THE LONG-RUN TIMBER OUTPUT POTENTIAL IN EASTERN VIRGINIA

by

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1. INTRODUCTION

1.1 Background of the Study

One of the more difficult problems facing foresters and land managers is the prediction of future yields from our timber resource. In pursuing a reasonable estimate, the manager calls upon his past experience, the published experiences of others, and his knowledge of social, political, economic, and biological factors affecting the resource. Wise decisions concerning the management of our forest resources obligate those in charge to analyze both past trends and future prospects.

The objective of this report is to analyze past trends and future prospects for the forest resource in a particular region--namely, eastern Virginia: Forest Survey Unit 1. This region includes 34 counties (Figure 1), covering approximately 6.36 million acres (Cost, 1976). It extends from the Potomac River on the north, 125 miles south to the North Carolina border. On the east it is bounded by the Atlantic Ocean. Stretching west 125 miles, it includes some counties partly in the Piedmont, so as to adjust the unit to county boundaries.

The unit, for the most part, is a gently undulating plain that rises from sea level to elevations of 300 feet at its western limits. "Tidewater," a term used for the eastern portion of the unit, refers to the area within the range of tides along the major water routes. There are five of these major routes: the Potomac, Rappahannock, York, James, and Chowan Rivers. Flowing directly into Chesapeake Bay, the first four constitute a system of natural harbors, important from both a commercial and a naval standpoint.

In general, the region possesses an ideal combination of topo-

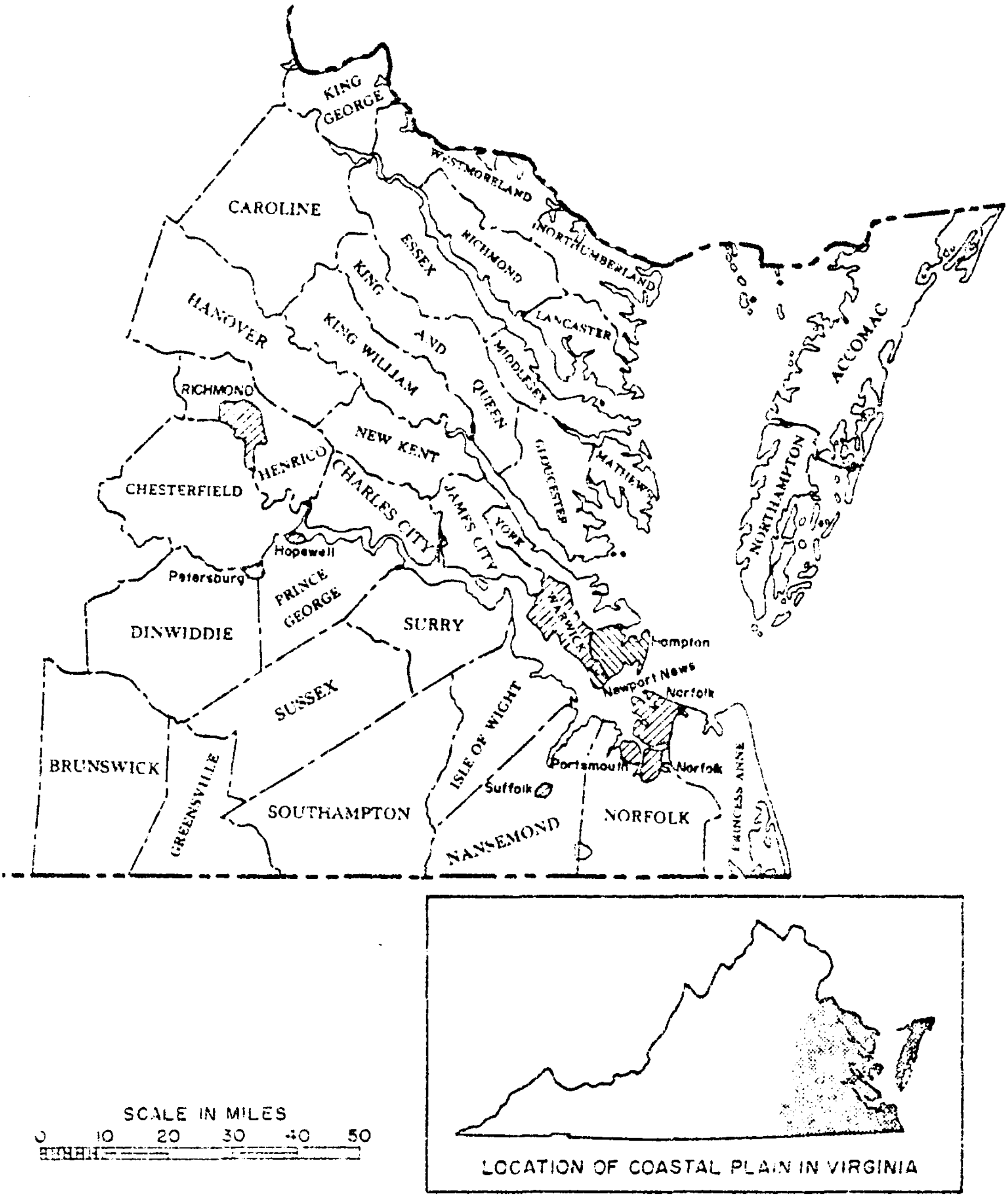

Figure 1.--Counties and independent (noncounty) cities in the Virginia Coastal Plain.

graphy, soil, water, and climate that is conducive to supporting a diversity of high-yield, high-quality agricultural and forestry enterprises. As a result, timber production has traditionally been a large industry in eastern Virginia; timberland accounts for nearly two-thirds of all land.

Impetus is given to this study by evidence that coastal Virginia's highly valued softwood growing stocks are being depleted. Foresters and wood-industry representatives alike have become distressed over the trends. According to the third Forest Survey (USDA, 1966), the volume of growing stock declined 2 percent in a decade: Pine decreased 8 percent and hardwood increased 3 percent. The trend continued to the fourth Survey (Cost, 1976): Softwood growing stock fell another 2 percent, and hardwood further increased 8 percent.

In 1976, the 240 million cubic feet of annual net growth exceeded removals of growing stock by 33 million cubic feet, or 14 percent, but most of the excess was in hardwood forests. There still existed a deficit in pine types, although none would be evident if it were not for the unusually high losses to pine bark beetles. Specifically, pine growth was 8 percent greater than in the previous measurements; pine removals were down; but mortality had risen 45 percent.

A closer look at removals in 1976 compared with 1966 show a 1-percent decrease in softwood cutting and a 2-percent increase in hardwood. Despite this reduction in softwood removals, pine still constitutes 42 percent of the inventory, produces 42 percent of the net growth, yet provided 53 percent of the removals.

Many questions are being raised by wood users and others about these trends. What is taking place in eastern Virginia? Are the trends between the third and fourth Surveys likely to continue? Can trends be altered?

Three avenues of analysis are available (Stebbins, 1975). The first is a mensurational approach, which analyzes the factors revealed by the Forest Survey that influence the timber-resource situation of the region. Among the factors analyzed are the acreage, volume, condition, ownership, and rates of growth and removal of timber in eastern Virginia and adjacent areas (Sheffield, 1978).

The second approach is the normative, which utilizes Forest Survey data and growth and yield estimates and then goes on to estimate the financial potentials of the resource. Phase One of this approach, consisting of the compilation of growth and yield data for coastal Virginia's principal types of forest, has been completed (Giauque, 1977).

The third avenue of analysis is the positive approach, which recognizes all the foregoing estimates, but also analyzes the social potentials of the resource. In general, this method recognizes inventory data, economic theory, and the management activities of timber owners.

The study reported here is Phase Two of the normative approach. The study addresses the question, "What are the financial factors that affect the long-range potential timber yield?" By following identified financial guidelines, forest owners could achieve a financially ideal long-run timber output. Herein lies the difference between the positive approach and the normative approach. The former strives to answer the question of what will happen, whereas the latter takes up the question of what could happen, given certain assumptions. Among these assumptions are a fully-regulated forest where all forest land in each major class of ownership is managed as if under one central, financially rational administration; the adoption of one silvicultural system for all forest land; and the attainment of regulation of all commercial forest acreage during a transition period. Of course the present study, while it concentrates on the question of "what could happen if," still sheds light on the problem of what will happen.

The study is confined to the analysis of timber output under a pulpwood, or cordwood regime. All volumes are expressed in cubic feet of growing stock in trees 5 inches and larger d.b.h. measured to a 4-inch top (Forest Survey Standard), and every cubic foot of wood is assumed to have the same value.

2. INFLUENCES UPON TIMBER OUTPUT

2.1 Plan for the Chapter

This chapter begins the analysis of the major factors affecting the long-run timber-output potential in eastern Virginia. Three general influences on timber output potential were cited in a study conducted in western Oregon and western Washington (Division of Forest Economics and Research, 1963). These are; the total acreage and the quality of land available for commercial timber production by major forest type, site class and major form of tenure, the management practices followed on these lands and the time element or stage reached in progression toward silvicultural goals.

The influence of management practices will be the topic of this chapter. Chapter 3 will seek to estimate commercial forest acreage for the long-run. Discussion of the time element will be interspersed through Chapters 2 and 3. Chapter 4 will take these results and produce some estimates of timber output potential in the long run. Finally, Chapter 5 will interpret these findings.

2.2 Management Intensity

In order to arrive at an estimate of a firm's timber production over any given period, one must analyze the firm's outlays upon the forest. Firms that funnel large per-acre investments into their growing stock can generally expect the highest gross revenues from their timber. Investments, not only in the amount and quality of timber, but in silvicultural measures to stimulate growth, means of protection from damage, and measures to utilize the resource fully mark the owners' management as "intensive" or "conservative." Conversely, any firm that makes minimal per-acre investments in its forestry endeavors is practicing "extensive" management.

How far a firm progresses in the intensity of its management is a function of its costs and revenues during the period under consideration. Within the context of the firm, whether it be a large integrated corporation or a small-woodlot owner, let us assume that the goal is to achieve the greatest net revenue per unit of time (i.e., the greatest excess of revenue over cost). This net revenue is not that from the enterprise alone, but that from the firm's total operation. For example, a forestry-based corporation may not be earning the greatest net revenues from its forest investments as an independent operation, but considering the overall performance of the firm, the forest segment is being managed in such a way as to earn the greatest net revenues for the business as a whole.

Benefits and costs need not be restricted to marketable goods or values. In the case of public ownership, considerable weight is attached to non-marketable values such as recreational and aesthetic experiences, water, soil, and wildlife. Yet it is still reasonable for public owners to strive for the highest net benefits. However, this goal is not just financially oriented, but rather it portrays an economic goal of efficient and wise allocation of resources, in order to derive the greatest net benefits, over time, for the people served.

This fundamental concept of maximizing net revenue will serve as a basis upon which to build this study. A successful analysis is then dependent upon the recognition of two classes of cost and revenue.

The first class includes those costs and revenues associated with the growing stock, a firm's primary determinant of wood production. Cost is measured in terms of interest on growing stock. Decisionable are rotation length and the level of growing stock that will be maintained per acre. This interest or cost of holding timber capital can be determined for a firm as a function of the opportunity to liquidate all or part of the timber and use the revenue for some alternative investment, or merely for personal consumption. An owner can therefore be expected to base his choice of rotation age on the alternatives available to him. If the owner is in need of quick revenue (i.e., if he has pressing personal obligations or very promising business alternatives) his rotations will be short. This reaction of a firm can be traced to its guiding rate of interest.

Revenues from timber originate in its physical growth and in the change in unit value of growth related to tree size, age, or even such values as aesthetic and environmental benefits. Taxes and changes in tax laws also bear on the costs and revenues of a forestry enterprise.

The second class of costs and revenues is related to the prospective price of a firm's timber, as generated through market conditions, silvicultural and protective measures, and utilization standards. Assuming all other factors to be equal, the higher the prospective revenues from its timber, the greater will be the desire on the firm's part to intensify its timber management. Such intensification motivated by timber price may include artificial regeneration, fertilization, timber-stand improvement, protection against fire and other enemies, and, in fact, any measures that involve outlays of labor or of capital other than timber growing stock.

2.3 Costs and Revenues: The Guiding Rate of Interest

For the timber-producing firm, interest is the cost of the use of capital. Because forestry is characterized by a long period of production and thus is very capital intensive, interest on forest capital dominates the cost of production. The capital investment of a firm in timber production determines the magnitude of its interest liability. But what guides a firm to invest X or Y amount of capital in forestry? The guide is the alternative opportunitites the firm must forgo when making investments in forestry. A rule for setting the alternative is, "where there is more than one alternative open to the firm, the one that governs is the alternative on which the rate is highest, after allowance for any differences in risk or other circumstances affecting the value of the return." (Duerr, 1960). In addition, the guiding rates of interest used in this report are strictly after-tax rates. For example, in setting the guiding rate of return, if the best investment an owner has available will return 5 percent, after taxes, providing all risks are equal, then 5 percent becomes the guiding rate of interest for investing in timber production. Any prospective investment in forestry not promising at least 5 percent should be rejected, and any such present investment should be liquidated.

The guiding rate may be determined by the opportunities for either investing capital or spending it. For investment purposes, the opportunity may be within the firm or external to the firm. Land acquisition, silvicultural measures, or improvement in manufacturing processes exemplify internal investment possibilities. Setting of the guiding rate is then governed by the prospective rate of return on these alternative uses or by the rate at which the firm can acquire funds, depending on which is less after allowance for risk. Where the rate of return on alternative investment or spending governs and is lower than the borrowing rate, the firm must have access to funds that do not require borrowing at interest.

When investments outside the business are undertaken, the rate is similarly set by the anticipated yields from those investments.

Another opportunity is to spend capital for personal consumption, a phenomenon familiar to everyone. In forestry circles, this alternative is often the one that governs the small-scale owner's guiding rate. Here the rate may be thought of as the owners "rate of time preference," or the annual percentage rate at which he subjectively discounts future values in order to compare the desirability of current consumption with that of future consumption. An owner whose time preference is high hesitates to invest in forestry, because of the length of time necessary to reap the benefits of the investment. He would rather invest in something that may yield him less from a financial standpoint, but will deliver him revenue in a shorter time.

The guiding rate is also affected by various fringe benefits attached to income from forestry or its alternatives. Included are the benefits to forestry derived through the long-term capital-gains provision of the federal income tax--and, in general, through the ownership of timberland as security for supplying a firm's manufacturing process with raw material. For public ownership, fringe benefits are derived from the nontimber resources created in public forests and from the insurance of continuing abundance that comes by stockpiling the forest's resources.

For those firms able to realize fringe benefits, the guiding rate applicable to their operation is lowered. In effect, the benefit causes forestry to gain some advantages so that it compares favorably, in a financial sense, with alternative investments.

Timber production is also vulnerable to certain noninsurable risks. These include (1) physical losses, as from wildfire, insects, disease, and weather; (2) operational hazards, as in the inability to secure necessary labor at crucial times; (3) marketing risks, where owners may realize losses through declining prices of timber or rising costs. As these risks become higher in the firm's outlook, relative to risks in alternative ventures, the higher the rate charged for the investment of forest capital. To become comparatively attractive as an investment, forestry must then earn that much more. In the case of large corporations operating with large acreages under sustained-yield management, with a stable labor force and large-scale integration, the effect of risk has been reduced to relatively low levels. For small-scale owners unable to achieve the stability of large corporations, operation usually labors under a substantial risk shadow.

Finally, the guiding rate may be affected by charges that need to be incurred in the course of transferring one's funds from forestry to some alternative use. For example, such a "transfer cost" arises where the owner is subjected to one extra income taxing beyond what would have been involved without a shift of funds. The result is to lower his guiding rate of return for forestry.

2.31 <u>Relation of the Guiding Rate to Timber Output</u>

In order to analyze the effect of interest on forest capital, a model using regulated, sustained-yield management is used (Duerr and Christainsen, 1973). It is assumed that this type of management is ideal. The Society of American Foresters has defined sustained-yield management as follows: "Management of a forest property for continuous production, with the aim of achieving, at the earliest practicable time, an approximate balance between net growth and harvest either by annual or somewhat longer periods." (Davis, 1966)

To illustrate the mechanics of such a model, a planted loblolly pine forest on site index 80 (base age 50 years) is used. The goal of this illustration is to provide a framework in which a range of management intensities may be formulated, based on the guiding rate of interest. The production objective is cubic feet of pulpwood.

Normal yield tables (Giauque, 1977) provide the necessary input for utilization of the model. Table 1, columns 1 and 2, show rotation ages and their associated yields, copied directly from the normal yield tables. Under a regulated forest policy, where an equal number of acres is devoted to each 1-year age class, such that a sustained even flow of stumpage is obtained, the average annual yield per acre is the normal yield (column 2) divided by the rotation age (column 1). The resulting figure is known as the mean annual growth (column 3).

From column 3 it is evident that an owner can increase his annual revenue per acre up to a point (as a result of increasing average annual timber yield) by increasing rotation age. The extra annual yield per acre resulting from each 5-year lengthening of rotation age is shown in column 4. These extra yields represent the advantage of a longer over a shorter rotation. Assuming no cost, the optimum rotation is at the cul-

Table 1.--Rate of return on extra growing stock as related to average annual timber yield per acre on regulated planted loblolly pine forests, site index 80, managed for one cut per rotation.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Rotation Age	Total Yield Per Acre	Annual Yield Per Acre	Marginal Yield Per Acre	Total Growing Stock	Growing Stock Per Acre	Marginal Growing Stock Per Acre	Return On Extra Growing Stock
Years	Cubic Feet						Percent
10	215	21.50		537.5	53.75		
			59.63			220.75	27.01
15	1217	81.13		4117.5	274.50		
			25.62			350.38	7.31
20	2135	106.75		12497.5	624.88		
			11.97			385.32	3.11
25	2968	118.72		25255.0	1010.20		
			5.11			388.55	1.32
30	3715	123.83		41962.5	1398.75		
			1.28			378.32	0.34
35	4379	125.11		62197.5	1777.07		
			-1.16			361.43	-0.32
40	4958	123.95		85540.0	2138.50		
			-2.77			340.78	-0.81
45	5453	121.18		111567.5	2479.28		
			-3.92			317.87	-1.23
50	5863	117.26		139857.5	2797.15		

mination of mean annual increment, which for planted loblolly pine is 35 years. The associated yield at this age is 125.11 cubic feet per acre per year. In financial terms, this is the age when the return on additional capital is zero. The owner is ensuring only that none of his capital earns less than nothing. Such a course is appropriate only for an owner with no productive alternative for his capital. Yet, in our modern economy, where land, capital, and labor cannot be obtained without cost, this type of management is not rational. As a result, a forest owner will generally aim for a rotation shorter than the one where mean annual growth culminates.

The cost of capital arises from the necessity for holding more growing stock, as a requisite to lengthening the rotation and raising the output. Column 5 of Table 1 estimates the growing stock necessary to operate at the alternative rotation ages. To arrive at these figures, the following line of reasoning is employed. It is assumed, for planted loblolly pine, that timber younger than 7.5 years contains no merchantable volume. Then all timber from age 7.5 to 12.5 years has the same volume as a stand of trees 10 years of age, all timber from age 12.5 to 17.5 years has the volume of a 15-year-old stand, and so on. For example, consider a 15-acre, 15-year-old, regulated forest. The volume in cubic feet of growing stock is determined as follows: There are 5 acres of timber with the volume of a 10-year-old stand (7.5 to 12.5 years, 5 x 215.0 = 1075.0 cubic feet), and 2.5 acres with the volume of a 15-year-old stand (12.5 to 15.0 years, 2.5 x 1217 = 3042.5), or a total of 4117.5 cubic feet. The growing stock can now be converted to a per-acre basis simply by dividing column 5 by rotation age (column 1). These figures in column 6 show what level of growing stock should be carried per acre. Column 7 shows the extra growing stock per acre needed to increase the rotation age 5 years. Finally, column 8 shows the rate of return that is earned on the extra growing stock to obtain a 5-year longer rotation. It is simply column 4 expressed in percent of column 7.

To this point, the discussion of rotation age and output has been restricted to the cubic-foot measure of volume. Since most firms think in terms of monetary measures, what would happen if a value per cubic foot of wood were interjected into the model? Actually, nothing would change, either in terms of the mechanics or in the results. Table 2 shows what happens when a value of 10 cents per cubic foot is introduced. Notice that the figures in the last column of Table 2 are identical to those in column 8 of Table 1. This occurs because the same value per unit of measure is assumed for all wood.

With the ability, now, to speak in terms of dollars and cents, we can estimate rotation ages and outputs for individual owners. For example, suppose an owner is debating a 20-year versus a 25-year rotation. His guiding rate of return is 4 percent. The decision, providing the owner is rational and seeks to maximize his net revenue, must be made with full knowledge of whether the rate of value growth of the stand, over the additional five years, is at least 4 percent. If the rate is less than this, the capital should be taken out of timber at age 20 and invested elsewhere. The figures in Table 2 show that to increase the rotation from 20 to 25 years, an additional $38.53 must be tied up in growing stock, which simultaneously increases annual timber output (extra output) $1.19, or 3.1 percent. If the owner has an alternative

Table 2.--Rate of return on extra growing stock as related to average annual timber yield per acre on regulated planted loblolly pine forests, site index 80, and managed for one cut per rotation, assuming a value of $10.00 per cunit.

Rotation Age	Total Yield Per Acre	Annual Yield Per Acre	Annual Value Yield Per Acre	Marginal Value Yield Per Acre	Value Of Total Growing Stock	Value Of Growing Stock Per Acre	Marginal Value Of Growing Stock Per Acre	Rate Of Return On Extra Growing Stock
Years	---- Cubic Feet -----		------------------	Dollars	-------------------------		----	Percent
10	215	21.50	2.15		53.75	5.38		
				5.96			22.07	27.01
15	1217	81.13	8.11		411.75	27.45		
				2.57			35.04	7.33
20	2135	106.75	10.68		1249.75	62.49		
				1.19			38.53	3.10
25	2968	119.72	11.87		2525.50	101.02		
				0.51			38.86	1.31
30	3715	123.83	12.38		4196.25	139.88		
				0.13			37.83	0.84
35	4379	125.11	12.51		6219.75	177.71		
				-0.11			36.14	-0.30
40	4958	123.95	12.40		8554.00	213.85		
				-0.28			34.08	-0.82
45	5453	121.18	12.12		11156.75	247.93		
				-0.39			31.79	-1.23
50	5863	117.26	11.73		13985.75	279.72		

opportunity that yields more than 3.1 percent, his best option is to forgo any lengthening of rotation and settle on procucing 106.5 cubic feet per acre per year over the next 20 years. True, he can increase revenues to $11.87 per acre per year by following a 25-year rotation. But, despite this possibility, a 20-year rotation is still financially the optimal alternative, for the owner can invest the $38.53 at 4 percent and add $1.54 to his $10.68 from forestry for a total of $12.22, versus the $11.87.

Tables 1 and 2, therefore, show how an owner's guiding rate of return and long-run timber-output goals are related. In short, an owner will base his decision about forest capital and timber output upon his guiding rate of return, as a measure of the efficiency of alternative uses for his funds. Lower rates stimulate higher outputs, while higher guiding rates stimulate lower output.

The only question that remains is how to make the determination of rotation age a continuous function and not discrete as it is in Tables 1 and 2. Graphing the column 8 figures over age produces a continuous curve that enables one to infer from any guiding rate of return, the appropriate rotation age (Figure 2). For example, the optimum rotation at a guiding rate of 4 percent is 21.1 years for planted loblolly pine.

