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AN EVALUATION OF THE MICHIGAN STATE FOREST CULTIVATION PROGRAM

By

Mark C. Vodak

A DISSERTATION

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ABSTRACT

AN EVALUATION OF THE MICHIGAN STATE FOREST CULTIVATION PROGRAM

By

Mark C. Vodak

Fifty-three percent of Michigan's total land area is forested and constitutes one of its greatest and most valuable resources. The Forest Cultivation Program was initiated in 1973 primarily to increase the revenue-producing potential of state forest lands through more intensive silviculture and management. In this way the Michigan taxpayers were to be eventually benefitted through increased employment and income to the state. From an initial allocation of $300,000 for the program's first year, funding for the Forest Cultivation Program increased to $1 million for 1978.

The program is concerned primarily with northern hardwood stand improvement, pruning and release of red and white pine, regeneration of jack pine, and aspen regeneration. Funds are also being used for fertilization studies, site conversion to hybrid aspen, road construction, and forest inventory. In four years the Forest Cultivation Program has accomplished 36,000 acres of northern hardwood stand improvement, 8,700 acres of jack pine regeneration, 2,800 acres of red and white pine release, 4,200 acres of aspen regeneration, 95 acres of site conversion to hybrid aspen, and 44 miles of roads constructed.

In view of the Forest Cultivation Program's objectives, its level of funding, accomplishments, and continuation, this study sought to analyze the decision process involved in investment of the allocated funds. A survey of all Forestry Division personnel was made to identify the decision-making procedures used and factors considered in making investment choices. These data were viewed in relation to acceptable applicable economic analyses, with the overall objective as increasing the program's efficiency. The survey was also used to obtain information about the program's administration and the administering personnel's impressions of the program.

It was found that the Forest Cultivation Program has not been operated or administered efficiently. No economic criteria exist for guiding investment choice, and, similarly, other than the pre-established northern hardwood priority set by the program, no investment priorities or alternative rankings have been made. The procedures for gathering and analyzing information for making investment choices varied somewhat from area to area, just as did the procedures and considerations for stand selection for each timber type involved. Similarly, the allocation procedure was found to be evolving but still variable. Current planning and inventory procedures and accomplishments are also not adequate to serve the program needs.

Teams of technicians were created for the program, specializing in selection and marking of northern hardwood stands. The Forestry Division's personnel agreed on the administrative roles of the area forester and the team in administering the program. However, while recognizing the advantages of a specialized team for hardwood treatments, there tended to be more of a focus on the negative aspects of the team

system. The Division personnel also indicated that to them the Forest Cultivation Program's objectives were worthwhile, were being achieved, and that the program should be continued.

Regional planning is recommended for the Forestry Division to determine those regions and areas of the highest potential for program investment. Alternatives such as possible fiber and fuelwood production should be included in the planning and evaluation effort. Such planning will result in allocating funds more efficiently and in providing more program direction.

After comparison of several possible profitability measures, the internal rate of return is recommended as the criterion for evaluating and ranking alternatives for investments under the Forest Cultivation Program. Such economic ranking should serve as a guideline to aid investment choice and efficiency. To aid further, capital budgeting techniques are recommended. But the importance and influence of non-economic factors on program decisions are pointed out as well. As for uncertainty in the program's investment process, it can be ignored.

From previous studies, expected rates of return from investment in Forest Cultivation alternatives are discussed. These studies indicate that an average rate of return from 6.0 to 7.0 percent can be expected from investment in northern hardwood stand improvement, 3.4 to 6.6 percent from investment in jack pine regeneration, 10.0 to 12.0 percent from investment in red and white pine release, 6.0 to 8.0 percent from investment in pruning red pine, and an average rate of return of 4.0 percent from investment in aspen liberation.

Disagreement exists as to the validity of managing northern hardwood by uneven-aged methods. Therefore, the Forestry Division should re-examine its objective of managing northern hardwood by uneven-aged methods. Expansion of investments in red pine under the program is recommended. Planting of red pine on good sites, and more emphasis on red pine release and pruning will result in good return on investment as well as help provide quality timber in the future. On the other hand, further study of liberation treatments in aspen is recommended before increasing or even maintaining the current level of investment. While such investment is expected to average a rate of return in the 4.0 percent range, previous studies have shown aspen liberation investments to return as little as 1.2 percent.

Updating and completing inventories on all state forest lands is recommended. And, also, it is recommended that a cost effectiveness study be undertaken by either the Forestry Division or by an outside party, possibly as another research study, to analyze and evaluate representative program investments to date and determine whether projected benefits warrant further similar investments.

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CHAPTER I

INTRODUCTION[1]

Michigan's forest lands constitute one of its greatest and most valuable resources. In the state of Michigan, 19,373,400 acres are forested, representing 53 percent of the state's total land area. Of this forest land, approximately 20 percent, or 3,819,960 acres are state-owned and are administered by the Forestry Division of the Department of Natural Resources. Some 12,457,800 acres, or approximately 66 percent, are owned by private and industrial interests, with the remaining 13 percent in other public ownership (Haskin, 1975). The State Forestry Division also gives professional and technical assistance to owners of these lands.

Michigan's forest land is in essence the foundation for the timber and recreation industries, two quite important industries within the state, particularly in the north. Due primarily to the proximity of Michigan state forests to urban population centers, recreation and wildlife will probably continue to receive emphasis in the management of these lands. However, more attention is beginning to be given to greater timber production, both as to quantity and quality.

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[1]Sources for much of the information in this section were short papers, reports, memos, and inter-office communiqués on file in the Lansing staff office of the Michigan State Forestry Division.

The present system of thirty-three state forests evolved slowly from 1903, when the first professional forester was employed. In the late 1800's, Michigan's forests were devastated by the early "timber barons" and their "cut-out and get out" policies. The present state forest system is primarily the reversion of tax-delinquent land, formerly privately owned, that had been cut-over, burned-over, partly farmed in many cases, and abandoned. Through development, management, and protection, increasing forest growing stock has been established, with timber sales and harvest in 1975 having increased nearly 100 times over those of 1940, when sales were practically non-existent.

Hardwoods predominate on Michigan's state forest lands, although softwood volume has been increasing at a more rapid rate (James, et al., 1974). In 1972, approximately 479,500 acres, or 12.7 percent of the state-owned forest lands were in the northern hardwood cover type.

Of the total northern hardwood acreage, it is estimated that approximately 8 percent is seedling-sapling size; 74 percent is pole size; and 18 percent is sawtimber size (Haskin, 1973). These hardwood stands are rapidly increasing in size and quality, with growth at about .65 cords or approximately four square feet of basal area per acre annually.

The Forestry Division's management objectives for northern hardwood are to practice all-aged management on medium and better sites, with quality sawtimber and/or veneer logs as principal products, and aesthetics as a highly desirable by-product. Presently, approximately 18 percent of the northern hardwood type is stocked in such a manner that it is believed that all-aged management can either be practiced at this time or within the immediate future. More and more of these

stands can be managed through commercial timber sales. It is believed that the remaining immature stands, mostly even-aged or two-aged, consisting of scattered old remnants over-topping thrifty poles, can benefit from pre-commercial stand improvement. Since a good market for hardwood pulpwood has not developed, timber stand improvement (TSI) funds are being directed towards these stands that cannot be improved economically through commercial cuttings. Thinning to produce pulpwood is not an objective, nor will non-commercial improvements be made in stands that can provide commercial opportunities within 10 years.

With the objective of accelerating tree growth, thinning is the major treatment applied. Therefore, the Division desires to obtain better quality growth and a reduction in the time required to produce quality products with minimum labor cost and no volume loss. A 10-year cutting cycle leaving 70 to 90 square feet of basal area as growing stock will be implemented in uneven-aged hardwood management.

In striving towards its management objectives for northern hardwood, the Forestry Division believes that resulting wildlife benefits will be significant. It is also expected that in some cases the need for stand conversion either to or from northern hardwood will arise.

The Forest Cultivation Program resulted from this recognized need for more intensive management of northern hardwoods. However, the program is not limited to only northern hardwood investments, but also includes red pine, jack pine, and aspen alternatives. Therefore, a decision process is involved to determine how the program funds should be invested. Thus, the present analysis was proposed to examine the decision process involved in administering the Forest Cultivation Program. Both stand selection and investment choice procedures were examined.

In view of its objectives and level of funding, the administration of the program was examined at all levels of the Forestry Division to determine how it was operating. Procedures being used for investment alternative analysis and decision-making, as revealed through interviews, are evaluated and related to recognized major economic analysis procedures. The program's need for increased efficiency is discussed and recommendations are made for increasing its efficiency and effectiveness, as well as by providing direction.

The objectives of this study are:

1) To identify the decision-making procedures used and the factors considered in making investment choices through the Forest Cultivation Program.
2) To analyze the degree to which these procedures result in investment choices which are in basic agreement with choices made on the basis of accepted major economic analyses.
3) To determine what additional information is needed, and make recommendations for increasing the efficiency of the decision process.

This study is based on a survey taken from all areas of the Michigan Department of Natural Resources State Forest System administering the Forest Cultivation Program. Forest Division personnel were interviewed primarily in Regions I and II. Personnel involved with administering the Program were interviewed at the Regional, District, and Area levels of the organization.

CHAPTER II

LITERATURE REVIEW

The Michigan Forest Cultivation Program deals directly with the allocation and investment of funds in silvicultural treatments on state forest lands. As northern hardwood constitutes a major forest type on state lands, both economically and in area, the program focuses on investments in northern harwood stand improvement. Other primary investments considered through the program are pruning and release of red and white pine, regeneration of jack pine by site scarification and necessary seeding or planting, and aspen betterment (i.e. after-sale timber stand improvement and cleanup). Obviously the investment decision process must consider silvicultural and physical factors in allocating funds, but it must also include analysis of economic factors. Over the past 20 to 30 years, many studies have evaluated various forest investment opportunities, profitability measures, and managerial guidelines for investment selection.

Young and Eyre (1931) found that diameter growth of red pine was almost directly proportional to the degree of release from competing vegetation. They concluded that release cuttings in mixed stands of aspen and red pine were worthwhile cultural operations. This conclusion was supported by Roe (1957), who reported that yields from pine plantations were improved by release from aspen early in the rotation. Ralston (1953) even found that red pine suppressed for 40 years

responded well to release. He also found that the response of the released pine was in direct proportion to the amount of overstory removed. Pine release can be carried out by both mechanical (removal and girdling) and chemical (foliage sprays and tree injection) means. While most studies and economic projections of red pine release utilized mechanical means, Arend and Roe (1961) reported costs for chemical release of pines. For competing vegetation that was as tall or only a little taller than the pines, foliage spraying with ground equipment was $5.00 or more per acre. The equipment used and the kind and amount of herbicide applied were the determining factors. Where the competition was much larger than the pine and completely overtopping it, three or four man-hours per 1,000 inches of tree diameter treated were needed for frilling and chemical spraying. The chemical solution cost ranged from 25 to 50 cents per 1,000 inches of tree diameter, and was directly proportional to the solution strength.

When faced with the alternative of releasing pine, estimates of resulting returns certainly assist in the decision process. Lundgren (1963) evaluated three red pine release experiments and demonstrated that not only could release of sapling pine stands be effective, but that under some conditions it could be highly profitable. He determined the differences in the discounted net returns, using a variation of the Faustmann formula, after projecting stand yields with and without the release. He concluded that releasing young pines from less valuable hardwoods should be given high priority in forest management.

Gunter and Rudolph (1968) estimated returns from release of red pine that had been planted under an oak overstory. Full release from

competing vegetation and intensive management were economically more feasible than no release and extensive management.

As wood quality becomes more important, pruning red and white pine is rapidly becoming recognized as both a feasible and a profitable investment. Shaw and Staebler (1950 and 1952) studied the economic and financial aspects of pruning investments in several western conifer species. In their first study, they identified costs, profits, and factors affecting growth of clear wood. They constructed tables that, given certain conditions and assumptions, could be used in many situations to find the cost per thousand board feet of clear wood produced at a given number of years after pruning, the period at which cost per thousand board feet is minimized, and the margin of profit or loss of any particular tree. In their second study, they illustrated that clear lumber was retailing for two to five times as much as knotty timber. Labor accounted for most of the initial pruning costs and there were large variations in cost per tree. Cost of pruning to a height of 18 feet averaged 40 cents per tree, but ranged from 15 cents to $1.00. Diameter growth was the most important factor in determining returns; pruning a tree with a diameter growth rate of less than 1.5 inches per decade (15 rings per inch) was not likely to be profitable.

In a pruning time study in red pine plantations, Ralston (1953) recommended pruning more crop trees to a height of 12.5 feet rather than fewer crop trees to 17 feet. He believed this might prove a better investment because the average cost per lineal foot for pruning the bole section between 12.5 feet and 17 feet was 70 to 80 percent greater than for the first 12.5 feet. Ralston and Lemmien (1955)

determined when pruning should be initiated in young pine plantations, by comparing pruning times for red, white and Scotch pines. Three pruning techniques were also evaluated. They found that the most clear wood could be expected by a three-step pruning procedure initiated by pruning young pines 8.5 to 10 feet when 16 to 20 feet tall and continuing with two later prunings to 17 feet. They projected between three to eight percent rates of return on the investment over a 60-year rotation.

In pruning white pine in New England, Allen (1964a and 1964b) projected a profit maximization by pruning in two steps: prune initially to 19 feet at age 20, followed by pruning an additional 18 feet at age 35. He concluded that a tree with only the butt log pruned is worth two-thirds, and an unpruned tree one-tenth, of the value of such a high pruned tree. He also found that a tree with a diameter growth of four rings per inch would yield a return of 16.4 percent when pruned to a height of 19 feet, as compared to 8.7 percent for a tree similarly pruned with a diameter growth of only eight rings per inch. In poorly stocked stands of white pine, butt logs should be pruned at an early age or stand conversion considered. On the other hand, Horton (1966) reported that pruning 16-foot butt logs on white pine up to 80 years of age was both efficient and economically justifiable. Pruning costs decreased with increasing stand age and growth was fairly uniform between the ages of 40 and 120 years, so he recommended a growth period of 40 years between pruning and harvesting. In another study of white pine pruning, Brace and Calvert (1969) found pruning increased lumber value by $9.50 per thousand board feet, and yielded a 14.2 percent investment return. Hocker (1974) also estimated increased lumber values

of pruning white pine under various conditions and assumptions. He found that stumpage prices should be increased $18.47 to $45.55 per thousand board feet for trees pruned at eight inches dbh and retained for 20 to 30 years until 14 to 16 inches in dbh.

Northern hardwood has increasingly gained attention as a valuable timber type over the past 25 to 30 years. Management and investment in thinning and timber stand improvement (TSI) of northern hardwood is of considerable potential value. After analyzing taxes, land value, logging cost, growth, mortality, defect and grade, Zillgitt (1948) recommended a stocking of approximately 5,500 board feet or 60 square feet of basal area per acre with a 15-year cutting cycle to provide good growth and a satisfactory investment return. In a comprehensive study of northern hardwoods by Eyre and Zillgitt (1953), managerial, silvicultural, marking, and TSI aspects were discussed and guides suggested. Although the possibility of even-aged management on a long rotation with repeated thinnings was considered, they recommended that more research was necessary to determine whether second-growth northern hardwoods should be managed by all-aged or even-aged silviculture.

A time study of felling cull trees by Gabriel and Nissen (1971) in northern hardwood in New York, showed that for an average cull tree 17.5 inches dbh, on an average slope of eight percent with medium underbrush and no snow, the felling time was 2.88 minutes. The time would need to be increased for unusual ground conditions.

Trimble (1971) reported release operations for 7- to 9-year-old Appalachian hardwood stands averaged 11.7 man-hours per acre for a 2-man operation, and 3.6 man-hours for a 1-man operation. An average of 111 crop trees per acre were released.

Good and Books (1971) determined the influence of stand density on stem quality in pole-size northern hardwood. From plots thinned to different densities, they recommended a residual basal area of 85 square feet per acre for northern hardwood management, which was believed to be a reasonable compromise between log quality and growth rate. McCauley and Marquis (1972) evaluated returns from investment in pre-commercial thinning of northern hardwood using three thinning levels. Returns 20 years after the treatment indicated that pre-commercial thinning investments would most likely be justified where a high value product is the goal and where short rotations or early returns are not required.

Martin and Rudolph (1975) evaluated TSI opportunities specifically to establish guidelines and management priorities for TSI practices in small privately owned northern hardwood stands in northern Lower Michigan. Internal rate of return was used and factors influencing financial returns were also analyzed to rank various alternatives as to financial desirability. Their results support the desirability of northern hardwood TSI investments under various conditions.

Several studies over the past several years have emphasized the necessity of using appropriate methods to evaluate forest investment alternatives. In these studies, procedures and guidelines for evaluating investment opportunities are illustrated and recommended for the forest manager. Webster (1960) evaluated investment opportunities

in planting conifers, hardwood cleanup and release, and thinning in both cove and northern hardwood stands. After finding that thinning in pole-size hardwood stands was the best timber management investment opportunity, he outlined a detailed procedure for analyzing investment opportunities using the present net worth method.

In a case study of managerial opportunities confronting the Pennsylvania Department of Forestry, Webster (1963) addressed the questions of which stands offered the best opportunities for stand improvement and where benefits would be large in relation to costs. The results were used to evaluate existing opportunities and formulate budgets and make investments accordingly.

