INVESTMENT ANALYSES

of Stand Improvement and Reforestation Opportunities in Appalachian Forests

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Contents

THE DECISIONS TO BE MADE

EFFECTIVE distribution of limited funds among many worthwhile activities is central in the planning and control of successful programs. And because administrators of forest-management programs must consider the need for timber-stand improvement and reforestation, criteria are needed for allocating available funds to the particular kind of projects that will yield greatest returns.

In a study carried out on the George Washington National Forest, 72 of the existing 143 site-stand condition classes were designated as candidates for timber-stand-improvement or conversion projects. But which projects are worth undertaking, and which should receive priority? These are decisions that confront program administrators and forest managers alike.

To help them in this we have made investment analyses of the 19 most prevalent (modal) project classes, which together encompass almost 124 thousand acres of this Forest in Virginia and West Virginia. By providing a basis for rating and comparing opportunities, these appraisals suggest what kinds of projects to favor in planning an efficient program for stand improvement and stand conversion.

STUDY APPROACH

At least two alternatives must be compared to evaluate a potential timber-stand-improvement or conversion opportunity. In this study we were concerned with expected rates of return on investment in stand treatment. Specifically, these rates reflect the difference between costs and returns for managing a timber stand under (1) a program with an initial investment in timber stand treatment followed by stand management that can include additional treatment investments as well as commercial timber cutting, and (2) a program in which the initial treatment is not made and any subsequent cutting is done exclusively by commercial timber sale.

Both stand-management programs include intermediate cutting to promote rapid growth but maintain adequate stand density to provide a fully stocked stand at maturity. These intermediate cuts are scheduled when at least 25 percent of the stand's basal area can be removed—provided, in the case of commercial cutting, this yields 2 thousand board feet of sawlogs or 5 cords of pulpwood per acre, the minimum net volume needed to be commercially operable.

Measuring Economic Desirability

The essential analytical concepts underlying investment analyses stress consistency and a standard method for evaluating stand-treatment opportunities as outlined by Marty et al. (*1966*). Our appraisals evaluate each project according to investment potential as measured by its internal rate of return. That is, the expected rates of return on investment in each stand-treatment project are based on value added by the project beyond that available from the untreated stand—in relation to the cost and length of time required to bring the stand to harvest.

Sequence of Evaluation

The sequence of evaluation includes choosing the project, estimating added yield, determining project cost, valuing additional yield, and computing rate of return. These steps concentrate attention upon the many factors (fig. 1) that play a part in defining project costs and returns.

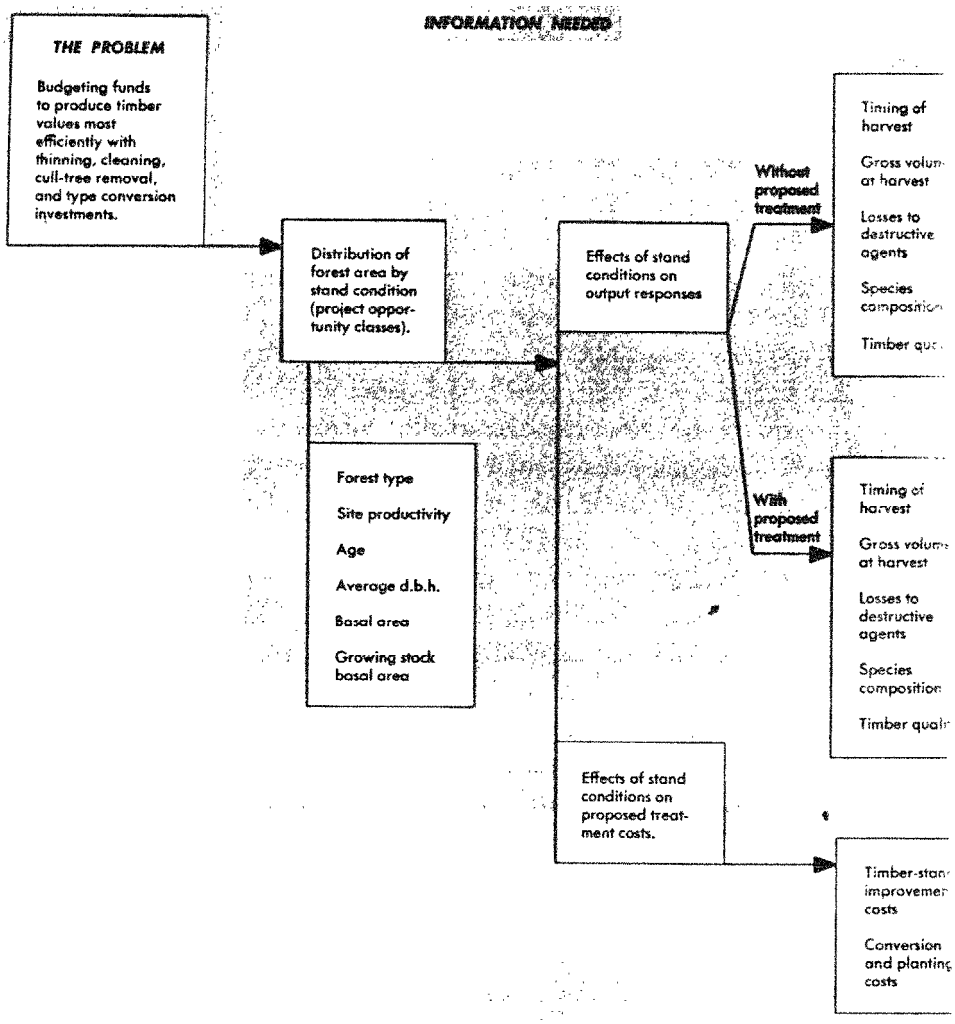
Timber stand conditions and the treatments, costs, markets, and prices used in these analyses are those experienced on the George Washington National Forest. The resulting rates of return apply directly to the most common project-investment opportunities found on this Forest. The results may extend to other properties under public forest management if similar conditions make this group of projects most important there also. However, projects omitted here because of their limited extent on the George Washington may provide higher rates of return than projects included in the analyses, and might be important elsewhere.