2.32 Influence of Fixed Costs on Timber Output

Questions frequently arise concerning the fixed cost of holding land that is currently under timber production. The contention is that heavy fixed carrying charges on land force a forest owner to manage for high yields. Only by raising yield and consequently revenue can the owner overcome these charges. The fact is, however, that being a fixed

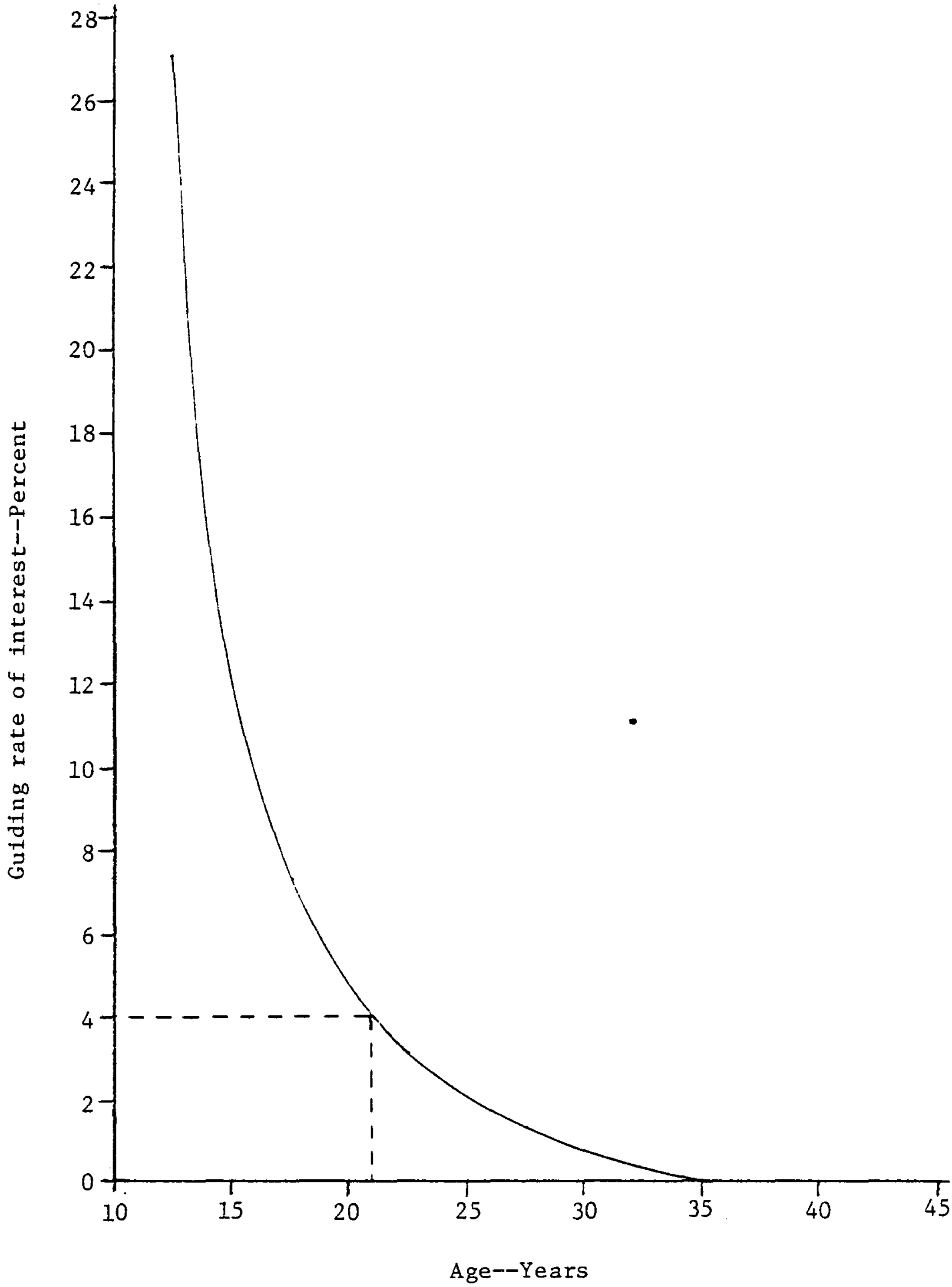

Figure 2.--A continuous determination of rotation age, as a function of the guiding rate of interest.

cost of production, the land-holding costs have no bearing on the management program. For example, take an owner whose best rotation is once again 20 years, for planted loblolly pine, with a 4-percent guiding rate of interest. Revenues from this rotation may be a poor return on his land investment. Yet, as shown in the preceding section, by lengthening the rotation and increasing yields, the owner only accomplishes a reduction in net revenue from $12.22 to $11.87 and in no way betters his position. A more realistic recourse would be to drop out of forestry altogether. Anyone who contemplates forest-land investments should analyze his prospective returns so as to avoid unnecessarily expensive purchases of land.

2.33 The Guiding Rate of Interest and the Time Element

It is necessary to identify the time period to which guiding rates are intended to be applicable. This study is aimed at the long run, in the sense that any of today's acreages could be converted to ones with normal age class distribution. A convenient reference point is at least as far in the future as the longest anticipated rotation. For eastern Virginia, that is 2020. The time, then, for speculation about interest rates will begin now and extend through 2020.

Given the factors that influence the determination of an owner's guiding rate, it is obvious that the rate will vary over time. Large corporations may experience variation as a function of changing risks, while small owners are variable with changing income, unexpected outlays, and so on. Therefore, to judge what rate is in effect on a property at any given time, one must seek to find the highest rate applicable up to that time. In other words, had a higher rate been in effect five years ago, the resultant impact on growing stock would be evident and consequently the property would still be reacting as if it were under the higher rate. For this study, however, all reasonable attempts will be made to align the analysis to those influences that tend to keep the guiding rate of interest down.

2.4 Forest Ownership and the Guiding Rate of Interest

The guiding rate of interest of an owner, whether arrived at implicitly or explicitly, is highly correlated with the management practices evident on the property. To lower the guiding rate is to increase timber production for that owner, class of owners, or for an entire region. A range of rates exists for timber management. The purpose of this section is to relate, what might be termed the "traditional" guiding rates of interest to broad ownership classes in eastern Virginia. It is important to note that these "traditional" rates are introduced only to serve as a logical starting point for the analysis to follow and not as unchallengeable doctrines.

2.41 Federally Owned Lands

Federal government management is generally considered the most conservative. Considerable argument has been generated concerning what interest rate is most appropriate for public investment. Some reports suggest rates as high as 5 to 6 percent. Others feel the rate should be more in line with the interest on the national debt, or approximately 3 percent. To better understand what rate is appropriate for federal forests one must first realize what these forests are managed for, in comparison to private holdings. Obviously, timber production is one goal, but perhaps not the most important. More binding, in many cases, are the fringe benefits of federal management, which accrue to society in general. These include nontimber values (recreation, water, wildlife, aesthetics, etc.), perpetuation of a national timber policy that advocates conservation and offers an example of such practice, and the assurance of a long-term national supply of raw material.

Yet, arguments still arise over the shorter rotations (those shorter than the culmination of mean annual increment) that eliminate some of the benefits derived from older forests in terms of aesthetics, water quality, and so on. From other sectors comes criticism of longer rotations, as public funds being invested and subsidized by government policy at the expense of other resources. In any case, capital in the form of growing stock, is invested, and the question is how much to invest and for how long. Whether a purely financial approach should be undertaken by federal managers is irrelevant. What is relevant is that something is being maximized, be it net dollars or net recreational experiences. Federal agencies are merely attempting to maximize the optimum blend of net financial revenues and net benefits over time. In this sense they are still following an "economic" rotation.

The foregoing line of reasoning is usually associated with the national forests of this country. Eastern Virginia, however, contains no national-forest land. Public ownership, which amounts to only 3.6 percent of commercial forest land, is 70.5 percent federally owned. This land is primarily in military reservations. The question is, can the preceding arguments be applied in this case. Since the military and its projects are publicly funded, it must be assumed that the funds are handled according to the arguments presented. In line with this reasoning, a 3-percent guiding rate is chosen for federal ownership. (Division of Forest Economics and Research, 1963)

2.42 Conservative Large-Scale Private Forest Owners

This group is exemplified by firms in the large integrated forest industries. Acreages of commercial forest land owned by an individual corporation can be quite substantial. In eastern Virginia, five corporations owning more than 40,000 acres apiece account for approximately 77 percent of all forest-industry lands (Virginia Division of Forestry, 1971).

Investments in the manufacturing process are the major source of profit, and high returns are hoped for. Forest investments may be thought of as serving the best interests of the firm and may not be considered a direct source of income or a profit-producing venture. A firm can afford this luxury because of the fringe benefits associated with forest ownership. One benefit is the security of having company woodlands operating at such a level as to sustain a flow of raw materials to the manufacturing process. Woodlands also protect the firm from highly variable risks in such areas as wood price, quantity, and transportation. They provide long-run stability in product markets and in company profits. They also make the firm eligible for federal income-tax benefits. Rates of return on timber, therefore, can be, and generally are, low.

Risks other than those mentioned above appear to be negligible. The large acreages accumulated by wood-products firms diffuse the risk of physical loss. Value loss also appears low, despite lulls or depressions in specific forest products. The supply of wood as raw material is secured over the long run.

Although the foregoing discussion may indicate, for large forest holdings, a guiding rate of zero percent, or a rotation equivalent to the culmination of mean annual increment, such a program is not common. The large corporations are commonly operating in the range of 3 to 5 percent. For this study, 3 percent is taken as representative (Division of Forest Economics and Research, 1963).

2.43 Owners with Intermediate Guiding Rates of Interest

Within this group are included those forest corporations with middle-sized forest holdings (less than 40,000 acres), some of the larger "corporate" farms that are practicing intensive use of all their lands for optimal financial gain, some private nonforest-based corporations, and state and local governments.

In general, the reasons for these owners not being considered more conservative are the higher risks they confront and their slight to moderate orientation to the future. A guiding rate appropriate for these owners is judged to be about 6 percent (Division of Forest Economics and Research, 1963).

2.44 Exploitive Owners

The owners in this group can generally be considered to own less than 500 acres. Included are the nonfarm, noncorporate miscellaneous private tracts and the small to medium-size farm holdings.

Miscellaneous private owners hold woodland for a variety of reasons. Many enjoy the opportunity a forest may offer as a recreational or peaceful retreat. Others may hold it for speculative purposes, with little desire to invest in the management of timber. Still others may hold it simply for the philosophical inspiration it provides. Traditionally, they have been accused of being very poorly acquainted with the potentialities of the timber resource and frequently, because of financial insecurity, unable to take advantage of any knowledge about these potentialities. Thus, their management is characterized by small capital investment in timber production.

The farm holdings suffer much the same treatment. Smaller farms generally have only a small fraction of available land in timber, which precludes any full-time forest enterprise. Farm forests have been characterized historically by over cuttings that have severly deteriorated what was once fine woodland. Worrell (1967) explained some of the reasoning behind a farmer's actions concerning his woodland: "For many farmers capital is the limiting factor of production. The marginal efficiency of additional capital inputs in row-crop or livestock production may be very high. If a farmer has all the necessary land, labor, and other capital equipment so that his value output could be increased materially by the addition of a tractor, or an irrigation system, or some pedigreed livestock, the capital invested in such things would yield high marginal return. One source of such additional capital may be the growing stock timber in the farm woodland. This growing stock may be producing a return of 6 percent on its capital value, but if the liquidated capital could produce a marginal return of 15 percent when invested in an irrigation system, there is not much question as to what the farmer might best do."

Because these owners are individuals with limited incomes, they tend to plan only in terms of their own lifetime. They may have a strong desire to liquidate today's timber and use the returns for immediate consumption that is enjoyable or perhaps necessary. Returns that are only occasional, such as with forestry, are not desirable alternatives.

In terms of a specific guiding rate for exploitive owners, the possibilities extend as far as 40 to 50 percent. To align the rate with logical silvicultural interpretation, such high rates must be rejected. A realistic rate is assumed to be 12 percent (Division of Forest Economics and Research, 1963). A higher rate would only suffice to allocate these owners little or no effect on timber output.

A summary of the guiding rate as a value index for forest ownerships is appropriate at this point. First, the guiding rate subsumes many considerations about an owner's valuation of capital. From the rate stem decisions concerning how much, where, and when to invest capital in forestry endeavors. Second, the guiding rate is by no means fixed over time. New investment opportunities, personal consumption needs, and capital availability help keep the rate variable. Third, owners are quite often not consciously aware of their use of a guiding rate. However, a rate can be inferred from the decisions a firm makes in the course of investing capital, so long as there is reasonable consistency over time in the firm's attachment of value to capital.

2.5 Effect of Increasing Tree Value with Age

Tables 1 and 2 illustrated the effect of volume growth on the optimum rotation length. Other factors may bear heavily on this decision. The Western Oregon and Western Washington study cites four additional factors weighing on value growth of timber (Division of Forest Economics and Research, 1963):

(1) Lower conversion costs per unit volume with advancing age and size of trees.

(2) The prospect of forest reestablishment costs following harvest.

(3) Improvements in timber quality, and therefore unit value, with increasing age.

(4) Inflation of timber values relative to the general values in the economy.

Each of these factors will be discussed in the following sections, relative to any effect they may have on this study.

2.51 Assumptions About Conversion Cost Differentials

Conversion cost is the cost per unit of logging, transporting, and processing timber. Traditionally, conversion has been cheaper (up to a point) for large logs than small ones. Maintaining this reasoning through the course of this study is not clearly warranted. Two reasons stand out clearly in support of this contention. The first, definitely of lesser importance, is that the increasing possibility of defect in older trees tends to reduce the advantage of size. Second, and more important, is that as the conversion industry has found itself processing smaller logs, it has been forced to adapt its operations through technological advancements. The time is rapidly approaching when conversion will be adapted, technologically and economically, to the smallest wood conceivably harvestable. Under such a circumstance, conversion costs will tend to level out over the tree-size range. Thus the assumption to be carried through this study is that in a stable economy, conversion costs will be irrelevant, because the methods of processing will match the materials being processed, so that the disadvantages of handling small-diameter logs will be minimized or eliminated altogether.

2.52 Assumptions About Quality Differentials

Some consideration needs to be given to the increase in the unit value of wood with advancing tree age and size. There is no doubt that opinions and judgments about quality differentials are diverse and controversial. In this study, however, it will be assumed that wood is wood and despite any differences in quality, will not be grown into the product, but will be manufactured into it mechanically or chemically. This reasoning supports the methods of this report in dealing strictly with cubic-foot volumes attainable through pulpwood rotations, without considering sawtimber rotations. Henceforth, any reference to rotation age or yields will be made in a pulpwood sense.

2.53 Assumptions About the Effect of Reestablishment Costs

Included under reestablishment costs are site preparation and planting. These costs must be taken into consideration, along with the interest charges on growing stock, when a firm is deciding how much capital to invest in timber, when to invest it, and how long the capital should remain tied up in timber. The influence of regeneration costs upon a rational owner is to lengthen rotation age so that he can reduce cost through postponement.

The effects of regeneration costs are quite clear and constitute no obstacle in this report. What is not clear is the prospective trend in costs and values and thus the degree to which rotations may be lengthened. Historically, regeneration costs (Table 3) have risen much more than stumpage values (Table 4). During the 24 years 1952-1976, prescribed-burning costs increased 1638 percent, mechanical site prepa-

Table 3.--Costs of forestry practices in the South, 1952, 1961, 1967, 1974 and 1976. 1/ 2/

Forestry Practice	Year				
	1952	1961	1967	1974	1976
	Current Dollars				
Prescribed burning	.21	.68	1.60	2.51	3.65
Chemical removal of undesirable trees	5.01	7.93	10.17	22.86	23.41
Timber cruising (10 percent)	.30	.41	.74	1.03	1.18
Marking trees for harvesting	.60	2.10	3.09	4.96	8.05
Mechanical site preparation	5.25	14.09	23.52	48.01	73.36
Planting by hand	.0111	.0163	.0228	.0534	.0534
Planting by machine	.0074	.0120	.0159	.0330	.0384
Release cutting of young growth	4.17	8.48	13.16	30.17	38.09
Seedbed preparation	----	----	16.64	33.17	38.57
Precommercial mechanical thinning	----	----	----	----	25.97

1/ Moak, Kucera, and Watson, 1977.

2/ All costs are on a per-acre basis except for planting by both methods, which are on a per-seedling basis. All costs are general weighted averages.

Table 4.--Average prices, per cord, received for southern pine pulpwood stumpage, 1955-1976. 1/

Year	Number Of Sales	Volume In Cords	South	State: Ala.	Ark.	Fla.	Ga.	La.	Miss.	N.C.	S.C.	Tenn.	Tex.
			Current Dollars										
1955	128	201,803	4.83	7.45	4.04	4.74	3.81	3.78	6.66	2.44	4.54	2.68	3.63
1956	178	239,327	5.88	6.46	4.37	6.58	4.93	4.89	7.09	3.13	5.40	2.75	4.74
1957	180	274,605	6.19	6.75	4.27	8.11	----	5.27	6.13	3.26	5.44	----	4.50
1958	240	382,958	5.73	5.72	3.56	6.97	4.12	4.44	6.35	4.01	6.10	----	4.22
1959	296	355,724	5.60	6.47	3.46	6.92	6.08	4.41	5.98	3.89	6.34	----	3.85
1960	237	325,162	5.62	6.42	3.76	7.50	4.17	4.32	4.92	3.68	6.40	----	3.78
1961	287	369,644	4.87	4.81	3.02	6.44	5.56	4.10	3.84	4.36	5.81	----	3.21
1962	252	343,997	5.07	4.58	3.29	6.30	6.00	3.86	3.77	3.67	6.48	2.67	3.66
1963	212	330,586	4.84	3.72	2.81	5.89	5.81	3.96	3.25	3.60	5.59	2.42	3.38
1964	186	312,781	5.15	4.11	3.45	6.02	4.28	3.75	3.73	3.25	6.05	----	2.61
1965	193	303,960	5.76	4.70	3.50	6.01	6.05	3.33	4.44	3.40	7.73	3.49	2.58
1968	261	361,978	6.05	6.36	3.92	8.05	7.17	5.39	4.87	4.08	6.86	1.99	3.72
1969	396	550,257	5.98	7.11	3.58	8.85	7.81	5.75	4.30	4.70	7.09	2.97	3.89
1970	344	553,284	6.42	7.04	3.28	10.14	6.17	5.43	4.89	3.05	7.85	2.08	4.10
1971	349	602,279	6.57	7.43	3.60	10.60	4.90	7.42	5.36	3.90	7.85	3.23	4.35
1972	415	677,445	7.82	11.08	4.82	12.63	5.16	10.03	5.90	4.11	9.32	1.99	4.28
1973	424	687,162	11.37	12.18	8.85	23.39	6.56	8.58	9.62	6.54	12.12	2.98	7.84
1974	304	571,319	11.44	10.89	8.67	22.27	4.97	8.80	8.13	10.26	11.59	2.60	9.03
1975	317	559,085	10.24	6.40	8.08	21.97	6.96	7.75	6.66	6.20	11.65	3.53	5.57
1976 2/	189	306,622	10.78	7.17	10.54	19.34	6.99	8.64	6.44	----	-----	3.46	7.42

1/ Sherman, 1977.

2/ First six months of 1976 only.

ration increased 1297 percent, and hand planting increased 381 percent. On the other hand, since 1955, stumpage prices have risen only 74 percent.

What are the reasons behind these large increases in costs? One is the increased cost of labor. Many of the regeneration alternatives are labor intensive. Second, the tendency used to be to site-prepare and plant only the most accessible areas. In recent years, as more of the accessible lands became otherwise occupied, owners began moving into those areas that are more difficult to site-prepare and plant. This of course led to higher regeneration costs. Third, inflation may play a small role in the relative regeneration-cost increase. The more dollars that are invested now, the more that are needed to recover the investment at harvest time. Probably the most important factors bearing on increasing costs are the equipment and energy component. In an effort to avoid higher labor costs, managers resorted to mechanizing their operations. With the energy crunch, however, they found mechanization costs rising faster than labor costs (Moak, Kucera, and Watson, 1977).

Two problems are recognizable before any further analysis can be performed. One is how to handle the inexpensive site-preparation costs (prescribed burning) versus the more expensive methods (mechanical). It was concluded that the least expensive methods would be the focus of this report, for the following reasons: The planted loblolly pine yield data derived specifically for this study depict the average yields attainable for eastern Virginia as a region. As such, these data are illustrative of the average yields one might expect from the less expensive methods of regeneration. Second, one must remain aware of the future vulnerability of mechanical site preparation, as well as machine planting, as viable reestablishment alternatives. With energy costs continuing to rise as supply diminishes, mechanical regeneration costs must surely do the same. Presently, many landowners are rejecting expensive regeneration methods. The situation will not likely change over the length of time involved in this study, as more and more firms turn to cheaper regeneration alternatives. Even more striking is the possibility of energy supplies running so low that energy for forest operation will receive low priority, making mechanical operations that much more vulnerable.

The second problem is how to project the effects of low-to-moderate regeneration costs over the long run considered in this study. As in the case of most projections into the future, the historic data were analyzed for recognition of a reasonable trend. First, the data for prescribed burning and hand planting were chosen as the optimum regeneration alternatives for the future, and the costs in 1952, 1961, 1967, 1974, and 1976 were taken from Table 3. (An assumption of 900 seedlings per acre of planting was made.) Stumpage values for these years were taken from Table 4. Where appropriate, the values were averaged over a period of years. (The 1955 stumpage price was used for 1952.) The specific paired values are presented in Table 5.

To facilitate the continuity of this report the procedures and results of this analysis will be presented in Chapter 4, along with the analysis of other forest types under consideration.

2.6 Assumptions About the Prospective Trends in Wood Values

What is the long-run prospect for pulpwood stumpage prices, as re-

Table 5.--Selected regeneration costs and stumpage prices for 1952, 1961, 1967, 1974 and 1976.

Year	Regeneration Costs Per Acre	Stumpage Value Per Cubic Foot
	---------------- Dollars	------------------
1952	10.20	.057
1961	15.35	.061
1967	22.12	.069
1974	50.57	.130
1976	51.71	.127

lated to the general price level and especially the costs of stumpage production?

Projections of domestic pulpwood consumption reflect an increasing demand for pulpwood. This demand is derived from the demands for paper, particleboard, hardboard, and other pulp products. Mid-range projections for the years 1970-2000 show pulpwood consumption increasing 120 percent (Cliff, 1973). With such an increase, one might expect a positive, upward pressure on the real price of pulpwood. But past evidence suggests that real price may be relatively stable. Between 1950 and 1970, southern pulpwood consumption rose approximately 136 percent (Cliff, 1973), but southern pulpwood stumpage price (i.e., current price, from Table 4) increased only 74 percent in the years 1955-1976, scarcely 3 percent per year, no greater than the rate of inflation. Thus for this report, we will assume a very modest real price increase prospect.

What will the prospect of very modest increases in real stumpage values mean to a timber owner? Two possibilities exist. One is that he will be given the incentive to carry heavier growing stocks and to lengthen rotations. The other is that, if a high real-price level materializes, he will be stimulated to intensify his management practices in other ways.

How, in general, would the anticipation of rising real stumpage value trends stimulate an owner to increase rotation age and growing stocks? If he could foresee the rate of value increase maintaining itself at or above his guiding rate of interest, he could afford to hold his existing timber, while at the same time gaining extra revenue from the annual growth. For eastern Virginia, this possibility must be assumed irrelevant. Given the almost negligible annual increase in real stumpage value over the past 24 years, even the most conservative owners should be hesitant about increasing stocks or lengthening rotations in anticipation of rising value.

2.7 Opportunities to Increase Output if Real Values Have Risen

Various measures are available to landowners who want to increase their production of timber through more intensive management, irrespective of stocking or rotation age. So long as the actual rise in the level of real timber values has been greater than that in the real value of labor and of capital other than growing stock, such intensification holds promise and can result in additional future timber output. Among the practices to be considered are protection and supervision, fertilization, regeneration, and timber stand improvement.

2.71 Forest Supervision and Protection

As wood value increases in relation to production costs, the more attractive and reasonable it becomes to open new roads to previously inaccessible areas, to initiate or improve existing protection programs, and to obtain technical assistance in the management of woodlands.

It is reasonable to assume that any increase in the price of pulpwood will serve to stimulate the construction of roads to the more inaccessible areas. Roads not only enhance the harvestability of areas, but also lend support to fire-control and prevention measures. Easy access to burning or threatened areas is a significant advantage.

It is also important to point out that the intensification of road networks has its disadvantages. The major drawback is that it leads to more use by the general public of these now accessible areas, which increases the risk of fire. Virginia as a whole, however, has an excellent fire-control record. Most of the state's forest lands are protected from fire through cooperative fire-control programs. The success of these programs has greatly reduced the risk of extensive loss. In 1975, only 4,660 acres were burned out of the 18,595,000 acres receiving protection (Forest Farmer, 1977). Therefore, it will be assumed that with continued private and public cooperation, nonsalvable timber losses will be negligible over the course of the study period.

Finally, it may be argued that the more exploitive owners, because of their high guiding rates of interest, place little emphasis on forest administration and protection, shifting the financial burden of supplying these services to state and federal agencies. This is not entirely true. Because of the size and location of most of their tracts, accessibility for administrative and protection purposes is already present, without any additional financial burden. Furthermore, their interest in immediate returns has motivated them to construct roads, where needed, that enable the grasping of current values while simultaneously improving protection opportunities.

2.72 Reforestation

In order to consider a firm's reaction to natural versus artificial regeneration, three items must be recognized. They are the anticipated increase in wood value, the costs involved in both planting and seeding, and the firm's guiding rate of interest. To incur the additional cost of artificial regeneration, an owner must be able to realize certain benefits not obtainable in natural stands. Among the advantages are better control over spacing and initial stocking, the ability to utilize genetically improved stock, avoidance of loss in growth due to failure to regenerate promptly, better adaptability for mechanical harvest, and higher yields. On the other hand, artificial regeneration has major disadvantages: Higher costs, greater chance of adverse soil disturbance, poorer early root-system development, and greater visual impact.

In general, exploitive owners with guiding rates of 12 percent can rarely justify the additional costs necessary to propagate plantations. Only when they can successfully secure partial government subsidies may they consider this alternative. Simply stated, they would forgo prospective timber yields in order to escape the immediate cost of regeneration.

At the other end of the spectrum, conservative forest owners can generally justify artificial regeneration of average to good sites because of the shorter rotations, higher yields, and reduced hardwood competition. Even on poorer sites, the additional outlay may be warranted, if significant delays in natural regeneration are anticipated.

Owners with intermediate guiding rates are less predictable in their reaction to artificial regeneration. So long as they can qualify for government subsidies, there is little doubt that they will choose planting. Without subsidies, based on the above arguments favoring planting, these owners would probably seriously consider artificial means of reestablishment only where natural regeneration promises to be delayed an inordinately long period of time.

2.73 <u>Forest Site Improvement</u>

Forest site improvement is generally achieved through the application of chemical fertilizer to the soil. Although considerable effort has been made to research the potentials of forest fertilization, no significant developments have arisen to warrant its use. The ever-increasing costs of purchasing and applying the fertilizer have precluded its use to any extent in eastern Virginia during the recent past. The only ongoing use of fertilization is a result of research and experimentation by some of the larger forest-industry firms in the area. Thus, in this study, it is assumed that the recovery and processing of fertilizer will keep the cost of its use at such a level as to exclude any but negligible use in eastern Virginia.

