3,608.21	5,098.74	2,107.02	4,649.45	2,996.25	18,459.67
% of tot.	19.6	27.6	11.4	25.2	16.2	

[a]The use of trade names is for illustration only and does not constitute an endorsement of any product.

[b]Does not include interest costs on operating capital

Table 10. Total annual variable and fixed costs for producing one acre of red maples (2,586 salable trees, B&B), USDA Climatic Zones 7 and 8, 1984

Year	Variable costs[a]	Fixed costs[a]	Sub-total	Compounded[b] subtotal	Avg. cost per tree to date	Trees sold	Tot. cost per tree sold	Price per tree	Net returns per tree
	dollars						dollars		
				METHOD 1					
1	278	---	278	322	0.12				
2	2,752	---	2,752	3,034	1.29				
3	1,682	2,962	4,644	4,876	3.18				
4	4,060	2,962	7,022	7,022	5.90				
Total				15,254		1,293 (8'-10')	11.80	15.00	3.20
5	4,345	2,962	7,307	8,070	12.14	1,293 (10'-12')	6.24	25.00	18.76
Total	13,117	8,886	22,003	23,324		2,586	9.02	20.00	10.98
Percentage of subtotal	60	40							
				METHOD 2					
1	278	---	278	322	0.12				
2	2,752	---	2,752	3,034	1.29				
3	1,682	2,962	4,644	4,876	3.18				
4	3,224	2,962	6,186	6,186	5.57				
Total				14,418		905 (8'-10')	15.93	15.00	-0.93
5	3,397	2,962	6,359	7,080	9.78	905 (10'-12')	7.82	25.00	17.18
6	7,588	2,962	10,550	11,625	24.76	776 (12'-14')	14.98	30.00	15.02
Total	18,921	11,848	30,769	33,123		2,586	12.81	23.00	10.19
Percentage of subtotal	61	39							

[a] costs include interest costs for each year at 5% interest rate
[b] total costs compounded to time of harvest at 5% interest rate

annual fixed costs and Method 2 included four years of annual fixed costs.

It was assumed that prices and costs remained constant throughout the production cycle. The costs invested in the crop were compounded to the time of harvest to account for the opportunity cost of the capital over this time. With an interest rate of 5%, the total cost compounded to the time of the last harvest was $23,324 with the model production Method 1. This total cost averaged over the total number of salable trees (2,586) was $9.02 per tree. This average cost per tree was $10.98 lower than the estimated average price for all trees sold.

The total cost compounded to the last harvest of Method 2 which grew some of the trees an additional year, assuming a 5% interest rate, was $33,123. The total cost averaged over the total number of salable trees (2,586) was $12.81 per tree which was $10.19 less than the estimated average price for all trees sold. The net returns by either method were estimated to be favorable. The average price per tree in Method 1 was more than twice as high as the average cost per tree. The average price per tree in Method 2 was estimated to be 80% higher than the estimated cost per tree.

By allocating the annual fixed costs only to the years that the field acerage was actually necessary for a tree crop, the assumption is implied that the nursery is in continual production. This assumes that the field acreage was being used by another crop while seedlings and liners were being developed in the propagation area. Relaxing this assumption and allowing the annual fixed costs per acre to be applied to each year of the entire production cycle as if the nursery was just

being established, the average cost per tree in this model increased to $11.74 for Method 1, and to $15.66 for Method 2. The $20 estimated average price per tree in Method 1 was 70% higher than the average cost per tree. The $23 estimated average price per tree in Method 2 was about 50% higher than the average cost per tree by this method.

Variations in the Interest Rate

The interest rate used in estimating the cost of production in this study is intended to represent the real interest cost of capital. Since the true real interest rate in 1984 was not estimated for this study, the cost of production was also estimated with interest rates of 3% and 7% and are shown in Table 11 and Table 12. The average net returns increased as the interest rate decreased. In each example, the returns were higher with Method 1, the shorter production cycle. The difference in returns between the two methods increased as the interest rate increased.

Variations in the Cost of Labor

The high returns estimated with the model production systems could very easily be due to an underestimation of production costs. One of the most important costs is for labor. Increasing the cost of labor by 50¢ per hour in Method 1 increased the average cost of production per tree by 15¢. This increase in the cost of labor per hour to $5.00 increased the cost of production per tree in Method 2 by 22¢.

The largest portion of the annual fixed costs was the annual salaries for management. Increasing this cost by $1,000 per year increased the average cost per tree by 3¢ with Method 1, and 4¢ with Method 2.