Manthy, Rannard, and Rudolph (1964) evaluated the profitability of red pine plantations using modificiation of the Faustmann formula to obtain present worth. Their results indicated that rates earned were low compared to earnings from other capital investments. Similarly, Lundgren (1965) used land expectation values to evaluate red pine thinning investments. He did not, however, set forth procedures and guidelines to the same extent as most other studies. Later, Lundgren (1966) prepared a much more procedurally oriented report in analyzing returns from growing red pine. Two profitability measures--expectation value and rate of return--were used to compare alternatives and the two profitability measures themselves.

Marty and Fedkiw (1966) outlined a guide for evaluating reforestation and stand improvement projects in timber management planning on the National Forests. They discussed value as a common denominator, compound interest as a preferred measure of rate of value growth, and capital budgeting as a system for fund allocation.

Marty and Newman (1969) ranked 60 timberland classes by the internal rate of return in a study of the economic efficiency of possible management intensification on national forests. Rates of return from three to 14 percent were estimated for 72 of the 96 million acres of unreserved commercial forest land within the national forest system. Similarly, in analyzing cooperative forest management in Pennsylvania, Manthy (1970) attempted to provide project administrators with sound investment guides for monitoring efficiency of program activities. Rate of return was used to rank investments, and evaluation procedures were explicitly outlined.

Lundgren (1971) suggests a closer look at investments ranked by rate of return, because present techniques for making alternative investments do not allocate capital efficiently among projects for which the rate of return varies with the amount invested. Derivation of a capital demand schedule is suggested for more efficient capital allocation. He also notes the difficulties still remaining with capital budgeting theory. As a result, he recommends another method for evaluating timber growing alternatives (1973). Cost-price, the production cost per unit of timber output, is suggested as a possibility. By calculating future net worth for an alternative and then solving for expected price, this method determines how much could be invested per acre on a given site to obtain a given rate of return.

In view of the increasing concern with forest valuation, the expanding role of computers and their potential as tools for analyzing forest investment alternatives should not be overlooked. Hall (1962) and Row (1963) were leaders in applying computer techniques for forestry investment evaluations. Schweitzer, Lundgren, and Wambach (1967)

followed with a slightly more capable computer program for investment analysis (NCRETURN). Schweitzer (1968), derived a program to evaluate timber production investments under uncertainty. Forster (1968) introduced the interval-halving technique to increase computer efficiency in calculating internal rates of return for forestry investment alternatives. Chappelle (1969) presented a computer program (IVST) capable of evaluating forest opportunities under three investment criteria. Lundgren and Schweitzer (1971) updated their previous efforts (Schweitzer, Lundgren, and Wambach, 1967) to include calculation of more profit criteria and other useful data for evaluating investment alternatives.

Two major studies involving the determination of Lake States timber investment priorities have been made by Meadows, et al. (1975), and Whaley (1969).

Whaley realized that public land management agencies needed guidelines for ranking investment opportunities in forest management. Michigan's state forests have a wide variety of timber types, stand conditions and site qualities, resulting in an extremely large number of investment opportunities. Whaley narrowed investment choices to five broad treatment classes: planting red pine, releasing red pine, conversion of oak on poor sites, aspen liberation, and crop-tree release and cull removal in northern hardwoods. Specific information for each treatment class was necessary for investment analysis. Site qualities, rotation lengths and management practices, yields, and expected products were determined or assumed for each class.

For planting red pine, Whaley divided costs into direct and indirect costs. Simple regression analysis was used to determine planting costs which are a major component of the direct costs.

Assumptions concerning growth response and yields were made for releasing red pine, and simple regression analysis was used to determine total cost per acre comparing total costs to the number of trees removed.

For oak conversion, Whaley used the previous red pine planting and yield data. Similarly, the same regression equation was used for oak removal costs. Total costs, then, were removal, chemical stump treatments, and pine planting. The same practice was used for oak removal costs. Total costs, then, were removal, chemical stump treatments, and pine planting. The same practice was used for evaluating aspen liberation treatments. The responses of overstory removal on aspen growth and yield were estimated. The mechanics of removing the overstory were identical to those of the pine release treatments.

With certain managerial, yield, and quality assumptions and estimates, Whaley also evaluated northern hardwood improvement treatments. A separate equation for tree removal costs was derived by simple regression. Total costs included administration, marking, and materials costs.

Whaley wrote a computer program to rank these alternatives according to the internal rate of return. This program can calculate rates of return for three variations in site quality from a single treatment. Present net worth per acre is determined for a stand with and without the given treatment for twenty-five different interest rates from zero to 20 percent. The difference in present net worth with and without treatment is given as an indication of the amount of money per acre that can be invested in that treatment for a given rate of return.

Expected yields, costs, and final product prices constitute the primary data inputs into his program. Also necessary are the number of alternatives, investment length, number of different products in any alternative, number of periodic costs in any alternative, number of sets of annual costs and number of sets of product final prices. Future yields of up to three products, prices for each product, anticipated changes in annual costs, and the value of the remaining stand at the end of the analysis period are considered. By varying stand conditions and site qualities, Whaley provided a ranking of 45 specific investment alternatives from the original five broad treatment classes to illustrate his investment analysis system. His rankings showed that 16 of the 18 red pine release treatments ranked ahead of all other treatments. All but one earned better than nine percent. The northern hardwood treatments followed next, with all but one earning more than seven percent. Whaley's calculations found investments in conversion of oak stands on poor sites to rank low in priority, as well as aspen liberation, which generally ranked near the bottom.

Meadows et al. (1975), provide useful economic guides for allocating resources to timber management activities in the Lake States in terms of relative profitability. They also used rate of return as the major criterion for guidelines. Stand conditions and timber management practices were used in analyzing timber management investment opportunities. Major Lake States forest types included white pine, red pine, jack pine, northern hardwoods, oak, aspen, and spruce-fir. These types, along with site productivity, stand size classes, and stand density, constituted the primary stand conditions considered. From the

large variety of timber management practices applicable to the different stands, a standard management scheme was developed for each stand condition. Thus, they developed a ranking of the profitability of more than 300 different management alternatives based on species, rotation age, site index, stocking, and management scheme. The rates of return for these management alternatives ranged from zero to more than 30 percent. Of the 36 alternatives with rates of return of nine percent or more, two were in northern hardwood stands, two in oak stands, and three in aspen stands; the remaining were investments in white pine, red pine and jack pine. Management schemes involving planting and thinning on pulpwood rotations in northern hardwoods, oak, spruce-fir, and red and white pine constituted the majority of those alternatives ranking at the bottom.

The procedure used by Meadows et al. (1975) parallels that of Whaley and includes identification of the timber management opportunities, development of cost relationships for estimating the costs for each of these opportunities, development of physical response relationships for estimating additional yield generated by each opportunity, estimation of probable future values of the various classes of timber provided by each opportunity, and synthesis of the data. Cost relationships, yields, and future prices were determined by regression analysis. The timber management practices analyzed were grouped from a cost standpoint into groups involving essentially the same operations. Primary cost determinants were then determined for each group and used in the equations with labor or equipment costs. This procedure was also reported by Hilliker, Webster, and Tritch (1969).

Physical response relationships in the form of multiple regression equations were developed for each forest type. Volume, quality, timing of yield, stand conditions and management practice were all considered in developing the system of equations. Projections of future values were made separately for the principal sawtimber species and the principal pulpwood species. In developing equations for future value projections, past history and future prospects of timber industries both on the national and regional levels were first analyzed. Then, the equations were determined by using time-series data on stumpage prices for each major species and analyzing the possible influence of demand and supply factors on future price trends. Thus, by calculating costs, yields, and incomes from "raw" data and the equations, rates of return were computed, either by using interest tables or computer programs.

The study by Meadows et al. also pointed out that the three primary variables affecting relative profitability are the productivity of the site, the forest type receiving treatment, and the length of the investment period for particular management practices. Returns from higher sites tend to be several times greater than those on lower sites. Similarly, different forest types yield different returns, often due to variations in responsiveness of the forest types to specific management treatments. Also, the time at which investments are made, and thus the length of time they are carried, directly affect the rate of return.

Thus, "...timber management programs over large areas can and should be designed to focus on the most productive sites, on the most responsibe and valuable types, and on the shorter and more result-specific investment periods" (Meadows, et al., 1975).

CHAPTER III

THE FOREST CULTIVATION PROGRAM

Establishment

Michigan has long been famous as a source of northern hardwood lumber, furnishing nearly one-half of all the maple lumber produced in the United States. It is also the leader in the combined production of elm, yellow birch, ash and basswood. Shortages of quality hardwood timber, because of past heavy cutting and past and current failure to manage hardwood forest lands for continuous production, have resulted in reducing the sawmill industry in Michigan, particularly in the Upper Peninsula. In 1954 there were 2,100 sawmills in Michigan; now there are less than 400 (Anon., MDNR-For. Div.).

Much of the cut-over land, though, particularly those that are state forests have regenerated to desirable species with fairly uniform age and stocking, but the trees are still small. However, these stands are often too dense for rapid growth, and there are many trees of low quality, poor form and undesirable species in competition with the desirable trees. Rapid growth of desirable trees could be obtained in these stands through thinning and removal of undesirable trees. These and other proper forest management procedures could help alleviate hardwood timber shortages now and in the future. Funding for such treatment is an important factor, as such silvicultural applications often are pre-commercial.

In the past there has been little timber stand improvement. Act 265 of the 1945 Michigan legislature set up the Forest Management Fund, whereby the funds from the sale of timber were to be used for reforestation in the counties where the sales were made. This was later changed to the use of timber sale funds throughout the state for reforestation. The Act was finally amended in 1962 to enable the use of timber sale funds for all timber management activities. State Representative Russell Hellman had been trying for increased forest management funding by the state legislature since 1965, while at the same time some Forestry Division administrators had been trying to make divisional program changes (Auble, 1976). Major interest centered on provision of forest products for anticipated future markets and the desire to see that the state forest lands contribute their full potential to the state's economic growth.

On March 9, 1972, Representative Hellman introduced House Resolution No. 374 calling for a special committee to study the state forests relative to the wood industry. The resolution cited Michigan's past "wealth and fame" resulting from its forest resources, the current low productivity of the state forest lands, and the need for more intense and better silviculture and management. The House of Representatives passed the resolution March 24, 1972. Thus, the special committee consisting of three members of the House was appointed by the Speaker, with Hellman as chairman. Its duties were "to appraise and study the conditions of the state forests with regard to the quality, the management, the facets of present use, the future potential economic purpose and rewards and their direct influence to the woods industry so that we may be assured that our state woodlands will be properly managed and controlled for future generations..."

Hearings were held by the committee between the 1972 and the 1973 legislative sessions. In one such hearing on May 5, 1972, the problem was identified as the need to "accelerate and improve the management of state forests to meet present and future needs for goods and services, and protect and improve the natural environment" (Anon., 1972). The acceleration of forest management planning, expansion of the commercial harvest level, and acceleration of cultural treatments on forest lands were viewed in the hearing as possible alternative solutions. Attention was also given to some aspects of management on forest lands in private ownership. The Forestry Division was not represented at these hearings.

Trips for observation were also made by the committee. One such trip was to Crossett, Arkansas from November 27 to December 1, 1972 (Hellman, 1972). R.G. Auble, Section Head, Cooperative Forestry in the Department of Natural Resources was included. The purpose of the trip was to observe actual intensive silvicultural and managerial techniques practiced by Georgia Pacific's Crossett Division. It was believed that similarities could be drawn between Michigan and Arkansas as to the overall problem of developing forest lands into a profitable, economic endeavor. In Representative Hellman's committee report to the House December 14, 1972, he concluded that intensive forest management and forest utilization were profitable and that programs used in Arkansas could be used on Michigan's state forest lands. He further concluded that Michigan hardwoods could return millions of dollars to the state's General Fund in a short time, as "good intensive forest management will very quickly rejuvenate and make...marketable and profitable" the state forest lands despite their current low grade.

A request to the Michigan legislature was made in the 1973-74 Forestry Division budget for specific funding to initiate an accelerated program for increasing the economic value and production of state forest lands. The criteria for allocation of such funds had priorities established as follows:

1) Need and potential for future utilization
2) Job needs and availability of local labor
3) Organizational ability to implement projects most efficiently
4) Site quality
5) Stand condition (need)

Supported by the findings of Representative Hellman's special study committee, Public Act No. 111 appropriated $300,000 in 1973 to the Department of Natural Resources for forest cultivation and management under the Economic Growth and Development Program. Thus, the Forest Cultivation Program was established.

Components and Guidelines

For its first fiscal year, 1973-74, the program was geared toward five main components: northern hardwoods, jack pine regeneration, hybrid aspen site conversion, and forest inventory and analysis.

Northern hardwood stand improvement

Initially, cultural treatments in the northern hardwood type were to receive emphasis in the program. The management objective for this type is to establish an all-aged stand structure for the production of sawtimber and/or veneer logs on medium and better sites (Anon., MDNR-For. Div.). It was estimated that two to three percent of this type,

aggregating between 9,000 to 15,000 acres, should receive treatments annually, and that the program should be continued at least 20 years (Haskin, 1974). A similar annual acreage was projected for harvesting. When the type was eventually brought under full regulation through improvement cuts and harvesting, approximately 40,000 acres would receive harvest cuts annually (Daw, 1973).

For improvement treatments, stands of 10 acres and larger were to be selected if the basal area of trees five inches in diameter at breast height (dbh) and larger exceeded 120 square feet per acre. Commercial timber sales, defined as sales returning net incomes to the state, were to be given first priority for treatment. Where there was a need for cultural work in addition to the removal of merchantable products, the sale price was to be reduced to offset the cost of the required cultural work. Only where the cost of cultural work was greater than 10 percent of the appraised stumpage value, where there was sub-merchantable timber suitable for the market (the value of the timber was less than the cost of doing the required cultural work), where there was no significant merchantable timber or where the cost of removing the merchantable material equaled or exceeded timber value, were any sales or contracts to be considered as being within the Forest Cultivation Program (Haskin, 1973). For situations where the estimated cost of cultural work exceeded the value of the merchantable timber, subsidized stumpage sales were to be made, but these were second in priority. Department projects where commercial or subsidized sales were not feasible constituted the third priority.

Timber management guides for the northern hardwood type in national forests published by the North Central Forest Experiment Station, U.S. Forest Service, were to be used by all the Division's field offices. The following are the Division's specific guides to the selection and treatment of northern hardwood stands:

1) Stands with trees that are generally seven inches and larger d.b.h. will be managed by basal area control, and will be thinned to not less than 70 square feet of basal area per acre in trees five inches and larger.
2) Small pole and sapling stands will normally be left to grow to large pole size or given second priority for treatment. When treated, it will be on the basis of releasing 30 to 100 crop trees per acre by removal or deadening of all trees seriously competing with or causing mechanical injury to the selected crop trees.
3) Treatment may include felling, girdling, and/or use of silvicides. The method to be used will be based on factors of cost and effectiveness for the particular stand.
    a. Felling provides the most positive control of unwanted trees and is therefore the preferred method.
    b. Girdling, particularly of larger trees, is generally most economical. It can be used on species susceptible to this treatment and when felling will cause damage to crop trees. Girdling without use of silvicides will involve a continuous axe cut or double saw cut completely around the tree and extending to the heartwood.

c. Silvicides approved for use by the Department Pesticide Committee may be applied in frills or with a hypo-hatchet, tree injector, or by basal spray for trees of small diameter.

4) All cultural operations will be recommended and approved through processing forest treatment proposal forms, and the work will be carried out in conformance with policies for multiple-use management and the protection of environmental and aesthetic enhancement.

Northern hardwood fertilization

Although subject to some controversy, it is believed that the use of fertilizers on northern hardwoods could prove to be a highly beneficial cultivation treatment. Initially, an annual allocation of $6,000 was suggested for fertilizing 300 to 400 acres annually to study responses (Daw, 1973). However, costs for fertilization in each of the two years that it has been done have exceeded the initial estimate.

The fertilization studies have been contracted with The Ford Forestry Center of Michigan Technological University (MTU). Both a single fertilizer application study for sugar maple and a fertilizer plan for northern hardwoods were proposed. The following are general procedures involved in the hardwood fertilization study (Anon., 1973):

1) All sites should be of uniform soil texture and landform, facing either east to southeast or southwest to northwest, with good access.

2) Trees between 9 and 16 inches d.b.h. should be given top priority, and selected on the following basis: a) potential crop tree at next cut; b) potential quality of tree. All fertilized trees should be marked, numbered and all pertinent data recorded.
3) The fertilizer is to be 10 pounds per tree of a 15-20-30 commercial blend, or 5 pounds per tree each of ammonium nitrate, triple super phosphate and muriate of potash.
4) Placement of the fertilizer should be around the base of the tree not to exceed a radius of four feet. May and June applications were recommended.
5) Data as to growth response, longevity of fertilizer response, and diameter classes with the best responses to fertilization will be obtained through remeasurement of treated trees each year at the same time for 5 years.

Jack pine regeneration

For the next 15 years, jack pine harvests are expected to amount to about 10,000 acres annually, as age classes are being adjusted to give a uniform flow of products from a regulated forest in the future. Eventually, the desirable annual cut will be approximately 7,000 acres. There are problems in regenerating jack pine, and estimates indicate a need to do approximately 5,700 acres of jack pine regeneration treatment annually (Daw, 1973a).

Two John Deere 740 rubber-tired four-wheel-drive skidders are used to pull a water-filled, rolling chopper in tandem with an

anchor chain for site scarification on jack pine sites. Each machine should be able to do approximately 100 acres in a full work week. Seed from the slash or broadcast seeding will then be utilized for regeneration. Occasionally planting or furrowing seeding will be used where applicable. Some prescribed burning will also be used.

On all areas designated for jack pine management, a continuing goal is the prompt and satisfactory regeneration of jack pine.