2.74 Timber Stand Improvement and Utilization

Gains in stumpage value in relation to costs will normally favor additional silvicultural measures aimed at increasing volume and value at harvest time. Among the stand-improvement measures are precommercial thinning, hardwood control and cleanings in young stands, and commercial thinnings.

Some of these measures may not yield any immediate returns, but find favor among owners in their positive effect on future output. If the anticipated timber values are high enough to offset treatment costs and still maintain a rate of return above the owner's guiding rate, the measure is justified. This acceptance test is applicable to opportunities yielding immediate as well as future returns. In the case of immediate returns, however, the measure may be desirable if these returns outweigh the immediate costs of performing it, irrespective of future gains in timber output.

Concerning future returns, for example, overstocking of young natural stands has a very adverse effect on future timber yields. A firm can easily find justification for precommercial thinning or cleaning of these stands, because the results will undoubtedly shorten rotations and hasten growth.

Consider now, plantations or natural stands that have received a very early treatment in order to adjust stocking to a "normal" level. With a pulpwood objective, implying short rotations, stands that are "normally" stocked should not experience any significant adverse effects of competition on volume yield. Therefore, a commercial thinning cannot be justified by extra future yields. Furthermore, given short rotations, the merchantable volume in cubic feet of pulpwood (5 inches d.b.h. to a 4-inch top) that is eligible for thinning, does not constitute a profitable logging chance for a rational operator. Therefore, this study will assume no commercial thinning.

One other measure that may present itself as a desirable opportunity is hardwood control in pine stands. Just as with other measures, if the anticipated extra returns outweigh the extra costs, the operation should be undertaken. The decision to implement hardwood-control measures is a direct function of the levels of hardwood invasion and the damage being done to the pine growth. A significant factor in favor of hardwood control is the potential for private owners to receive government subsidies. Obviously, the chance of reducing the burden of cost will stimulate the owner to further consideration of this alternative, but, we assume, not to an extent where it will significantly influence future timber yields.

With respect to utilization of wood from pulpwood rotations, the logging industry has advanced technologically to the point where, irrespective of stumpage values, it can economically harvest as much of the wood as is humanly and mechanically possible. The advent of the total tree harvester has produced this outcome. Because of these advancements, any assumption about greater utilization with rising stumpage value is purely academic: Total utilization is already a reality.

2.8 Forest Taxation

2.81 The Property Tax

As with any cost, the property tax may influence an owner's decision about forest management. Three types of influence will be discussed here: (1) How a property tax, irrespective of its being fixed or variable, becomes confiscatory; (2) How fixed property taxes that are not confiscatory affect management decisions; and (3) How variable property taxes that are not confiscatory affect management decisions.

A property tax becomes confiscatory when it promises to eliminate the value of the land for forestry endeavors or reduces it to a level below the value for any other use. In other words, when the capitalized value of a forest property is driven below its liquidation value, the financial return to the land as a productive agent is zero. For the landowner faced with this situation, the best alternative is to sell the existing merchantable timber and cease practicing forestry altogether.

Consider now, a property tax that is fixed over time, such that any change in the rate of the tax is unrelated to the condition of the forest. Take, for example, a fixed property tax of $1.00 per year versus one amounting to $2.00 per year. Incorporating these figures as deductions from column 4, Table 2, illustrates that the tax affects total revenue, but not marginal revenue, rotation age, or timber output (Table 6). Therefore, it must be considered a fixed cost and, short of confis-

Table 6.--The effect of a fixed property tax.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Rotation Age	Total Yield Per Acre	Annual Yield Per Acre	Annual Value Yield Per Acre			Marginal Value Yield Per Acre		Value Of Growing Stock			Rate On Extra Growing Stock	
			With No Tax	With $1 Tax	With $2 Tax	With $1 Tax	With $2 Tax	Total	Per Acre	Marginal Per Acre	With $1 Tax	With $2 Tax
Years	Cubic Feet		Dollars								Percent	
10	215	21.50	2.15	1.15	.15			53.75	5.38			
						5.96	5.96			22.07	27.01	27.01
15	1217	81.13	8.11	7.11	6.11			411.75	27.45			
						2.57	2.57			35.04	7.33	7.33
20	2135	106.75	10.68	9.68	8.68			1249.75	62.49			
						1.19	1.19			38.53	3.10	3.10
25	2968	118.72	11.87	10.87	9.87			2525.50	101.02			
						0.51	0.51			38.86	1.31	1.31
30	3715	123.83	12.38	11.38	10.38			4196.25	139.88			
						0.13	0.13			37.83	0.34	0.34
35	4379	125.11	12.51	11.51	10.51			6219.75	177.71			
						-0.11	-0.11			36.14	-0.30	-0.30
40	4958	123.95	12.40	11.40	10.40			8554.00	213.85			
						-0.28	-0.28			34.08	-0.82	-0.82
45	5453	121.18	12.12	11.12	10.12			11156.75	247.93			
						-0.39	-0.39			31.79	-1.23	-1.23
50	5863	117.26	11.73	10.73	9.73			13985.75	279.72			

cation, has no bearing on management practice decisions. This form of the property tax, which is presently practiced in eastern Virginia, either through statute or tradition is assumed applicable over the course of this study.

A variable property tax arises from changes in the assessed value of property. Two types of changes are recognizable, and each affects forest management differently. One change stems from some unexpected and uncontrollable sources, such as a forest catastrophe or monetary inflation. These changes, since they are uncontrollable and inescapable, have no effect on an owner's timber-management decisions.

The second type of variable property tax affects forest management because changes in property value are either planned or in some way forseeable. Assessments may rise according to the value growth of a stand or fall when value decreases as a result of harvesting. If an owner is aware of these changes he can alter their effect through changes in his forest practices. The most obvious alternative may be illustrated once again using Table 2. Suppose that for each succeeding 5-year interval, the tax rate increases $.10 per 100 cubic feet of wood, beginning with $1.00 at age 10. This cost is once again deducted from column 4, Table 2. The resulting marginal rates of return (Table 7), however, show that the owner faced with this circumstance will shorten rotation age (column 10, Table 7) and reduce output, as a means of reducing the property value and tax bite.

2.82 <u>The Income Tax</u>

The income tax, unlike the property tax, may tend to favor conservation. An owner may temporarily avoid the income tax by postponing

Table 7.--The effect of a variable property tax. 1/

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Rotation Age	Total Yield Per Acre	Annual Yield Per Acre	Annual Value Yield Per Acre	Annual Value Yield Per Acre With Variable Tax	Marginal Value Yield Per Acre	Value Of Total Growing Stock	Value Of Growing Stock Per Acre	Marginal Value Of Growing Stock Per Acre	Rate Of Return On Extra Growing
Years	Cubic Feet		Dollars						Percent
10	215	21.5	2.15	1.15		53.75	5.38		
					4.96			22.07	22.47
15	1217	81.13	8.11	6.11		411.75	27.45		
					1.65			35.04	4.71
20	2135	106.75	10.68	7.76		1249.75	62.49		
					0.36			38.53	0.93
25	2968	118.72	11.87	8.12		2525.50	101.02		
					-0.24			38.86	-0.62
30	3715	123.83	12.38	7.88		4196.25	139.88		
					-0.53			37.83	-1.40
35	4379	125.11	12.51	7.35		6219.75	177.71		
					-0.69			36.14	-1.91
40	4958	123.95	12.40	6.66		8554.00	213.85		
					-0.78			34.08	-2.29
45	5453	121.18	12.12	5.88		11156.75	247.93		
					-0.80			31.79	-2.52
50	5863	117.26	11.73	5.08		13985.75	279.72		

1/ Assume \$.10 per 100 cubic foot increase in growth from age 10, beginning with \$1.00 per 100 cubic feet at age 10.

timber harvest, thus building up growing stock, lengthening rotations, and increasing total output.

An income tax also acts like a transfer cost, by setting up a barrier to the shifting of capital out of forestry and into alternative investments. (This point was discussed in the section on guiding rate of return).

Beyond these general influences are the special effects of federal income tax. First, the tax subsidizes forest investment through the treatment of forest income as long-term capital gain. It also encourages owners to incur conservation costs by permitting some of these costs to be expensed against ordinary income. Included are such practices as certain silvicultural treatments and protection measures, watershed management, and road construction costs. In general, the favorable treatment of forest revenues motivates intensification of forestry investment, which leads to higher output, especially in the long run.

The assumption to be made here concerning the income tax is that the Internal Revenue Code will be largely unchanged throughout the course of this study.

3. LAND USE

3.1 Introduction

The analysis to this point has been concerned with the management alternatives of an owner, as dictated through the costs and revenues associated with timber management. In this chapter, the discussion is shifted to land use in Eastern Virginia in 2020. Projections include the total commercial forest acreage available in this region in 2020, by ownership class and forest type. Thus the question now is how many acres will be available for management in accordance with Chapter 2 principles.

Present land-use patterns are discussed and projections made according to economic, political, and social factors. The sheer magnitude of potential variables in these areas precludes the discussion, let alone recognition, of every change that may occur in the four decades to 2020. An attempt will be made to recognize and discuss the clearly significant variables in supporting the bases for all forecasts.

One qualifying assumption must be considered before the actual analysis proceeds. This is that the United States and the world in general will be experiencing a transition during the next 40 years, from primarily fossil fuels to alternative sources of energy. The concept of wood as an energy source of the future is being more seriously considered. Studies have been and will continue to be fostered, in an effort to determine the feasibility of this alternative. However, to simplify matters, projections of land use to be made here assume that our life style and economy in general will remain constant, so far as concerns energy and its derivation from wood.

Being freed from the energy restraint, we can now proceed with the land-use analysis. Consider the changes in use of all land (including inland water) in coastal Virginia from 1940 to 1976 (Table 8). In 1940, commercial forest acreage amounted to 3,919,200 acres. The figure increased to 4,067,100 acres by the 1956 survey. The subsequent increase, to a peak of 4,079,300 acres in 1966, was just a paper increase due to the reclassification of unproductive, low-site forest land: Total forest land actually declined during this period. With the fourth Forest Survey, this downward trend was confirmed as commercial forest acreage dropped to 4,003,539 acres.

By looking a little closer at the figures in Table 8, one can get a general overview of the past trends in land use on the coastal plain. Between 1940 and 1956, agricultural land showed a 319,200-acre decline. This change was accompanied by increases in both forest land and nonfarm-nonforest uses such as urban and residential areas and marshes. As the decline in agricultural land slowed to 136,600 acres between the second and third Surveys, forest land showed a slight decline (as previously explained), while nonfarm-nonforest acreage began to accelerate in growth. The same general trend continued through the fourth Survey as urban "sprawl" maintained a significant drain on both forest and agricultural lands. A more rigorous analysis of these trends is presented in the following sections, as a basis for projecting commercial-forest acreage to 2020.

3.2 Projection of Total Commercial-Forest Acreage to 2020

To forecast a dynamic, ever-changing situation such as land use, one must surely find a suitable blend of scientific evidence and "gut" feeling to serve as a basis. Developing a mathematical model with sufficient

Table 8.--Trends in land-use areas, by land-use class and survey completion date, 1940, 1956, 1966 and 1976. 1/

	Year of Survey			
Land Use	1940	1956	1966	1976
	Thousand acres			
Commercial Forest	3,919.2	4,067.1	4,079.3	4,003.5
Noncommercial Forest 2/	24.6	48.9	20.1	71.8
Total Forest Land	3,943.8	4,116.0	4,099.4	4,075.3
Cropland 3/	1,766.5	1,444.3	1,305.3	1,190.9
Pasture	150.5	153.6	155.9	147.7
Total Agricultural Land	1,917.0	1,597.8	1,461.2	1,338.6
Other Nonforest 4/	502.1	574.9	711.2	831.0
Water	506.2	580.4	597.3	624.2
Total Area	6,869.1	6,869.1	6,869.1	6.869.1

1/ Cost, 1976.

2/ Includes unproductive forest land and productive-reserved land.

3/ Includes idle farmland.

4/ Includes urban areas, marsh and other farmsteads.

and necessary variables to accomplish the desired goal would be so complicated and unwieldy that such a method must be rejected as being beyond the scope of this study. On the other hand, basing projections solely on the judgment of one or a few people is not consistent with good research.

For this study, the first step was to analyze all appropriate and recognizable trends in commercial forest land use for eastern Virginia. From these data were made the best projections suited to the study's scope and time allotment. These preliminary estimates were then presented, for comments and criticism, to various knowledgeable persons working in eastern Virginia. Combining their advice with the preliminary estimate produced a composite projection. This composite forecast was then bracketed above and below by a percentage of acres equal to the difference in acres between the preliminary and composite estimates, divided by the number of acres in the composite estimate.

3.21 Past Trends in Agriculture

The primary source of information on this subject was the U.S. Census of Agriculture, 1950-1969. On a regional basis, the trends in agriculture are very enlightening. From Table 8, the decline in agricultural acreage from 1950 to 1966 totaled 455,800 acres, or a 23.78-percent drop. The statistics behind this reduction are not readily apparent from the table. Although farm land has been steadily decreasing, the number of farms has experienced significant declines, while the average farm size has increased substantially. In 1950, the average size farm was about 109 acres. By 1969, this average had skyrocketed to 200 acres. The trend is obviously away from the small family farm toward the large corporate farm.

Consider the rapidly increasing cost of maintaining a farm on even a small profit level. Fertilizer, seed, fuel, and spare parts for machinery are only a small portion of the expenses contributing to the trend in rising costs. Under these circumstances, the smaller farmers are finding themselves in a potentially devastating predicament. Their livelihood is dependent upon the productivity of the farm, yet they are relatively helpless in coping with the economics of the situation. The only recourse for many of these persons is to drop out of farming altogether, whereby the land usually reverts to an owner whose goal may or may not be agricultural in nature.

The larger farms, which now and will continue to constitute a clear majority of farm acreage, are generally more suited to absorbing higher costs and still maintaining a profitable status. Their corporate nature derives for them certain benefits through economies of scale and through taxation. By the same token, the large initial capital investment in farm land, machinery, and buildings in sufficient magnitude to insure a reasonable rate of return places severe restrictions on potential entrants into agriculture.

The eventual outcome of these trends indicates a virtual disappearance of the small family farm, except in cases of philosophical appeal or where the owner is not dependent on the output of his farm for a livelihood. (These latter classes of farm owner will always be present and will continue to move in and out of the agricultural community.) Conversely, the large farms will at least maintain, and most likely increase, their aggregate acreage. In either case, they will bring to the agricultural economy a more stable land use.

The major point to derive from this discussion is that by 2020 agricultural acreage should be approaching a "steady state." Although stability should come about of its own accord, this is not guaranteed. Some purposeful social action may be necessary, else the urban hunger for land will critically deplete our forests. Specific remedial measures will be discussed in the next section.

3.22 Past Trends in Population and Urbanization

People are the primary movers of land-use change. The more inhabitants a region houses, the more land is needed for housing, public-service facilities, recreational needs, places of employment, roads, etc. An addition of only a few hundred people in an area can cause significant increases in the various land requirements just mentioned. A good example of this is eastern Virginia. Between 1940 and 1972, population rose nearly 140 percent. During the period 1940-1976 (closest comparable period for Forest Survey data), there was more than a 60 percent increase in nonfarm-nonforest acreage (Table 8). Much of this increase was a consequence of expanding metropolitan centers, including Richmond, Petersburg and Colonial Heights, Hampton, Newport News, Norfolk, Portsmouth, and Virginia Beach within the study area, as well as Fredericksburg and Washington D.C., outside the area but nearby. Lands in close proximity to these centers are subject to all sorts of urbanization, such as commercial, industrial, and residential development. Even lands many miles away are subject to the influence of a major city. For example, people are finding it more desirable to commute a few miles to as far as 40-50 miles to the city each day, rather than suffer through inner-city living. The clusters of outlying homes are commonly referred to as "bedroom communities". A good example can be found in King George County: Workers from Fredericksburg and Washington, D.C., are residing in the county, but commute to their jobs each day.

Consequently, with a 40-percent increase in population projected for 2000 (Commonwealth of Virginia, 1975), one can be confident that a further increase in nonfarm-nonforest land is forthcoming for 2000 as well as for 2020. As a rough measure, the changes stemming from metropolitan expansion can be broadened into a general geographic region for 2020. It includes an area fifty miles on either side of Interstate 95, south from its entrance into Unit 1 to Petersburg, and a belt of equal width centered on Interstate 64, east from where it enters Unit 1 to its terminus on the coast.

It would be difficult to dispute the fact that population changes will produce a significant drain on farm and forest acreage. The question is, can the state manage the change in such a way as to minimize the adverse effects on forestry and agriculture while at the same time increasing the efficiency of land-use patterns. Most of the planning districts in the coastal plain have realized that the linear sprawl of residential, commercial, and industrial land use, if it continues, will put unnecessary and wasteful pressure on agricultural and forest land. The inefficient side effects of sprawl also create major problems. For example, take the situation usually referred to as "strip development." This phenomenon is associated with major highways (excluding limited-access routes), where commercial establishments line both sides of the road, gobbling up valuable farm and forest land as businesses spread along the route. Traffic congestion, safety problems for adjacent residential areas, unnecessary clutter and noise, and the commercial and residential blight associated with this use pattern create a very undesirable situation (Crater Planning District Commission, 1973). What can the local planners and administrators do to alleviate this problem?

3.221 <u>Potential Answers to the Urbanization Problem</u>

The ultimate solution is the grouping of residential and commercial land uses in an effort to end the fractionalization of agricultural and forest lands. One alternative is the "proper" implementation of zoning. The objective of zoning is the division of municipalities into districts, within which certain regulations are applicable. Included among these regulatory goals are to minimize congestion in streets; insure safety from fire, panic and other dangers; provide adequate light; prevent overcrowding of land; avoid unnecessary concentration of population; and secure adequate provision of transportation, water, sewage, schools, parks and other public requirements. The major problem with zoning is that it is so deeply entrenched in local politics that it permits little progress in the conservation of agricultural and forest land.

Two recent legislative measures hold real potential in the pursuance of efficient land-use patterns. One is the Use-value Law passed by the Virginia legislature in 1971. Use-value taxation of real estate means "that qualifying land is valued and taxed in accordance with the use being made of it, rather than taxed in accordance with its fair market value." (Marshall, 1977). Fair market value is the price that property will bring when offered for sale on an open market. Use-value is the value of a tract of land as derived from the use being made of it. The two values become equivalent when the tract in question has no alternative use that can be valued higher than the qualifying use under present market conditions. Four specific classifications of real estate are recognized under this law. They are agriculture, horticulture, forest and open space. The preservation and proper use of these lands is the major thrust of the legislation. In addition, the bill seeks to conserve natural resources from erosion, protect and safeguard water supplies, preserve scenic beauty, promote proper and necessary land-use planning to accommodate expanding populations and reduce pressures on the aforementioned lands for conversion to more intensive use. Furthermore, the bill is distinguished from zoning in that it states that the use of land, not the zoning classification will serve as the basis for taxation.

Enactment of the Virginia Agricultural and Forestal District Act is another significant step in the drive toward conservation of forest and agricultural land to 2020. The purpose of this Act is "to provide a means by which agricultural and forestal land may be protected and enhanced as a viable segment of the State's economy and as an economic and environmental resource of major importance." (Marshall, 1977). In general, the Act permits owners of farm or forest land to band together and form districts in order to derive certain benefits. Six significant benefits are evident (Marshall, 1977):

1. Use-value taxation is available to qualifying lands within the district.
2. The powers of local government are restrained. For example, ordinances against spreading manure, burning off land and

spraying crops cannot be enforced within a district, except where they relate directly to public health.

3. Land in such districts is no longer subject to unregulated impacts brought about by public agencies. This applies to cases affecting location of new roads or relocation of existing roads.

4. The right of government or public-service corporations to exercise the power of eminent domain is restrained.

5. Expenditure of public funds for nonfarm-related reasons is subject to restraints.

6. Local tax assessments and levies cannot be imposed on owners within a district for nonfarm-nonforest purposes.

These two pieces of legislation have widespread potential in the the conservation of agricultural and forestal lands in Virginia. All depends on the extent to which they "catch on." In this analysis, their potential effect has been taken into account in the bracketed projection of commercial forest acreage for 2020.

3.23 Trends and Projections of Commercial Forest Land

Past trends indicate that changes in commercial forest acreage are complexly intertwined with changes in agricultural and urban acreages. The discussion to this point has attempted to unravel some of these complexities. First, the conclusion has been reached that the reduction in agricultural acreage will continue to slow as 2020 approaches and that the aggregate farmer owned acreage will converge to a "steady state." This land will represent a substantial block of real estate, that will be relatively stable in ownership. Very little cropland and pasture will be lost to outside influences when this stable situation is reached. Yet most farms will be composed, not only of cropland and pasture, but also of forest land. Consequently, as cropland and pasture become less vulnerable to loss, so should farm woodland. The degree of stability in farm woodland, however, will not be as great, because of its potential for conversion to cropland and pasture. (This point will be discussed in more detail in a later section.) The first conclusion of the present discussion is that when one speaks of a farm and how it will react to certain pressures over time, one must include both agricultural and forest land, for a farmer's forest land is only as stable as the agricultural success of his farm. The contention, then, is that agricultural land on the whole will approximate a steady state by 2020, but farm woodland will become only partially stable, as a result of internal rather than external influences.

The second conclusion is that urbanization will most likely continue as a major drain on forest land and, for a time, on agricultural land.

These conclusions, in conjunction with the figures in Table 8, give some insight as to how and where the urban drain will be directed. As previously mentioned, between 1940 and 1956 agricultural acreage experienced its largest decline. As a result, forest and nonforest-nonfarm uses were able to realize increases. In the periods 1956-1966 and 1966-1976, the slowing of decreases in agricultural acreage produced different results. Nonforest-nonfarm use was able to increase substantially as rising population stimulated rapid urbanization. Forest acreage, however, ceased to increase. Urban sprawl had begun to overflow out of agricultural acreage into forest lands. This trend is deemed likely to continue to 2020 as forest land suffers an ever larger loss to urbanization.

On the foregoing reasoning a procedure was developed for projecting commercial forest acreage to 2020 on a county-by-county basis with the use of published population forecasts. Evidence suggests that counties with zero or negative population growth experience little change in forest acreage. On the other hand, counties that are showing large increases in population tend to experience simultaneous, significant decreases in commercial forest acreage. Although this relationship is not universal, it is the most recognizable, reasonable, and consistent one that could be found. For this reason, the relationship is used as the basis for the procedure to be presented. Table 9 gives data for 30 of the 34 counties and independent cities in Virginia Unit 1, as an example of the relationship.

The procedure for forecasting commercial forest acreage in 2020 is as follows:

1. Population projections for all counties and independent cities are obtained for 2000. (Commonwealth of Virginia, 1975).
2. The average annual percentage rates of population increase are figured for the period 1972 through 2000 (Table 10).
3. It will be assumed that these averages will not change significantly if extended to 2020, no projections being available to 2020.
4. Reductions below the 1976 commercial-forest acreage were then estimated for each county on the basis of estimated population

Table 9.--Trends in commercial forest acreage by counties and population changes.

County	Population Change (1952-1972)	Commercial Forest Acreage Change (1956-1976)
	Percent	
Accomack	-15.5	+2.5
Brunswick	-20.5	+8.9
Caroline	+17.9	+5.8
Charles City	+34.7	+0.2
Chesterfield	+111.1	-6.3
Dinwiddie	+16.8	+7.9
Essex	+11.8	+1.5
Gloucester	+45.0	0.0
Greensville	-40.6	-1.0
Hanover	+90.1	-5.2
Henrico	+182.9	-9.0
Isle of Wight	+27.5	+3.3
James City	+208.6	-4.8
King and Queen	-14.3	+2.9
King George	+23.7	-6.1
King William	+0.1	-4.6
Lancaster	+5.3	-8.3
Mathews	+9.1	+15.6
Middlesex	-3.2	0.0
New Kent	+47.6	-7.1
Northampton	-13.3	-18.6
Northumberland	-9.1	-7.7
Prince George	+4.2	+0.9
Richmond	+1.8	+2.8
Southampton	-30.2	+3.6
Surry	+2.9	-0.9
Westmoreland	+26.1	-2.1

Table 10.--Population change to 2000. 1/

County	Average Annual Rate of Change 1972-1980	1980-1985	1985-1990	1990-1995	1995-2000	Grand Average 1972-2000
	Percent					
Accomack	+.6	+.5	+.5	+.4	+.4	+.49
Brunswick	-.6	+.2	+.3	+.4	+.4	+.06
Caroline	+.7	+.6	+.6	+.5	+.5	+.59
Charles City	+2.2	+1.6	+1.4	+1.5	+1.4	+1.68
Chesapeake	+1.5	+1.1	+1.0	+.6	+.6	+1.01
Chesterfield	+4.9	+2.7	+2.6	+2.1	+2.0	+3.08
Dinwiddie	+1.6	+2.0	+1.8	+1.5	+1.5	+1.67
Essex	+.7	+.5	+.5	+.5	+.5	+.56
Gloucester	+2.3	+2.0	+2.0	+1.4	+1.2	+1.83
Greensville	-.9	-.5	0.0	-.2	-.2	-.42
Hampton	+1.7	+1.6	+1.3	+1.1	+1.0	+1.38
Hanover	+4.6	+3.4	+3.3	+2.6	+2.6	+3.44
Henrico	+2.3	+1.5	+1.4	+1.3	+1.3	+1.64
Isle of Wight	+.6	+.5	+.5	+.4	+.4	+.49
James City	+3.2	+3.7	+3.0	+2.8	+2.8	+3.11
King and Queen	+.2	+.4	+.4	+.3	+.3	+.31
King George	+.7	+.7	+.7	+.6	+.6	+.66
King William	+.3	+.3	+.3	+.5	+.5	+.37
Lancaster	+.1	+.2	+.2	+.2	+.2	+.17
Mathews	+.5	+.5	+.5	+.5	+.5	+.50
Middlesex	+.6	+.6	+.6	+.5	+.5	+.56
New Kent	+3.0	+2.5	+2.5	+2.2	+2.1	+2.52
Newport News	+1.1	+1.0	+.8	+.8	+.8	+.92
Northampton	+.7	+.7	+.8	+.8	+1.0	+.79
Northumberland	-.3	0.0	0.0	0.0	+.2	-.05
Prince George	+1.4	+1.8	+1.6	+1.5	+1.5	+1.54
Richmond	+.4	+.3	+.3	+.3	+.3	+.33
Southampton	-.3	0.0	0.0	0.0	0.0	-.09
Suffolk	+1.2	+1.0	+1.0	+.7	+.7	+.95
Surry	-.8	0.0	0.0	0.0	0.0	-.23
Sussex	-.2	-.2	0.0	+.2	0.0	-.05
Virginia Beach	+3.3	+2.8	+2.1	+1.7	+1.4	+2.37
Westmoreland	+1.1	+.8	+.8	+.8	+.6	+.85
York	+3.0	+3.5	+2.8	+2.6	+2.6	+2.91

1/ Commonwealth of Virginia, 1975.

change. The reduction factors are given in Table 11.