Table 11. Total annual variable and fixed costs for producing one acre of red maples (2,586 salable trees, B&B), assuming a 3% interest rate, USDA Climatic Zones 7 and 8, 1984

Year	Variable costs[a]	Fixed costs[a]	Sub-total	Compounded[b] subtotal	Avg. cost per tree to date	Trees sold	Tot. cost per tree sold	Price per tree	Net returns per tree
	dollars								
				METHOD 1					
1	275	---	275	300	0.12				
2	2,725	---	2,725	2,891	1.23				
3	1,666	2,739	4,405	4,537	2.99				
4	4,020	2,739	6,759	6,759	5.60				
Total				14,487		1,293 (8'-10')	11.20	15.00	3.80
5	4,302	2,739	7,041	7,476	11.38	1,293 (10'-12')	5.78	25.00	19.22
Total	12,988	8,217	21,205	21,963		2,586	8.49	20.00	11.51
Percentage of subtotal	61	39							
				METHOD 2					
1	275	---	275	300	0.12				
2	2,725	---	2,725	2,891	1.23				
3	1,666	2,739	4,405	4,537	2.99				
4	3,193	2,739	5,932	5,932	5.28				
Total				13,660		905 (8'-10')	15.09	15.00	-0.09
5	3,363	2,739	6,102	6,512	9.16	905 (10'-12')	7.20	25.00	17.80
6	7,514	2,739	10,253	10,858	23.15	776 (12'-14')	13.99	30.00	16.01
Total	18,736	10,956	29,692	31,030		2,586	12.00	23.00	11.01
Percentage of subtotal	63	37							

[a] costs include interest costs for each year at 3% interest rate
[b] total costs compounded to time of harvest at 3% interest rate

Table 12. Total annual variable and fixed costs for producing one acre of red maples (2,586 salable trees, B&B), assuming a 7% interest rate, USDA Climatic Zones 7 and 8, 1984

Year	Variable costs[a]	Fixed costs[a]	Sub-total	Compounded[b] subtotal	Avg. cost per tree to date	Trees sold	Tot. cost per tree sold	Price per tree	Net returns per tree
	dollars								
				METHOD 1					
1	281	---	281	344	0.13				
2	2,779	---	2,779	3,182	1.36				
3	1,698	3,185	4,883	5,225	3.38				
4	4,099	3,185	7,284	7,284	6.20				
Total				16,035		1,293 (8'-10')	12.40	15.00	2.60
5	4,387	3,185	7,572	8,694	12.92	1,293 (10'-12')	6.72	25.00	18.28
Total	13,244	9,555	22,799	24,729		2,586	9.56	20.00	10.44
Percentage of subtotal	58	42							
				METHOD 2					
1	281	---	281	344	0.13				
2	2,779	---	2,779	3,182	1.36				
3	1,698	3,185	4,883	5,225	3.38				
4	3,255	3,185	6,440	6,440	5.87				
Total				15,191		905 (8'-10')	16.79	15.00	-1.79
5	3,430	3,185	6,615	7,678	10.44	905 (10'-12')	8.48	25.00	16.52
6	7,662	3,185	10,847	13,511	27.85	776 (12'-14')	17.41	30.00	12.59
Total	19,105	12,740	31,845	36,380		2,586	14.07	23.00	8.93
Percentage of subtotal	60	40							

[a] costs include interest costs for each year at 7% interest rate
[b] total costs compounded to time of harvest at 7% interest rate

Increasing the budget for management salaries in the model by $5,000 increased the average cost of production per tree by 15¢ with Method 1, and by 21¢ with Method 2.

Number of Trees Harvested

The production system modeled in this study spread the harvest of trees over several years. This was necessary since the trees were assumed to be planted at a 4' x 4' spacing in the field and it was necessary to remove some trees to allow the crowns of larger trees to develop in later years. Two previous studies of shade tree production (5, 62) have modeled a harvest spread over four years. These models of selective harvest systems are consistent with the reports of nurserymen who are growing trees to be balled and burlapped. The systems illustrate the problem of estimating cost of production for large trees. Is the appropriate cost of production per tree the average cost to date or the total unrecovered cost at the time of harvest?

Aware of the total accumulated cost at the time of the first harvest, the nursery manager would know the price which would cover these costs. If the manager knew for certain how many trees would be sold in future years, prices below the total cost of production to date at the first harvest would be acceptable since returns in the later years would presumably off-set the initial losses. But uncertainty about the future would suggest that the only acceptable price at the first harvest would be one which covered the entire costs to that date per tree. Unrecovered total costs at the time of the next harvest would be much lower and yet the price per tree is higher for the larger tree.