Project Selection

Site-stand conditions, together with their prescribed treatments, define project opportunities. By subdividing stand conditions into fairly homogeneous groups and choosing the most representative project opportunity from each group, we can make a single evaluation that can serve for a range of similar projects.

Project opportunities were selected for evaluation by choosing the "modal" or most frequently occurring conditions on the George Washington National Forest. Compartment examination and timber-inventory records provided a set of site-stand condition classes and an indication of the extent of each class. For each class a modal site-index and stand condition were determined, representing the most frequent situation within that class. Grouping of forest conditions involved six factors: forest type, site class, main-stand size class, age class, total basal area, and basal area in growing-stock trees. Three forest types were included in the study: conifer, oak, and cove hardwood. Three levels of site quality were used to subdivide each type. The four main-stand size classes used were seedling-and-sapling stands, pole stands, small sawtimber stands, and large sawtimber stands. Ten 20-year age classes and nine 20-square-foot basal-area classes formed the final classifications. Total basal area includes all four main-stand tree classes: desirable, acceptable, undesirable, and cull. Growing stock includes only desirable and acceptable trees.

Treatments tailored to modal conditions of each site-stand class were assigned on the basis of common practice, available management guides, and research information. In general, intermediate or improvement cuts are undertaken to increase timber yield (both volume and value) by reducing overstocked or fully stocked stands toward the lowest level of residual basal-area stocking that allows trees to fully utilize the site. The *Timber management guide for upland central hardwoods* (*Roach and Gingrich 1962*) identifies this basal area as the B-level of stocking, and the lower limit of stocking that is needed to reach the B level in 10 years on average sites as the C-level (fig. 2). A third stocking-guide level, B^1, was used to define the minimum total basal area that would allow intermediate cuts to include at