Aspen regeneration

This portion of the Forest Cultivation Program is primarily concerned with approximately 750,000 acres of aspen on site index 51 or above that is capable of growing over 30 cubic feet (.38 cord) per acre per year. Presently, some 23,000 acres are being harvested annually, which is approximately 6,000 acres above the projected desirable annual cut for a fully regulated aspen forest of 750,000 acres; but this rate of cutting is temporarily necessary to obtain adjustments in age class distribution to attain regulation (Daw, 1973).

The unmerchantable residual trees left after harvesting can cause severe competition for aspen regenertion. This residual overstory should be reduced to no more than 15 square feet of basal area per acre where aspen is to be perpetuated as a desirable timber crop. The Wildlife Division desires 35 percent of the forest cover to be in aspen in areas of high wildlife production. Since the Wildlife Division is responsible for about 50 percent of the aspen in high deer-kill areas that are given further treatment after a timber sale, it is estimated that the Forest Cultivation Program should include some 5,000 to 10,000 acres of "aspen betterment" (Haskin,1974).

Site conversion to hybrid aspen

Sites are often occupied by species that are not the best timber producers for those sites, such as poor quality hardwoods on natural red and white pine sites, or sites better suited to aspen. Where desirable, cutting can convert such sites to aspen.

On the Pere Marquette State Forest, conversion of low quality oak to aspen on site index 50 or better sites for aspen appears desirable from both timber and wildlife standpoints. On lower sites, jack pine should be favored, not only for timber, but for wildlife where additional coniferous cover is desired. Although red and white pine are often even more productive than jack pine in such cases, there are various objections by wildlife managers to the conversion of these sites to red or white pine.

Conversion on poor hardwood sites under the Forest Cultivation Program primarily involves planting hybrid aspen developed by Dean Einspar at the Institute of Paper Chemistry in Wisconsin. Of particular interest is a cross between Camescens big-tooth aspen (from Europe) and the Lake States big-tooth aspen, which has shown adaptability to the sandy soils of the Lake States. There are approximately 200,000 acres of poor quality hardwood sites that could possibly be converted. Initially, 20 to 40 acres of these sites are projected as annual goals for conversion to hybrid aspen. Planting stock and advisory assistance are to be provided by the Institute of Paper Chemistry. Conversion costs and growth results will be checked carefully before any larger scale operations are undertaken.

Stand improvement and pruning in red and white pine

Red and white pine are the most productive timber types on a large proportion of Michigan soils. Both respond well to release, thinning, and pruning. Presently on many sites, especially those well suited to growing pine, poor quality hardwood is over-topping or providing severe competition to the pine. These areas should be included in the Forest Cultivation Program. Where the competing hardwood is unmerchantable, it has been suggested that timber stand improvement and release of seedling-sapling stands of red and white pine be initiated wherever: 1) pine is the best species for the site; 2) timber production is a principal objective of management; and 3) patches of 10 or more acres can be developed. An approximate estimate of 3,000 acres annually for red and white pine timber stand improvement and release has been projected (Daw, 1973a).

The desirability of pruning pine is still somewhat controversial, and has therefore been given a low priority. It has been projected that approximately 3,400 acres of red and white pine should be pruned annually. Pruning would be to a height of about 17 feet.

Access roads

The lack of adequate access roads in the State Forest system is considered an important problem. Obviously, good timber management necessitates good access roads, not only because suitable timber often is not harvested due to lack of access, but also because temporary poorly-built roads often result in reduced stumpage sales and prices. Therefore, it has been projected that approximately 60 miles of access roads be constructed annually with Forest Cultivation Program funds

(Daw, 1973a). Most of the work will be contracted, and a maintenance schedule developed. Although these roads will not be high standard roads, they will be of value for recreation as well as for timber management.

Inventory and Analysis

The state of Michigan established a continuous forest inventory (CFI) system during 1950-1957. Some 7,863 one-fifth-acre plots were established. Due to changes in forest and district boundaries since the plots were established, the data obtained are considered to be accurate only on a regional basis. The diagnostic inventory designed in 1968, based upon photo interpreted type maps, is intended to eliminate the need for CFI on a small unit basis and answer specific needs of individual forests. Until it is fully implemented and regulation is achieved by changing from volume to area control, CFI will be continued at the regional level.

Michigan Technological University has a contract to remeasure the plots and process the CFI data from the Baraga and Michwabic State Forests. The University will also establish and monitor plots on areas treated under the Forest Cultivation Program, including fertilized areas, to check growth response. It is hoped that such monitoring can be expanded to all state forests and include all timber types treated under the Forest Cultivation Program.

Administration

In discussing the administration of the Forest Cultivation Program, reference will be made to the organizational charts in

Appendix A, depicting the present organization of the Forestry Division at the state, regional and district levels.

Administration is centered in the Lansing staff office. The Forest Cultivationist and Silviculturist works with the Forest Management Planner in administering the program. The Forest Cultivationist and Silviculturist is responsible for all aspects of the program except those pertaining to future planning, for which the Forest Management Planner is responsible. Both in turn report to the Forest Management Supervisor, who reviews and evaluates the reports and proposals pertaining to the program and he in turn submits recommendations concerning the program to the Forestry Division Chief.

Based upon inventory data from the field, decisions on project proposals are made at the staff level. A field order is then issued to the Regional Forest Supervisor, who directs it to the District Forest Supervisor, who then directs it to the Forest Cultivation Team Leader. This is the formal chain of command; informally, the Forest Cultivationist and Silviculturist routinely works directly with the District Forest Supervisor and the Team Leader administering the program.

Accomplishments

1973-1974

For the fiscal year 1973-1974, the Forestry Division requested $260,000, primarily to treat stands in the northern hardwood type. Through inventory and programmed budget planning in anticipation of the appropriation, it was determined that some 31,000 acres of state forest lands would need timber stand improvement annually, and 14,000

acres would need after-sale treatment annually. Of the total 45,000 acres, from 9,000 to 15,000 acres of northern hardwood would need timber stand improvement annually.

The actual appropriation for the Forest Cultivation Program for 1973-1974 was $300,000. The funds were allocated as follows:

1.	Northern Hardwood Stand Improvement:	
	Region I	$161,100
	Region II	57,900
2.	Northern Hardwood Fertilization	3,500
3.	Jack Pine Regeneration	44,000
4.	Site Conversion to Hybrid Aspen	3,500
5.	Inventory and Analysis	30,000
		$300,000

The Lansing office was allocated $43,000 and expended $47,500. Total expenditures in Region I were $202,343, with an initial allocation of $199,600. In Region II, $50,699 was actually spent with a $57,400 initial allocation. The major portion of the total expenditures constituted salaries and contract treatment costs, with some expenditures for equipment.

The program also funded seven additional full-time personnel assigned as follows:

1 Assistant Area Forester	-	Mishwabic State Forest
1 Forest Technician	-	Iron Range State Forest
2 Forest Technicians	-	Ford River State Forest
1 Forest Technician	-	Escanaba River State Forest
1 Forest Technician	-	Jordan River State Forest
1 Assistant Area Forester	-	Jordan River State Forest

The addition of these positions was an important provision of the program, because they were needed for its implementation.

Four two-day training sessions were held in June and July, 1973, on northern hardwood management to update all personnel involved in the program. Carl Tubbs, U.S. Forest Service, North Central Forest Experiment Station, presented the program (Daw, 1973b).

In 1973-1974, 15 state forests, all but one in Region I, received program funds for treatment application. Northern hardwood areas proposed for timber stand improvement totalled 7,500 acres in Region I and 2,500 acres in Region II. In Region I there were also 400 acres of northern hardwood stands proposed for fertilization, 1,176 acres for jack pine regeneration, and 120,000 acres to be inventoried and the data analyzed. In Region II, 40 acres were proposed for site conversion to hybrid aspen.

Northern hardwood stand improvement.--During the year, 26,828 acres of northern hardwood were examined to determine qualificiations for stand improvement under the program, treatment proposals for 14,944 acres were submitted, and 7,555 acres actually received treatment. Table 1 lists the various procedures used, the areas treated, and average costs per acre.

Table 1.--Accomplishments and costs of treatments applied to northern hardwood stands in 1973-1974.

Procedure	Area treated, acres	Costs per acre[a]
Reduced stumpage timber sale	291	$14.18
Subsidized timber sale	172	17.63
Pre-commercial TSI contracts	3,748	15.35
Hired crews for TSI	3,344	16.58
Total	7,555	

[a]Cost of examination, tree-marking, and supervision by regular personnel not included.

Jack pine regeneration.--One thousand five hundred twenty-eight acres of jack pine were examined to determine the need for treatment under the program, and 1,904 acres were proposed for treatment. In the Upper Peninsula state forests, 890 acres were scarified for jack pine seed bed preparation at a direct cost of $12.55 per acre, using a rolling chopper in tandem with an assembled anchor chain drag. An average cost of $25 per acre was incurred in planting 150 acres of jack pine. In Region II, only 50 acres were scarified, and 291 acres of jack pine were seeded on land prepared by scarification or prescribed burning.

Site conversion to hybrid aspen.--Hybrid aspen was planted on 23.5 acres in Manistee County and on eight acres in Benzie County. Good

growth was obtained, and in a portion of the plantings left unprotected to determine the effect of deer browsing, some browsing was apparent, despite the fact that the area did not have a particularly high deer population.

Hardwood fertilization.--Because fertilizer was not available, the hardwood fertilization project was delayed until the following year.

Inventory and analysis.--Michigan Technological University remeasured and analyzed 131,585 acres on the Baraga and Mishwabic State Forests. Upon review of the inventory data, it was considered not useful on a forest or district basis, but that it should be maintained on a regional basis, at least until the diagnostic inventory was completed and forest regulation achieved. The areas on which plots were established to monitor growth responses following treatment totalled 120 acres.

1974-1975

For the fiscal year 1974-1975, the Forestry Division requested and received an additional $450,000 for the program, so that the total appropriation was $750,000. The reasons for the increased funding were based upon the present condition of state forest lands, and the increasing shortage of raw materials for lumber products for which demand was increasing, as well as an emphasized need for access roads. The following is the recommendation summary (Anon., 1974):

> Accelerate treatment of state forest timber lands to 20,000 acres annually. Treatment will include thinning, weeding, and fertilization of hardwood stands, scarification and direct-seeding of harvested jack pine areas, after harvest treatment of aspen stands to secure optimum vegetative regeneration, limited planting including the introduction of genetically superior trees on selected areas, and thinning and pruning of red and white pine stands.
>
> Initiate a ten-year program in Upper Peninsula State Forests to construct and improve 300 to 400 miles of low speed service roads in selected areas for the purpose of providing logging and management access. An annual program for completion of 30 miles of such roads..., work (to) be done by contracting with loggers and others for installation of roads, culverts, and bridges...(with) construction costs...estimated at $4,000 to $5,000 per mile.

Lessening the susceptibility of forest stands to insect and pathogen infestation by improvement of vigor through treatments, subsequent soil stabilization, aesthetics maintenance, use of installed timber roads for fire control and hunter access, and the boost to local economies through construction contracting and logging activity, were arguments used in gaining further support for the program.

Between July 1, 1974 and June 30, 1975, 18,739 acres of state forest lands were treated, 24 miles of access roads were constructed, 360 permanent sample plots were established on the Iron Range State Forest, and 3,200 bushels of jack pine cones were purchased from northern Michigan residents for use in direct seeding.

A summary of the goals set for the fiscal year and actual treatments accomplished are listed in Table 2.

Table 2.--Goals and accomplishments for the Forest Cultivation Program in 1974-1975.

Activity	Goals, acres	Accomplishments, acres
Improvement of existing stands	12,500	13,998[a]
Jack pine regeneration	3,400	2,194
Aspen regeneration	1,200	1,782
Hardwood fertilization	400	403
Site conversion	30	23
Red pine planting	-	339
Totals	17,530	18,739

[a]All northern hardwood except 2,931 acres

Northern hardwood stand improvement.--The emphasis of the program again was upon timber stand improvement in the northern hardwood type, where 11,461 acres were marked for treatment, and 11,068 acres were actually treated (Table 3). Average direct costs amounted to $19.60 per acre, or 68¢ per square foot of basal area removed. The basal area removed averaged 29 square feet per acre. Total costs, including direct costs and overhead costs of examination, marking, supervision, and administration, averaged $31 per acre.

Table 3.--Accomplishments and costs of treatments applied to northern hardwood stands in 1974-1975.

Procedure	Area treated, acres	Costs per acre
Reduced stumpage timber sale	608	$ 5.97
Subsidized timber sale	798	18.88
Pre-commercial TSI contracts	7,167	18.88
Hired crews	2,495	20.71
Totals	11,068	$19.60

The Forest Forestry Center of Michigan Technological University was allocated $5,000 from the 1974-1975 program budget to complete installation of permanent plots to monitor northern hardwood response to treatment. Plots have been established in five state forests.

Hardwood fertilization.--Michigan Technological University fertilized 403 acres on seven different sites in the northern hardwood type. Monitoring plots were established on these areas to measure responses to fertilization, soil characterization, and tree-soil nutrient status. Eight or nine potential high quality sugar maple crop trees per acre received ten pounds of fertilizer each at a cost of just over $15 per acre for fertilizer and labor.

Jack pine regeneration.--Scarification on 2,194 acres of cutover jack pine stands was accomplished with equipment purchased through program funds. Cost averaged $15 per acre, including labor, supervision, supplies and equipment depreciation. On 983 acres of the scarified area, direct seeding was done by helicopter at an average cost of $14.10 per acre. The seeding attachment used on the helicopter was partially funded from the program. For jack pine direct seeding, 5,200 bushels of cones picked from areas selected by the Area Foresters were purchased at a cost of $22,000.

Aspen regeneration.--Where good aspen sites had unmerchantable aspen and/or low quality northern hardwoods left after a commercial clearcut, and improving deer habitat was not important, the residual trees were cut to facilitate regeneration of quality aspen. An average of 25 square feet of basal area per acre was removed on 1,787 acres at a direct cost of $12.25 per acre.

Site conversion to hybrid aspen.--In cooperation with the Institute of Paper Chemistry, 8,000 trees representing three different hybrid crosses were test planted on 23 acres where yields of oak and hardwood had been very low. Costs of preparing the site totalled $5,600. A weather station borrowed from the U.S. Forest Service was installed to obtain a continuous record of pertinent weather information for better evaluation of the test planting.

Red and white pine.--On 1,614 acres of natural and planted red and white pine, release from overtopping hardwoods was completed. On 1,317 acres of red and white pine, from 100 to 200 crop trees per acre

were pruned to a height of 17 feet. Comprehensive Employment Training Act labor was used for most of this work, with only saws, other small equipment and some hand labor charged to the Forest Cultivation Program.

On The Kalkaska State Forest, 339 acres were planted with approximately 200,000 red pine seedlings. Contract planting and partial cost of the planting stock supplied by the U.S. Forest Service totaled $7,280.

Road construction.--Local contractors built 21 miles of road for timber access with an additional three miles completed the next year, at a total cost of $49,800.

Inventory and analysis.--Michigan Technological University remeasured 360 permanent sample plots on the Iron Range State Forest at a cost of $39,000. This averaged 49¢ per acre for the total forest area. The data will be used in management planning for the Iron Range State Forest over the next several years.

1975-1976[2]

A total appropriation of $1 million was received for the operation of the program for 1975-1976. Statewide expenditure reductions reduced the amount available to $955,000. Of this amount, $228,000 was committed to a resource use study to be made by Jaakko-Pöyry and Co., of Finland, a forestry consulting firm. Thus, $735,000 remained for program activities.

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[2]The source for the data in this section was the annual report for 1975-1976 by Botti and Rose (1976).

Table 4 is a summary of the goals set for the year and the actual treatments accomplished.

Table 4.--Goals and accomplishments for the Forest Cultivation Program in 1975-1976.

Activity	Goals, acres	Accomplishments, acres
Northern hardwood stand improvement	11,500	8,940 (13,195 marked)
Jack pine regeneration	3,000	5,339
Aspen regeneration	1,700	1,741
Red and white pine release	1,000	1,302
Site conversion	30	30
Totals	17,230	17,352
Road construction	20 miles	6 miles

Northern hardwood stand improvement.--The program emphasis remained upon thinning in northern hardwood stands, with 13,195 acres marked and 8,940 acres thinned. The area either under contract and not yet completed or included in timber sale contracts totaled 4,211 acres. The average thinning cost was about $20 per acre.

Efforts were being made to accomplish more of the thinnings commercially and reduce the amount of wood left on the ground. Lower costs and increased amounts of work were possible as thinnings were increasingly accomplished through commercial sales.

Jack pine regeneration.--Mechanical scarification and prescribed burning were the two methods used to expose mineral soil for jack pine regeneration. Most areas were then direct-seeded by helicopter. If the seeding results were unsuccessful, seedlings were to be planted at a later date.

Of the total acreage receiving regeneration treatments, 2,507 acres were mechanically scarified, while 723 acres were prescribed burned. Direct seeding was completed on 1,565 acres. Seedlings were planted on 544 acres. Approximately 3,200 acres of well stocked jack pine were expected to result from these treatments. Treatment costs averaged $10.00 per acre. The Forestry Division estimated a rather low rate of return from this investment, but it was believed that the regeneration treatments would be more than justified by counteracting the detriments resulting from untreated, poorly stocked stands.

Aspen regeneration.--Aspen regeneration treatments totaled 1,741 acres and consisted of removing the residual overstory to eliminate shading and encourage sprouting. The average cost per acre for aspen regeneration treatment was $23.00. On a 40-year pulpwood rotation, the Forestry Division also estimated a rather low rate of investment return from this treatment.