A more realistic method to estimate the average cost per tree when several harvests occur is to average the costs occuring each year by all the trees in the field. The average cost per tree would thus be the accumulated investment in each tree to that date. The average accumulated cost for a 12' - 14' tree in Method 2 was estimated by this method to be $24.76 which was only $5.24 below the estimated average price for that size of tree. The transportation cost for this size tree to Chicago was estimated as $3.12 so that the total cost of this tree in Chicago was approximately $27.88 while the estimated catalog price for this tree was $30.00.

The difference between total costs and price was greatest for the 10' - 12' trees grown by the model production Method 2. The estimated average cost of production was $9.78 and the estimated average catalog wholesale price was $25.00. The average cost of production for this same size of tree with Method 1 was estimated to be $12.14 per tree. The average total cost per tree is greatly affected by the number of trees remaining in the field at the time of harvest.

Nurseries which spread harvests over more years with fewer trees remaining in the field at the time of the last harvests would have higher average costs of production per tree. To avoid this variability, the only standard way of evaluating the cost of production for a particular size of tree would be to model a production system which produced only one size of tree with only one harvest. This is unrealistic for larger trees. To know how the average cost of production for a tree of a certain size actually compares with the average price of that tree, the average cost of production would have to be found for all nurseries

growing that size of tree. Since there are so many different sizes of nurseries, and harvest schedules are so variable, the average cost of production would probably have a wide range. There is no way of knowing how the costs developed by the model in this study compare with the aggregate average of all nurseries growing red maples.

Internal Rate of Return and Net Present Value

Within the limits of the model used in this study, a comparison can be made of the difference of returns between the shorter method and the longer one. Two different methods for comparing relative profitability were used to compare the two methods. One is called the internal rate of return and the other is the net present value approach.

The internal rate of return is defined as "the maximum rate of interest that could be paid for the capital employed over the life of an investment without loss on the project" (35, p. 379). It is calculated by finding an interest rate "that equates the present value of the cash inflows to the present value of the investment or cash outflows" (24, p. 193). The internal rate of return method of analysis has an implicit assumption that the cost of capital is the same as the indicated rate of return. If this rate of return is higher than the real interest rate, the assumption is that net revenues could be reinvested at higher than market rates which is unrealistic beyond certain bounds. This built-in assumption automatically favors shorter projects and makes comparisons between different projects difficult.

The net present value method uses a minimum desired rate or "target rate" to discount all expected cash flows to the present. If

the result is positive, the project is assumed to be desirable since the returns exceed the desired minimum. There is a built-in assumption that the target rate is the same rate that reinvestment of net returns will earn. This automatically favors longer projects since any project will reinvest at this same minimum rate. The validity of the net present value method is related to how close the target rate approximates the real opportunity cost of capital.

The internal rate of return and the net present value were estimated and are shown in Table 13. The comparison was made as if a descision was being made before starting production so annual fixed costs were added to the variable costs in each year. The fixed costs in the beginning of the first year also included $8,718 which was the initial investment per production acre for the land, buildings, and equipment. The variable and fixed costs exclude the annual interest costs so that these costs are not double counted. The receipts at the time of the final harvest include not only the returns from sale of the trees but also the salvage value of the land, buildings, and equipment used for the length of the production system. The value of the land was assumed to have not changed over the length of the production cycle. Both of these measures of profitability indicate that the shorter production method would have higher returns. The internal rate of return to the total capital investment with Method 1 was 28.4%, and with Method 2 was 23.4%. The estimated net present value of all cash flows with Method 1 was $17,434, and with Method 2 was $15,790.

Table 13. Estimates of internal rate of return and net present value for two alternative methods of producing an acre of red maples (2,586 trees, B&B), USDA Climatic Zones 7 and 8, 1984

Time	Var. costs[a]	Fixed costs[a]	Total costs	Total receipts	Net
	dollars				
			METHOD 1		
0	271	11,122[b]	11,393	---	-11,393
1	2,685	2,404	5,089	---	-5,089
2	1,641	2,404	4,045	---	-4,045
3	3,961	2,404	6,365	19,395[c]	13,030
4	4,239	2,404	6,643	38,352[c]	31,709
Net present value at 5%				17,434	
Estimated internal rate of return				28.4%	
			METHOD 2		
0	271	11,122[b]	11,393	---	-11,393
1	2,685	2,404	5,089	---	-5,089
2	1,641	2,404	4,045	---	-4,045
3	3,145	2,404	5,549	13,575	8,026
4	3,314	2,404	5,718	22,625[d]	16,907
5	7,403	2,404	9,807	28,768[d]	18,961
Net present value at 5%				15,790	
Estimated internal rate of return				23.4%	