5. Table 12 gives the results of the commercial-forest acreage forecasts to 2020, county by county.

6. The projection of total commercial-forest acreage for 2020 is 3,658,470 acres, or an 8.61 percent decrease below 1976 acreages.

As previously stated, the forest-acreage estimate is a composite result of past trends and advice of knowledgable persons who work in eastern Virginia. A prior estimate based solely on past trends yielded a figure that was 3 percent less than the composite estimate. This prior estimate will serve to give us a spacing between the composite and the bracketing estimates. The three possibilities for commercial-forest acreage in 2020 are--

1. High estimate........................3,768,224 acres
2. Composite estimate...................3,658,470 acres
3. Low estimate.........................3,548,715 acres

3.3 Forest Ownership

Given the projection of a decline in total commercial forest acreage, it is possible to move on to the question of how this reduction will be allocated among ownership classes. The four classes recognized in this study are public, forest industry, farmer, and miscellaneous private (corporate and individual). Table 13 gives the trend in commercial forest acreage by ownership, 1956-1976. For each ownership class, a breakdown of commercial forest acreage by forest type is needed. Table 14 gives this information for 1966 and 1976. Note that the 1976 data recognize the distinction between natural and planted loblolly-

Table 11.--Estimated reductions in commercial forest acreage, by population change.

Population increase (Average annual growth, 1976 to 2020, in percent)	Reduction factor (Percent of 1976 commercial-forest acreage)
-1.00 to 00.00	1.0
+0.01 to +0.50	3.0
+0.51 to +1.00	5.0
+1.01 to +1.50	10.0
+1.51 to +2.00	15.0
+2.01 to +2.50	20.0
+2.51+	25.0

Table 12.--Projections of commercial forest acreage in eastern Virginia to 2020.

County	1976 Acreage	Average Annual Population Change to 2020	Reduction Factor	2020 Acreage
	Acres	Percent		Acres
Accomack	114,092	+.49	3.0	110,669
Brunswick	290,505	+.06	3.0	281,790
Caroline	263,294	+.59	5.0	250,129
Charles City	87,509	+1.68	15.0	74,383
Chesapeake	113,784	+1.01	10.0	102,406
Chesterfield	211,294	+3.08	25.0	158,471
Dinwiddie	246,146	+1.67	15.0	209,224
Essex	107,164	+.56	5.0	101,806
Gloucester	96,044	+1.83	15.0	81,637
Greensville	138,074	-.42	1.0	136,693
Hampton	6,523	+1.38	10.0	5,871
Hanover	198,593	+3.44	25.0	148,945
Henrico	71,760	+1.64	15.0	60,996
Isle of Wight	123,178	+.49	3.0	119,483
James City	62,651	+3.11	25.0	46,988
King and Queen	160,961	+.31	3.0	156,132
King George	69,762	+.66	5.0	66,274
King William	125,112	+.37	3.0	121,359
Lancaster	51,686	+.17	3.0	50,135
Mathews	34,106	+.50	3.0	33,083
Middlesex	53,831	+.56	5.0	51,139
New Kent	101,407	+2.52	25.0	76,055
Newport News	15,442	+.92	5.0	14,670
Northampton	31,586	+.79	5.0	30,007
Northumberland	69,188	-.05	1.0	68,496
Prince George	119,660	+1.54	15.0	101,711
Richmond	79,027	+.33	3.0	76,656
Southampton	263,927	-.09	1.0	261,288
Suffolk	134,912	+.95	5.0	128,166
Surry	133,958	-.23	1.0	132,618
Sussex	248,554	-.05	1.0	246,068
Virginia Beach	57,598	+2.37	20.0	46,078
Westmoreland	86,931	+.85	5.0	82,584
York	35,280	+2.91	25.0	26,460
Totals	4,003,539			3,658,470

Table 13.--Trends in area of commercial forest land by owner class, 1956, 1966 and 1976. 1/

Ownership Class	Year of Survey 2/ 1956	1966	1976
	Acres		
Public	116,000	131,300	146,237
Forest Industry 3/	758,600	758,800	766,834
Farmer	2,813,200	1,857,000	1,650,439
Miscellaneous Private	379,300	1,332,200	1,440,029
Total	4,067,100	4,079,300	4,003,539

1/ Sheffield, 1978.

2/ The 1940 data is omitted because of differences in source of data and changes in definitions.

3/ Fee simple land only.

Table 14.--Commercial forest acreage by ownership and forest type, 1966 and 1976. 1/

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Forest Type	Type of Ownership							
	Public		Forest Industry		Farmer		Miscellaneous Private	
	1966	1976	1966	1976	1966	1976	1966	1976
	Acres							
Planted Loblolly Pine		3,382		215,900		65,418		64,578
	44,300		323,700		423,200		354,100	
Natural Loblolly Pine		49,524		252,820		324,705		335,276
Oak-pine	26,600	18,945	153,900	115,382	431,900	299,459	273,300	278,219
Upland Hardwood	54,300	63,212	215,000	137,231	897,900	762,582	623,300	591,713
Bottomland Hardwood	6,100	10,724	66,200	45,501	110,600	198,275	86,300	170,243

1/ Cost, 1976.

pine acreages. The 1976 format is the one desired for the projections of forest types to 2020.

Two assumptions must be made in order to qualify the discussion to follow. First, only one set of projections will be made for public and forest industry holdings. The acreages will not be considered variable with the bracketed estimates of total commercial forest acreage in 2020. The farm and miscellaneous private holdings, because of their historical variability, will be variable with the bracketed assumptions.

The second point that needs consideration concerns the productive-reserved forest acreage. According to the Forest Survey definition, productive-reserved land is "forest land sufficiently productive to qualify as commercial forest land, but withdrawn from timber utilization through statute or administrative designation (Cost, 1976)." There is no question that forested parks, recreational areas, and wildlife refuges should be covered under the classification. Moreover, there is some support for placing additional lands in this category. An example is the small parcel of forest land, perhaps 5 to 25 acres, in which someone builds a home. Lured by the aesthetic qualities, quiet atmosphere, shade, and country living, he, like many others, has been caught up in a forested-site syndrome. His reasons for purchasing the land preclude any thought of ever harvesting the timber. In fact, in many cases, he could not even if he wanted to, because ordinances have been passed in many forested communities which prohibit certain activities between designated hours of the day or require permits for these and other activities. The result, whether deliberate or not, is to restrict or eliminate altogether the potential to harvest timber. Consequently, it is difficult for some people to accept such land as commercial forest and not productive-reserved forest. But since the Forest Survey is the basis for this analysis and does not recognize this acreage as productive-reserved, the only alternative is to consider it as a "potential" commercial source of wood, remote as the possibility may be.

3.31 Public Ownership

Both past trends and opinions of knowledgeable persons working in eastern Virginia indicate a continuing increase in public ownership of forest land. The increase will be due largely to the acquisition of forested areas by counties and municipalities. State agencies are not directly funded for immediate purchase of additional lands. They are at the mercy of the legislature for appropriation of funds for land purchases. Therefore, the only additions to state land will be gifts from individuals or groups.

The other significant feature of public ownership is the commercial forest land in military reservations. The acreage amounts to over two-thirds of the total public ownership. Some of the larger installations include Fort A.P. Hill, Fort Pickett, Camp Peary, and Fort Eustis. One would expect that future purchases of commercial forest acreage by the military to occur primarily out of necessity for expanding various operations. Therefore, prospects for commercial forest acreage in military reservations between now and 2020 would indicate slight increases at sporadic intervals.

The trend in public ownership between 1956 and 1976 has been nearly linear, with increases of approximately 15,000 acres during each ten-year period. Extending this trend to 2020 yields a total increase of

60,000 acres. This trend, however, is not likely to continue, in light of the ever-increasing cost of land acquisition. A more realistic estimate is in the neighborhood of 40,000 acres. This will drive the total commercial forest acreage in public hands to 186,237 acres.

Productive reserved acreage should also increase somewhat by 2020, but not at the 1966-1976 rate. That 55,656 acre jump was due primarily to the transfer of ownership, from forest industry to public, of portions of the Dismal Swamp. No specific projection of productive-reserved acreage will be made, since any increase has already been accounted for in the total reduction of commercial forest acreage.

3.311 Acreages of Public Owners by Forest Type

Table 14 (column 3) gives a breakdown of public acreage in 1976 by each of the five forest types. (See Chapter 4 for a definition of each forest type.) The 40,000 acres of additional public forest will be assumed to enter the oak-pine and upland hardwood categories in a proportion equal to the total acreage in each, according to the 1976 Survey. This ratio is 2.18 acres of upland hardwood to each acre of oak-pine. Thus, oak-pine will rise from 18,945 acres to 31,523 acres, while upland hardwood goes from 63,212 acres to 90,634 acres. This is reasonable, since active pine management programs are not generally practiced on state, county, and municipal holdings. Similarly, there will be a tendency on these lands to allow the present pine stands to revert to oak-pine and upland hardwood.

Unlike the other public forests, the military reservations are being given more intensive management in terms of pine. In recent years there has been a noticeable trend towards conversion of oak-pine and upland hardwood to pine stands. These trends are significant enough to warrant the assumption that there will be an even tradeoff between conversion to pine in military reservations and reversion from pine in other public ownerships.

Only two considerations remain for public ownership. First is the mix of natural and planted loblolly pine for 2020. Given the tendency of the military to propagate pine, planted loblolly pine will increase to 7,500 acres as natural loblolly pine falls to 45,856 acres. Second, bottomland hardwood will be assumed to remain constant. The typical bottomland site is not conducive to conversion to pine or any other use. Table 18 contains a summary of the preceding projections to 2020.

3.32 Forest Industry

There is varying evidence and opinion about how forest-industry owned (i.e., fee simple lands) acreage will change between now and 2020. The following considerations should throw light on the probable outcome.

First, continuing urbanization, expanding outward from the metropolitan centers, drives up real-estate prices beyond a point where land can be purchased and then managed profitably by forest industry.

Second, industry owns a considerable amount of waterfront acreage in eastern Virginia. The desirability of this land for home sites results in great demand at premium prices. At such exorbitant rates, industry can hardly afford to forgo such a lucrative alternative in favor of forest management.

Third, forest-industry land has become a primary target of public-works projects such as roads, power line rights of way, etc. Governmental agencies show strong preference for dealing with industry versus other private landowners, who will most likely be vehement in their opposition to relinquishing any land for these projects. The resultant court battles and legal hassles are forcing these agencies to deal with forest industry whenever the opportunity arises.

Fourth, one corporation has recently sold approximately 20,000 acres in the southeastern portion of Virginia to a buyer desiring to convert it to cropland. Large sales such as this, and gifts to the public, are not everyday occurrences. But they do occur from time to time, and although forest industry strives to replace this acreage in the same region, the attempt cannot always be successful.

Fifth, the southern tier of rural, agrarian counties is still a relatively active source of forest acreage for forest industry. The price shadows created by urbanization are not being felt here to the extent that they are in the northern counties. Whether this area can supply the necessary requirements of industry to 2020 is questionable. Perhaps many companies will have to look towards North Carolina and beyond, for acreage to replace that lost in Virginia.

Given the foregoing rationale of large potential reductions in industry acreage, but substantially restricted potential to replace land which is lost, forest-industry owned lands are projected to remain unchanged from the present 766,834 acres.

3.321 Acreages of Forest Industry by Forest Type

The question now is, how will the 766,834 acres of forest industry land projected for 2020 be distributed among the five forest types. Table 14 shows the present situation. Past evidence indicates a significant trend away from hardwood and oak-pine and into pine. Prospects for 2020 should follow this trend. The extent of conversion, however, will not be 100 percent. At least one large corporation in eastern Virginia is presently following an active hardwood-management program and foresees a continuance of this policy. Using the corporation's figures as a basis, one may estimate that 100,000 acres will remain in oak-pine, upland hardwood, and bottomland hardwood in 2020. It is assumed that bottomland hardwood acreage will remain unchanged from the present 45,501 acres. The difference, 54,499 acres, will be divided between upland hardwood and oak-pine in proportion to their 1976 acreages, which was 2.18 acres of upland hardwood to every acre of oak-pine. Thus, for 2020 we have 17,138 acres of oak-pine and 37,361 acres of upland hardwood.

From Table 14 it is seen that the oak-pine, upland hardwood, and bottomland hardwood types accounted for 298,114 acres of the forest industry's total forest acreage in 1976. With only 100,000 acres projected as remaining in these types for 2020, this leaves 198,114 acres unaccounted for. It is assumed that all 198,114 acres will be converted to pine. It is also assumed that these acres will funnel equally into the planted and natural loblolly pine types. This equal division would not be expected today because more converted acres are being regenerated through planting than through natural means. One must, however, take into account the potentials of direct seeding and the future costs of planting. If the costs associated with planting continue to skyrocket and the effectiveness of direct seeding can be made equal to that of planting, a whole new trend could be initiated. It is for these reasons that the foregoing assumption is made, resulting in 314,957 acres of planted loblolly pine and 351,877 acres of natural loblolly pine for 2020. Table 18 summarizes all projections of forest industry acreage to 2020.

3.322 Leasing and CFM Programs of Forest Industry

There is another very important point to be considered about forest industry. As land prices steadily rise and drains on forested acreage accrue, how can the firm insure a steady supply of raw material to operate the mill? Since land purchasing is becoming a relatively poor investment, how can the desired goal be achieved through less expensive means? The answer at present may seem to lie in leasing and cooperative forest management (CFM) of privately owned land. The significance of these programs for this study is that, although the land remains technically in farmer or miscellaneous private ownership, it is managed as if it were in forest industry hands. Thus, the rotations and yields are equivalent to those on industry lands.

From a number of industry people, it was learned that leasing, on the whole, is not a promising alternative. The annual outlay required, in conjunction with the risk involved, is a deterrent to active leasing programs. However, at least one corporation is interested in leasing, which may result in perhaps a small increase in its use by 2020.

For CFM programs, the prospects appear much brighter. Although each company program may differ somewhat, the primary benefits are the same. These are-- (1) Professional help and advice in determining the best alternatives for a landowner's property; (2) Drawing up management plans; (3) Assistance in site preparation, seedling purchase, and planting with industry equipment, at cost; (4) Aid in the paper work necessary to apply for various governmental incentives and for sales to the company doing the CFM work.

The companies' position here is that by close, personal, honest cooperation with landowners, they will receive their fair share of the wood produced on these lands without entering into contractual agreements.

At present there is a wide spectrum of intensity in the use of CFM. One corporation has instituted a separate department, of 8 to 10 employees, whose sole purpose is to work with landowners on CFM programs. Others have medium to small programs, while a few have none at all.

Given present evidence and opinions, the acreage projected as being under CFM and leasing options in 2020 is between 150,000 and 200,000 acres. The midpoint, 175,000, is used as the estimate. In estimating how this acreage will be subdivided between farmers and miscellaneous private owners, some difficulty is encountered. What evidence does exist points to a majority of this land being in the nonfarm ownership. Therefore, 25 percent is allotted to the farmers and the remaining 75 percent to the nonfarm owners. Furthermore, it is assumed that all 175,000 acres will be in pine, since it would not be in the best interest of pine-using corporations to cooperatively manage or lease for the production of hardwoods. By the same token, corporations utilizing hardwoods need not institute CFM or leasing programs, because of the present overabundance of hardwood acreages. Finally, 50 percent of the acreage allotted to each ownership is estimated as being in planted loblolly pine and the other 50 percent is projected to be in natural loblolly pine. The results of these projections are summarized in Table 19.

3.33 Farm and Miscellaneous Private Ownership

These two ownership classes will be discussed together because of their close interrelationship in terms of changes in commercial forest land. By examination of Table 14, it is readily apparent that the majority of any given reduction in farm-owned forest has ended up primarily in miscellaneous (nonfarm-nonindustry) private ownership. Any excess of farm acreage change was usually accounted for by small increases in public, industrial, and productive reserved acreages or in a general reduction of all commercial forest land.

Opinions among experts, as well as past evidence, intimates that farmers will experience the largest loss in commercial forest acreage. The nonfarm owners, however, become very elusive when one studies forecasts of their acreage for 2020. Estimates range from a hefty increase to a slight decrease. Because of this variability, the three alternative assumptions of reductions in commercial forest acreage will be accounted for in farm and nonfarm ownerships. That is, these two groups will be subjected to varying additions and subtractions of acreage depending on the alternative under consideration. To fully understand the rationale behind these changes, one must be aware of their origins.

Consider, then, how the farmer may lose his woodland. First, there is the continuing loss, of cropland as well as woodland, to urbanization. The value attached to a farmer's land for purposes of urbanization is often enough to coax him out of farming. This is especially true for the smaller farms.

The second significant drain on farm woodland is a direct function of the ever-increasing size of farms. As the owners of larger farms begin to resemble corporations, they must continually intensify the use of their existing acreages so as to maintain optimum financial returns. Two alternatives are apparent. The farmer can either purchase adjacent or nearby land or convert some of his own woodland in an effort to gain more cropland. Since agriculture is the livelihood of the farm, the woodland is relegated to a subordinate role. (This is even more apparent when one considers the peculiarities of forestry, such as length of investment and low interest on the investment.) When a need for more cropland is realized, the farmer would not hesitate to convert woodland if this is cheaper than land acquisition. Because of high land values, woodland conversion is presently quite prevalent in eastern Virginia and may be expected to continue.

Third is the pressure on the smaller-scale farmers as they find it impossible to compete: Their productivity is low; their profits are small; their opportunities outside farming are relatively attractive. In most cases where the farm was the primary source of income and the land is sold, it is not retained as farm or forest.

There is very little forseeable likelihood of additions to farm woodland. Two exceptions are: When a farmer purchases some unusually cheap land and holds it for future conversion to cropland or when worn-out cropland must be taken out of production for rehabilitation and thus may revert to forest in some instances. These influences are small and should have no significant bearing on the overall trend in farm woodland to 2020.

The drains on forest land of the nonfarm owners are not so severe as those on farm forests. True, the loss to urbanization is still prevalent and probably at least as severe as the farmer's, if not more so. However, very little of the nonfarm woodland is likely to revert to cropland or be lost because of financial burdens. The farmer would prefer to purchase open space rather than clear forest for new cropland, unless forest land is extremely inexpensive.

Given the nature of the miscellaneous private owner, whose livelihood is not, as a rule dependent on the productivity of the forest, one would expect him to be less vulnerable than the farmer to financial pressures. He would tend to retain his land under conditions that would find many farmers selling out. Only when the price is sufficiently high would he consider selling, and in this case a farmer is not apt to be the buyer.

The prospects for increases in nonfarm holdings are somewhat brighter than for farms. Because of their better financial standing, owners such as doctors, lawyers, and dentists are able to buy land that is being lost by the farmers who are going out of business. In addition to the woodland being bought, the agricultural land will be left to revert to forest, since the new owners are not interested in agricultural endeavors. All this presumes that buyers with more intensive land uses in mind will not outbid the prospective forest owners.

With the preceding arguments, it is reasonable to conclude that farmers will suffer the greatest forest loss, while the nonfarm-nonindustry owners will slightly increase or decrease their forest holdings.

A comparison of past trends in farm and nonfarm ownerships gives a clue to how they might trend to 2020. In Table 13, it is seen that farm woodland experienced a sharp decline from 1956 to 1966. During the period 1966 to 1976 this trend slowed considerably as farm woodland began leveling off. It is vital to note that the same trends are evident in cropland (Table 8). This suggests that the assumption of an approaching "steady state" (in the extreme, a steady and slow decline) in farmland can be sufficiently extended to include cropland and woodland individually. Consequently, a bottom limit for farm-forest acreage is here estimated by extending the 1956-1976 data linearly to 2020 (Figure 3). By inspection, one can set this limit at 1,050,000 acres.

Conversely, the nonfarm-nonindustry owners increased their acreage sharply from 1956 to 1966 and like the farmer, began a leveling-off phase from 1966 to 1976. In line with the conclusion that the total of these nonfarm holdings will possibly increase slightly in acreage, the 1956-1976 data were extended linearly to 2020 as an upper limit. The result is an upper bound of 1,700,000 acres.

With these limits in mind, it is now possible to make some projections of farm and miscellaneous private forest acreage to 2020. In conjunction with each of the three alternative reductions in total commercial-forest acreage (high, composite, low), four options will be considered, resulting in twelve projections for each ownership (Table 15). Options one and two are presented as illustrations of what could happen if farmers and miscellaneous private owners were to attain the above limits--i.e., 1,050,000 acres and 1,700,000 acres, respectively. Option one merely restricts the farmers to their lower limit of commercial forest acreage. Option two requires the nonfarm-nonindustry owners to attain their upper limit. Since these six projections for each own-

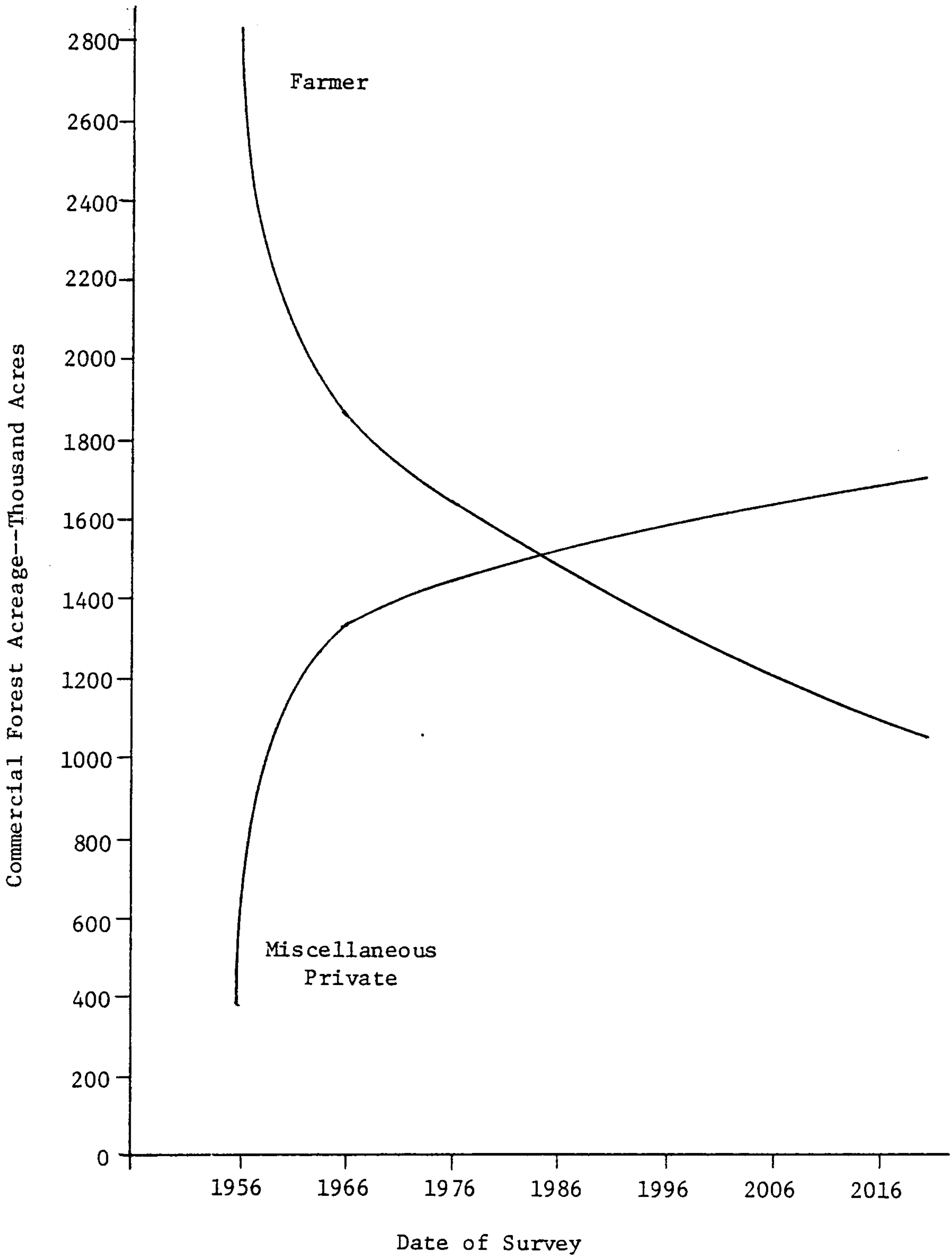

Figure 3.--Comparison of commercial forest acreage in farm and miscellaneous private ownerships.

ership do represent bounds rather than probable outcomes, no further analysis will be carried out on their behalf. However, if further investigation into these projections were desired, the task would not be difficult.