Red and white pine release.--Pines were released from overstory competition on 1,302 acres at an average total cost of $31.00 per acre. Federal Comprehensive Employment Training Act (CETA) and Title X programs supplied most of the labor involved in this activity.

In 10 to 20 years, the Forestry Division expects returns from the first thinnings on these treated areas to cover the costs of treatment. Subsequent thinnings are expected to net a return of approximately five percent or more.

Road construction.--Six miles toward a projected goal of 20 miles of roads were constructed or improved during the year. Several more miles were under construction at the fiscal year closing.

Site conversion.--Experimentation with conversion of poor hardwood stands to hybrid aspen was continued in cooperation with the Institute of Paper Chemistry. Thirty acres were planted in Alger County. The site was prepared by bulldozing. Of the 30 acres, good survival was obtained on 12 acres, while the remaining area had poor survival. Further observations and measurements were to be continued.

Forest inventory.--On the Ford River and Sturgeon River State Forests, 430 continuous forest inventory sample plots were remeasured in 1976 by Michigan Technological University at a cost of approximately $56,500. In cooperation with MTU a stand examination system was also developed and installed on its computer system at an approximate cost of $9,500. The project was initiated on the Baraga State Forest with intentions for its eventual use on all state forests.

Fertilization study.--Fertilization studies with northern hardwoods were continued during the year in cooperation with Michigan Technological University. There are no conclusions as to the value of this practice at this time.

Seed procurement.--The Forest Cultivation Program also provided funds during 1976 for the purchase of nearly 4,000 bushels of pine and spruce cones. The seed is to be used for production of nursery stock and for direct seeding.

Resource use study.--On March 25, 1976, a contract totalling $228,000 was signed for a resource use study by the Jaako-Pöyry Company of Helsinki, Finland, a world-wide forestry consulting firm. The Baraga-L'Anse region of the Upper Peninsula was chosen as the study area.

"The overall aim of the study is to develop productive and profitable management and use of Michigan's forests: 'pursuing circumstances which will allow single or multiple investors to own and manage timber lands and processing industries profitably, and in environmentally responsible ways'" (MFA, 1976). The study is expected to result in "identification of markets for Michigan wood; analysis of transportation capabilities; decisions on suitable products for manufacture; detailed plans for industrial development including kinds of industries; and exploration of circumstances which may adversely affect profits of land-owners and wood industries" (MFA, 1976). An "ad hoc" contract and review committee of 14 members was formed, representing a cross-section of Michigan's forest industries.

1976-1977[3]

One million dollars was again allocated to the Forest Cultivation Program for 1976-1977. Table 5 is a summary of the

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[3]These data were obtained from Bill Botti of the Forestry Division, Michigan DNR, who is preparing the annual program report.

goals set for the year and the actual treatments accomplished. Accomplishments were short of projected goals for this year. However, much of this resulted from contracts that had not been completed by the fiscal year closing.

Table 5.--Goals and Accomplishments for the Forest Cultivation Program in 1976-1977.

Activity	Goals, acres	Accomplishments acres
Northern hardwood stand improvement	13,795	5,979
Jack pine regeneration	6,400	2,674
Aspen regeneration	2,800	675
Red and white pine release	3,071	180
Site conversion	23	23
Totals	26,029	9,531
Road construction	32.5 miles	3.25 miles

Northern hardwood stand improvement.--In addition to thinning 5,979 acres of northern hardwood stands, 24,466 acres were examined and 9,275 acres were marked.

Jack pine regeneration.--Two thousand one hundred and twenty-six acres were examined for jack pine regeneration. A total of 2,674 acres received scarification and/or planting. Of this total, 1,705 acres were scarified either by bulldozer or burning and 869 acres were planted or seeded.

Aspen regeneration.--The residual overstory was removed to encourage young aspen sprouting and growth on a total of 675 acres.

Red and white pine release.--Examinations for release treatments were made on 2,046 acres of pine, and removal of the competing overstory was completed on 180 acres.

Site conversion.--Another test-planting of hybrid aspen was completed on approximately eight acres in Cheyboygan County. The site was formerly occupied by black cherry and rock elm. Hybrid poplar was test-planted on another site of about 15 acres in Arenac County. The site had previously supported mixed lowland brush, aspen and white birch. Survival and initial growth appeared promising on both areas.

Road construction.--At the close of the fiscal year, 3.2 additional miles of access roads had been completed.

Other projects.--A total of 1,762 bushels of pine cones was purchased during 1976-1977, of which 187 bushels were jack pine cones. The seed will be used for production of nursery stock and for direct seeding.

Pruning was completed on 987 acres of pine. The forest inventory system initiated on the Baraga State Forest was completed. Use of the system is still to be extended to all state forests.

The forest fertilization project was continued during the year. The northern hardwood plots previously established were remeasured and pine fertilization trials were added.

Fertilization project results at the end of the year showed that fertilizer applications can have an effect on the growth of jack and red

pine. Despite variation in the kind and magnitude of response, tree growth was significantly increased by an application of phosphorus plus lime. However, results for jack pine were inconclusive. For sugar maple, the results showed that the fertilized trees were growing 12 percent faster than the control trees. It was concluded that more needs to be known about soil-site parameters affecting productivity; better recommendations and predictions could then be made. Continued monitoring and testing were proposed.

Resource use study.--In March, Jaakko-Pöyry and Company reported initial findings and evaluations of its resource use study in Michigan (Jaakko-Pöyry and Co., 1977). This initial phase was reported in two volumes. Volume one covers the forestry sector of the study. Conclusions were drawn concerning the following aspects: the general conditions for forestry and forest industries in the Upper Peninsula, forest resources and their utilization, human resources ownership structure, harvesting and transport, and economics of wood growing. Recommendations were made on policy-making, legislation and taxation, subsidies and loans, research and development, services for non-industrial private land owners, training, industrial structure, and the establishment of a forest "test" industry as a model and example. Some impacts of these recommendations were also projected.

Volume two contains the market survey and an evaluation of potential industries for the pilot project. The objective of the market survey was to determine and analyze the market potentials of the main wood products that could be produced in the pilot project. Present

and future market sizes, price levels, and price structures were analyzed. Potential industries with a variety of manufacturing alternatives to determine the best combination of mills were evaluated by analyzing the products and mill sizes of the alternatives. This part of the report includes a preliminary evaluation of possible sites for the pilot project, brief mill and process descriptions of the alternative mills, feasibility and economic analysis of using wood for electricity and heat generation, preliminary estimates of capital costs, preliminary estimates of manufacturing costs, and pre-feasibility calculations. From these, the most attractice mill or set of mills for the project will be determined. Based on economic calculations, a complex consisting of a sawmill and a hardboard mill appear to be the best alternative. Further investigation of this alternative will be made in the next, the "feasibility," phase of the project.

1977-1978[4]

Table 6 gives a summary of the projected goals by region for the 1977-1978 fiscal year which began October 1, 1977. The total projected acreage for the program in 1977-1978 is almost equally divided between northern hardwood and pine treatments. As in the previous year, $1 million has been allocated for the program.

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[4]Taken from preliminary data supplied by Bill Botti, Forestry Division, Michigan DNR.

Table 6.--Proposed Treatment Goals for the Forest Cultivation Program in 1977-1978

Activity	Region I, acres	Region II acres	Total acres
Northern hardwood stand improvement	5,830	4,000	9,830
Jack pine regeneration (and planting)	2,390	3,233	5,623
Aspen regeneration	530	0	530
Red and white pine release	1,700	2,000	3,700
Red pine planting	85	300	385
Totals	10,535	9,533	20,068
Road construction	23 miles	1 mile	24 miles

Summary

Table 7 is a summary of accomplishments to date under the Forest Cultivation Program. Approximately 52,000 acres of state forest lands have received cultural treatment through the program. In addition, some 2,300 acres of red and white pine have been pruned; approximately 8,800 bushels of pine cones were acquired for seed; a forest fertilization project was undertaken and is being monitored; a resource use study of Michigan's forests and forest industries is in progress; and a computerized forest inventory system has been initiated that is intended to include all of the state forest system.

Table 7.--Summary of accomplishments under the Forest Cultivation Program, 1973-1977.

Activity	Accomplishments, 1973-1977, acres
Northern hardwood stand improvement	36,000
Jack pine regeneration	8,700
Aspen regeneration	4,200
Red and white pine release	2,800
Site conversion to hybrid aspen	95
Total	51,795
Road construction	44 miles

CHAPTER IV

STUDY METHODS

To determine the factors and criteria involved in the program's decision process, personnel at all levels of the Forestry Division of the Michigan Department of Natural Resources were interviewed. Besides the staff personnel responsible for coordinating the program, all Regional, District, and Area foresters administering the program were interviewed. So, too, were the cultivation team leaders and several team members.

The interviews were arranged at the convenience of the individual forester. Thus, all the interviews were held in the Divisional office of the particular forester. There were also trips taken into the field to observe areas that were either treated, being treated, or being examined for treatment through the Forest Cultivation Program. While requested by me, these trips were completely optional and left to the discretion of the individual forester. Time was the overall constraint. The amount of time necessary for the interview process ranged from approximately three-quarters of an hour to three hours. The forester's schedule, the degree of involvement with the Forest Cultivation Program, and field trips primarily determined the interview length.

An open-ended questionnaire was devised to obtain the desired information from the interview. It was used primarily as a guide for the interview. Appendix B provides a copy of the questionnaire used.

In addition to questions for determining stand selection factors and procedures, questions were also devised to moniter concepts of the program, based on individual observations and opinions of the program, its administration, and its objectives. The questionnaire was used only as a tool for interview guidance and uniformity. Those interviewed were not required to respond to any question. Also, in some instances, all of the questions were not applicable.

Analysis of the data obtained in this manner must necessarily be of a qualitative nature. This can prove to be quite arduous where more than a few respondents are to be analyzed. For this study, each response from each question of every respondent was recorded and grouped through comparison and similarities.

An analysis of existing forest investment studies and existing information was made to determine critical decision-making factors and identify optimal investment procedures. These factors were used as a basis of comparison with the factors and procedures used in stand selection and other decision-making aspects of the Forest Cultivation Program. Resulting conclusions and recommendations were then stated.

The Michigan Forestry Division has four administrative levels; the Lansing office, or staff level; the regional level; the district level; and the area level. The state is divided into three regions and six districts with two of the regions each being divided into three districts. Each district is then further divided into areas, the smallest administrative unit. For the Forest Cultivation Program, teams were created to perform the associated field work, particularly for northern hardwood treatments. These teams, while working on the

area level, were not limited to just one area and were primarily responsible to the district forester. Thus, the following is the administrative chain of command: the teams work with the area foresters, while being primarily responsible to the district forester; the area forester reports to the district forester; and the district forester reports to the regional forester, who, in turn, is directly responsible to the Lansing staff office. At each administrative level, practically all division personnel involved with the program were interviewed at their respective offices using the prepared questionnaire.

CHAPTER V

SURVEY RESULTS

This chapter presents the results of the survey of the Forestry Divison personnel taken during the summer of 1976 to obtain an idea of how the Forest Cultivation Program was operating and being administered.

Stand Treatment Selection Procedures

Aspen.--Most aspen site betterment work had been accomplished through funding by the Wildlife Division for deer habitat improvement. Generally, Forest Cultivation funds were used for aspen betterment treatments only when and where the Wildlife Division would not treat the area. In such cases, CETA crews were often used. Where the price of aspen stumpage was low, there was a reluctance to do any aspen treatment with Forest Cultivation funds.

As for the actual area selection, the process appeared to be a simple one. First, harvested aspen areas or aspen sites requiring cleanup were located. It was then just a matter of determining whether or not continued aspen production was a desirable objective on that particular site.

Jack pine.--In selecting areas for jack pine scarification treatment, involved personnel cited knowledge of past sales and harvests, coupled with the managerial decision to maintain the area in jack pine,

as the most important selection factors. It appeared to be a "cut and dried" concept of having harvested the area and wanting to get it back into production. The time of entry into the stand for scarification varied, however, from immediately after the harvest, to three to four years after the cut.

Except in predominantly jack pine areas, site quality did not seem to be given much emphasis. However, site was alluded to, through consideration of the problems of seed availability, sod and brush. These were frequently cited as factors in determining the desirability of scarification. Another factor specifically mentioned was the amount of red pine standing after harvesting the jack pine; the area would not be selected for scarification if there was "too much" red pine to be knocked down.

The priority given jack pine scarification treatments varied according to the importance of jack pine within the area.

In addition, success of the treatments varied from good to poor throughout the state.

Northern hardwood.--The area selection procedures for northern hardwood treatments vary from area to area, ranging from explicit and systematic to more general and less regimented. In practically all instances, the related procedures involved checking old aerial photographs, old type maps and diagnostic inventories, knowledge and experience of the forester in the area, and some type of field check. In a few forests with completed management plans, those stands that could be commercially treated in five to ten years were noted. Prescriptions for stands possibly qualifying for treatment through the

program were also noted and field checked. The field check varied from simply a "walk-through" visual inspection, taking a very few sample plots to a systematic plot sampling to determine the basal area in saplings, poles, culls, etc., and what should be removed. Where management plans were not completed, but compartments and years of entry had been determined, stands for possible treatment were being noted during compartment examinations and diagnostic inventories for planning. Diagnostic inventories were being done in some forests with sufficient detail to allow for further use in determining Forest Cultivation treatments, eliminating the need for future field checks.

There was, however, a strong reliance upon the experience and knowledge of area personnel in selecting northern hardwood stands for treatment. For the most part, experience and knowledge formulated the basis or starting point of the selection procedures where no formal management plans had been previously drawn up, or where diagnostic inventories and the planning processes were behind schedule.

Other factors in selecting northern hardwood stands for treatments were records of past sales, consultation of soil maps which also tended to be outdated, and accessibility of non-commercial stands.

Red pine.--One procedure for determining red pine release needs consisted of field observations noting the percentage of tree crowns over-topping the pine. The stand was not considered needing treatment if the overtopping crowns totaled 15 square feet of basal area of less. Funding for labor was through CETA, with treatments being done only when no other forest activities in the area were more pressing.

Another procedure was based upon the compartment examination system started in 1972. Beginning then, those red pine plantations that were "eligible" were noted by planting data and scheduled for treatment according to age.

Little pruning in red pine had been done. On one forest, though, practically all the plantations had been pruned, mostly trees five to eight inches in diameter, although some larger trees were pruned. CETA crews were used in these treatments, although it was believed that enough labor was available in the area without CETA to complete approximately one year of such remaining work.

In another forest, site and age were examined in determining pruning possibilities, and some stands had been pruned up to 17 feet using prison inmate labor.

Road access needs.--Few comments concerning road construction needs were received. Those responding said that they knew the areas which needed access, and they proposed roads in these areas to reach jack and red pine stands. However, the point was made that larger allocations for road construction would be desirable.

Factors Considered in Stand Selection

Procedures for preliminary stand selection.--All areas utilized some type of preliminary procedure for stand selection for northern hardwood TSI treatments. These varied greatly as to detail and intensity. About half of the areas used a "walk-through" ocular examination with perhaps a basal area check by a point-sample or two. The remaining areas employed a system whereby sample points or plots

were taken to determine basal area, species, and size classes. Many of these used inventory or diagnostic cruises to obtain the necessary data, while others, developed systematic sampling methods specifically for the program. Choice of stands for examination was often based upon personal experience and knowledge of the area by the forester.

In these preliminary procedures for stand selection, basal area was a major factor that specifically determined whether or not a stand would receive treatment. Other factors were stand quality or potential, the merchantable volume present, species, and site quality and tree size. Stocking, height, cull volume present, and soil were also mentioned. Additional factors ranged from "our impression", and Forest Treatment Proposal requirements, to wildlife habitat considerations.

Factors eliminating stands from treatment consideration.--Paralleling the factors examined in the stand selection process, were those that automatically eliminated the stand from consideration for treatment.

In northern hardwood, low basal area and poor quality and potential, were the two criteria most often used for immediate stand elimination. Species composition was also indicated as an important factor. In some regions, too much cull, red maple, beech, aspen or elm within a stand were cited as reasons for eliminating it. Other factors were site quality, tree size, time until commercial harvest, tree height, soil type, coppice growth, and number of crop trees.

For red pine stands the eliminating factors were age, size, stocking, and the amount, size and species of the overstory. In jack pine areas, excessive brush, high red pine stocking, and terrain characteristics were the major elimination factors for a scarification

treatment. These data were usually taken from inventories, plantation records, and aerial photographs.

Site factors.--In determining whether a northern hardwood stand would receive TSI, several site factors were used as guidelines in stand selection. The procedure most often used in the actual stand selection was a visual inspection to "look at what's there". Factors most often mentioned were the stocking, quality, and potential of the stand. While soil maps and soil types were also frequently cited as factors in selection, site index was not checked or used.

Other site related factors mentioned in the selection of northern hardwood stands for treatment were: personal knowledge and experience within the area, species, height, the history of the area particularly regarding fire, and indicator species such as basswood, ash or sugar maple. Thus, while site index was not widely used in actual stand selection, several factors related to site index were being used.

In those forests with large areas of jack pine, there was not much emphasis upon site quality because little variation existed; inventory data furnished the information needed for managerial decisions. Also, for investment decisions involving red pine, neither site quality nor site index were really considered.

Basal area for northern hardwood treatments.--Basal area was the most important factor in the stand selection process for northern hardwood TSI. Stands needed to have 120 square feet or more per acre for consideration for TSI treatment. A large percentage of the foresters indicated that 120 to 130 square feet of basal area per acre

was the minimum, and that they had not treated any stands with less basal area. The absolute lowest basal area acceptable was 90 square feet where crop tree thinning was considered. In such stands, 70 square feet was considered the lowest minimum basal area to leave, compared to the usual 80 square feet. Such factors as tree size, wolf trees, or large cull volumes were considered in reducing stands to these minimum basal areas.