[a]Does not include interest cost on operating capital each year

[b]Includes $8,718 for the initial investment per acre for land, buildings, and equipment

[c]Includes $6,027, the salvage value of the land, buildings, and equipment used for 5 years

[d]Includes $5,488, the salvage value of the land, buildings, and equipment used for 6 years

CHAPTER V

SUMMARY

Nurseries in the United States produce more than a billion dollars worth of woody ornamental crops annually which generate more than three billion dollars of retail sales. Deciduous shade and flowering trees have been the fastest growing sector of the nursery industry. Tennessee has been a leader of ornamental tree production in the South and maples have been one of the most commonly grown on nurseries in Tennessee.

Past studies and observations suggest a very favorable economic situation in the nursery business of the South. Even though the number of nurseries and total acerage is increasing in Tennessee, producers suggest that there has been no problem of selling whatever shade trees are produced. If demand is high and prices are higher than cost of production, competition would be expected to enter production to capture some of the profits. The difference between the minimum average total cost of production and the average revenue indicates the degree of competition in the market pricing. A highly competitive market in the long-run will theoretically have prices which are equal to the minimum average total costs.

This study investigated the cost-price relationship of the red maple shade tree grown in the South. A model production system was synthesized for red maples from interviews with Tennessee nurserymen. An enterprise budget was derived for producing an acre of red maples from seed up to five years (Method 1) or six years (Method 2) on a model small nursery. Costs and prices represented 1984.

The results of this research suggest that returns are relatively favorable for this shade tree which is consistent with past studies. The average cost per tree with the short cycle (Method 1) was $9.02, with an estimated average revenue per tree of $20. The average cost of production per tree with the production system which grew trees to a larger size (Method 2) was $12.81, while the average revenue for those trees was $23.00. These averages were the total costs for all trees of different sizes divided by the total number of trees sold. When average costs for each size of tree were estimated, it was found that the price differential was the least for the trees grown out to the largest size.

Both Padgett (54) and Badenhop (5) suggested higher returns for the larger field crops. This study found the opposite to be true. The results reflect the added costs incurred with harvesting larger B&B material with machinery. Uncertainty about demand for larger trees in the future, the high returns available for the smaller trees, and the high costs expected at the harvest of the larger trees would all combine to cause a nursery manager to be reluctant to keep trees in the field an extra year.

The prices appeared to be high in relation to costs, but the costs did not account for some very real problems with growing B&B trees. One factor which should be included in production costs is the cost of the soil sold with the tree. If this cost were included, returns would not appear to be as high. Risk is another problem which should be considered when studying the costs and returns for a long-term investment. Transplanting larger trees with older root systems is more difficult and

transplantation survival is less certain than with smaller trees. Weather disasters and changes in the market are also risks to be considered. If prices are not high enough to cover losses which may result in the future, production of this crop may be judged to be too risky.

There is no way of knowing how the costs developed by the model in this study actually represent average costs for small nurseries in the South. Some smaller nurseries may have higher costs per tree. However, most of the nurseries from which the information was developed for this study were much larger than 50 acres so that there is a chance that they may have been producing at costs even lower than with this model. There seems to also be a wide variation in harvest schedules for shade trees. Since varying the number of trees remaining in the field greatly affects the average cost of production, it would be difficult to know what the average cost was for a particular size of tree for all nurseries in 1984. The model in this study hopefully approximates this average for the small nurseries.

The results of this study indicate more favorable returns for the smaller trees, and this would suggest the possibility of price competition for these trees. The apparent lack of much price competition may suggest that inherently producers believe that the cost of production is actually higher than that estimated by this model due to other costs (such as the cost of soil loss and of risk-taking). Competition may be less than expected also, due to a lack of awareness of the relative profitability of shade trees of certain sizes. High returns for red maples may go unnoticed when returns for the entire nursery are normal. Cost of production studies such as this, if adapted to the conditions of a particular nursery, could be helpful for maximizing net returns.

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CRANESHILL CREST

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Upon returning in 1982 he worked in Sevierville, Tennessee while taking Evening School courses at the University of Tennessee, Knoxville. He entered full-time graduate studies in the fall of 1983 and was awarded the Master of Science degree with a major in Agricultural Economics in the fall of 1985. While working toward the degree and conducting research he was employed by the Tennessee Agricultural Experiment Station as a Graduate Research Assistant in Agricultural Economics. He is a member of Gamma Sigma Delta.