The remaining two options represent the most likely trends in commercial forest acreage of farmers and miscellaneous private owners. They illustrate a range of possibilities within which the ownership of forest acreage will most probably fall. For alternative one (high projection), for nonfarm-nonindustry owners, the range is from a 10-percent increase to no change in their total commercial forest acreage (options 3 and 4, respectively). Given the minimal losses in total commercial forest acreage estimated for alternative one, the trends of the recent past will tend to prevail: A moderate reduction of farm woodland as miscellaneous private acreage increases slightly.

The composite estimate, alternative two, offers a range of +5 percent to -5 percent for the change in commercial forest acreage of nonfarm-nonindustry holdings, options 3 and 4 respectively. Here is where the prospects for the miscellaneous private owners become most elusive. With a larger projected reduction in commercial forest acreage, the farmer is still expected to bear the larger burden of loss, but the miscellaneous owners are becoming more susceptible to acreage loss as we move into alternative two.

As projected losses in commercial forest acreage reach a maximum under alternative three (low projection), the miscellaneous owners can expect nothing less than to lose some acreage. The estimate, then, for their commercial forest acreage ranges from no change (option 3) to a

Table 15.--Twelve projections of commercial forest acreage for farm and miscellaneous private ownerships to 2020.

Alternative Projections of Total Commercial Forest Acreage	Forest Ownership	Options: Option 1	Option 2	Option 3	Option 4
		Acres			
Alternative I		Projection (1,1)	Projection (1,2)	Projection (1,3)	Projection (1,4)
(High Estimate)	Farmer	1,050,000	1,115,153	1,231,121	1,375,124
	Miscellaneous Private	1,765,153	1,700,000	1,584,032	1,440,029
Alternative II		Projection (2,1)	Projection (2,2)	Projection (2,3)	Projection (2,4)
(Composite Estimate)	Farmer	1,050,000	1,005,399	1,193,369	1,337,371
	Miscellaneous Private	1,655,399	1,700,000	1,512,030	1,368,028
Alternative III		Projection (3,1)	Projection (3,2)	Projection (3,3)	Projection (3,4)
(Low Estimate)	Farmer	1,050,000	895,644	1,155,615	1,299,618
	Miscellaneous Private	1,545,644	1,700,000	1,440,029	1,296,026

10-percent loss (option 4).

Table 15 illustrates the results of the twelve projections under consideration for each ownership. Projections (2,2) and (3,2) are invalid because they violate the lower limit for farmers--i.e., 1,050,000 acres. Projection (1,1) is inacceptable because it violates the upper limit for the miscellaneous private group. Remaining as possible estimates are projections (1,2), (2,1) and (3,1), but as previously stated no further work will be done on options 1 and 2.

From options three and four, a range of estimates is desired for use in the following analysis. For this purpose, projections (1,3), (2,3), (2,4) and (3,4) are chosen. The two selections from the composite projection of total commercial forest acreage in eastern Virginia for 2020, are included because they represent the probable range of outcomes in farm and miscellaneous private holdings. Projections (1,3) and (3,4) are included since they represent the most likely outcomes from alternative 1 and alternative 3, respectively.

3.331 Acreages for Farmers and Miscellaneous Private Owners by Forest Type

Farm and miscellaneous private ownership of commercial forest acreage, by forest type for 1976, was presented in Table 14. In considering how these acreage figures will change by 2020, one must deal with two problems for each of these ownerships. First, given that farmer-owned commercial forest in eastern Virginia is projected as decreasing between 1976 and 2020, it must be decided how this reduction will be allocated amongst the five forest types. Likewise, for a projected decrease in miscellaneous private ownership of commercial forest acreage (projections (1,3) and (2,3)), the same consideration must be dealt with. But in addition, some decision must be made concerning projections of increasing commercial forest acreage in miscellaneous private ownership (i.e., projections (1,3) and (2,3)), and how the added acreage will be allocated to the five forest types.

Second, after deciding how the farmer and miscellaneous private acreage in each forest type will react to the various increases and decreases in commercial forest acreage, we must give consideration to the acreage remaining after these changes, in terms of shifts from one forest type to another.

There is no concrete solution to the problem of allocating acreage changes to forest types. The farmer is naturally inclined to convert the best sites (i.e., those in pine) to cropland. Yet a farmer who has made an investment in pine, especially by planting, would be reluctant to convert such stands to cropland before rotation age. At the very least, he would explore the possibility of converting some poorer sites before relinquishing his investment in pine. As for reductions due to urbanization, there should be little preference as to site or forest type. However, to simplify the matter of determining where the reductions in farmer-owned forest will come from, it is assumed that losses, be they for urbanization, cropland, or any other use, will be incurred without preference for site or forest type. This simplification means that any reduction in forest acreage of farmers will occur in proportion to the acreage in each forest type according to the 1976 Survey (e.g., planted loblolly pine represented 65418 acres/1,650,439 acres = .04 of the total commercial forest acreage owned by farmers). Therefore, the percentage reductions in column 3 (rounded to nearest whole number), Table 16, are applied to the difference between the 1976 acreages (column 2) and the 2020 commercial acreages under the four projections chosen for analysis (i.e., projections (1,3), (2,3), (2,4), and (3,4)). For example, the difference in commercial forest acreage of farmers between 1976 and 2020 for projection (1,3) is 419,318 acres (1,650,439 acres minus 1,231,121 acres). Four percent of this reduction will be lost in the planted loblolly pine acreage (.04 times 419,318 acres equals 16,773 acres), leaving 48,645 acres (65,418 acres minus 16,773 acres).

Since the major source of acreage loss for miscellaneous private owners is urbanization, there is little necessity for preference among sites of varying quality or forest type. For instance, a good site with a poor location may not be as valuable as a poor site in a good location. Therefore, reductions in each forest type as a result of reductions in commercial forest acreage of miscellaneous private owners are assumed to be in proportions to the 1976 acreage, just as in the case of the farmer. Table 17 shows the percentage reductions for projections (2,4) and (3,4) in column 3, as applied to the difference between the 1976 acreage and the projected acreage in 2020 (i.e., the calculations are performed identically with those for the farmer).

What happens when the miscellaneous private holdings increase in commercial forest acreage, as with projections (1,3) and (2,3)? Some sort of percentage increases must be determined. Since the bulk of any loss in farmer-owned commercial forest acreage has historically ended up in miscellaneous private ownership, this relationship is assumed to con-

Table 16.--Adjustment of farm woodland due to reduction in commercial forest acreage, by forest type.

(1)	(2)	(3)	(4)	(5)	(6)	(7)
			2020 Acreage			
Forest Type	1976 Acreage	Percent Reduction	Projection (1,3)	Projection (2,3)	Projection (2,4)	Projection (3,4)
	Acres	Percent	Acres			
Planted Loblolly Pine	65,418	4	48,645	47,135	52,895	51,385
Natural Loblolly Pine	324,705	20	240,841	233,291	262,091	254,541
Oak-pine	299,459	18	223,982	217,186	243,107	236,311
Upland Hardwood	762,582	46	569,696	552,330	618,571	601,204
Bottomland Hardwood	198,275	12	147,957	143,427	160,707	156,177
Totals	1,650,439	100	1,231,121	1,193,369	1,337,371	1,299,618

tinue to 2020 and the percentage reductions used for the farmer are instituted as percentage increases for the miscellaneous private owners (column 6, Table 17), as applied to the difference between the 1976 acreage and the 2020 acreage for projections (1,3) and (2,3). Table 17 gives the results for all increases and decreases of miscellaneous private commercial forest acreage for the various projections under consideration.

It is now time to resolve the second problem concerning farm and miscellaneous private ownership of commercial forest acreage in 2020—namely, how will the commercial forest acreage projected for 2020, Tables 16 and 17, respectively, change, if at all, with respect to forest type.

The general feeling is that the farmers as well as the miscellaneous private owners will be converting a fair amount of their oak-pine and upland hardwood to pine, natural and planted. Because oak-pine and upland hardwood are not producing optimal returns for their owners, their conversion to the more intensive use is a believable prospect.

Evidence suggests, however, that conversion of oak-pine and upland-hardwood sites to pine is not financially feasible. Row (1973) found that for site index 60, on hardwood sites being converted to pine, the financial outcome for an owner with a 5-percent guiding rate of return is not sufficient to justify the investment. This is true for both thinned and unthinned stands. Only when site index 80 is reached does the return warrant the investment. Therefore, since upland-hardwood sites in eastern Virginia average only site index 60, it would not be realistic to expect anyone with a guiding rate of 5 percent or more to

Table 17.--Adjustment of miscellaneous private woodland due reduction in commercial forest acreage, by forest type.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
			2020 Acreage			2020 Acreage	
Forest Type	1976 Acreage	Percent Reduction	Projection (2,4)	Projection (3,4)	Percent Increase	Projection (1,3)	Projection (2,3)
	Acres	Percent	Acres	Acres	Percent	Acres	Acres
Planted Loblolly Pine	64,578	5	60,977	57,378	4	70,338	67,458
Natural Loblolly Pine	335,276	23	318,716	302,155	20	364,077	349,676
Oak-pine	278,219	19	264,539	250,858	18	304,140	291,180
Upland Hardwood	591,243	41	562,193	532,672	46	657,954	624,833
Bottomland Hardwood	179,243	12	161,603	152,963	12	187,523	178,883
Totals	1,440,029	100	1,368,028	1,296,026	100	1,584,032	1,512,030

convert these stands to pine. With average oak-pine sites of 70, conversion to pine would be slightly more attractive, but still not financially sound.

3.332 <u>Incentive Programs for Private Owners</u>

Yet conversion to pine is occurring at a significant rate. District foresters estimate that 10,000-11,000 acres of oak-pine and upland hardwood were converted to pine in the past year alone (in both farmer and miscellaneous private ownerships). The driving force behind this phenomenon is almost entirely the state and federal subsidy programs in conjunction with the Virginia Seed Tree Law. Following is a list of opportunities available to landowners and a brief background discussion of each.

A. Cooperative Forest Management Program.

The program is administered by the Virginia Division of Forestry. A landowner may request assistance whereupon, a county forester examines his land and provides a description of the property, a description of the timber, a map, and a recommendation for management of the resource.

B. Virginia Seed Tree Law.

This legislation is applicable to any acre where yellow poplar, loblolly pine, shortleaf pine, pond pine, or white pine singly or collectively constitute 10 percent or more of the live trees 6 inches or more dbh. In general, the law specifies that a certain number of seed trees be left uncut. If this requirement is not fulfilled, the owner has the alternative of either planting or direct seeding the harvested area. However, in the case where neither of these options is taken, the party responsible for the cutting is guilty of a misdemeanor and subject to a fine for each seed tree cut. In addition to the fine, a bond must be posted for each seed tree cut, as assurance that the land will be reforested (Virginia Division of Forestry, 1972).

C. Reforestation of Timberlands.

Under this state program an owner has a number of alternatives for reforestation. First, he can perform the reforestation by renting state equipment, by using his own equipment, or by hiring a contractor, and receive up to 50 percent (but not to exceed $30.00 per acre) of the cost. Second, an owner may obtain an interest-free loan up to 75 percent of the cost, but not to exceed $45.00 per acre, for site preparation and planting trees. The loan is payable in 30 years or before the timber is cut. Only applicants owning 500 acres or less can qualify for monies, so that forest industry is excluded. Also, one cannot receive funds under this program on an acre or part of an acre already being subsidized through a federal program (Commonwealth of Virginia, 1971).

D. Federal Incentives Program.

To qualify for this program, one must be a private forest landowner (excluding forest industry from this program), owning no more than 500 acres of eligible land. This land must be suitable for reforestation, meet minimum productivity standards, and have had no commercial harvest in the past five years (excluding salvage cuttings, cuttings to regenerate unproductive stands, cuttings to convert unproductive species, and cases involving change of ownership). If he qualifies, an owner can receive 50-75 percent of the reforestation costs, depending on the cost-share rate set by the state and individual county.

The maximum amount of cost sharing per year for an owner is $10.00, provided that no acre receive cost sharing twice. Since its inception in 1973, this program has successfully planted 18,544 acres in 27 Virginia counties and independent cities (USDA, 1975).

E. Agricultural Conservation Program.

This program is designed specifically for farmers. It permits cost sharing up to 50 percent of the total amount expended for reforestation. In 1976, farmers in 18 Virginia counties reforested 750 acres (ACP, 1977).

In order to forecast, with assurance, the number of oak-pine and upland hardwood acres to be converted to pine, one must stress two points. First, the subsidy programs and the Seed Tree Law or programs of similar nature must be available to landowners through 2020. Second, the acreage converted this past year cannot be logically projected to 2020 in a linear fashion. As more and more acres are converted to pine, resulting in increases in pine growing stock, the clamor for more pine will tend to subside. In other words, production will be much nearer to satisfying wood user's wants. Also, despite the subsidy programs, the rising costs of artificial regeneration of loblolly pine will serve to dampen the rate of conversion.

The projection for conversion of upland hardwood and oak-pine to pine is as follows (including both farmers and miscellaneous private owners):

1. Start in 1977 with an annual base of 10,000 acres of conversion.
2. Project a 1-percent annual decrease on each succeeding new base. At this rate, a total of 357,386 acres will be converted

through 2020.

3. The allocated reductions in oak-pine and upland hardwood are based on the advice of district foresters. The reductions are proportional to the acreage of each type in 1976. Upland hardwood was the more extensive type, by a 2.18 to 1 ratio. For 2020, the resulting forecast is a 112,380-acre conversion of oak-pine and a 245,006-acre conversion of upland hardwood to loblolly pine.

4. Allocation of these acreages between farmers and miscellaneous private owners is more difficult. In the southern tier of counties, which are agrarian, the major conversion practices are carried out by farmers. But moving north, one begins to find fewer farms and more miscellaneous private holdings. Consequently, most of the conversion is performed by these nonfarm owners. The countervailing influence of the two situations suggests an equal allocation of conversion among farmers and nonfarmers. Thus, farmers and nonfarmers will each convert 56,190 acres of oak-pine and 122,503 acres of upland hardwood to loblolly pine plantations.

It must now be determined how these various conversions will affect farmer-owned forest for 2020. First, we must subtract form the upland hardwood and oak-pine acreages of the farmer, 122,503 and 56,190 acres, respectively. Although all of these acres are assumed to be converted to planted loblolly pine, not all of them will exist as such in 2020. It is assumed, then, that acres regenerated by planting prior to 2000 and harvested before 2020 will be regenerated again to planted pine only 17 percent of the time, while the other 83 percent will be regenerated to natural loblolly pine. These percentages stem from the 1976 Survey, which showed that 17 percent of all farmer-owned loblolly pine was planted. They are deemed reasonable for 2020, assuming that there are no significant advancements in the knowledge and use of direct seeding or technical breakthroughs which will curb the skyrocketing costs of regenerating pine by artificial means.

The acres planted prior to 2000 are forecast to number 206,835 of the 357,386 scheduled for conversion. Of these 206,835 acres, one-half, or 103,418 acres, will be farmer-owned, and of these, 17 percent, or 17,581 acres, will be in planted loblolly pine and 83 percent, or 85,837 acres, in natural loblolly pine in 2020.

Of the 150,551 acres expected to be converted to pine at or beyond 2000, one-half, or 75,275 acres, will be farmer-owned, and all will exist as planted loblolly pine in 2020. Thus, we have a total of 92,856 acres (17,581 acres + 75,275 acres) funneling into planted loblolly pine and 85,837 acres into natural loblolly pine by 2020.

How the acreages of the miscellaneous private owners will change as a result of conversion of upland hardwood and oak-pine can be projected as identical to the farmer's case. If we follow such a projection, conversion of oak-pine and upland hardwood is found to be 122,503 acres and 56,190 acres, respectively, for the nonfarm owners. These are subtracted from the 2020 acreages of oak-pine and upland hardwood appearing in Table 17. The calculations are identical with those of the farmer in determining how these acreages will be divided between planted and natural loblolly pine, except that the percentages of planted and natural pine are 16 and 84 percent, respectively. Thus, of the 103,418 acres regenerated by miscellaneous private owners before 2000 and harvested before 2020, we have 16 percent, or 16,547 acres, in planted loblolly pine and 84 percent, or 86,871 acres, in natural loblolly pine by 2020. Also, it is projected that the 75,275 acres regenerated at or beyond 2000 by miscellaneous private owners will still be planted loblolly pine acreage in 2020. This gives a total of 91,822 acres (16,547 acres + 75,275 acres) funneling into planted loblolly pine acreage and 86,871 acres into natural loblolly pine acreage under nonfarm ownership by 2020.

Table 18 summarizes all projections of 2020 commercial forest acreage for farm and miscellaneous private ownership, as well as public and forest industry ownership.

Table 19 summarizes all projections for all ownerships and accounts for CFM and leasing programs of forest industry.

Table 18.--Projections of commercial forest ownership for 2020.

Type of Ownership	Forest Type: Planted Loblolly Pine	Natural Loblolly Pine	Oak-Pine	Upland Hardwood	Bottomland Hardwood	Total Acreage
	Acres					
Public	7,500	45,856	31,523	90,634	10,724	186,237
Forest Industry	314,957	351,877	17,138	37,361	45,501	766,834
Farmer:						
Projection (1,3)	141,501	326,678	167,792	447,193	147,957	1,231,121
Projection (2,3)	139,991	319,128	160,996	429,827	143,427	1,193,369
Projection (2,4)	145,751	347,928	186,917	496,068	160,707	1,337,371
Projection (3,4)	144,241	340,378	180,121	478,701	156,177	1,299,618
Miscellaneous Private:						
Projection (1,3)	162,160	450,948	247,950	535,451	187,523	1,584,032
Projection (2,3)	159,280	436,547	234,990	502,330	178,883	1,512,030
Projection (2,4)	152, 799	405,587	208,349	439,690	161,603	1,368,028
Projection (3,4)	149,200	389,026	194,668	410,169	152,963	1,296,026

Table 19.--Projections of commercial forest acreage for 2020, including CFM and leased lands.

Type of Ownership	Forest Type: Planted Loblolly Pine	Natural Loblolly Pine	Oak-Pine	Upland Hardwood	Bottomland Hardwood	Total Acreage
	Acres					
Public	7,500	45,856	31,523	90,634	10,724	186,237
Forest Industry	402,457	439,377	17,138	37,361	45,501	941,834
Farmer:						
Projection (1,3)	119,626	304,803	167,791	447,193	147,957	1,187,371
Projection (2,3)	118,116	297,253	160,996	429,827	143,427	1,149,619
Projection (2,4)	123,876	326,053	186,917	496,068	160,707	1,293,621
Projection (3,4)	122,366	318,503	180,121	478,701	156,177	1,255,868
Miscellaneous Private:						
Projection (1,3)	96,535	385,323	247,950	535,451	187,523	1,452,782
Projection (2,3)	93,655	370,922	234,990	502,330	178,883	1,380,780
Projection (2,4)	87,174	339,962	208,349	439,690	161,603	1,236,778
Projection (3,4)	83,575	323,401	194,668	410,169	152,963	1,164,776

4. ANALYSIS OF LONG RUN TIMBER OUTPUT

4.1 Plan for the Chapter

The purpose of this chapter is to build upon the foundations established in Chapters 2 and 3, in order to formulate some estimates of annual timber yields that might economically be produced in eastern Virginia in 2020. To facilitate the analysis, these directions will be followed:

1. Assume that all forest land in the region will be managed as if it were under one central administration. This assumption is consistent with the underlying assumption that individual owners act with financial rationality. Furthermore, since the goal of this study is not to compare silvicultural systems, the regulated-sustained-yield model is adopted for all land. Once again, the consistency of this assumption lies in the fact that under a normative approach, dealing with the long run, any projection of future yields reflects forest acreage that has been managed for timber production on a continuing basis.

2. This model forest is assumed to be attained during a transition period, during which all commercial forest acreage comes under regulation.

3. Identify the forest types to be dealt with, along with their respective growth and yield prospects.

4. Insert the above information into the regulated sustained yield model presented in Chapter 2 (Table 1). It is necessary to recall at this point that the information retrieved from this model reflects a wood is wood approach to analysis, where management of timber is based on pulpwood rotations.

5. Consider a range of optimum management intensities, by ownership and forest type, as a function of the guiding rate of interest.

6. Add to the model any additional variables that need consideration. For this study, only the effect of regeneration costs is analyzed.

7. Adjust the optimum management intensities to account for the effect of regeneration costs.

8. Combine the above information into a projection of long-run timber output.

4.2 Growth and Yield of the Forest Types in Eastern Virginia

What forest types should be considered in this report? It would be a simple matter to define dozens of distinct forest types in eastern Virginia, based solely on species composition, without considering soil and topographic features. The final choices must be precise enough to portray actual forest conditions, while simultaneously maintaining a reasonable degree of practicality. This report recognizes five major forest types in eastern Virginia.

1. and 2. Planted and Natural Loblolly Pine. "These are forests in which loblolly pine, shortleaf pine, or other southern yellow pines, except longleaf or slash pine, singly or in combination, comprise a plurality of the stocking." (Cost, 1976).

3. Oak-pine. "Forests in which hardwoods (usually upland oaks) comprise a plurality of the stocking, but in which pines comprise 25 to 50 percent of the stocking." (Cost, 1976).

4. Upland Hardwood, (i.e., oak-hickory). "Forests in which upland oaks or hickory, singly or in combination, comprise a plurality of the stocking, except where pines comprise 25 to 50 percent, in which

case the stand would be classified oak-pine." (Cost, 1976).

5. Bottomland Hardwood. This classification is a consolidation of the oak-gum-cypress and the elm-ash-cottonwood types.

a. Oak-gum-cypress. "Bottomland forests in which tupelo, blackgum, sweetgum, oaks, or southern cypress, singly or in combination, comprise a plurality of the stocking, except where pines comprise 25 to 50 percent, in which case the stand would be classified oak-pine." (Cost, 1976).

b. Elm-ash-cottonwood. "Forests in which elm, ash, or cottonwood, singly or in combination, comprise a plurality of the stocking." (Cost, 1976).

It is possible to place every acre of commercial forest in eastern Virginia into one of the classifications.

Development of yield information for these five types was the purpose of Phase I of this normative study. The results of this work appear in Tables 20 through 24. They are presented according to forest type for average coastal Virginia sites. All volumes are expressed in cubic feet of wood in trees 5 inches and larger in diameter at breast height (dbh), to a 4-inch top, outside bark.

Why choose average sites and not a range of site classes? Granted, there are wide variations in sites, even within a single forest type. Yet, to identify and analyze all the possibilities would be a colossal task. So why not account for both the poorer and better sites by striking a realistic average? This was the objective of Phase I. Following directly behind the identification of average site comes average normal yield for the acre of average site.

Table 20.--Normal yield table for planted loblolly pine in eastern Virginia, average site index 80, base age 50. 1/

Age	Yield Per Acre	Mean Annual Growth Per Acre
Years	---------------- Cubic Feet	------------------
10	215	21.50
15	1217	81.13
20	2135	106.75
25	2968	118.72
30	3715	123.83
35	4379	125.11
40	4958	123.95
45	5453	121.18
50	5863	117.26

1/ Giauque, 1977.

Table 21.--Normal yield table for natural loblolly pine in eastern Virginia, average site index 80, base age 50. 1/

Age	Yield Per Acre	Mean Annual Growth Per Acre
Years	Cubic Feet	
15	657	43.80
20	1551	77.55
25	2358	94.32
30	3080	102.67
35	3715	106.14
40	4264	106.60
45	4726	105.02
50	5103	102.06
55	5393	98.05
60	5597	93.28

1/ Giauque, 1977.

Table 22.--Normal yield table for oak-pine in eastern Virginia, average site index 70, base age 50. 1/

Age	Yield Per Acre	Mean Annual Growth Per Acre
Years	Cubic Feet	
15	255	17.00
20	793	39.65
25	1291	51.64
30	1748	58.27
35	2163	61.80
40	2538	63.45
45	2871	63.80
50	3163	63.26
55	3414	62.07
60	3624	60.40
65	3793	58.35
70	3921	56.01

1/ Giauque, 1977.

Table 23.--Normal yield table for upland hardwoods in eastern Virginia, average site index 60, base age 50. 1/

Age	Yield Per Acre	Mean Annual Growth Per Acre
Years	Cubic Feet	
20	148	7.40
25	478	19.12
30	796	26.53
35	1104	31.54
40	1401	35.03
45	1687	37.48
50	1961	39.22
55	2225	40.45
60	2478	41.30
65	2720	41.85
70	2951	42.16
75	3171	42.28
80	3380	42.25

1/ Giauque, 1977.

Table 24.--Normal yield table for bottomland hardwoods in eastern Virginia, average site index 80, base age 50. 1/

Age	Yield Per Acre	Mean Annual Growth Per Acre
Years	Cubic Feet	
20	539	26.95
25	1019	40.76
30	1475	49.17
35	1908	54.51
40	2318	57.95
45	2704	60.09
50	3066	61.32
55	3404	61.89
60	3720	62.00
65	4011	61.71
70	4279	61.13

1/ Giauque, 1977.