The amount of basal area to be removed was not a factor in attracting treatment contractors. Contract bids were about the same for areas to be treated heavily as for areas to be treated lightly. Accessibility was of greater importance in stimulating bids. However, in some areas, the forester depended heavily on existing markets, since the proposed TSI was tied closly to timber sale contracts to get the work done. Also, the minimum basal area to be removed was not as important as a minimum volume of about six to seven cords of pulpwood per acre to be removed in the commercial treatment.

Regeneration in northern hardwood treatments.--Regeneration was not a factor in determining stand selection for treatment in northern hardwoods. Concern with TSI treatments centered more along the lines of "putting wood on crop trees". Regeneration, while recognized as desirable, was usually considered an objective following commercial sawtimber harvests. In pole-size stands of northern hardwoods, regeneration was not a factor. Where wolf trees or large culls were encountered within stands, there was no hesitation in opening up the stands which might encourage regeneration. The belief was also expressed that there were enough seedlings and saplings already in most

stands to provide sufficient regeneration when the stand's basal area was reduced to 70 or 80 square feet by TSI treatment. Usually little consideration was given regeneration except where deer were important or where a low quality stand occupied a good site.

Other Factors Influencing Program Investments

Management objectives.--For northern hardwood treatments, the two major management objectives most often cited were basically the same as the goals of the program for northern hardwoods: establishment and perpetuation of uneven-aged management, and production of high quality sawtimber for the future. On the area level, different policies were followed in different areas. These policies were based upon such priorities as salvaging elm, discriminating against cherry, beech and poor quality hardwoods, favoring certain species where good markets exist, aesthetics, recreation, and wildlife, and the timing of cuttings to benefit wildlife. Among these, mentioned most often were those concerning the objectives benefitting wildlife.

There was some indication that managerial objectives exerted little influence on the selection of stands for cultivation treatments, regardless of whether the managerial objectives originated at the region, district or area level. Most indications, however, were that these objectives influenced the timing of timber sales and of TSI contracting. TSI contracting was often postponed until the stand became commercially operable and then done in combination with the commercial timber sale or following the sale. Difficulties in administration due to this combination of contracts, and the time involved in completion of these contracts were also cited. This relates directly to the belief that

program funding affects project timing; as the TSI program moves more towards dependence upon commercial timber sale programs, conflict is created because of the fiscal year planning method used and the reporting system for the program.

Another influence of management objectives upon area selection was the instilled belief that "the money is there to be spent," or of "having" to spend the allocations and implement treatments. Despite the overall limitations of money and personnel, such beliefs resulted in prescribing treatments for some stands that were marginal as to investment desirability.

Market factors.--Market factors for the different products with which the forest cultivation program is concerned vary widely from area to area throughout Michigan. This variation tends to be particularly pronounced between the northern Lower Peninsula and the Upper Peninsula. The emphasis given the different market factors in the decision process also varied widely.

In the case of northern hardwoods, minor market factors mentioned were firewood demand and the favoring of locally valuable species in thinning, such as basswood. There were, however, only a few areas where the market could be termed good for pulpwood or small products. Thus, in most cases there was no decision to make regarding possible pulpwood merchantability of a stand. As a result, Forest Cultivation funds were utilized to contract for TSI. The lack of a good hardwood pulpwood market within an area tended to encourage TSI treatments in stands that normally would have been held for later commercial pulpwood thinning. Also, since the money was available, the area forester no longer had to

wait until a stand was commerically operable to treat it. Most area foresters tried, however, to make removal cuttings commercially operable within the next five or six years, any stand treatments would be postponed until then.

From all indications, sawtimber and boltwood markets will play a larger role in treatment decisions made in the future. As more and more of the commercially inoperable stands receive treatment, the TSI treatments become more dependent upon commercial timber sales, either in combination or as after-sale treatments. Thus, the extent of timber sales in the future will determine how much TSI is done. In many areas, pulpwood and sawtimber sales have already influenced the timing of TSI operations under the Forest Cultivation Program.

Markets for red pine tended to be good in those areas concerned with red pine management. The situation for jack pine was similar; however, decisions concerning red and jack pine were not greatly affected by such market factors. Similarly, little indication was given that market factors affected program decisions concerning aspen treatments, although aspen site betterment would naturally be determined to some extent by aspen harvests.

Thus, market factors played the greatest role in decisions concerning TSI treatments in northern hardwoods. The Forest Cultivation Program provided funds to improve those stands silviculturally that were commercially inoperable due to a lack of hardwood pulpwood markets. Overall, though, until markets get better, especially for hardwood pulpwood, market factors do not seem to influence treatment procedures under the program. If anything, only the timing of TSI

treatments has been affected, primarily by sawtimber and boltwood markets. These influences can be expected to increase in the future.

Employment and labor supply.--Because an objective of the Forest Cultivation Program was to stimulate employment in areas of high unemployment, an indication of the program's impact upon the employment situation was sought from those administering the program.

Major effects upon employment generated by the program would be focused in those areas with hardwood TSI treatments, as practically all such work is contracted. Foresters interviewed in those areas were about equally divided as to whether or not significant new employment was generated. However, the majority doubted the significance of the program's impact on employment. For the most part, "new" employment was in the form of spare-time or after-hours jobs, or jobs during the off-season, spring breakup, or school breaks. Indications were that the regular jobbers within an area picked up program treatment contracts to supplement their income or to carry them through when wood markets were low or during the spring breakup. Thus, the situation was more of a transfer by jobbers from other woods work to work under the program, rather than new jobbers coming into the program.

The program did not have much impact, either, because of the small amount of money spent in an area. There really was not enough money involved to impact unemployment appreciably.

When asked whether the employment situation--particularly as to employment to be generated or availability of experienced labor--was considered in the selection procedure, those foresters surveyed

answered no. Thus, employment factors did not constitute a major consideration.

Wildlife management.--In the Forest Cultivation Program, practically all proposed treatments must receive approval of the Wildlife Division before implementation. Thus, it was of some interest to determine the degree to which Wildlife Division objectives influenced stand selection decisions under the program.

Most area foresters indicated that there were minor influences of wildlife management objectives upon stand selection and treatment applications. However, this was only in areas having either small or no deer populations, with low priority deer cover types, or areas primarily in jack pine or aspen. Other foresters indicated that wildlife objectives did, to varying degrees, influence decisions as to stand selection and treatment. Winter cuttings, particularly in stands within close proximity to deeryards, were a major concern. Also, the treatments were often drawn out over a considerable period of time within one block. Openings were also desired within northern hardwood stands. Similarly, reduction of basal areas to between 55 and 70 square feet in stands bordering deeryards was recommended. Most of the foresters indicated that they rarely reduced the basal area of a stand below 80 to 85 square feet. Other concerns included leaving den trees, hemlock and beech.

An important influence of the Wildlife Division's management objectives upon Forest Cultivation practices was found in aspen management. In many cases the Wildlife Division used its funds for aspen betterment (after-sale TSI), particularly where deeryards were

in close proximity. This allowed the Forest Cultivation funds to implement treatments on additional areas that might not have otherwise been done.

A conflict between the Forest Cultivation Program and Wildlife Division policy concerns red pine management. The Wildlife Division consistently discourages any planting of red pine, often advocating planting jack pine on red pine sites, as it believes red pine to be an undesirable species for wildlife. This affected practices in areas with sites favorable for red pine, as well as having unfavorable implications for future timber production from red pine.

There is also some conflict over what the percentage of cover types should be for wildlife within a management area. Evidently various biologists state different requirements for this aspect.

Assignment of Managerial Priorities

Priority assignment in selecting stands for treatment.--No system was utilized to assign priorities in selecting northern hardwood stands for treatment. However, practically all areas not using any priority system usually noted basal area, quality, accessibility, markets and degree of commerical operability, season of year, personal experience, or "how it looked". Basal area was the major criterion used, with the highest priority assigned to pole-sized northern hardwood stands with basal areas of 120 square feet or more per acre. Other approaches used included species potential, size of the stand, and basal area. In general, however, the "best, biggest, most dense" stands were given first priority for treatment.

Similarly in jack pine areas, there appeared to be no system for assigning priority for treatment. However, such factors as mechanical limitations, heavy brush areas, or strong recreational influences were considered in the scheduling process.

Priorities within the program and between it and other activities.--Priority given the Forest Cultivation Program varied somewhat among the different areas concerned with its administration. For the most part, the program was given either a lower priority than regular timber sales or was put on an equal priority with timber sales, wildlife, and recreation. There were also manpower related time limitations as to the priorities given the program. In most cases, a certain percentage of time for the program had been allocated to the different areas by the Lansing office. Naturally, for the Forest Cultivation team, the program was first priority.

Priorities within the program were geared towards northern hardwood TSI where applicable. The remaining activities were given no differential priorities. However, it was believed that road building, red pine release, and pruning should be given greater attention.

Program Administration

Allocation methods.--The methods by which Forest Cultivation funds were allocated to each district and area office varied in certain respects. Basically, the Lansing office made the allocations to the regions, earmarking them as to program activity, such as for northern hardwood TSI. Initially, the Lansing staff and regional personnel were responsible for allocating funds, but more recently, the district

personnel have been included for their input. The district forester, in turn, receives input from the area forester on acreage and treatment opportunities. Thus, the districts formulate funding requests to the region, and the region to the Lansing office.

The allocation was in a lump sum from the Lansing office, with no constraints, as with "line items". However, the Lansing office based its allocation decisions on the combined regional estimates of the treatments that could be done on state forest lands, and on the district proposals as well. This approach allowed considerable flexibility both within the region and within the district.

Basically, the program budget was monitored and administered at the regional level. The regional forester allocated the money to the districts based on the estimates submitted by the district foresters, or on the number of districts within the region. The district forester then divided the allocation for the different area offices. There were some differences in this procedure. Most area foresters indicated that the district forester, knowing the amount of funding the district would receive, asked area foresters for estimates of the work to be done, and then informed them of their allotments. The district foresters are beginning to use input from the area offices in formulating the allotments. When an area received its allocation from the district, it was earmarked for a specific program activity, such as hardwood TSI, jack pine regeneration, roads, etc.

Responses as to whether changes should be made in the allocation procedure tended to vary widely, depending on how the procedure was perceived as operating in a particular area of district. Generally,

there were no real complaints. Some foresters, though, indicated a need for changes, specifically in updating forest inventories, and for operating on the basis of a management plan. It was believed that all areas should be examined first for an overall management plan before any treatments were undertaken. It was also indicated that efforts should be made in each area and district to determine the opportunity for various treatments under the program, and that the allocation per acre between districts should also be examined.

Administrative quotas.--As in practically any managerial situation, goals or quotas were set for investing in the various program treatments. A small proportion of the foresters indicated that funding quotas were initially used and still were being used in some instances. Acreage quotas or annual area goals, though, were being formulated and utilized in most cases. However, there was no set procedure by which these quotas were calculated and assigned.

From the data submitted by the district foresters, the Lansing office had estimated acreages by area for different treatments, from which quotas and allocations were assigned accordingly. These estimates were initially submitted by the area foresters to the district foresters and consisted of the forest type area, and how much could be treated annually for the next ten years. These estimates were based upon type maps, aerial photographs and experience. In most cases, the quotas were area or district quotas.

The ideal procedure would be to have the district forester ask the area forester how much can be treated, and then submit the request through the regional office to the Lansing office. However, some regions

still use funding quotas, where the district or area offices are simply allocated a certain sum for the program. As costs differ, such a system causes variations in workload by area. In some instances the allocated funds were not based on what the area forestry personnel were able to do.

Administrative roles and interaction.--In regard to the various administrative levels and their interaction in the program, there was general agreement as to the role of the district forester. The primary concern of the district forester pertained to budgeting aspects of the program. Since the teams were administered by the district forester, it was believed that he should act as a coordinator between areas.

There were differences in how the area foresters and teams viewed their function or interaction in administering the program. Practically all of the administrative work should be the area forester's responsibility. He should indicate to the team possible stands for treatment, provide supervision, keep a check on the standards used by the team in applying treatments, and handle much of the data processing. Road building or improvements and harvest cuts should also be handled by the area forester.

Practically all the remaining responsibilities and tasks should go to the team. Thus, although the area forester would initially contact the team and be kept informed as to its activities within that area, the team should draw up all treatment proposals, do the marking, and get contracts for the TSI. It was also believed that the team should spend more time on diagnostic inventories, handle combination timber TSI sales, and do aspen betterment work. Thus, the area forester should make recommendations and provide supervision for the team, turning over to

the team as much of the field activities as possible, particularly all non-administrative duties.

Some area foresters seemed concerned over losing control in their areas to the teams. They felt that the team function was marking, and all other functions should be done by the area forester.

Thus, while there was general agreement as to what functions the district forester, area forester, and team should have in administering the Forest Cultivation Program, there were differing views of the relationships between the area and the team. This difference hinged around whether the team's duties should include anything besides marking for northern hardwood TSI, and if so, to what degree.

The team concept.--The team concept was initiated for northern hardwood TSI treatment. Most respondents recognized the advantages of the concept, but some focused on the negative aspects, and the disadvantages of the specialized team concept. Advantages were identified as more efficiency, consistency, uniformity and higher quality of work.

Some foresters believed that although the team concept required considerable travel time, it resulted in timesaving for the area forester, which could be used for other activities. There were also advantages in having specific personnel to implement the program who were also trained in hardwood management.

Major disadvantages of the team concept were monotony, boredom, and a feeling of confinement resulting from the specialization involved. The lack of variety or diversification in the job of a team member lessened the quality and quantity of work done, as well as lowered the morale and increased job dissatisfaction. Further, the team

lacked a feeling for how individual stands fit into the forest plan. This tended toward a "cookbook" approach in examining and treating stands.

Lower promotional potential was the next most often cited disadvantage. There were no avenues for advancement, the individuals assigned to the teams were obtaining a narrow experience base. In the long run, this might result in a need for more training of present personnel, or of more personnel for the Forestry Division. Another problem was that no differences existed in compensation between specialists and other technicians.

Finally, there were doubts about the cost and efficiency of the team concept. Perhaps a better system would be to assign one or two additional permanent personnel to the area level staff, with a certain percentage of their time to be spent on the Cultivation Program. The team leader position would be at the district level to administer and coordinate the program. In this manner, some degree of specialization could be obtained, along with the advantages of increased work quality, quantity, and consistency. At the same time there would be enough diversification to maintain morale, job interest, and provide for a broader experience base.

Planning and Inventory

Current planning and inventory procedures were not considered adequate to serve the program needs. Not enough inventory and planning had been completed before the program was instituted, or, in many cases, what was completed was not detailed enough to meet the program needs. Forest management activities including inventory and planning were

proposed to be included under the Forest Cultivation Program, particularly at the State Forest level. Funding through the program for inventory and planning activities was recommended to be done only if it did not detract from activities presently being pursued under the program.

Other respondents believed that inventory and planning techniques were adequate, even though the program could have run better and more smoothly had every forest completed its inventory and management plan. Along these same lines, it was suggested that more manpower should be acquired through the program at the area level for inventory and planning.

Impressions of the Program

As to whether the objectives of the Forest Cultivation Program were worthwhile, the response was practically a unanimous "yes". It was believed that the program gave the foresters a means to practice good forestry.

There was also practically unanimous agreement that the program objectives were being achieved. Concern was expressed, though, about the emphasis on northern hardwoods, because this was placing "all the eggs in one basket". Another concern expressed was that the program was progressing too slowly.

Response was also unanimous that the program should be continued at least on the same level, with frequent reviews. Also, as one forester expressed it, as long as it was not a "crash program... going from crisis to crisis", it should be continued. Suggested changes, however, included broadening the program, not only as to activities, but

also to include other timber types and species. Red maple on good sites and stand regeneration in swamps and lowlands were two possibilities suggested. Jack pine planting and direct-seeding, and a closer look at red and white pine pruning and release should be included. Similarly, it was believed that provisions for efficient land utilization and increased future timber supplies were not being made by failing to include more intensive red pine management in the program. There was also a need for research on weed-species such as ironwood, and for more training in log-grading, cull and defect, and market conditions for all personnel involved in administering hardwood treatments.

Other proposed changes related to broadening the program and changing its emphasis, particularly as more hardwood TSI was accomplished, included equipment purchases of such items as a dumptruck with a loader, a small forest grader, improved planting equipment, seed extractors for cones, and four-wheel drive vehicles; more emphasis on construction and maintenance of forest access roads; and obtaining aerial photographs.

Other comments concerned funding the program. At the region and district levels, the lump sum allocation of funds was highly favored. Some problems concerning the fiscal year were related to program funding. Where hardwood TSI was combined with commercial timber sales, conflicts were occurring between completion dates and fiscal year ending dates. This was viewed as becoming more of a problem as the program continued. It was even suggested that the funds should be available without undo pressures to spend them, and even carrying them over at the end of a fiscal year so unspent funds were not lost.

Other suggested changes were that program objectives should focus more on timber management, beginning with complete diagnostic surveys and ending with administrative level planning; there was too much detailed reporting required in administering the program beyond the district level; and that there was a need to review the program structure to improve communication.

Finally, there were several responses indicating that more time should be spent in training personnel for marking northern hardwood stands for TSI; that more time should be spent in actually selecting and marking the timber stands before treatment; that more attention should be given to soils and sites, and species to be grown on a given site; and that more definite treatment priorities should be established.

Summary of Treatment Decision Procedures

The three primary variables affecting relative profitability are the productivity of the site, the forest type receiving treatment, and the length of the investment period for particular management practices. None of these variables were considered directly at any administrative level in determining investment of program funds. There also were no economic criteria mentioned for guiding investment choice. It appeared to be a situation of a program having been initiated for several specific management alternatives, without fully recognizing the need for alternative comparison or priority established within the program. In short, the Forest Cultivation Program has not been administered efficiently.

The survey results showed that other than the established northern hardwood priority, the remaining activities or alternatives within the program were given no differential priorities. In a given area, there were usually arbitrary amounts invested in northern hardwood treatments, jack pine, red pine, and aspen based upon some estimate of the total treatments to be accomplished. And although northern hardwood received top priority with some established qualifying guidelines concerning site, vigor and basal area, none of the other investment choices had any uniform guidelines. Also, there was no comparison for making the most efficient choice among the alternatives based on expected returns. There were, however, biological and external factors which would preclude investment based solely on economic considerations. The program itself is a constraining factor. It was set up to deal only with the certain specific treatments within certain forest types, thus narrowing investment choices. Efforts should still be made, however, to compare and determine the most desirable alternatives.

At the field level, there were several factors considered in making investment choices. What forest types were actually present in an area strongly influenced investment decisions, especially in northern hardwood. While factors such as stocking, stand quality, and species were often used as site indicators in making a treatment choice, site index was not used. Most foresters believed that simply occupation of an area by a northern hardwood stand was an indication of a good site in itself, as indicated by Eyre and Zillgitt (1953), who found that the potential productivity of sites occupied by northern hardwoods did not vary significantly.

The procedures for gathering and analyzing information for making investment choices varied, but most involved checking old aerial photographs, old type maps, and diagnostic inventories, knowledge of the area, and some type of field check. Management plans were utilized in those areas where they had been completed.

Existing markets were also given some weight in making investment choices. Market factors primarily tended to influence stand entry decisions and how the treatments were to be carried out.

For red pine treatments, the primary factor considered in making investment choices was the percentage of over-topping tree crowns. Other factors were age and site. Again, there appeared to be no uniform procedure among those areas concerned with red pine treatments. Also, site productivity was not stressed, since most red pine treatments were aimed towards plantations, and site considerations presumably had been included in the past decision to plant.

The primary factors considered in making aspen investment choices were whether or not the Wildlife Division would carry out the treatments, what the price for aspen was currently in the area, and whether or not there were stands within the area that had been harvested that were to remain in aspen and needed cleanup. Similarly, site quality and returns on the investment were not mentioned, directly.

Knowledge of past harvests and the desire to maintain areas in jack pine were the primary factors considered in making jack pine investment choices. Site was alluded to only through consideration of the problems of sod, available seed, and brush which affect scarification desirability.

Thus, there appears to be a need for regional planning to identify potential investment areas for more uniform stand selection criteria for treatment, and a more appropriate and uniform procedure for making investment decisions.

CHAPTER VI

DISCUSSION

The specific objectives of this study are to identify and evaluate the decision-making procedures used in making stand selections and investment choices, to examine the degree to which these procedures result in investment choices that agree with those of accepted economic analyses, and to identify ways to increase the program's efficiency.

The Forest Cultivation Program's history, characteristics, and accomplishments were discussed in the first and second chapters. In the fifth chapter, the program's operation was examined. It is primarily from this chapter that the inefficiency in administrating and operating the program is apparent. Such inefficiency is not surprising when a program such as the Forest Cultivation Program is new and still within its initial stages. But, being well over four years old, the program is no longer new. And in view of the program's accomplishments, its level of funding, and its continuation, improving the program's efficiency is important. Analyzing program objectives and alternatives, establishing procedures for guiding stand evaluation and selection, and utilization of investment guides and priorities would greatly increase the program's current efficiency. The program must, however, be concerned with its future operation as well. Just as the world is constantly changing, so, too, do forestry markets and trends change. And

for a program such as the Forest Cultivation Program this means that for both efficiency and continuation it should be prepared and able to change with and utilize these trends and market changes.

Thus, while there are many changes needed in the present stand selection and investment decision processes, particularly at the lower administrative levels, a broader perspective should be the initial focus in improving the Cultivation Program. Increased efficiency now, as well as in preparation for the future, insures the program's value and continuation. Therefore, product trends and future markets should be examined, particularly those of fiber and fuelwood, as well as of sawtimber. Both current and developing markets for these products will affect the Cultivation Program's alternatives, administration, and fulfillment of objectives.

Good regional planning can identify those regions and areas of greatest potential for a given managerial alternative. It can also aid in identifying local markets for various products, which can vary greatly within the state, particularly between the Upper and Lower Peninsulas. In analyzing alternatives for the Forest Cultivation Program, it is important not only to identify areas of high potential for current program practices, but also for other possible practices. Developing fiber and fuelwood markets and their implications for the program are examples. Therefore, some system of regional planning is needed and should be investigated by the Forestry Division. Implementing regional planning would aid the Forest Cultivation Program by making the allocation system more efficient, aiding investment decisions, utilizing the best markets, providing program direction, and allowing the program more flexibility.

Sawtimber production will probably continue to be important, both as a program objective as well as with regard to the public and political forces. Market trends should therefore be monitored. But future markets and values of sawtimber will not necessarily remain the same or increase. Growing sawtimber in Michigan is a long-run endeavor, and many changes can occur in 50 to 100 years. Thus, the program must be able to recognize and utilize or adapt to other products trends and markets. Along this vein, fiber and fuelwood markets and production alternatives cannot be overlooked.

The demand for fiber has been increasing, and shows signs of continuing to do so. With the exception of a sharp drop in 1975, pulp and paper production has increased steadily over the last 15 years, and data indicate that through 1976 and into 1977 the trend is again increasing (U.S. Dept. of Commerce, 1977). Michigan appears to follow the national trend, with a significant increase in both woodpulp production and consumption of pulp for paper and board in 1976, over the low production in 1975 (U.S. Dept. of Commerce, 1976). The Forest Cultivation Program could easily use good fiber markets to its advantage. Not only could the program benefit the state through supplying the involved fiber industries, but also through sales of both previously unmerchantable stands and TSI contracts. Treatments such as aspen betterment and TSI in northern hardwood, red pine and jack pine that have previously cost the program to implement could be contracted and sold for fiber where good markets are present. As a result, the funds that normally would be used to perform the treatments could be used elsewhere within the program, such as in planning or in setting up and administering other program treatments. The increasing

use and acceptance of in-woods whole-tree chipping operations also support the possibility of selling proposed program treatments for fiber. Good fiber markets would encourage and allow the program to investigate managerial alternatives in brush types, lowland types, and other softwood types. It may even be necessary to examine the program's hybrid aspen project for possible use and expansion. In any case, identifying and utilizing developing fiber markets insures better efficiency by making the program more flexible and valuable.

Fuelwood also looks promising as an important market in the future, particularly in Michigan. Nelson (1974) has compiled impressive data on the amount and availability of wood for energy in the United States and Michigan. Citing available technology, favorable economics, and the advantages of wood over fossil fuels, he recommends a "biotherm energy system" of small generating plants using wood fuel. Establishment of a demonstration plant of commercial scale is currently underway at Winn, Michigan.

The Michigan Public Service Commission (1977) also recommends the development and utilization of wood residue as an alternate source of fuel for generating electric power. The technology exists for both the commercial harvesting of wood fuel and the conversion of wood fuel to energy. Wood is a valuable potential source of energy, particularly for Northern Michigan.

Like fiber, the program could use fuelwood markets advantageously to meet its objectives of stand improvement and increased employment. Where good fuelwood markets exist, TSI treatments, particularly in northern hardwoods, could be contracted out with only administrative

and marking cost to the program. Again, not only would this free program funds for other uses within the program, but it could also generate income to the state. There is also some value in the good public relations generated by supplying fuelwood, especially to local markets and to individuals or small contractors. Good fuelwood markets could encourage the program to investigate other possible alternatives, such as other forest types and poorer types and stands either not considered under the program or previously considered unmerchantable or unprofitable. Identifying and using fuelwood markets will aid program efficiency and help it to grow.

Thus, if trends and future markets in forestry are recognized, planning can help take advantage of them. The program can change and be ready to change with changing markets and still work towards its objectives. As a result, such market changes as increasing fiber and fuelwood demand or decreasing sawtimber demands need not jeopardize the Cultivation Program's future, but will actually make the program more viable and valuable. As various markets develop they can be used to implement treatments that are now an expense for the Forestry Division. In fact, income could even be generated from such treatments. And in such instances where good markets exist for such products as fiber or fuelwood, the program function becomes primarily one of administration--locating, selecting, marking, selling, etc.--as opposed to that of actually expending funds to implement treatments. This is, in fact, desirable and recommended wherever possible within the program with all managerial alternatives. It is more efficient and allows the program funding to be used for more and wider ranges of alternatives. Thus,

with good planning and recognition of future trends and markets in forestry, the Forest Cultivation Program could emerge as a valuable, versatile, continuing program.

Current Administration

The survey results indicated that overall, the Forest Cultivation Program is not being administered efficiently. No uniform procedures exist for stand selection for treatment. The factors considered in stand selection, as well as the factors influencing program investments, also varied widely.

Some standardization or uniformity is desirable. For stand selection, more uniform procedures involving specified stand factors would be advantageous for the program. As noted in the previous chapter, with the exception of northern hardwood, there apparently have been no priorities or guidelines established for evaluating and selecting stands for treatment. For nothern hardwood, the basal area of a stand coupled with its age and quality were most often used in the selection procedure and are valid. And while selection of stands on good sites is important and should be noted, it is perhaps not as crucial in the case of northern hardwood where site differences usually are not significant (Eyre and Zillgett, 1953). The remaining question with northern hardwood treatments is whether uneven-aged management is an appropriate objective for northern hardwood. The Forestry Division should re-examine this objective.

There is the need, however, to establish more uniform stand selection guidelines for jack pine, red pine, and aspen stand treatments.

Again, the productivity of the site is important, and for stand selection in these three forest types, site index should be more closely considered. Closer identification of potential problems on sites to be regenerated to jack pine would be advantageous. Obviously, where two sites of equal potential exist for regenerating jack pine, the one posing a lower cost due to less sod or lighter brush cover may warrant priority in selection. Similarly, for release and pruning of red pine stands, not only is site important, but there should also be criteria for the number of trees to be pruned and to what height, as well as when and how to release red pine. While such decisions are apparently being made by the individual forester, it would be advantageous to have Division-Wide policies or guidelines for better efficiency and uniformity.

More attention should also be given to stand selection procedures for aspen liberation treatments. Due to the somewhat low investment returns often resulting from such treatments, site index and remaining overstory are important factors to consider. Both directly affect investment yields; the higher the site index, and the less remaining overstory, the better the yield and investment returns.

Similarly, allocation methods are not optimal, nor is any type of investment priority system used, aside from the priority assigned to northern hardwood. In short, there are no profitability measures used in guiding allocations and investment decisions. Administrative effectiveness is important, and it should be evident that the program's effectiveness and efficiency could be increased considerably if investment opportunities were more systematically prioritized.

To aid in investment efficiency and to prioritize investment opportunities, some measure of economic efficiency is necessary. Profitability measures commonly used in forestry are net future value, net present worth, internal rate of return, and benefit-cost ratio. The pay-back period has also been suggested for forest managers. All of these measures are discussed and compared in Appendix C.

For administering the Forest Cultivation Program, the use of IRR as the major profitability criterion for evaluating and ranking investment alternatives is desirable; capital budgeting techniques should be useful; and the influence of non-economic factors on decision-making should be recognized. In general, uncertainty can be ignored in the program's decision process.

As with the need for regional planning, planning at the field level would greatly increase the problem in administrative efficiency and more is needed. Such planning would help identify local markets, as well as identifying those stands of highest potential within an area. And since in the allocation procedure there should be competition for funds at the district level, as well as among the areas within, good planning and completed inventories are needed to supply the necessary data. It is also within this framework that the economic criteria suggested to improve the decision process of the program are important.

If the IRR is to be used for stand and other area selection for treatment and investment of Forest Cultivation funds, then some idea of the rates of return expected from the various program activities is in order. This will permit the various investment alternatives to be ranked in decreasing order of priority for funding, to the limit of

appropriated Forest Cultivation funds.

Treatment Rankings by the Internal Rate of Return

In northern hardwood TSI, both Whaley (1969) and Meadows, et al., (1975) assumed crop tree release in pole and small sawtimber stands. Whaley found that the rate of return ranged from a low of 6.6 percent to a high of 9.2 percent, depending on the thinning level. Rates of return computed by Meadows ranged from a low of 5.4 percent to a high of 8.1 percent. Thus, for this activity, rates of return averaging 6.0 to 7.0 percent can be expected from similar investments made with Forest Cultivation Funds.

For pulpwood rotations as short as 45 years with one thinning, Meadows found the rate of return ranged from a low of 11.4 percent to a high of 14 percent. However, the average rate of return for sawtimber products was lower, and that for pulpwood much higher than those estimated for northern hardwood in the Northeast (McCauley and Marquis, 1972).

For red pine plantings, Whaley analyzed alternatives with a merchantable first thinning at age 25 or 35 that reduced the basal area to about 90 square feet, with subsequent thinnings at 10-year intervals until harvest at age 85. The rate of return ranged from 3.7 percent on a hand-planted poor site to 6.0 percent on a hand-planted good site. For machine-planted stands, returns ranged from 4.3 percent on a poor site to a 6.7 percent on a good site.

For similar conditions, Meadows used an 80-year rotation with commercial thinnings, four site classes, one stocking level, and only

machine planting. The rates of return ranged from 3.9 percent on site index 40, to 7.3 percent on site index 80. Planting method and site quality, along with selected rotation length and thinning regime, are important factors. Thus, planting red pine on areas averaging site index 60 under the Forest Cultivation Program can be expected to give a rate of return averaging 5.5 to 6.0 percent.

Both Whaley and Meadows considered aspen liberation as an investment alternative. For good, medium, and poor sites, with three levels of overstory density, Whaley found the rate of return to range from 1.2 percent on a poor site with a large number of stems to be removed, to 6.9 percent on a good site with a small number of trees to be removed. Meadows evaluated three sites and two overstory levels, and found an even wider range in the rate of return, from 2.8 to 13 percent. Realistic rates of return to be expected from aspen liberation with Forest Cultivation investments will probably average 4.0 percent.

Whaley also considered oak conversion to red pine on poor oak sites, and red pine release. He found the rates of return for converting oak to pine to be low, ranging from 4.3 to 5.1 percent. For red pine release, the amount of overstory basal area per acre to be removed was important, with the rate of return ranging from 8.2 to 20 percent. Low quality oak stands that have been or are contemplated to be converted to red pine under the Forested Cultivation Program should yield rates of return averaging 4.5 percent. For red pine release, the rates would be higher, averaging perhaps 10 to 12 percent.

Meadows analyzed and ranked many management opportunities not investigated by Whaley, such as planting, thinning and pruning red

pine, and planting, thinning and pruning oak. The rankings for the red pine treatments ranged from 13.1 to 15.3 percent for thinning existing stands, and 4.1 to 7.4 percent for planting, thinning, and pruning new stands. The alternative involving oak treatments ranged from 0 to 13.2 percent, depending on treatment, rotation, site, and stocking. Where red pine stands need thinning with Forest Cultivation funding, average returns of 14 percent can be expected. For new plantations carried to sawtimber rotation, the rate of return would average 5.5 percent.

In addition, Meadows analyzed and ranked jack pine management alternatives. For jack pine on a 45-year pulpwood rotation, with periodic thinnings on three sites with two stocking levels, rates of return were about 26 percent. For jack pine regeneration projects involving mechanical site preparation, planting and later thinning, the rate ranged from 3.4 to 6.6 percent depending on density of present cover and site quality. These results are indicative of what might be expected from similar investments under the Forest Cultivation Program.

Neither Meadows nor Whaley directly evaluated investment opportunities in pruning red or white pine; Meadows evaluated pruning opportunities only in conjunction with other treatments such as planting and thinning. However, pruning has steadily gained support as a profitable and desirable investment opportunity (Shaw and Stabler, 1950 and 1952; Ralston, 1953; Hocker, 1974). Rate of return from pruning red pine plantations in Michigan has been estimated to range from 3.0 to 8.0 percent (Ralston and Lemein, 1956). A pruning study of white pine in New Hampshire estimated returns ranging from 8.7 percent to 16.4 percent (Allen, 1964). Thus it appears that returns of 6.0 to 8.0

percent from pruning vigorous red pine stands can be expected from investing Forest Cultivation funds.

CHAPTER VII

SUMMARY AND RECOMMENDATIONS

The Michigan Forest Cultivation Program was initiated in 1973 primarily from a recognized need for more intensive management of northern hardwoods. As the overall productivity on state forest lands was much less than its potential, better and more intense silviculture and management were needed. The program is geared toward northern hardwood stand improvement, pruning and release of red and white pine, regeneration of jack pine, and aspen regeneration. Funds are also being used for fertilization studies, site conversion to hybrid aspen, road construction, and forest inventory. From an allocation of $300,000 the first year for these program investments, the program's funding has increased each year, and stands at $1 million for 1978.

The broad goals of the Forest Cultivation Program are to increase the value and economic returns of state forest lands to the state, and to attack the state's unemployment problem through forest-related activities and industries. Thus, program funds are allocated to those districts and areas with forest types of concern to the program. Estimates of the acreages needing treatments annually for each type are made. Stand treatments are then carried out at the area level in the various forest types, often with specific acreage goals within the particular area or district. The following has been accomplished through the Forest Cultivation Program from 1973 through 1977: 36,000 acres of

northern hardwood stand improvement, 8,700 acres of jack pine regeneration, 2,800 acres of red and white pine release, 4,200 acres of aspen regeneration, 95 acres of site conversion to hybrid aspen, and 44 miles of roads constructed.