4.3 Economic Rotations and Yields

All five forest types are analyzed according to the regulated sustained-yield model developed in Chapter 2, Table 1. The results appear in Tables 25 through 29. Once again, the last column in each table serves as a measure of acceptability, for any given rotation length, to an individual owner with a particular guiding rate of interest. By graphing these figures, for each forest type, one can achieve a continuous interpretation of rotation age over a range of guiding rates of interest (or vice versa). Table 30 (columns 2,5,8,11, and 14) lists the rotation ages that would be followed by an owner with a particular guiding rate of interest, ranging from 3 to 12 percent, plus the zero percent guiding rate (i.e., the culmination of mean annual increment), for each forest type.

The next step is to determine the total yield per acre per year for each of these rotation ages. This may be accomplished by graphing yield versus rotation age and inferring from the curve the cubic-foot yield for the desired age. Table 30, columns 3,6,9, 12 and 15 depict the total harvestable yields per acre at rotation age for each forest type, across the range of guiding rates of interest. To obtain the average yield per acre per year, or mean annual growth, simply divide the total yield by rotation age. These figures, by forest type and guiding rate of interest, appear in columns 4,7,10,13 and 16 in Table 30.

4.4 Analysis of Regeneration Costs

The consideration of this variable, as affecting rotation age and yield, is necessarily confined to the discussion of only one of the five forest types, planted loblolly pine. It was concluded in Chapter 2 that

Table 25.--Rate of return on extra growing stock, for planted loblolly pine on average site in eastern Virginia.

Rotation Age	Total Yield Per Acre	Annual Yield Per Acre	Marginal Yield Per Acre	Total Growing Stock	Growing Stock Per Acre	Marginal Growing Stock Per Acre	Return On Extra Growing Stock
Years	Cubic Feet						Percent
10	215	21.50		537.5	53.75		
			59.63			220.75	27.01
15	1217	81.13		4117.5	274.50		
			25.62			350.38	7.31
20	2135	106.75		12497.5	624.88		
			11.97			385.32	3.11
25	2968	118.72		25255.0	1010.20		
			5.11			388.55	1.32
30	3715	123.83		41962.5	1398.75		
			1.28			378.32	0.34
35	4379	125.11		62197.5	1777.07		
			-1.16			361.43	-0.32
40	4958	123.95		85540.0	2138.50		
			-2.77			340.78	-0.81
45	5453	121.18		111567.5	2479.28		
			-3.92			317.87	-1.23
50	5863	117.26		139857.5	2797.15		

Table 26.--Rate of return on extra growing stock, for natural loblolly pine on average site in eastern Virginia.

Rotation Age	Total Yield Per Acre	Annual Yield Per Acre	Marginal Yield Per Acre	Total Growing Stock	Growing Stock Per Acre	Marginal Growing Stock Per Acre	Return On Extra Growing Stock
Years	Cubic Feet						Percent
15	657	43.80		1642.5	109.5		
			33.75			248.63	13.57
20	1551	77.55		7162.5	358.13		
			16.77			319.27	5.25
25	2358	94.32		16935.0	677.40		
			8.35			340.27	2.45
30	3080	102.66		30530.0	1017.67		
			3.48			339.97	1.02
35	3715	106.14		47517.5	1357.64		
			0.46			328.99	0.14
40	4264	106.60		67465.0	1686.63		
			-1.58			312.04	-0.51
45	4726	105.02		89940.0	1998.67		
			-2.96			291.58	-1.02
50	5103	102.06		114512.5	2290.25		
			-4.01			268.89	-1.49
55	5393	98.05		140752.5	2559.14		

Table 27.--Rate of return on extra growing stock, for oak-pine on average site in eastern Virginia.

Rotation Age	Total Yield Per Acre	Annual Yield Per Acre	Marginal Yield Per Acre	Total Growing Stock	Growing Stock Per Acre	Marginal Growing Stock Per Acre	Return On Extra Growing Stock
Years	Cubic Feet						Percent
15	255	17.00		637.5	42.50		
			22.65			120.38	18.82
20	793	39.65		3257.5	162.88		
			11.99			175.82	6.82
25	1291	51.64		8467.5	338.70		
			6.63			196.80	3.37
30	1748	58.27		16065.0	535.50		
			3.53			202.86	1.74
35	2163	61.80		25842.5	738.36		
			1.65			201.52	0.82
40	2538	63.45		37595.0	939.88		
			0.35			196.06	0.18
45	2871	63.80		51117.5	1135.94		
			-0.54			188.11	-0.29
50	3163	63.26		66202.5	1324.05		
			-1.19			178.59	-0.66
55	3414	62.07		82645.0	1502.64		

Table 28.--Rate of return on extra growing stock, for upland hardwood on average site in eastern Virginia.

Rotation Age	Total Yield Per Acre	Annual Yield Per Acre	Marginal Yield Per Acre	Total Growing Stock	Growing Stock Per Acre	Marginal Growing Stock Per Acre	Return On Extra Growing Stock
Years	Cubic Feet						Percent
20	148	7.40		370.0	18.50		
			11.72			58.90	19.90
25	478	19.12		1935.0	77.40		
			7.41			93.27	7.95
30	796	26.53		5120.0	170.67		
			5.01			111.33	4.50
35	1104	31.54		9870.0	282.00		
			3.49			121.31	2.87
40	1401	35.03		16132.5	403.31		
			2.46			126.74	1.94
45	1687	37.49		23852.5	530.06		
			1.73			129.39	1.34
50	1961	39.22		32972.5	659.45		
			1.23			130.32	0.95
55	2225	40.45		43437.5	789.77		
			0.85			130.14	0.65
60	2478	41.30		55195.0	919.92		
			0.55			129.16	0.42
65	2720	41.85		68190.0	1049.08		
			0.31			127.60	0.24
70	2951	42.16		82367.5	1176.68		
			0.12			125.62	0.10
75	3171	42.28		97672.5	1302.30		
			-0.03			123.33	-0.02
80	3380	42.25		114050.5	1425.63		

Table 29.--Rate of return on extra growing stock, for bottomland hardwood on average site in eastern Virginia.

Rotation Age	Total Yield Per Acre	Annual Yield Per Acre	Marginal Yield Per Acre	Total Growing Stock	Growing Stock Per Acre	Marginal Growing Stock Per Acre	Return On Extra Growing Stock
Years	Cubic Feet						Percent
15	35	2.33		87.5	5.83		
			24.62			70.30	35.02
20	539	26.95		1522.5	76.13		
			13.81			140.57	9.82
25	1019	40.76		5417.5	216.70		
			8.41			171.72	4.90
30	1475	49.17		11652.5	388.42		
			5.34			186.15	2.87
35	1908	54.51		20110.0	574.57		
			3.44			192.31	1.79
40	2318	57.95		30675.0	766.88		
			2.14			193.79	1.10
45	2704	60.09		43230.0	960.67		
			1.23			192.43	0.64
50	3066	61.32		57655.0	1153.10		
			0.57			189.26	0.30
55	3404	61.89		73830.0	1342.36		
			0.11			184.97	0.06
60	3720	62.00		91640.0	1527.33		
			-0.29			179.86	-0.16
65	4011	61.71		110967.5	1707.19		
			-0.58			174.13	-0.33
70	4279	61.13		131692.5	1881.32		

Table 30.--Optimum rotations and yields, by guiding rates of interest and forest type for eastern Virginia.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Guiding	Planted Loblolly Pine			Natural Loblolly Pine			Oak-pine		
Rate Of	Rotation Age	Yield Per Acre		Rotation Age	Yield Per Acre		Rotation Age	Yield Per Acre	
Interest		Total	Annual		Total	Annual		Total	Annual
Percent	Years	--- Cubic Feet ---		Years	--- Cubic Feet ---		Years	--- Cubic Feet ---	
0	35.0	4379	125.11	38.6	4119	106.71	44.4	2833	63.81
3	23.0	2645	115.00	26.1	2525	96.74	28.5	1615	56.67
4	21.1	2325	110.19	24.2	2235	92.36	26.1	1395	53.45
5	19.7	2082	105.69	22.8	2013	88.29	24.4	1233	50.53
6	18.5	1868	100.97	21.8	1851	84.91	23.2	1117	48.15
7	17.7	1723	97.34	21.0	1719	81.85	22.4	1037	46.29
8	17.1	1612	94.27	20.3	1602	78.92	21.6	957	44.31
9	16.6	1519	91.51	19.6	1482	75.61	21.0	896	42.67
10	16.1	1426	88.57	19.1	1396	73.09	20.5	845	41.22
11	15.7	1350	85.99	18.6	1309	70.38	20.0	793	39.65
12	15.3	1274	83.27	18.3	1257	68.69	19.6	752	38.37

Table 30.--Optimum rotations and yields, by guiding rates of interest and forest type for eastern Virginia (continued).

	(11)	(12)	(13)	(14)	(15)	(16)
Guiding Rate Of Interest	Upland Hardwood			Bottomland Hardwood		
	Rotation Age	Yield Per Acre		Rotation Age	Yield Per Acre	
		Total	Annual		Total	Annual
Percent	Years	--- Cubic Feet ---		Years	--- Cubic Feet ---	
0	76.6	3239	42.28	58.5	3627	62.00
3	37.0	1224	33.08	32.0	1651	51.59
4	33.7	1025	30.42	29.1	1395	47.94
5	31.5	890	28.25	27.3	1232	45.13
6	29.8	784	26.31	25.8	1094	42.40
7	28.5	702	24.63	24.6	981	39.88
8	27.5	638	23.20	23.7	896	37.81
9	26.6	581	21.84	23.0	830	36.09
10	26.0	542	20.85	22.4	772	34.46
11	25.4	503	19.80	21.8	714	32.75
12	24.9	471	18.92	21.4	676	31.59

the ultimate effect of regeneration costs is to lengthen rotations and thus increase yields. The problem is to estimate the amount of lengthening and increase, particularly since these costs are so highly variable.

Five sets of historical costs and revenues (Table 5) were run through the regulated sustained-yield model (Appendix, Tables A-1 thru A-5), in an attempt to find a relationship that might offer a reasonable projection for the long run. The mechanics of this procedure are presented now.

First, the respective stumpage values for 1952 through 1976 are applied to the cubic-foot yields of column 3, Table 20. Second, to reduce the burden of regeneration costs, a firm may elect to spread these costs over a longer rotation, as shown in Table 31. These figures are now incorporated into the model by deducting the cost of regeneration at each rotation age from the value of the annual yield per managed acre in column 4 (Tables A-1 thru A-5). The result is a lengthening of the rotation, being the smallest with 1952 costs and revenues and largest with 1976 costs and revenues. Table 32 shows the change in rotation age and yields for planted loblolly pine, beginning with no regeneration cost (column 2), moving to the 1952 level of costs and revenues (column 3) and ending with the situation as it existed in 1976, in terms of rotation age, total harvested yield per acre, and average annual yield per acre (columns 4,5,6).

The proposal offered here is to assume that changes in the cost of regeneration and in the revenues associated with planted loblolly pine to 2020, will approximate the rates of change since 1952. By applying

Table 31.--Effects of spreading regeneration costs over progressively longer rotations, for 1952, 1961, 1967, 1974 and 1976.

Rotation	Regeneration Costs Per Acre Per Year				
Age	1952	1961	1967	1974	1976
Years			Dollars		
10	1.02	1.54	2.21	5.06	5.17
15	0.68	1.02	1.47	3.37	3.45
20	0.51	0.77	1.11	2.53	2.59
25	0.41	0.61	0.88	2.02	2.07
30	0.34	0.51	0.74	1.69	1.72
35	0.29	0.44	0.63	1.44	1.48
40	0.26	0.38	0.55	1.26	1.29
45	0.23	0.34	0.49	1.12	1.15

Table 32.--The effects of regeneration costs on rotation age and a projection of rotation age and output for planted loblolly pine in 2020.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Guiding Rate Of Interest	Rotation Age			Yield Per Acre		Change In Rotation Age From 1952 To 1976	Projected Rotation Age In 2020	Yield Per Acre	
	Unadjusted From Table 30	With 1952 Costs And Revenues	With 1976 Costs And Revenues	Total Harvested In 1976	Average Annual In 1976			Total Harvested In 2020	Average Annual In 2020
Percent	Years			Cubic Feet		Years		Cubic Feet	
3	23.0	23.6	24.8	2936	118.39	+1.2	27.2	3307	121.58
4	21.1	21.8	22.8	2612	114.54	+1.0	24.8	2936	118.39
5	19.7	20.4	21.3	2359	110.75	+0.9	23.1	2661	115.21
6	18.5	19.3	20.1	2152	107.08	+0.8	21.7	2427	111.84
7	17.7	18.4	19.2	1993	103.82	+0.8	20.8	2273	109.30
8	17.1	17.7	18.4	1850	100.54	+0.7	19.8	2100	106.04
9	16.6	17.1	17,7	1723	97.33	+0.6	18.9	1940	102.65
10	16.1	16.6	17.1	1612	94.29	+0.5	18.1	1796	99.23
11	15.7	16.2	16.6	1519	91.52	+0.4	17.4	1668	95.84
12	15.3	15.8	16.1	1426	88.55	+0.3	16.7	1538	92.09

the change in rotation age from 1952 to 1976 (column 7, Table 32) at each guiding rate of interest, doubling it, and adding this figure to the 1976 rotation age, we obtain a projection of rotation ages that may be anticipated for planted loblolly pine in 2020. Columns 8, 9 and 10 of Table 32 show the ages and yields from these projections.

At the lower guiding rates of interest, the rotations of planted loblolly pine in 2020 are slightly longer than the rotations of natural loblolly pine. Should the regeneration costs associated with the propagation of planted loblolly pine continue to increase between now and 2020 at a rate that is greater than the concurrent rate of monetary increase in pine stumpage, the desirability of planting loblolly pine will become somewhat dampened.

4.5 Projection of Long-Run Timber Output

Now that specific values have been formulated for long-run commercial forest acreage and for a range of management intensities, how will a projection of long-run timber output be obtained? At least two alternative solutions to this problem are available. One is to assign a guiding rate of interest to each of the four ownership classes, using the assumptions discussed in Chapter 2. This solution dictates the rotation age and average annual yield per acre for each class of owner, by forest type. Applying each of these annual yields to its respective projection of commercial forest acreage in 2020, offers an estimate of long-run regional timber output. The primary objection to this procedure is that by assigning these guiding rates of interest to owners, one may not be judging timber-management conditions with any degree of accuracy. For instance, to assume that farmers, as a group, will operate at an average guiding rate of interest of 12 percent, may or may not reflect what they will actually produce.

The second avenue of analysis offers a solution. Make an assumption concerning the guiding rates of interest for the owners whose management is well documented and relatively easy to approximate--namely, the public and forest industry. It is assumed that both public and forest-industry management of commercial forest acreage is performed at a 3-percent rate. This assumption is based on the discussion in Chapter 2 concerning the financial status and long-range planning horizons of the large corporations and governmental agencies. Under these circumstances, we find public forest land, for the most part, managed to the culmination of mean annual increment, while forest industry, as a whole, operates in the range of 3 to 5 percent. Thus, given the proportion of commercial forest acreage in public and forest industry ownership in 1976 to be approximately 4 percent and 19 percent, respectively, and with a moderate increase in public ownership of forest acreage to 2020, the guiding rate of interest of the two together should approximate 3 percent over the course of the study period.

It should be borne in mind, however, that the above assumption is made in order to serve as a starting point for the forthcoming analysis and not as an unchallengable dictum. On the contrary, its soundness will be scrutinized throughout the analysis.

One further assumption is made at this juncture: With the information at hand, there is no justification for assigning different guiding rates of interest to farm and miscellaneous private owners. Substantiation or contradiction of this assumption will be obtained as the analysis proceeds.

With these two suppositions as a starting point, it is now possible to proceed with the analysis that will determine the guiding rates of interest for farm and miscellaneous private owners. The procedure calls for taking the 1976 commercial forest acreage by ownership class and forest type (Table 14) and determine the guiding rate of interest for farm and miscellaneous private owners (given that the public and forest industry are operating at 3 percent) that will generate the 240,304,000 cubic feet of total current annual growth reported in the 1976 Forest Survey.

Table 33 shows that by applying the acreage information from Table 14 and a 3-percent rate for public and forest industry and 4 percent for farmers and miscellaneous private owners (yields for planted loblolly pine are from Table 32 and for the other forest types from Table 30), the annual growth derived for 1976 is 237,993,321 cubic feet. This estimate is the best attainable (to the nearest .1 percent), given the foregoing assumptions, being 99.0 percent of the reported Forest Survey growth.

One point of contention may be raised: The validity of comparing current annual growth from the Forest Survey with mean annual growth from this report. The yield figures from Tables 30 and 32 assume a fully regulated forest system.

However, the 240,304,000 cubic feet of current annual growth is the best measure available of current annual output of timber in eastern Virginia. Considering this fact, the comparison is not only reasonable, but inescapable. Yet, beyond the fact that this comparison is made out

Table 33.--The mix of guiding rates of interest mecessary to approximate the current annual growth reported in the 1976 Forest Survey of eastern Virginia, by ownership and forest type.

Type Of Ownership And Guiding Rate Of Interest	Forest Type	1976 Commercial Forest Acreage	Average Annual Growth	Total Annual Growth
		Acres	------- Cubic	Feet -------
Public;	Planted Loblolly Pine	3,832	118.39	453,670
	Natural Loblolly Pine	49,524	96.74	4,790,952
3	Oak-pine	18,945	56.67	1,073,613
	Upland Hardwood	63,212	33.08	2,091,053
Percent	Bottomland Hardwood	10,724	51.59	553,251
	Sub-total	146,237		8,962,539
Forest	Planted Loblolly Pine	215,900	118.39	25,560,401
Industry;	Natural Loblolly Pine	252,820	96.74	24,457,806
3	Oak-pine	115,382	56.67	6,538,698
Percent	Upland Hardwood	137,231	33.08	4,539,601
	Bottomland Hardwood	45,501	51.59	2,347,397
	Sub-total	766,834		63,443,903
Farmer;	Planted Loblolly Pine	65,418	114.54	7,492,978
	Natural Loblolly Pine	324,705	92.36	29,989,753
4	Oak-pine	299,459	53.45	16,006,083
	Upland Hardwood	762,582	30.42	23,197,744
Percent	Bottomland Hardwood	198,275	47.94	9,505,303
	Sub-total	1,650,439		86,191,861
Miscella-	Planted Loblolly Pine	64,578	114.54	7,396,764
neous	Natural Loblolly Pine	335,276	92.36	30,966,091
Private;	Oak-pine	278,219	53.45	14,870,805
4	Upland Hardwood	591,713	30.42	17,999,909
Percent	Bottomland Hardwood	170,243	47.94	8,161,449
	Sub-total	1,440,029		79,395,018
	Grand Total	4,003,539		237,993,321

of necessity, some additional support is available.

Under a fully regulated forest system, the average current annual growth per acre is equal to the mean annual growth per acre of the oldest stands. As a system, or region (eastern Virginia) in this case, diverges from full regulation, average current annual growth and mean annual growth also diverge. If an overabundance of stands older than the age of culmination of mean annual increment exists within the system, the average current annual growth will be somewhat deflated in relation to the mean annual growth. If a substantial portion of young stands exists within the system, two possibilities are evident. A preponderance of stands below merchantibility (zero current annual growth) will once again cause the average current annual growth of the system to be deflated relative to mean annual growth. However, if these young stands are actually of merchantable size, then their current annual growth will be very high, leading to an average current annual growth that is greater than mean annual growth. By looking at the 240,304,000 cubic feet of current annual growth in terms of the age of all acres of commercial forest in eastern Virginia, it can be determined whether the foregoing comparison is reasonable.

The necessary information for making this comparison can be found in Table 34, which gives acreage information for eastern Virginia by age class, forest type, and ownership. First, take the age at which mean annual increment culminates (Table 30) for each of the four forest types (using natural loblolly pine as representative of the pine group), and determine the number of acres younger than this age. Summing this acreage over forest types and dividing it by the total acreage in the table,

Table 34.--Rotation lengths by forest type, ownership and 10-year age class for acres showing promise for management in eastern Virginia, 1976. 1/

Type Of Ownership	Forest Type	0 - 10	10 - 20	20 - 30	30 - 40	40 - 50	50 - 60
		Acres					
Public	Pine	5,399	-----	17,936	14,205	3,832	3,832
	Oak-pine	-----	875	200	175	5,400	3,832
	Upland Hardwood	7,500	96	1,568	-----	3,575	4,603
	Bottomland Hardwood	-----	-----	-----	-----	-----	3,382
Forest Industry	Pine	130,426	121,331	44,047	26,418	41,590	59,450
	Oak-pine	33,071	23,100	7,930	17,243	14,324	-----
	Upland Hardwood	23,825	8,008	2,981	11,455	5,764	7,822
	Bottomland Hardwood	2,975	-----	5,009	-----	2,034	7,358
Farmer	Pine	67,501	50,332	49,579	76,553	42,324	50,740
	Oak-pine	45,557	29,404	33,480	35,758	30,532	48,322
	Upland Hardwood	81,613	74,986	77,322	69,120	75,821	78,731
	Bottomland Hardwood	2,946	-----	11,821	10,030	20,974	21,552
Miscellaneous Private	Pine	58,521	60,606	61,190	71,163	67,342	41,322
	Oak-pine	60,912	23,668	35,659	34,073	59,553	26,781
	Upland Hardwood	61,858	52,582	41,890	33,879	55,555	94,360
	Bottomland Hardwood	6,317	9,122	12,461	2,708	25,569	26,443
All Ownerships	Pine	261,847	232,269	172,752	188,339	155,088	155,344
	Oak-pine	139,540	77,047	77,269	87,249	109,809	78,935
	Upland Hardwood	174,796	135,672	123,761	114,454	140,715	185,516
	Bottomland Hardwood	12,238	9,122	29,291	12,738	48,577	59,185
Grand Total	All Types	588,421	454,110	403,073	402,780	454,189	478,980

1/ USDA, 1976.

Table 34.--Rotation lengths by forest type, ownership and 10-year age class for acres showing promise for management in eastern Virginia, 1976 (continued). 1/

Type Of Ownership	Forest Type	Age Class (Years) 60 - 70	70 - 80	80 - 90	90 - 100	Total
		Acres				
Public	Pine	-----	-----	-----	-----	45,204
	Oak-pine	-----	3,832	2,410	-----	16,724
	Upland Hardwood	9,252	3,832	15,717	3,227	49,370
	Bottomland Hardwood	3,378	-----	1,877	-----	9,087
Forest Industry	Pine	19,523	9,149	8,254	-----	459,918
	Oak-pine	-----	7,038	2,976	-----	105,682
	Upland Hardwood	15,023	2,981	16,994	8,484	103,337
	Bottomland Hardwood	-----	5,323	8,133	2,650	33,482
Farmer	Pine	21,387	17,553	5,453	3,175	384,597
	Oak-pine	26,910	9,335	17,819	5,457	282,574
	Upland Hardwood	70,500	34,218	17,774	32,656	612,741
	Bottomland Hardwood	27,496	9,801	5,652	15,167	125,439
Miscellaneous Private	Pine	12,922	5,580	3,008	-----	381,654
	Oak-pine	3,177	9,070	-----	6,798	259,691
	Upland Hardwood	48,679	32,860	28,098	43,434	493,195
	Bottomland Hardwood	18,529	5,342	6,316	11,550	124,357
All Ownerships	Pine	53,562	32,282	16,715	3,175	1,271,373
	Oak-pine	30,087	29,275	23,205	12,255	664,671
	Upland Hardwood	143,454	73,891	78,583	87,801	1,258,643
	Bottomland Hardwood	49,403	20,466	21,978	29,367	292,365
Grand Total	All Types	276,501	155,914	140,481	132,598	3,487,052

1/ USDA, 1976.

71.34 percent of the acres are found to be younger than the culmination of mean annual increment. But since mean annual increment curves characteristically approach and nearly maintain a zero slope at their apex, there is a considerable range over which mean annual increment is approximately the same (Davis, 1966). Therefore, of the 28.34 percent of acres older than the culmination of mean annual increment, a certain portion are yielding about the same annual yields as those at the culmination. Thus, it is reasonable to conclude that the number of old aged acres is not large enough to cause the 240,304,000 cubic feet of current annual growth to be excessively deflated.

The other possibility for a deflation of current annual growth lies in an abundance of young stands below merchantability. Using 10 years for pine and 15 years for the other three types as upper bounds on unmerchantable volume, we calculate that 28.1 percent of all acreage between zero years and the culmination of mean annual increment to be younger than these ages. If full regulation were present, we would expect equal acreage in each age class. Thus, the total percentage of acres expected to be younger than 10 years for pine and 15 years for the other three types, under full regulation, is 26.2 percent. Comparing this with 28.1 percent, it becomes evident that the percentage of unmerchantable acres is not excessively deflating the current annual growth reported in the 1976 Survey.

Finally, looking at the distribution of acres between zero and the culmination of mean annual increment, for each forest type, we see that there is no major concentration of acreage in any one age class. We would expect, then, that the 240,304,000 cubic feet of current annual growth is not excessively inflated.

It appears that divergence in eastern Virginia from a fully regulated system is not sufficient to invalidate the comparison of average current annual growth with mean annual growth at rotation age.

Before moving immediately to estimates of long-run timber output, some further investigation must be made of the striking result that shows farmers and miscellaneous private owners operating at lower guiding rates of interest (i.e., 4 percent) than would be generally anticipated. Substantiation of this finding may be gleaned from data of the fourth Forest Survey of eastern Virginia.

What variables would best reflect a tendency on the part of owners to manage their timber for high output (i.e., at low guiding rates of interest)? The rotation length followed by owners may be one indication of the level of management intensity. Levels of growing stock being carried per acre may also reveal some tendency of owners toward higher output.