In view of the decision process for investing program funds, this study was made to examine this process in relation to the administration of the Forest Cultivation Program. Efforts were made to identify the decision-making procedures used and the factors considered in making investment choices in the program. These were examined in relation to other accepted economic analyses procedures. All of this was done with the overall objective of increasing the program's efficiency. A survey was taken of all Michigan Forestry Division personnel administering the program to obtain the necessary data and to determine their perceptions of the program.

At the field level, it was found that the procedures varied for gathering and analyzing information for making stand investment choices. They primarily involved checking old aerial photographs and type maps, diagnostic inventories, knowledge of the area, and some type of field check. Where completed, management plans were utilized. Market factors, such as stumpage prices for different species and products, were also considered to some extent in analyzing program alternatives. Most often they influenced stand entry decisions and how the treatments were applied.

Management objectives, while often exerting little influence on stand selection and investment decisions, did influence the timing of timber sales and of TSI contracting. TSI contracting was often

postponed until the stand became commercially operable and then done in combination with, or following, the commercial timber sale. But as the TSI program has moved towards dependence upon the commercial timber sale program, problems have arisen because contract completion dates often do not correspond with the fiscal year planning and reporting method used.

Similarly, employment factors did not constitute a major consideration in the investment selection procedure. There is also no evidence that the program has had any significant impact on unemployment. This is primarily because the amount of money spent in an area is relatively small, thereby not impacting unemployment appreciably, and because little new employment is generated. Most employment under the program is more that of a transfer by jobbers from other woods work, rather than new jobbers coming into the program.

Management objectives of the Wildlife Division also influenced stand selection procedures, particularly in areas with large deer populations. Timing of TSI treatments in northern hardwood was sometimes affected. In aspen, TSI after commercial sales was often financed by the Wildlife Division. The Wildlife Division also discouraged planting of red pine.

Site factors such as stocking, stand quality, and species were used in stand selection at the field level when considering northern hardwood treatments. However, occupation of a site by northern hardwood was considered sufficient indication of a good site.

The percentage of over-topping tree crowns was the primary factor considered in making stand choices for red pine release. Age and site

were other factors considered. There appeared to be no uniform procedure among those areas concerned with red pine.

Similarly, site quality and investment return factors were not considered in making aspen investment choices. Factors considered were whether there were any harvested stands that were to remain in aspen and needed cleanup; whether or not the Wildlife Division would carry out the treatments, and what the current price for aspen was in the area.

The primary factors considered in selecting jack pine stands for investment were knowledge of past harvest areas and the desire to maintain these areas in jack pine. Again, site was only alluded to through consideration of scarification problems concerning sod, on-site seed source availability, and brush.

In administration of the Forest Cultivation Program, allocations were generally made in a lump sum from the Lansing office to the regions, which was then divided among the districts within each region and among the areas within each district. There were no guidelines for allocating program funds at either the regional or district levels and the procedures varied. Although some Division personnel suggested improvements in the allocation procedure, it appeared that there were no major problems other than the use of funding quotas.

The team concept was initiated for northern hardwood TSI treatment. Teams of technicians specializing in selecting and marking northern hardwood stands were created. While the advantages of the specialized team concept were recognized, the negative aspects tended to draw more attention. The concept resulted in more efficiency,

consistency, uniformity and higher quality of work, as well as a time saving for the area. However, there are disadvantages of monotony, boredom, and lower promotional potential, resulting in decreased morale and job satisfaction. The cost and efficiency of the concept were also questioned.

It was generally held that the administrative role of the district forester in the Forest Cultivation Program should pertain primarily to the budgeting aspects. The district forester should also coordinate the team among areas. However, there were some differences in how administrative roles of the area forester and the team were viewed. The majority indicated that practically all of the administrative work should be the area forester's responsibility. He should indicate to the team possible stands for treatment, provide supervision, keep a check on the standards used by the team in applying treatments, handle much of the data processing, and supervise road building and harvest cuts. The team should handle the remaining responsibilities of drawing up treatment proposals, marking, and TSI contracting.

Current planning and inventory procedures were not considered adequate to serve the program needs. There is a need for more thorough inventory and management planning at all levels. Not enough inventory and planning was completed before the program was instituted, and that completed was not detailed enough to meet the program needs.

The survey also found that the Forestry Division personnel definitely believed that the objectives of the Forest Cultivation Program were worthwhile, were being achieved, and that the program

should be continued. The major suggestions for improving the program centered around broadening it to include other timber types and management activities.

Finally, it was found that no economic criteria for guiding investment choice were being used. The need for comparing alternatives and establishing priorities for investing funds under the Forest Cultivation Program has not yet been realized. Other than the pre-established northern hardwood priority, no guidelines or procedures were used for ranking the economic desirability of the remaining activities within the program. Although some guidelines concerning site, vigor, and basal area had been established for northern hardwood, none had been established for the other investment choices. Site index was given little direct attention, even for northern hardwood.

In studies conducted by Meadows, et al. (1975) and Whaley (1969), various forest investment opportunities in the Lake States region were ranked by the internal rate of return. Their results should prove useful in improving the investment decision processes in the Forest Cultivation Program.

Their studies indicate that rates of return averaging 6.0 to 7.0 percent can be expected from northern hardwood TSI treatments. For red pine release, program investments could be expected to average a 10 to 12 percent rate of return. Although pruning red and white pine was not evaluated separately by either Meadows or Whaley, other studies indicate that average returns of 6.0 to 8.0 percent could realistically be expected from such investments. An average rate of return of 3.5 to 6.5 percent could be expected from investments in jack pine

regeneration involving mechanical site preparation. Returns from investment in aspen liberation could be expected to be quite low, probably averaging around 4.0 percent.

Northern hardwood is a timber type whose potential high value is dependent on quality. High returns have also proven possible from red pine investments. These types have received the majority of the funding, and to this extent, program investments are in general agreement with those that would be made on the basis of accepted economic analyses.

The program has not lessened Michigan's unemployment to any extent. This was one of the program goals. In the Upper Peninsula alone, forest industry in 1961 was easily the most important in terms of employment (James, 1961). The program could prove beneficial through stimulation of forestry-oriented employment.

Whaley (1969) pointed out that most public timber management agencies do not have formalized procedures for establishing investment priorities. Systems used are usually based on maximizing future timber yields, covering as many acres with trees as possible, increasing employment opportunities in certain regions, distributing funds evenly between administrative districts, and distributing funds in response to local legislators or pressure groups. Desirable procedures for establishing investment priorities are missing because specific goals, data, and specific means for adequately analyzing alternatives are lacking. In general, Whaley's observations apply to the Michigan State Forestry Division.

Regional planning is recommended for improving the Forest Cultivation Program's efficiency, and for providing program direction.

It is important to recognize that certain regions and areas within the state have a greater production potential for various managerial alternatives. These areas should be identified and emphasized accordingly through the program. Regional planning provides for such a process.

It is also important that the Cultivation Program can recognize and use changing market trends. The implications of improving fiber and fuelwood markets are examples. Such markets can easily be used to improve the program's efficiency. Hence, too, regional planning is important in identifying and monitoring market trends. Thus, such planning will increase the program's efficiency by improving the allocation procedure, providing direction, and by helping to keep the program a flexible, viable, and contributing one.

The efficiency and effectiveness of the Cultivation Program can be further improved by developing and adopting suitable procedures for evaluating timber management investment opportunities. The internal rate of return is recommended as the profitability measure for evaluating and ranking investment opportunities for the Forest Cultivation Program. It is reasonably easy to understand and apply, equally applicable at all levels, data are obtainable, and it is a useful evaluation measure. Treatment costs, yield projections with and without treatment, expected stumpage prices, and discount interest rates are the basic data needed for evaluating and comparing treatment opportunities. A minimum acceptable rate of return for investments should also be determined by the Forestry Division. Investment in any alternative yielding an expected rate of return below this rate would not be undertaken. Much

of the necessary data for rate of return evaluations should be available from the Forestry Division's records. Studies such as those by Whaley (1969) and Meadows, et al. (1975) also provide useful information.

Capital budgeting techniques should be included in the evaluation-decision procedures. Coupled with the use of the internal rate of return, investment opportunities can be evaluated, ranked, and selected in a systematic, efficient way. Thus, investments are made in the most desirable alternatives. Continual monitoring and reevaluation of investment selections is also advised and facilitated by such a procedure. The "lump sum" method of allocating funds that is currently used in the Forest Cultivation Program need not be changed completely. A uniform evaluation procedure based on economic acceptance criteria will enable more efficient allocation of "lump sums" by rate of return to specific areas.

In evaluating and comparing investment alternatives, the influence of non-economic factors on the final decision must not be disregarded. The nature of the Cultivation Program, secondary impacts, political and external influences, and objectives other than efficient timber management are factors affecting investment choice. Such factors may delegate investing in an alternative yielding a rate of return below the minimum acceptable rate. Therefore, in implementing a more efficient, uniform evaluation system a "comprehensive analysis" approach is recommended to weigh more than just the economic factors in the decision (Marty, 1975).

The program has not been administered efficiently. There is, however, increasingly more input by the area foresters into the administrative process. More interaction among the area, district, regional, and staff levels is encouraged. Such action will facilitate use of the uniform evaluation procedure which should be developed.

For actual stand selection, uniform procedures and guidelines should be established for evaluating potential forest stands for treatment. Factors such as site index, age, quality, overstory, accessibility, and markets would assist the forester in stand selection decisions.

The emphasis on northern hardwood was and is reasonable, from both an investment and political standpoint. Disagreement exists, however, concerning the validity of uneven-aged management for northern hardwood; therefore it is recommended that the objective of uneven-aged management for nothern hardwoods be reexamined.

Expansion of red pine investment through the program is recommended. But planting jack pine on good red pine sites is not a good investment, and should be avoided when possible. Presently, however, red pine management conflicts with management objectives of the Wildlife Division. But investment in release treatments of red pine can yield as good or better returns than northern hardwood treatments. Therefore, continued or even increased investment in red pine release is recommended.

Further investigation of investment in pine pruning opportunities is recommended, while continuing investment at the present rate. Growth rate of pruned trees and recognition of the increased value of pruned trees in stumpage prices are major factors affecting pruning returns.

Similarly, further study of liberation treatments in aspen is recommended, because expected returns appear to be quite low. Other factors however, such as wildlife management objectives and aesthetics may justify such an otherwise low priority investment.

Methods for evaluating road construction alternatives should be developed. Road building is an important and vital aspect in practically every phase of forest management. Determination of evaluation criteria or procedures for investment would at least insure proper study of road building alternatives. More efficient investment allocation would also result.

Increased efforts should be made to update and complete inventories of all state forest lands. Updated inventories allow for better planning and more efficient management. Subsequently, better investment decisions will result. The inventory should be uniform and provide data sufficient for program needs.

For good forest management, managerial tools such as recent aerial photographs are also important. New aerial photographs should soon be available, and if necessary, Forest Cultivation Program funds should be used to obtain suitable aerial photographs of state forest lands.

The team concept used with the program for administration and field work has drawn much comment from Forestry Division personnel. Efforts are being made to minimize the disadvantages of such specialization by limiting the time a member is assigned to a team. The area forester should make recommendations and provide supervision for the team. The remaining program activities, particularly all non-administrative duties, should be the team's responsibility.

Finally, a representative sample of program investments thus far should be anlayzed and evaluated by the Forestry Division. Growth response studies for the different program treatments should be undertaken to provide data needed for the analysis. Such analysis of investments already made will indicate whether projected benefits warrant further similar investments, or whether more beneficial investment alternatives exist.

Investment efficiency is difficult for any public agency, and particularly so for a public timber management agency. In general, financial analysis has not been widely used in public forest management planning in the United States. The efficiency of the Forest Cultivation Program can be increased by better planning and by developing and adopting guidelines for stand evaluation and selection and uniform investment evaluation procedures utilizing the internal rate of return and capital budgeting techniques.

APPENDICES

APPENDIX A

FORESTRY DIVISION ORGANIZATION

Figure A-1.--Forestry Division organization, staff, existing organization.

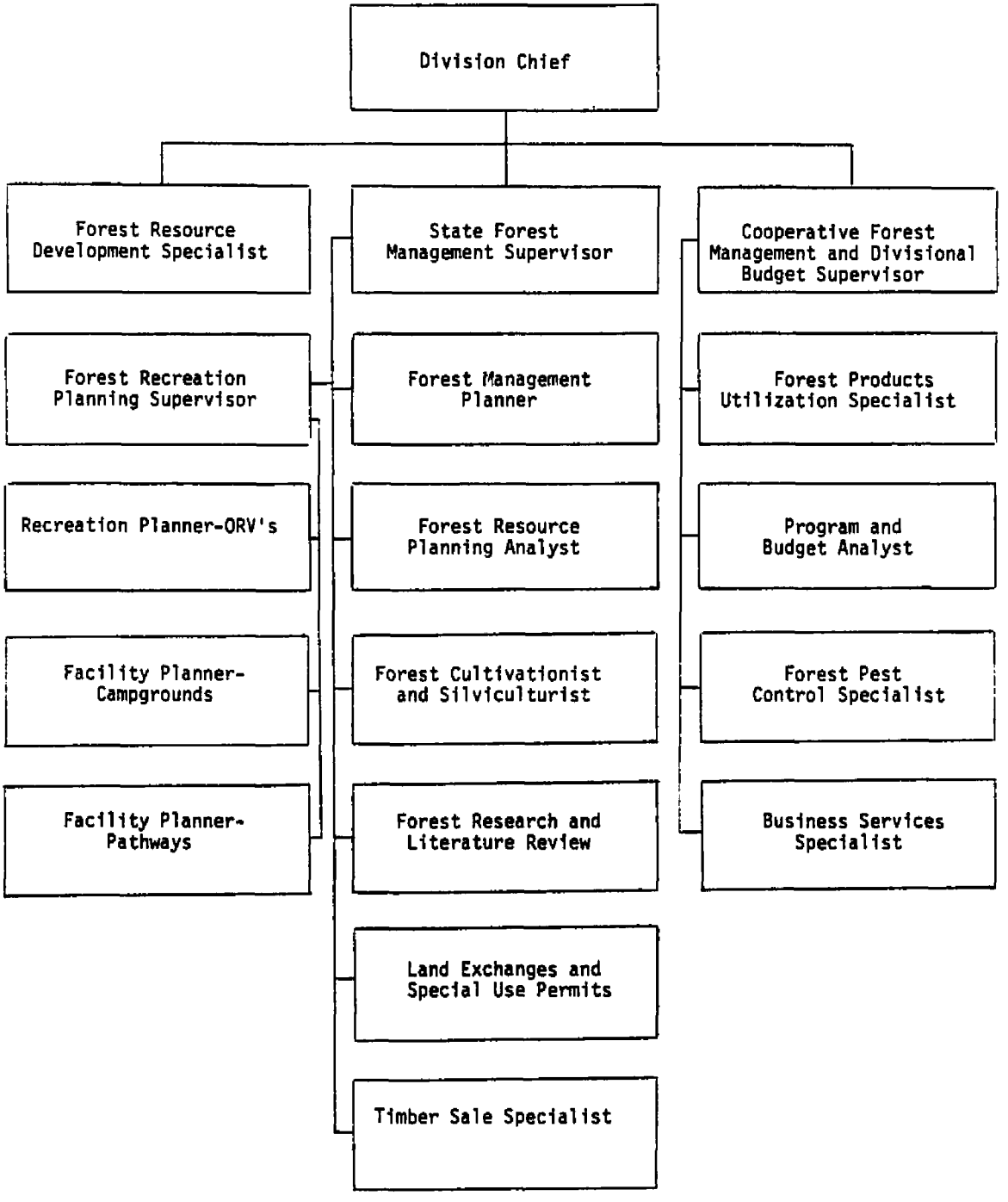


Figure A-2.--Forestry Division organization, existing region and districts (Region I).