4.51 Analysis of Rotation Lengths in Eastern Virginia

In the case of rotation length, justification for the low guiding rates of farm and miscellaneous private owners can be offered if these owners, in general, are carrying a substantial amount of their timber at ages where the average annual yield per managed acre is higher than this same yield at their presumed financially optimal rotation length. For instance, the assumption was made in Chapter 2 that the guiding rate of return for farmers and miscellaneous private owners is 12 percent. To uphold the claim that these owners are actually operating in the 4-percent range, it must be shown that a considerable portion of their acreage in each forest type is being allowed to grow longer, and consequently, yield greater average annual yields per acre, than the 12-percent financial optimum would permit. For this reason, Table 34 is used as a data base in justifying this contention. Only those acres that show promise for management (as judged by Forest Survey field men) are accounted for in Table 34. These acres represent 87.1 percent of the total commercial forest acreage reported. The 12.9 percent that is unaccounted for is best described as a conglomeration of stands with numerous age groups and species, offering little in the way of management or classification opportunity.

A first glance at Table 34 shows that substantial gaps exist in the data for public ownership and for the bottomland hardwood forest type. Because of this deficiency and the fact that these two groups are rather insignificant in terms of total acreage (a possible reason for the lack of information), no analysis is performed on them in reference to the rotation-length question. Given the remaining three ownership classes and three forest types, where planted and natural loblolly pines have been combined into the one pine group, it will be shown that there does exist evidence of low guiding rates among farmers and miscellaneous private owners.

First, it is assumed that farm and miscellaneous private owners operate at a guiding rate of interest of 12 percent. Given this assumption, we can estimate their appropriate rotation ages and average annual yields per managed acre from Table 30. Using natural loblolly pine as representative of the pine group, the procedure for analyzing rotation lengths can be illustrated. Extending the yield data from Table 21 to

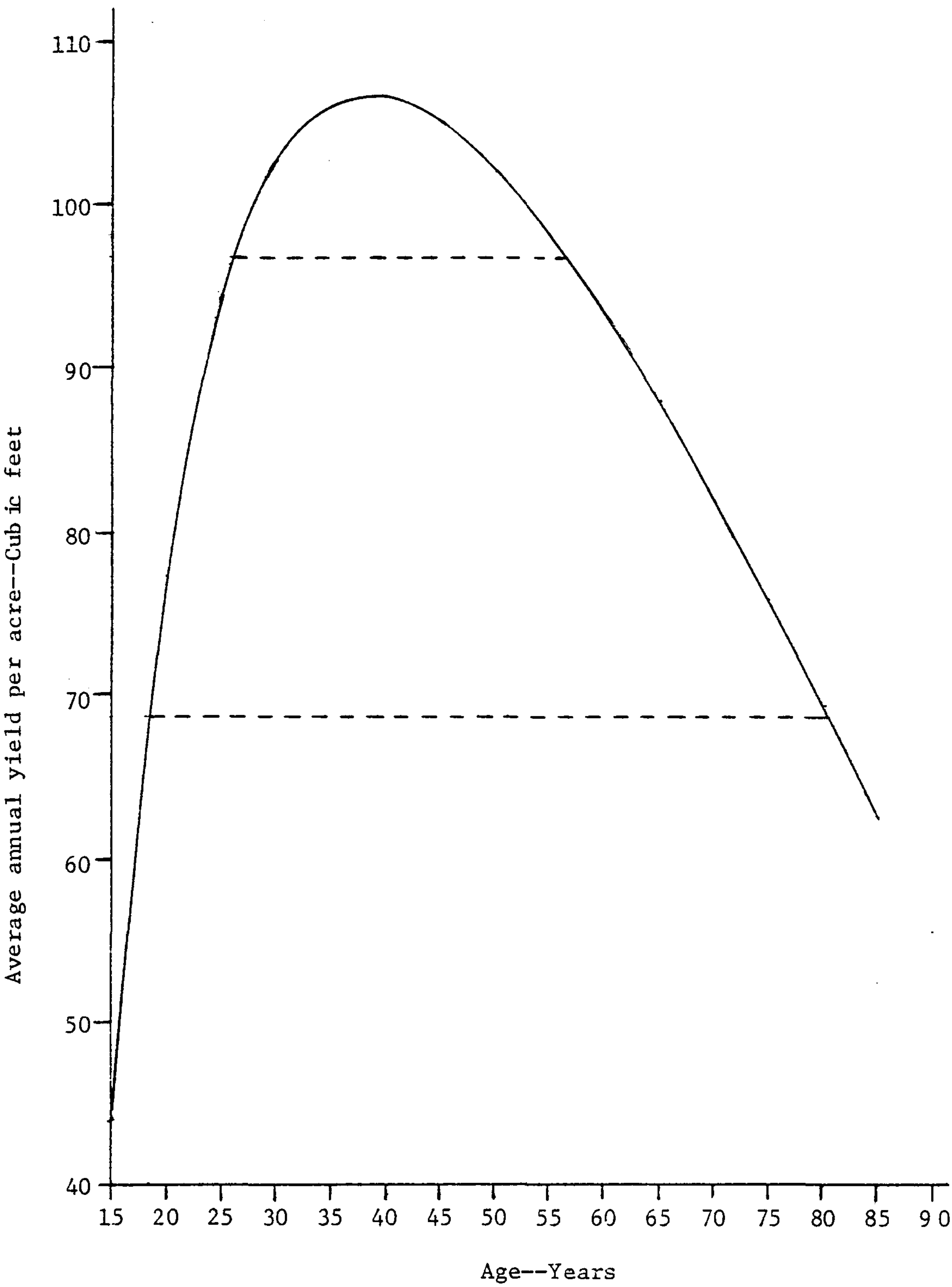

Figure 4.--Mean annual growth of natural loblolly pine.

90 years and graphing the mean annual growth, we can achieve the curve presented in Figure 4. We now locate the optimum rotation age and annual yield (i.e., 18.3 years and 68.69 cubic feet, respectively) for a guiding rate of 12 percent on the positive-sloping side of the curve and draw a line horizontally to the point where it intersects the negative-sloping portion of the curve. This point of intersection is 81 years for pine. Any acres producing a greater average annual yield per acre than those acres at or below the financial optimum rotation age, will be above the horizontal line between 18.3 years and 81 years. It is important to note that any acres to the right of the culmination of mean annual increment are producing negative rates of return, but a certain portion of these acres are still yielding greater average annual yields than those at or below the financial optimum rotation age and are helping to boost the average annual yield above the optimum.

For the pine type owned by farmers and miscellaneous private owners, the proportion of acres above the horizontal line is 69.5 percent and 70.3 percent, respectively. With such a large proportion of the acreage above the line, the average annual yield per acre is boosted substantially, which in turn implies longer rotations than 18.3 years and lower guiding rates of interest than 12 percent. By comparison, the forest industry has a financially optimal rotation for natural loblolly pine of 26.1 years, yielding 96.74 cubic feet per acre per year. Once again, by extending a line horizontally from 26.1 years, we intersect the curve at approximately 56.5 years. Above this line we find only 26.9 percent of the forest industry acreage yielding greater annual yields than those at or below the financially optimal rotation.

Some additional information may be obtained by making a comparison between the industry and nonindustrial private owners, by dropping the latter's rate to 3 percent. This comparison shows that farm and miscellaneous private owners are holding 44.5 and 49.6 percent of their acres, respectively, beyond the optimal rotation for this 3 percent rate. Thus, even at a rate that is equal to that of the forest industry, farmers and miscellaneous private owners are still holding more acres that are yielding higher average annual yields than acres at or below the horizontal line (Figure 4) depicting a 3 percent financial optimum.

Does this comparison indicate that farm and miscellaneous private owners are operating at lower rates than the forest industry? Consider for a moment the differences in these owners. The forest industry can be considered the most homogeneous of the three classes in terms of timber management. This fact is evident in Table 34 when we note that a large percentage of the industry pine acreage is concentrated in the younger age classes. This approaches what we might expect of a completely homogeneous, optimally managed forest: All of its acres falling in age classes younger than the optimal rotation.

The nonindustrial private owners, however, can be considered the most heterogeneous owners. Looking at Table 34, we can see that their acreage is spread over a wide range of ages.

What would cause the forest industry and especially the nonindustrial owners to manage for lengthy rotations? One reason is that many acres are held for sawtimber, with inherently longer rotations than the pulpwood rotations with which this report is concerned. Other acreage may have been forced into long rotations as a result of local ordinances or statutes. In the case of nonindustrial owners, a substantial portion of these older acreages may be owned by people who hold the timber for nonfinancial reasons.

Thus, we can see that the heterogeneity of the farm and miscellaneous private holdings is consistent with their percentages of acres yielding greater annual yields than those at or below a 3-percent financial optimum. Therefore, the possibility does exist for the nonindustrial private owners to be operating at rates below those of the forest industry.

The procedure used to analyze the rotation-length question for the pine type was also used in the analysis of the oak-pine and upland hardwood types, Figures 5 and 6, respectively. It should be noted that in each of these figures the negative-sloping portion of the mean annual growth curve fails to intersect the horizontal line depicting the financial optimum of 12 percent for the nonindustrial private owners. This merely indicates that no acres beyond the culmination of mean annual increment were reported as producing less than the average annual yields per acre at the financial optimum.

Table 35 summarizes all the calculations for the rotation-length analysis of the oak-pine type and the upland hardwood type, as well as for the pine type. It is readily apparent from these figures that the nonindustrial private owners are carrying large percentages of their oak-pine and upland hardwood acreages at ages where they are yielding greater annual yields than those acres at or below the horizontal line depicting a 12 percent optimum. In addition, we find that at a 3-percent rate the nonindustrial private owners are still carrying more acreage

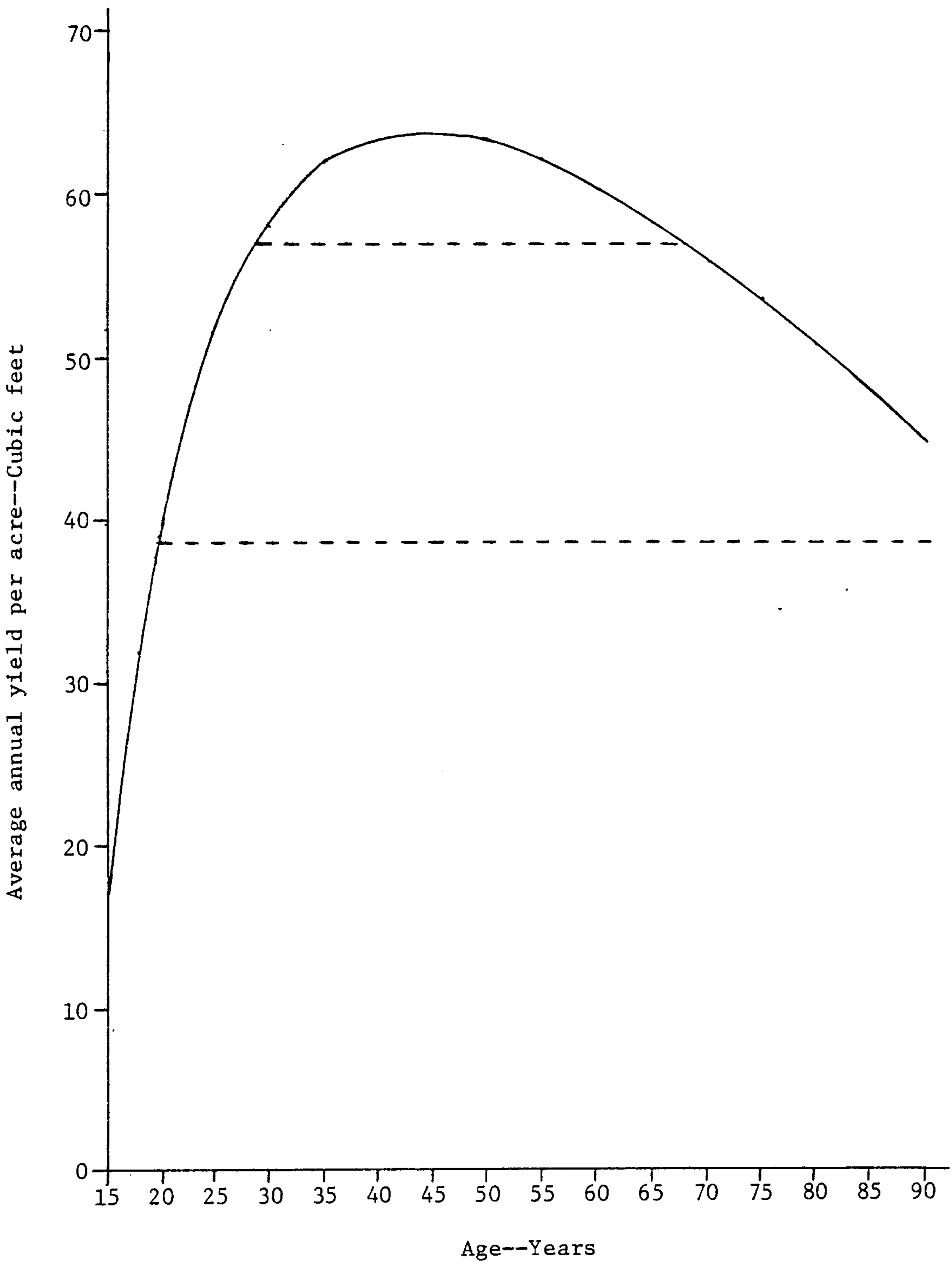

Figure 5.--Mean annual growth of oak-pine.

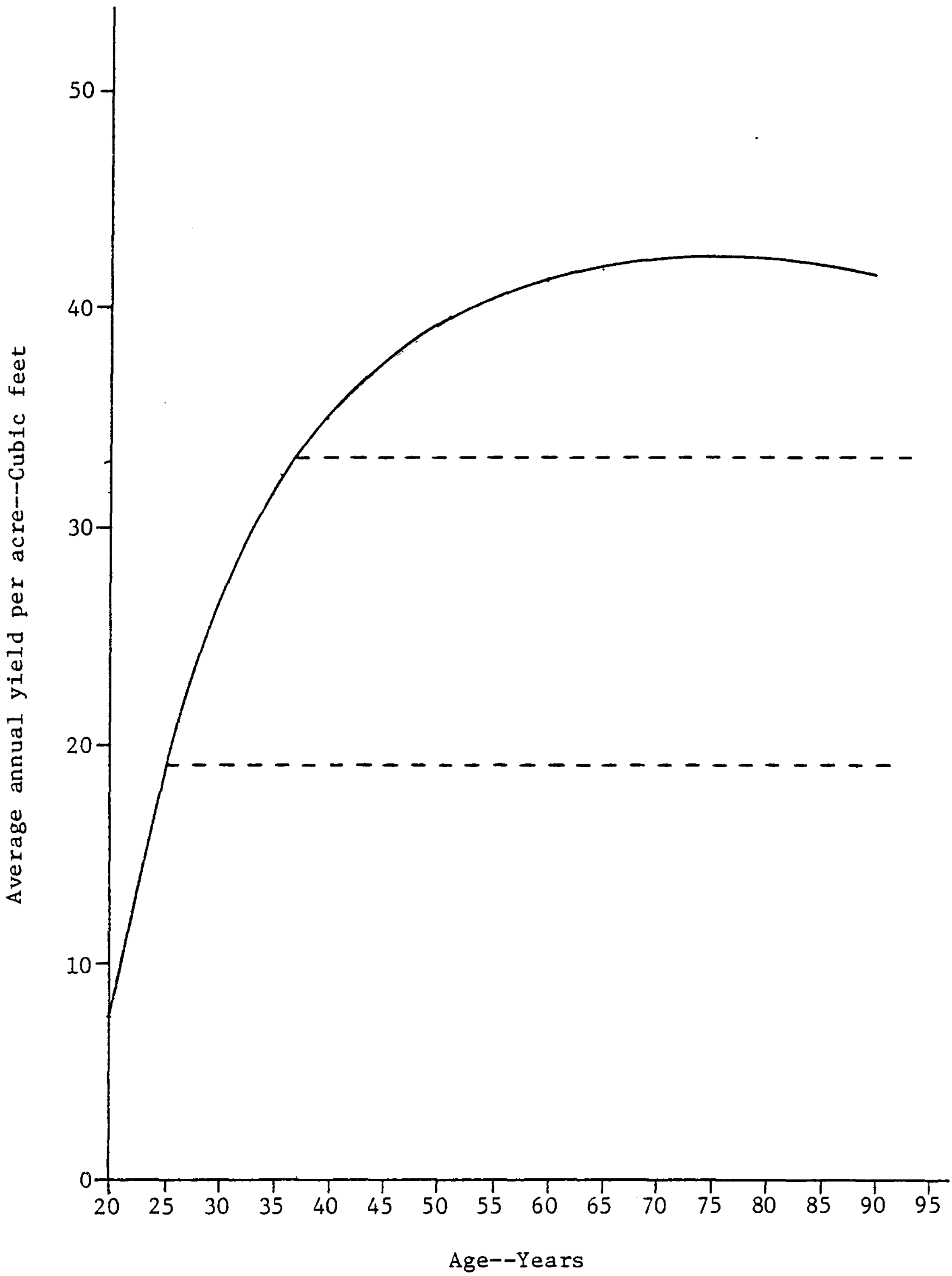

Figure 6.--Mean annual growth of upland hardwood.

Table 35.--Number of acres and percentage of acres yielding larger average annual yields per acre than those acres at or below a specified, financially optimal guiding rate of interest, by ownership and forest type.

Forest Type	Type Of Ownership	Guiding Rate Of Interest	Number Of Acres	Percentage Of Acres
		Percent	Acres	Percent
Loblolly Pine	Farmer	12	267,238	69.5
	Farmer	3	171,194	44.5
	Miscellaneous Private	12	270,212	70.3
	Miscellaneous Private	3	189,228	49.6
	Forest Industry	3	123,829	26.9
Oak-pine	Farmer	12	208,789	73.9
	Farmer	3	142,507	50.4
	Miscellaneous Private	12	176,058	67.8
	Miscellaneous Private	3	128,456	49.5
	Forest Industry	3	32,757	31.0
Upland Hardwood	Farmer	12	418,254	68.3
	Farmer	3	402,017	65.6
	Miscellaneous Private	12	358,229	72.6
	Miscellaneous Private	3	349,432	70.8
	Forest Industry	3	60,505	58.6

beyond the optimum than is the forest industry. This indicates, as with the pine type, the possibility that nonindustrial private timber is managed more capital-intensively than is the timber of forest industry.

4.52 Analysis of Growing Stock Levels in Eastern Virginia

To determine whether the growing-stock variable can lend support to the proposition that the nonindustrial private owners are managing their forest more intensively than generally anticipated, the data of Table 36 is used. Once again, because public ownership and the bottomland hardwood type account for only a small portion of the total commercial forest acreage, consideration of the two is omitted.

From Table 36, it is readily seen that farm and miscellaneous private owners are, acre for acre, carrying pine and oak-pine growing stocks that are greater than those being carried by the forest industry. These higher levels of growing stock, assuming that the forest industry is managing at a 3-percent rate, would indicate comparatively longer rotations and lower guiding rates for the nonindustrial private owners. Therefore, we have additional evidence that these owners are operating not only below a 12 percent rate, but possibly at a lower rate than the forest industry. But since the attainment of higher growing-stock levels is due in part to longer rotations, reference must be made to the rotation-length analysis. The foregoing implication is reasonable if nonindustrial private owners are following longer rotations than the forest industry. By recalling the results of the rotation-length analysis, we know that the nonindustrial private owners are holding larger percentages of the older acres than the forest industry. The evidence, then, that these owners may be operating at lower rates than the forest

Table 36.--Average net volume per acre of growing stock on commercial forest land in eastern Virginia, by ownership and species group. 1/

Forest Type		All Ownerships	Public	Forest Industry	Farmer	Miscellaeous Private
			Ownership Class			
		Cubic Feet				
Pine Type	Growing Stock;					
	Softwood	1268	1828	1007	1483	1323
	Hardwood	247	318	176	323	252
	Total	1515	2146	1183	1806	1575
Oak-pine Type	Growing Stock;					
	Softwood	602	892	514	606	608
	Hardwood	659	946	487	720	636
	Total	1261	1838	1001	1326	1244
Upland Hardwood Type	Growing Stock;					
	Softwood	142	205	139	146	130
	Hardwood	1150	1507	1177	1092	1179
	Total	1292	1712	1316	1238	1309
Bottomland Hardwood Type	Growing Stock;					
	Softwood	212	204	244	218	196
	Hardwood	1399	1821	1678	1323	1345
	Total	1611	2025	1922	1541	1541
All Types	Growing Stock;					
	Softwood	595	701	736	554	555
	Hardwood	798	1183	493	870	842
	Total	1393	1884	1229	1424	1397

1/ Cost, 1976.

industry is consistent with respect to the age variable.

For the upland hardwood type, it is seen that growing stocks per acre of forest industry and the nonindustrial private owners are nearly equal. The indication is, as one might expect, that upland hardwood is generally held over for sawtimber, on longer rotations than for pulpwood. Given that the levels of growing stock of the nonindustrial private owners are approximately equal to those of the forest industry, whose operation is assumed to be carried out at 3 percent, the hypothesis that these owners are managing their timber at a rate less than 12 percent is verified.

But is there any evidence in the upland hardwood type that the nonindustrial private owners have lower guiding rates than the forest industry? The only positive indication of this is in the rotation-length data. We know from the analysis of those data that the nonindustrial private owners are holding larger percentages of the older acres than is the forest industry.

It is appropriate at this time to summarize our findings concerning rotation length and growing stock. The most important finding is evidence to support the hypothesis that the farm and miscellaneous private owners are operating at guiding rates lower than the initial assumption of 12 percent. In addition, the assumption of identical guiding rates of interest for farm and miscellaneous private owners held up throughout the analyses. From Tables 35 and 36, it is evident that the two classes of owners are remarkable similar in their management of timber, so far as age distributions and growing stocks are concerned. Thus, we have no justification for altering our original assumption.

One unexpected discovery also came out of these analyses. This was the possibility that the nonindustrial private owners are actually operating at rates below those of the forest industry. The question, then, is what effect the rotation-length and growing-stock analyses have on our estimate of the guiding rate of interest of the forest industry.

Given that the forest industry is the best-documented owner, in terms of timber management and guiding rate of interest, we cannot realistically alter our assumption of a 3-percent rate. The rotation-length and growing-stock data do not offer sufficient evidence to deduce a different rate.

By the same token, a specific rate of interest for farm and miscellaneous private owners cannot be deduced from the data alone. But evidence at hand does offer strong arguments against the assumption that these owners operate at a 12-percent rate. In fact, the implication is that perhaps they are operating at a rate below 3 percent. Although a situation such as this would be financially irrational for farm and miscellaneous private owners, it is not totally unrealistic. Suppose that these nonindustrial owners, over and above holding timber longer because of sawtimber potentials and local restrictions on cutting, are holding a considerable amount of timber in the older age classes because of philosophical or sentimental commitments. In this case, it is conceivable that the nonindustrial owners as a whole are operating below 3 percent--i.e., at an intensity of management that is irrationally high in financial terms. However, the rotation-length and growing-stock analyses support only this conclusion: We cannot justifiably overlook our original finding, that if the public and forest industry are operating at a 3-percent interest rate and the nonindustrial private owners are operating at a 4-percent rate, we can explain the 240,304,000 cubic feet of current annual growth reported in the fourth Forest Survey.

4.53 Projection of Timber Output in Eastern Virginia in 2020

What guiding rates of interest should be applicable to the various ownership classes in eastern Virginia for 2020? We have unexpectedly found the 1976 guiding rates (i.e., 3-percent for public and forest industry and 4-percent for farm and miscellaneous private owners) to be very conservative, indicating extremely intensive management of the timber resource. Raising the rates to 5,6 or 7 percent is unfounded, given our present knowledge. However, should the guiding rates of interest rise, this would have extremely adverse effects on the timber output potential.

The most reasonable assumption is that the 1976 rates will be maintained through 2020. Table 37 illustrates the calculations of projected timber output for 2020, using the yield figures from Table 30 for natural loblolly pine, oak-pine, upland hardwood, and bottomland hardwood, the yield figures from Table 32 for planted loblolly pine, the commercial forest acreage projections from Table 19, 3 percent guiding rates for public and forest industry and 4 percent for farmers and miscellaneous private owners. Projection (2,4), which was deemed the most likely estimate for commercial forest acreage in 2020, shows the total annual growth to be 258,219,969 cubic feet, an increase of 17,915,969 cubic feet, or 6.9 percent. This estimate becomes extremely revealing when one considers that the increase in total annual growth of eastern Virginia's timber from 1966 to 1976, alone, was greater than 40 million

Table 37.--Projection of timber output in eastern Virginia, for 2020.

Forest Ownership	Forest Type	Projection (1,3)	Projection (2,3)	Projection (2,4)	Projection (3,4)
		Acres			
Public	Planted Loblolly Pine	911,850	911,850	911,850	911,850
	Natural Loblolly Pine	4,436,109	4,436,109	4,436.109	4,436,109
	Oak-pine	1,786,408	1,786,408	1,786,408	1,786,408
	Upland Hardwood	2,998,172	2,998,172	2,998,172	2,998,172
	Bottomland Hardwood	553,251	553,251	553,251	553,251
	Subtotal	10,685,790	10,685,790	10,685,790	10,685,790
Forest Industry	Planted Loblolly Pine	48,930,722	48,930,722	48,930,722	48,930,722
	Natural Loblolly Pine	42,505,330	42,505,330	42,505,330	42,505,330
	Oak-pine	971,210	971,210	971,210	971,210
	Upland Hardwood	1,235,902	1,235,902	1,235,902	1,235,902
	Bottomland Hardwood	2,347,396	2,347,396	2,347,396	2,347,396
	Subtotal	95,990,560	95,990,560	95,990,560	95,990,560
Farmer	Planted Loblolly Pine	14,162,522	13,983,753	14,665,679	14,486,910
	Natural Loblolly Pine	28,151,605	27,454,287	30,114,255	29,426,937
	Oak-pine	8,968,482	8,605,236	9,990,714	9,627,467
	Upland Hardwood	13,603,611	13,075,337	15,090,388	14,562,084
	Bottomland Hardwood	7,093,058	6,875,890	7,704,293	7,487,125
	Subtotal	71,979,278	69,994,503	77,565,329	75,580,523
Miscellaneous Private	Planted Loblolly Pine	11,428,778	11,087,815	10,320,529	9,894,444
	Natural Loblolly Pine	35,588,432	34,258,355	31,398,890	29,869,316
	Oak-pine	13,252,927	12,560,215	11,136,254	10,405,004
	Upland Hardwood	16,288,419	15,280,878	13,375,369	12,477,340
	Bottomland Hardwood	8,989,853	8,575,651	7,747,248	7,333,046
	Subtotal	85,548,409	81,762,914	73,978,290	69,979,150
	Grand Total	264,204,037	258,433,767	258,219,969	252,236,023

cubic feet. (The exact increase is difficult to ascertain since changes in volume tables have been made between surveys.)

By including projections (1,3), (2,3), and (3,4) a range of output is obtained for 2020. This range is from a low of 252,236,023 cubic feet for projection (3,4) to a high of 264,204,037 cubic feet for projection (1,3).

We can also establish a maximum biological potential for eastern Virginia. This is accomplished by taking the projected 2020 acreages by forest type and multiply each by its respective average annual yield at the culmination of mean annual increment. The estimation of the biological potential in 2020 for projections (1,3), (2,3), (2,4), and (3,4), respectively, is 304,633,263 cubic feet, 297,529,877 cubic feet, 297,315,486 cubic feet, and 289,997,814 cubic feet. Comparing these to the estimated biological potential in 1976, which was 283,945,601 cubic feet, we see that there is very little room for further intensification.

5. CONCLUSIONS

The issues addressed in this report involve some very old and deeply entrenched perceptions held by the forestry profession. This final chapter attempts to isolate these issues and propose some answers.

An important part of traditional forestry thinking concerns the "problem" of the nonindustrial private timber owners. Foresters have traditionally perceived of these owners as ill-advised, poorly financed individuals who exhibit very little hesitation about cutting their timber as fast as it reaches merchantibility. There is an abundance of proposals for mobilizing this vast "untapped" resource as a hedge against expected increases in future demand. Education of the timber owner on the "proper" management of his timber is often considered the most expedient route by which we can achieve this objective.

There is little doubt that the "problem owner" actually exists. The question is whether the exploitive owners featured in the lore constitute a very large proportion of the nonindustrial private group in eastern Virginia. The results of this study strongly indicate that they do not and that they may, in fact, represent only a small minority. A substantial quantity of information has been presented here as evidence to support this hypothesis. First, we found that to explain the current annual growth reported in the 1976 Forest Survey, it is necessary to assign low guiding rates of interest (i.e., 4 percent) to the nonindustrial private owners. This placed their management nearly on a par with the public agencies and forest industry, who were assumed to be operating at 3 percent. In an effort to check this finding, we turned to the rotation-length and growing-stock data collected by the Forest Survey in eastern Virginia. From an analysis of these data, we not only found justification for assigning low guiding rates to the nonindustrial private owners, but also discovered that these owners may in fact be operating at lower rates than the forest industry.

Before closing this controversial subject, let us offer a final piece of evidence in opposition to the traditional image of the nonindustrial private owners. Table 38 shows the cubic feet of current annual timber growth reported in the 1976 Forest Survey, on both a total and a per-acre basis. The figures are divided into public, industrial, and nonindustrial private ownerships. For comparison with these "actual" growth figures, consideration is given to 3 different situations for 1976, based on the yields and rotation ages, by guiding rate of interest, developed for this study (Table 30). The first of these assumes the nonindustrial private owners to be operating at a 12-percent guiding rate of interest and the public and forest industry operating at 3 percent. Comparing the per-acre annual growth under these conditions with the actual growth, we see that the forest industry is falling far short of the per-acre growth expected at a 3-percent guiding rate. The nonindustrial owners, however, are considerably surpassing their growth potential at the 12-percent rate. At a 4-percent rate, for case 2, we find the nonindustrial private owners still producing slightly in excess of the growth potential expected at that rate. The final situation finds the biological growth potential for eastern Virginia (i.e., zero percent guiding rate) subdivided into the biological growth potential for each of the three ownership classifications. Here we see the forest industry producing only 69 percent of its biological growth potential,

Table 38.--Total and per-acre current annual timber growth, for public, industrial private and nonindustrial private ownerships.

Ownership Class	1976 Forest Survey Growth		1976 Growth Calculated; Nonindustrial Private Owners Assumed Exploitive		1976 Growth Calculated; Nonindustrial Private Owners Assumed Conservative		1976 Biological Potential	
	Total	Per Acre	Total	Per Acre	Total	Per Acre	Total	Per Acre
	Cubic Feet							
All Commercial Forest	240,300,000	60	187,600,000	47	238,100,000	59	283,900,000	71
Public	9,800,000	67	7,900,000 (3) 1/	54	7,900,000 (3)	54	10,300,000 (0)	70
Industrial Private	48,400,000	63	64,100,000 (3)	84	64,100,000 (3)	84	70,000,000 (0)	91
Nonindustrial Private	182,100,000	59	115,600,000 (12)	37	166,100,000 (4)	54	203,600,000 (0)	66

1/ Numbers in parenthesis indicate the guiding rate of interest, in percent, used to calculate the total growth directly above it.

while the nonindustrial private owners are producing 89 percent of their potential. Although these figures may not exhibit pinpoint accuracy, they are reasonable estimates of the true figures and do point up, once again, the heretofore unrecognized intensity with which the nonindustrial private owners are managing their timber.

What has been occurring in the nonindustrial private sector to bring about this conservative management of the timber resource? Our private forests appear to be taking on new directions as they begin falling into the hands of citizens who are either well informed of the potentials of the resource or have moved beyond the traditional financial goals of timber production. Those who have shunned purely financial objectives are interested in nonmarket goals, including recreational, aesthetic, and philosophical or sentimental aims. The forestry profession seems to have lost touch, in part, with the changing attitudes and goals of private nonindustrial forest owners. In order for the profession successfully to assist the general public in timber-management decisions, it must keep abreast of changes in owner attitudes and objectives.

Now that we have brought to light the conservative timber management of the nonindustrial private owners, what bearing does this have on future output potentials in eastern Virginia? The only reasonable conclusion to be drawn is that increases in timber output through intensified management are likely to minimal. Realistically, we cannot expect the private owners to intensify their timber management, which is already extremely conservative. Does this conclusion portend a strictly decreasing trend in timber output? Are any alternatives available for at least maintaining and perhaps increasing the long-run timber-output potential in eastern Virginia?

One alternative is the conservation of today's commercial forest acreage. We cannot expect to maintain or exceed present output levels if the basic ingredient of timber production, land, is not available.

Since eastern Virginia is a pine-oriented region, this species requires special attention when considering future output potentials. First, forest owners who are presently managing pine forests need to regenerate these acres to pine immediately after harvest, so long as this alternative remains consistent with their objectives. Reversion of this acreage to some species other than pine will obviously reduce the timber-output potential, but in addition, it will increase the financial burden of bringing pine back to pine land. Thus, if we lose pine acreage now through lack of immediate regeneration, it will become increasingly difficult to induce owners to bear the additional financial burden of type conversion.

Beyond the maintenance of present pine acreages, there still exists the possibility of hardwood conversion to pine. If owners can be convinced, through subsidies or other means, to bestow their low rates of interest upon faster growing species, provided the change does not conflict with their goals, future output potentials can be increased. For instance, this report is forecasting the maintenance of a substantial number of upland hardwood stands. If more of these acres can be converted to pine, we might expect the timber output potential to increase.

Before ending this discussion, one possible pitfall must be recognized. If the forestry profession were successful in convincing private timber owners to follow a purely financial management program, the result might be a reduction in timber output. Many owners are already following longer rotations than are rational from a financial viewpoint. Their nonmarket approach to timber management, with long rotations, is actually subsidizing intensified timber production for the general public. To apply financial standards to their management could force a cutback in rotation length and consequently reductions in timber yields.

Perhaps it is time for the forestry profession to step back and take a fresh look at our nonindustrial private forests. The necessity for accurate forecasts of future timber output potentials in eastern Virginia, as well as the entire nation, obligates the profession to broaden its outlook upon nonindustrial private forest management.

APPENDIX

Table A-1.--Rate of return on extra growing stock, for planted loblolly pine on average site in eastern Virginia, with 1952 regeneration costs. 1/

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Rotation Age	Yield Per Acre		Annual Value Yield Per Acre	Regen-eration Costs Per Acre	Annual Value Yield Adjusted For Costs	Marginal Value Yield Per Acre	Growing Stock Per Acre	Value Of Grow-ing Stock Per Acre	Marginal Value Of Growing Stock Per Acre	Rate Of Return On Extra Growing Stock
	Total	Annual								
Years	-- Cubic Feet --		------------ Dollars	-------------			Cubic Feet	--- Dollars	-----	Percent
10	215	21.5	1.23	1.02	0.21		53.75	3.06		
						3.73			12.59	29.63
15	1217	81.1	4.62	0.68	3.94		274.50	15.65		
						1.64			19.97	8.21
20	2135	106.8	6.09	0.51	5.58		624.88	35.62		
						0.78			21.96	3.55
25	2968	118.7	6.77	0.41	6.36		1010.20	57.58		
						0.36			22.15	1.63
30	3715	123.8	7.06	0.34	6.72		1398.75	79.73		
						0.12			21.56	0.56
35	4379	125.1	7.13	0.29	6.84		1777.07	101.29		
						-0.04			20.60	-0.19
40	4958	123.9	7.06	0.26	6.80		2138.50	121.89		
						-0.12			19.43	-0.62
45	5453	121.2	6.91	0.23	6.68		2479.28	141.32		

1/ Regeneration costs per acre are $10.20 and a cubic foot of wood is worth $.057.

Table A-2.--Rate of return on extra growing stock, for planted loblolly pine on average site in eastern Virginia, with 1961 regeneration costs. 1/

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Rotation Age	Yield Per Acre		Annual Value Yield Per Acre	Regen-eration Costs Per Acre	Annual Value Yield Adjusted For Costs	Marginal Value Yield Per Acre	Growing Stock Per Acre	Value Of Grow-ing Stock Per Acre	Marginal Value Of Growing Stock Per Acre	Rate Of Return On Extra Growing Stock
	Total	Annual								
Years	-- Cubic Feet --		------------ Dollars			-------------	Cubic Feet	--- Dollars	----	Percent
10	215	21.5	1.31	1.54	-0.23		53.75	3.28		
						4.16			13.46	30.91
15	1217	81.1	4.95	1.02	3.93		274.50	16.74		
						1.81			21.37	8.47
20	2135	106.8	6.51	0.77	5.74		624.88	38.11		
						0.89			23.51	3.79
25	2968	118.7	7.24	0.61	6.63		1010.20	61.62		
						0.41			23.70	1.73
30	3715	123.8	7.55	0.51	7.04		1398.75	85.32		
						0.15			23.08	0.65
35	4379	125.1	7.63	0.44	7.19		1777.07	108.40		
						-0.01			22.05	-0.05
40	4958	123.9	7.56	0.38	7.18		2138.50	130.45		
						-0.13			20.79	-0.63
45	5453	121.2	7.39	0.34	7.05		2479.28	151.24		

1/ Regeneration costs per acre are $15.35 and a cubic foot of wood is worth $.061

Table A-3.--Rate of return on extra growing stock, for planted loblolly pine on average site in eastern Virginia, with 1967 regeneration costs. 1/

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Rotation Age	Yield Per Acre Total	Yield Per Acre Annual	Annual Value Yield Per Acre	Regen- eration Costs Per Acre	Annual Value Yield Adjusted For Costs	Marginal Value Yield Per Acre	Growing Stock Per Acre	Value Of Grow- ing Stock Per Acre	Marginal Value Of Growing Stock Per Acre	Rate Of Return On Extra Growing Stock
Years	-- Cubic Feet --		------------ Dollars			-------------	Cubic Feet	--- Dollars ---		Percent
10	215	21.5	1.48	2.21	-0.73		53.75	3.71		
						4.86			15.23	31.91
15	1217	81.1	5.60	1.47	4.13		274.50	18.94		
						2.13			24.18	8.81
20	2135	106.8	7.37	1.11	6.26		624.88	43.12		
						1.05			26.58	3.95
25	2968	118.7	8.19	0.88	7.31		1010.20	69.70		
						0.49			26.81	1.83
30	3715	123.8	8.54	0.74	7.80		1398.75	96.51		
						0.20			26.11	0.77
35	4379	125.1	8.63	0.63	8.00		1777.07	122.62		
						0.00			24.94	0.00
40	4958	123.9	8.55	0.55	8.00		2138.50	147.56		
						-0.13			23.51	-0.55
45	5453	121.2	8.36	0.49	7.87		2479.28	171.07		

1/ Regeneration costs per acre are $22.12 and a cubic foot of wood worth $.069.

Table A-4.--Rate of return on extra growing stock, for planted loblolly pine on average site in eastern Virginia, with 1974 regeneration costs. 1/

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Rotation Age	Yield Per Acre		Annual Value Yield Per Acre	Regen- eration Costs Per Acre	Annual Value Yield Adjusted For Costs	Marginal Value Yield Per Acre	Growing Stock Per Acre	Value Of Grow- ing Stock Per Acre	Marginal Value Of Growing Stock Per Acre	Rate Of Return On Extra Growing Stock
	Total	Annual								
Years	-- Cubic Feet --		------------ Dollars ------------				Cubic Feet	-- Dollars ---		Percent
10	215	21.5	2.80	5.06	-2.26		53.75	6.99		
						9.43			28.70	32.86
15	1217	81.1	10.54	3.37	7.17		274.50	35.69		
						4.18			45.54	9.18
20	2135	106.8	13.88	2.53	11.35		624.88	81.23		
						2.06			50.10	4.11
25	2968	118.7	15.43	2.02	13.41		1010.20	131.33		
						0.99			50.51	1.96
30	3715	123.8	16.09	1.69	14.40		1398.75	181.84		
						0.42			49.18	0.85
35	4379	125.1	16.26	1.44	14.82		1777.07	231.02		
						0.03			46.99	0.06
40	4958	123.9	16.11	1.26	14.85		2138.50	278.01		
						-0.21			44.30	-0.47
45	5453	121.2	15.76	1.12	14.64		2479.28	322.31		

1/ Regeneration costs per acre are $50.57 and a cubic foot of wood is worth $.13.

Table A-5.--Rate of return on extra growing stock, for planted loblolly pine on average site in eastern Virginia, with 1976 regeneration costs. 1/

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Rotation Age	Yield Per Acre		Annual Value Yield Per Acre	Regeneration Costs Per Acre	Annual Value Yield Adjusted For Costs	Marginal Value Yield Per Acre	Growing Stock Per Acre	Value Of Growing Stock Per Acre	Marginal Value Of Growing Stock Per Acre	Rate Of Return On Extra Growing Stock
	Total	Annual								
Years	-- Cubic Feet --		------------ Dollars ------------				Cubic Feet	--- Dollars ---		Percent
10	215	21.5	2.73	5.17	-2.44		53.75	6.83		
						9.29			28.03	33.14
15	1217	81.1	10.30	3.45	6.85		274.50	34.86		
						4.12			44.50	9.26
20	2135	106.8	13.56	2.59	10.97		624.88	79.36		
						2.03			48.94	4.15
25	2968	118.7	15.07	2.07	13.00		1010.20	128.30		
						1.00			49.34	2.03
30	3715	123.8	15.72	1.72	14.00		1398.75	177.64		
						0.41			48.05	0.85
35	4379	125.1	15.89	1.48	14.41		1777.07	225.69		
						0.04			45.90	0.09
40	4958	123.9	15.74	1.29	14.45		2138.50	271.59		
						-0.21			43.28	-0.49
45	5453	121.2	15.39	1.15	14.24		2479.28	314.87		

1/ Regeneration costs per acre are $51.71 and a cubic foot of wood is worth $.127.

REFERENCES CITED

Bertelson, D. F. 1977. Southern pulpwood production, 1976. U.S.D.A. For. Serv., South. For. Exp. Stn. Resource Bulletin SO-66. 21pp.

Boyce, S. G. and J. P. McClure. 1975. How to keep one-third of Georgia in pine. U.S.D.A. For. Serv., Southeast. For. Exp. Stn., For. Serv. Res. Pap. SE-144. 23pp.

Bryan, M. B. 1957. Forest statistics for the Coastal Plain of Virginia, 1956. U.S.D.A. For. Serv., Forest Survey Release No. 50. 42pp.

Cost, N. D. 1976. Forest statistics for the Coastal Plain of Virginia, 1976. U.S.D.A. For. Serv., Southeast. For. Exp. Stn., For. Res. Bull. SE-34. 33pp.

Cliff, E. P. 1973. Timber: The renewable material. The National Commision on Materials Policy. 151pp.

Commonwealth of Virginia. 1971. Reforestation of timberlands regulations. Department of Conservation and Economic Development, Division of Forestry. 8pp.

Commonwealth of Virginia. 1972. Virginia Seed Tree Law. Department of Conservation and Economic Development, Division of Forestry, Publication 59. 10pp.

Commonwealth of Virginia. 1975. Population projections, Virginia counties and cities 1980-2000. Division of State Planning and Community Affairs. 15pp.

Commonwealth of Virginia. 1976. Manual of the State Land Evaluation Advisory Committee. State Land Evaluation Advisory Committee, Richmond, Va. 157pp.

Crater Planning District Commission. 1973. 1990 Land Development Plan. Crater Planning District Commission. 106pp.

Cruikshank, J. W. 1943. The forest situation in the Coastal Plain of Virginia. U.S.D.A. For. Serv., Appalachian For. Exp. Stn., Forest Survey Release No. 12. 71pp.

Davis, K. P. 1966. Forest management. McGraw-Hill Book Co., New York. 519pp.

Division of Forest Economics and Research. 1963. Timber trends in western Oregon and western Washington. U.S.D.A. For. Serv. Pacific Northwest For. and Range Exp. Stn., Res. Pap. PNW-5. 154pp.

Duerr, W. A. 1960. Fundamentals of forestry economics. McGraw-Hill Book Co., New York. 579pp.

Duerr, W. A. and N. B. Christiansen. 1964. Exercises in the managerial economics of forestry. Oregon State University Bookstore, Inc., Corvallis. 325pp.

Giauque, J. A. 1977. Derivation of data for estimating Coastal Virginia's potential timber growth. M.S. Thesis. Virginia Polytechnic Institute and State University, Div. of For. and Wildl. Res. 97pp.

Hatch, C. R., G. M. Allen, G. L. Houck, and K. M. Sowles. 1976. Timber supply projections for the state of Idaho. Univ. of Idaho, Bull. No. 15. 19pp.

Knight, H. A. and J. P. McClure. 1967. Virginia's timber, 1966. U.S.D.A. For. Serv. Southeast. For. Exp. Stn. Res. Bulletin SE-8. 47pp.

Marshall, J. P. 1977. Use-value taxation in Virginia. Virginia Polytechnic Institute and State Univ., Cooperative Extension Service. 18pp.

Marshall, J. P. 1977. Virginia's Agricultural and Forestal Act: A review. Virginia Polytechnic Institute and State Univ., Cooperative Extension Service. 4pp.

Marshall, J. P. 1977. Virginia's Agricultural and Forestal Act: Some questions and answers. Virginia Polytechnic Institute and State Univ., Cooperative Extension Service. 14pp.

McElwee, R. L. and E. D. Frame. 1975. Forest products directory. Extension Division, Virginia Polytechnic Institute and State Univ., MT-76. 88pp.

Middle Peninsula Planning District Commission. 1976 Land-use policy plan for the Middle Peninsula Planning District. 59pp.

Mivilie-Deschenes, R. 1975. Goals for timber production in the lower Saint Lawrence Gaspe region of Quebec. M.S. Thesis. State Univ. of New York College of Environmental Sciences and Forestry, Syracuse. 160pp.

Moak, J. E., J. M. Kucera, and W. F. Watson. 1977. Current costs and cost trends for forestry practices in the South. Forest Farmer, Volume 36, No. 5, pp16-21.

Montgomery, A. A., V. L. Robinson, and J. D. Strange. 1976. Impacts of land-use competition and other constraints on Georgia's future timber supply. Georgia Forest Res. Council Rep. No. 36. 24pp.

Robert Davenport Associates, Inc. 1974. Population and economic study of Chespeake, Virginia-summary. 54pp.

Row, C. 1973. Probabilities of financial returns from southern pine timber growing. U.S.D.A. For. Serv. 428pp.

Sheffield, R. M. 1978. Coastal Virginia's timber resource-trends, present conditions, and opportunities for improvement. U.S.D.A. For. Serv., Southeast. For. Exp. Stn., For. Res. Bull. SE-43. 23pp.

Sherman, R. L. 1977. Forest product price trends. Forest Farmer, Volume 36, No. 5, pp108-109.

Stebbins, E. J. 1975. A plan for investigating timber trends and prospects in eastern Virginia. M.S. Thesis. Virginia Polytechnic Institute and State Univ., Div. of For. and Wildl. Res. 90pp.

Tsang, C. S. and J. P. Marshall. 1976. Procedures for determining ranges of use-values for agriculture, horticulture, forest, and open space land in Virginia. State Land Evaluation Advisory Committee. 37pp.

United States Bureau of Census. U. S. Census of Agriculture, 1954. Volume 1, counties; part 15, Virginia and West Virginia. U. S. Government Printing Office, 1956.

United States Bureau of Census. U. S. Census of Agriculture, 1959. Volume 1, counties; part 22, Virginia. U. S. Government Printing Office, 1961.

United States Bureau of Census. U. S. Census of Agriculture, 1964. Volume 1, counties; part 24, Virginia. U. S. Government Printing Office, 1967.

United States Bureau of Census. U. S. Census of Agriculture, 1969. Volume 1, counties; part 24, Virginia; section 1. U. S. Government Printing Office, 1972.

United States Department of Agriculture. 1929. Volume, yield, and stand tables for second-growth southern pines. Misc. Publ. No. 50. 202pp.

United States Department of Agriculture. 1966. Preliminary Forest Survey statistics for the Coastal Plain of Virginia, 1966. Div. of Marketing Utilization and Resources Research. Southeastern For. Exp. Stn. 14pp.

United States Department of Agriculture. 1969. A reassessment of the timber situation in eastern Virginia based on projection techniques. Unpublished report by the Forest Survey Project. Southeast. For. Exp. Stn. 17pp. Mimeogr.

United States Department of Agriculture. 1974. Forest Survey field instructions for Virginia. Southeastern For. Exp. Stn. 93pp.

United States Department of Agriculture. 1975. Virginia Unit 1. 4th Survey 75363. Unpublished computer output of the Forest Survey. Southeastern For. Exp. Stn. Copy.

United States Department of Agriculture. 1975. Forestry Incentives Program (FIP). Agricultural Stabilization and Conservation Service. 8pp.

United States Department of Agriculture. 1977. Agricultural Conservation Program. Section II, Summary of accomplishments under the Agricultural Conservation Program. 8pp.

Virginia Division of Forestry. 1971. Private forestland ownership for the State of Virginia. 171pp.

Virginia Division of State Planning and Community Affairs. 1975. Virginia local and regional planning, 1975. 43pp.

Willistio, H. L. and W. E. Balmer. 1976. Managing for natural regeneration. Forest Farmer, Volume 35, No. 3, pp6-8.

Willistio, H. L. and W. E. Balmer. 1977. Direct seeding of southern pines-a regeneration alternative. U.S.D.A. For. Serv., Southeast area, State and Private Forestry. 6pp.

Worrell, A. C. 1967. Economics of American forestry. Wiley, New York. 441pp.

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THE LONG-RUN TIMBER OUTPUT POTENTIAL IN EASTERN VIRGINIA

by

Curt Charles Hassler

(ABSTRACT)

Some alarming trends in commercial forest acreage and pine growing stocks have been developing over the course of four Forest Surveys in eastern Virginia; Forest Survey Unit 1. The importance of the timber resource to the region's economy has brought about a need for research into the long-run timber prospects.

Long-run timber output potentials in eastern Virginia are primarily dependent upon two factors: Prospective changes in commercial forest acreage and the intensity with which the forest acreage is managed. An analysis of past trends and a study of the opinions of knowledgeable persons in eastern Virginia lead to the estimate that commercial forest acreage will decrease approximately 9 percent by 2020. As for timber-management intensity, the study commences with data on cubic-foot yields for the five major forest types, as related to stand age and stocking. From these data, potential yield, per acre and total, is estimated for each class of forest owner.

The study finds that in eastern Virginia, nonindustrial private owners are managing their timber much more intensively than generally supposed. In fact, their timber output per acre is on a par with that of public and forest industry owners. If pine timber output is to be increased in the long run, apparently conversion of hardwood stands to pine, not more intensive management of existing stands, will be the means.