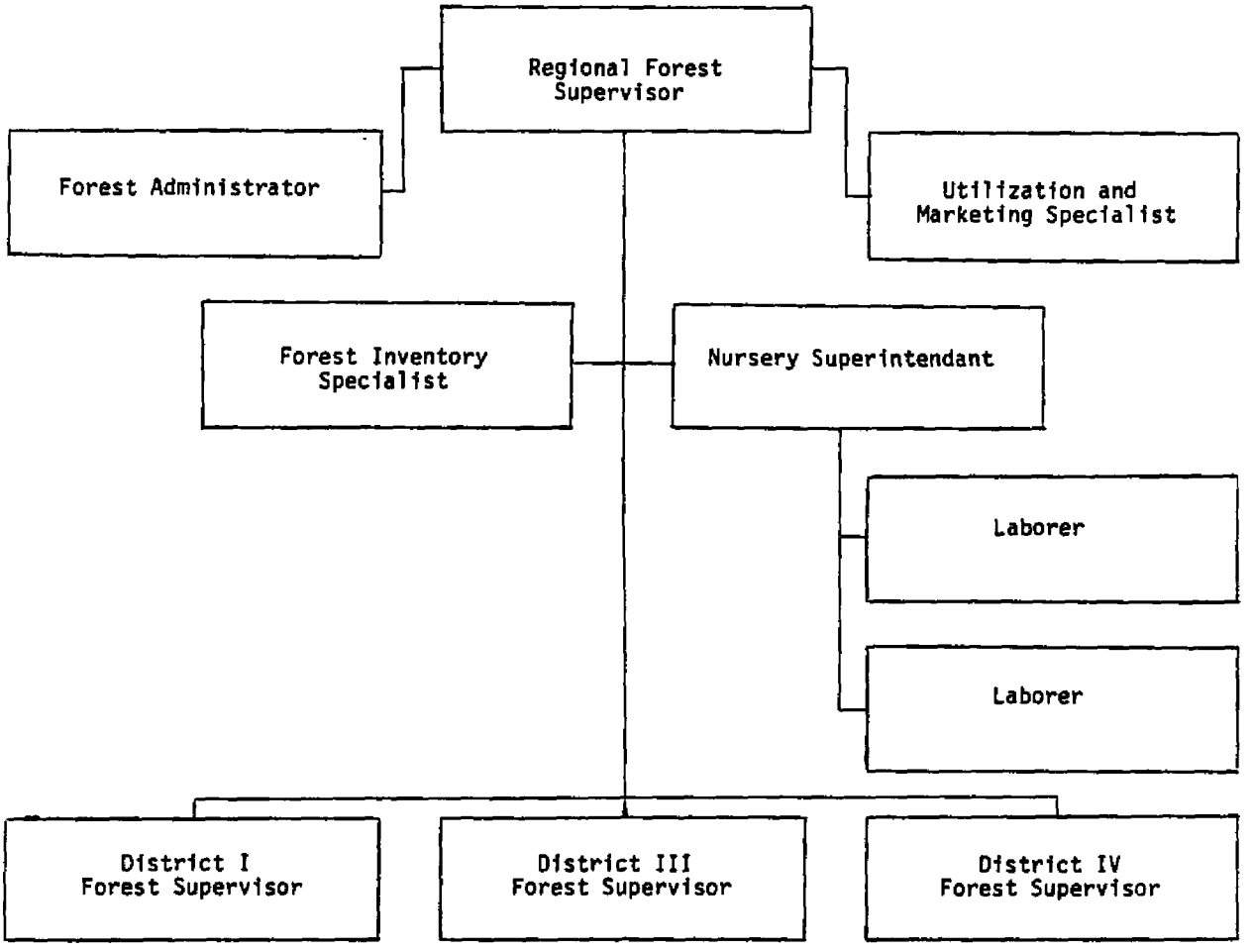
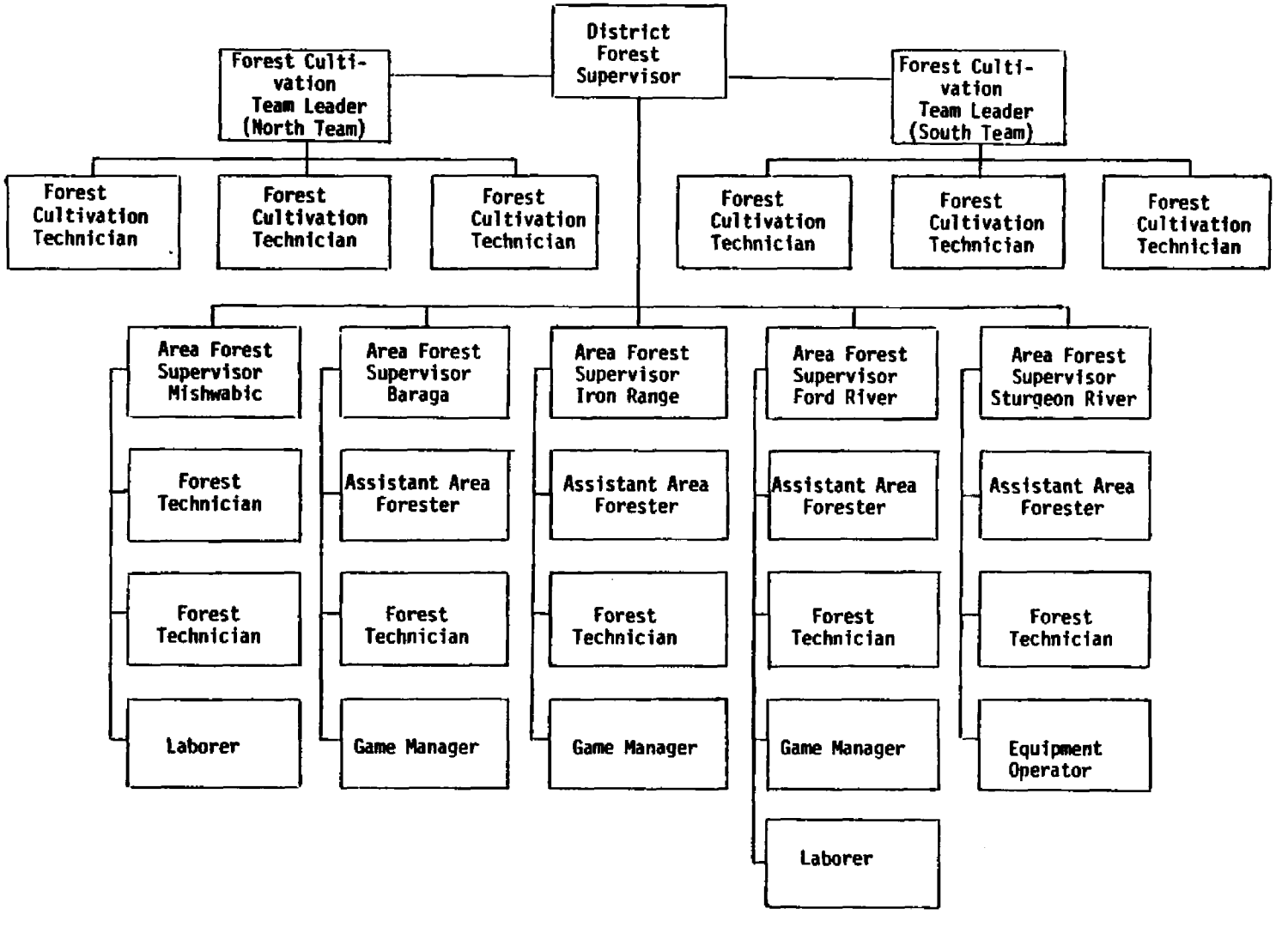


Figure A-3.--Forestry Division organization,existing organization (District I).



APPENDIX B

SURVEY QUESTIONNAIRE

APPENDIX B

SURVEY QUESTIONNAIRE

NAME:_____AREA:_____FOREST_____PLACE:_____

DATE:_____

1. Describe your treatment area selection procedure (for hardwood, TSI, jack pine scarification, aspen betterment, red and white, roads)?

2. What management objectives do you take into account for a given area or stand (region, district, or area policy)? How do they influence what areas are or are not selected to receive treatment under the program? (Both as to the basis for site selection and as to project timing?)

3. Where and how do market factors come into your decisions concerned with the program?

4. What part do site factors play in your investment decision? How do you determine site? (Guidelines used? Species? Density?)

5. What influence does wildlife and its management objectives have upon stand selection and treatment applications under the program?

6. How do you view the employment situation in light of the program? Do you think it has helped to provide significant additional employment in needed areas? (Or are "transfers" occurring?) Do you find that in selecting areas for treatment you consider the employment situation (as to generation and as to experienced labor)? What effect does knowing where an experienced or inexperienced labor supply is, have upon the selection procedure?

7. Do you use a "diagnostic inventory", or some similar type of preliminary look at a stand to see if it qualifies? What preliminary procedures for stand selection do you use? And what specifically determines whether or not the area should receive treatment?

8. Do you assign any priority in appraising stands for treatment? If so, what?

9. Along these same lines and paralleling the selection factors, are there any things you look for initially in examining a stand which automatically say "no", and what are they?

9A. Do you have a priority by treatments? What is done first? (Returns considered).

10. What is the lowest BA a stand could average and still be eligible or considered for treatment? How much would necessarily have to be removed to attract contractors?

11. In these determinations of stand selection and treatment do you consider regeneration a factor or objective? If so, how? And what weight is assigned it?

12. Are there "acreage quotas" or annual area figures that you try to meet each year? If so, how are these figures arrived at? Do you view this as a good procedure or not? Or has this provided unnecessary pressure and perhaps encouraged, if not caused, treatment entry into what possibly could be considered stands of lower priority under the program?

13. How are the allocations for each district and area arrived at and made?

14. Do you think changes should be made in this procedure?

15. Do you feel that the program's objectives are desirable and worthwhile? Do you think the objectives are being adequately met? Should the program be continued? If not, why? If so, what changes would you like to see made? (Funding reduced? program broadened? elimination of separate funds?)

16. In administering the program, how do you view the roles of the district forester, area forester, and the team leader? What do you feel is the optimal role and interaction of these people in administering the program?

17. How do you feel about the team concept, particularly as to efficiency, uniformity of work, work quality and overall effectiveness? Compare it to the initial procedure used when the program began. What do you see as the advantages and disadvantages of the team concept, particularly as to the aspect of specialization?

18. Do you feel that planning and inventory procedures are currently adequate to serve the program needs? Can you suggest changes? (further needed?)

APPENDIX C

DISCUSSION OF PROFITABILITY MEASURES

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DISCUSSION OF PROFITABILITY MEASURES

For evaluating investment alternatives, it is necessary to select some measure of economic efficiency. Such economic criteria provide evaluation and comparison guides that are uniform, can be used at different organizational levels, and are easily understood by management. Commonly used profitability measures include net future value, net present worth, internal rate of return, benefit-cost ratio, and payback period. With the exception of the last measure, all have been used extensively in evaluating forest investment alternatives. Payback period refers to the number of years required to recover the initial cash investment. It has two major weaknesses: it fails to consider cash flows after the payback period, and does not consider the magnitude or timing of cash flows during the payback period (Beirman and Smidt, 1971; Van Horne, 1977). Thus, the payback period cannot really even be considered a measure of profitability. As Fedkiw (1960) states, "There is no necessary correlation between (the payback) period and the productivity of investments, and therefore (the payback period ought not to be used as a substitute for rate of return on investment...The main requirement in the hierarchical management of a forest enterprise should not be early payback periods, but maintenance of the value of the capital assets of realization of an

earning rate that satisfies the guiding rate of return." Thus, although it has been suggested (Nelson, 1961), the payback period is not an appropriate economic measure of efficiency for forest investments.

Net future value is an easily understood profitability measure whereby all cash flows are compounded to the end of the investment period and compared. However, managers are usually more interested in present values, and the discounting methods involved with net present worth, internal rate of return, and benefit-cost ratio measures are preferred.

Net present worth is probably used more frequently than all other economic measures of efficiency. It involves combining the expected cash flows of an investment after discounting them to their present value by a suitable interest rate. The determination of the discount rate is important in calculating net present worth.

The benefit-cost (B/C) ratio, also known as the profitability index (Van Horne, 1977), or the index of present value (Beirman and Smidt, 1971), is simply the present value of cash inflows divided by the present value of initial investment outlay. A ratio of zero or greater benefits to costs indicates a favorable investment.

The internal rate of return is the rate of interest equating the present values of cash inflows with that of outflows for an investment opportunity. It could be thought of as the rate of growth of an investment.

For the four commonly used profitability measures--rate of return, net future value, benefit-cost ratio, and net present worth--values of incomes and costs and future values of incomes and costs are necessary for analyzing any investment opportunity. Also, all of these

measures are consistent with one another in the sense that a cash flow sequence found acceptable under one measure for an alternative would usually be acceptable under the other measures (Marty, 1976). However, they will not always provide the same rankings of alternatives where more than a single investment opportunity exists.

In choosing a profitability measure to use in evaluating investment alternatives, net present worth (NPW) is usually preferred over benefit-cost ratio, especially for mutually exclusive projects. NPW expresses in absolute terms a project's expected economic contribution; the B/C ratio expresses only its relative profitability. Thus, the size of the initial investment outlay influences evaluation results when using the B/C ratio methods.

Similarly, net present worth methods and internal rate of return (IRR) give identical answers with respect to acceptance or rejection of an investment opportunity. But, when two investments are mutually exclusive, these methods can give contradictory results. The IRR method assumes or implies that during the investment period funds are compounded at the IRR, while present worth methods imply compounding at the required rate of return used as the discount rate. In choosing between the two measures, the question hinges on the appropriate rate of reinvestment for intermediate cash flows. According to Van Horne (1977), "if a choice must be made, the present value method generally is considered superior", because the reinvestment rate is the same for each proposal and represents the minimum return on the available opportunities. Beirman and Smidt (1971) also support the use of net present worth methods over IRR, primarily because IRR reflects average rather than incremented cash flows. Also, there are

technical problems when IRR is used as a ranking device (Marty, 1970), in that 1) the rankings are not consistent with net present worth rankings unless the comparisons are among alternate sets of investments with identical net present worths of costs and identical investment periods; 2) the average IRR for a given project depends on its scale, which is a function of the alternative rate of interest; 3) the effect upon investment rankings is not clear, since IRR is a ratio and its value changes depending on whether cash flows are treated in net or gross terms.

The IRR method however, can be modified so that it involves incremental analysis for mutually exclusive alternatives (Van Horne, 1977). IRR allows comparisons with alternate investment opportunties without the necessity of computing either net present worth or net future value. There is also difficulty in determining an alternative rate of return in public program administration, but the forest manager does not have to specify an alternate rate of return for calculation.

Similarly, Bierman and Smidt (1971) make no claim that net present worth methods can be used to rank independent investments where that ranking will be used to eliminate some independent investments with positive present values. A major disadvantage of present worth methods is that only investments of relatively the same size can be compared. Thus, a management alternative requiring the largest investment will be favored in any analysis where investments differing greatly in size are ranked. The IRR is more useful in ranking investment alternatives as it readily permits the allocation of a limited budget in descending order. It is only necessary to specify a range for the

alternative rate of return, rather than an exact alternative rate for any specific investment. Also, many financial managers believe that the IRR is easier to visualize and interpret than net present worth measures. "To the extent that the required rate of return is but a rough estimate, the use of the internal rate of return method may permit a more realistic comparison of projects" (Van Horne, 1977).

One remaining shortcoming of the IRR method of investment evaluation is the possibility of multiple IRR's for a given investment opportunity. Marty (1970) proposed an algorithm for computing a composite rate of return that would provide a unique solution consistant with present value decisions. Van Horne (1974), on the other hand, states that "the existance of multiple IRR's is unusual," and that unique IRR exists for the typical investment opportunity.

Gaffney (1957) concluded that, theoretically, the only correct method of evaluating alternative investment opportunities is the Faustman formula or soil rent approach, a form of contribution to net present worth reflecting opportunity costs associated with both timber and land. However, in a comparison of four profit criteria that included internal rate of return and contribution to net present worth, Webster (1965) found that nearly the same results were obtained for the two measures and proposed that the criteria either best understood or most easily used by the analyst or manager are the appropriate ones to use.

Any criteria reflecting discounted costs, output response, timing, and discounted future values would appear to give similar results and would be appropriate for use by the forest manager in evaluating the relative profitability of timber management investment opportunities. However, IRR actually measures the rate of capital growth, while present

worth measures absolute size of an investment opportunity. Since various profit criteria often measure slightly different values, it can be advantageous for the manager to combine the use of several criteria in evaluating investment alternatives. IRR may still be the best alternative for the manager, particularly where capital is the primary limiting factor (Webster, 1965). Given that all other things are equal, a high rate of return on any investment is preferable to a low one, and all available funds can be invested in the higher yielding options.

The use of IRR as an economic measure of investment efficiency can also augment capital budgeting techniques. Capital budgeting involves the generation of investment proposals, the estimation of cash flows for the proposals, the evaluation of cash flows, the selection of projects based upon an acceptance criterion, and the continual re-evaluation of investment projects after their acceptance (Van Horne, 1977). There are instances where many investment alternatives are available to the administrator, and rather than being mutually exclusive, any or all may be selected. In such cases, a ranking by IRR and capital budgeting techniques would aid greatly in the decision process. However, the same problems of time and scale must be considered here as in contrasting any valid investment comparisons (Marty, 1976).

Other factors beside economic considerations often affect investment decisions. Financial analysis has not been widely used in public management planning in the United States, and the inappropriateness of a strictly financial analysis system has slowed its application (Marty, 1975). This is particularly true for public

administration of natural resources such as forestry, where specific biological factors, legal or external institutional constraints, organizational factors or constraints, and objectives other than efficient timber management must be taken into account in addition to economic consideration. Marty (1975) suggests "comprehensive analysis" for such investments, which includes not only benefit-cost analysis and environmental impact analysis, but also recognizes the diversity of effects and allows for decisions which are necessarily judgmental.

Uncertainty in timber management investments, although important, has not been adequately handled by existing models for analyzing alternatives. Newport (Lundgren and Thompson, 1972), Worrell (1959), and Dowdle (1962), address the problem of uncertainty in relation to forest management investments by utilizing a predetermined, often random, percentage estimate of costs in the investment evaluation. Thompson (1968) suggested Bayesian decision theory as a model for forest management decision-making under uncertainty. As another solution, Marty (1964) simplified the choice among investments with uncertain predicted outcomes by varying assumptions about underlying conditions. But his method is difficult to apply and warranted only when the final choice is important enough to justify the necessary analytical costs. With certain assumptions in investments with returns equally distant in time, uncertainty can be ignored (Flora, 1964).

In reviewing profitability measures for use in evaluating forest investment opportunities, the concept of financial maturity cannot be overlooked. Financial maturity is the point where the current value growth rate of a tree or stand equals the alternative rate of return

(Duerr, 1969). It is a marginal analysis, and is a form of contribution to present net worth (Webster, 1965). The principle of financial maturity is consistent with traditional soil rent theory and is also advocated by Duerr, Fedkiw, and Guttenburg (1956). Worrell (1953), on the other hand, advocated IRR over the financial maturity method, as financial maturity considers only the cost of leaving funds tied up in the form of standing timber, neglecting the opportunity cost associated with the land occupied by the timber.

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