THE PROBLEM
Budgeting funds to produce timber values most efficiently with thinning, cleaning, cull-tree removal, and type conversion investments.
INFORMATION NEEDED
Distribution of forest area by stand condition (project opportunity classes).
Forest type
Site productivity
Age
Average d.b.h.
Basal area
Growing stock basal area
Effects of stand conditions on output responses
Without proposed treatment
With proposed treatment
Timing of harvest
Gross volum at harvest
Losses to destructive agents
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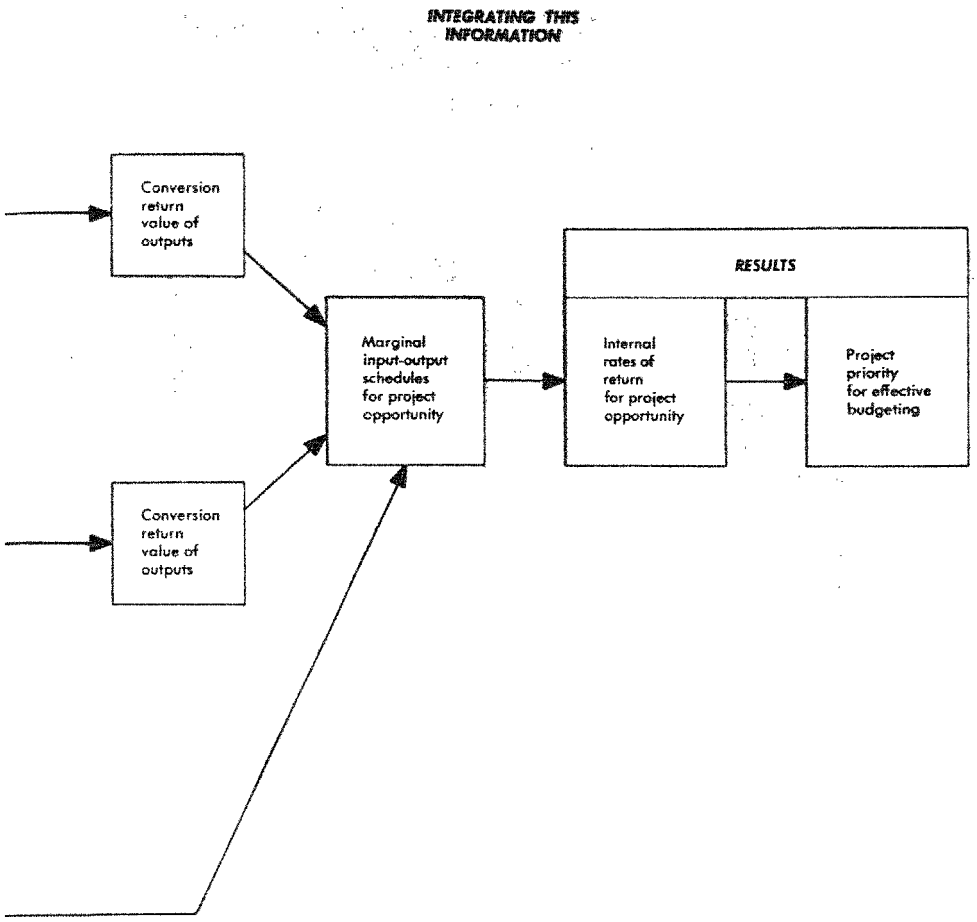

Figure 1.—Steps in the analysis of opportunities for timber-stand improvement and restocking.

least 25 percent of the total basal area and still keep residual stocking at the B-level.

These stocking-guide levels provide a framework for identifying likely timber-stand-improvement or conversion opportunities. Stands with less than C-level of basal area per acre in growing-stock trees were considered for a type-conversion treatment. Those with a growing-stock basal area above C-level per acre but a total basal area less than B^1 per acre were to be retained but were considered to need no immediate treatment. Stands with growing-stock basal areas above C and total basal areas above B^1 per acre were considered to be candidates for a thinning treatment.

From the 72 site-stand condition classes identified by these criteria as candidates for treatment, 15 project opportunities involving the greatest acreage, plus 4 that represented younger age classes, were selected for evaluation. All selected projects fell in

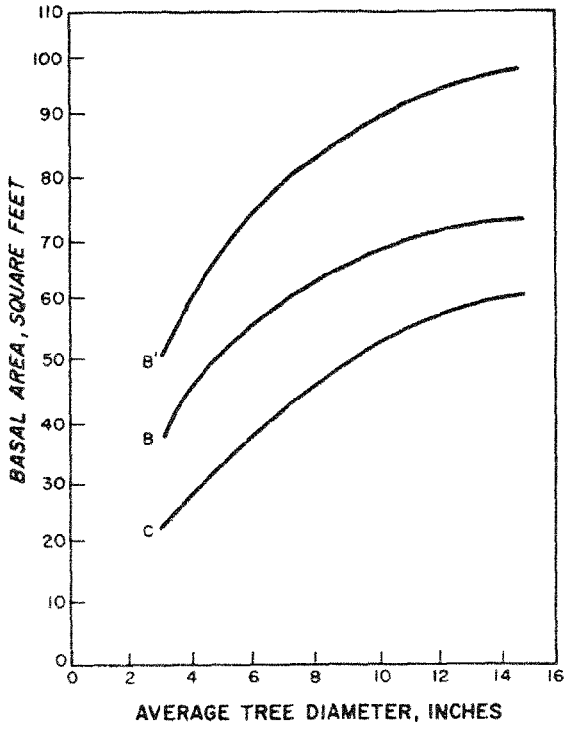

Figure 2. Upland hardwood basal area guides used for stand treatment prescription.

the oak forest type. In appendix B a complete description and schedule of costs and returns is given for each of these project opportunities.

RESULTS - - EVALUATING THE OPPORTUNITIES

We have used three cost and price levels to reflect low, average, and high job-difficulty in stand-treatment and timber-harvest activities; with market availability options for (1) both sawtimber and pulpwood, and (2) sawtimber only. Accordingly, under each market situation, the average and likely high and low limits for expected rates of return were computed for each project opportunity. This enables us to rank projects on the basis of their expected productivity so that those with the highest rates of return can be financed first. And those projects falling below some minimum level of economic desirability can be excluded from the competition for funds.

These evaluation procedures are discussed further later. But for those readers interested mainly in finding out how projects ranked and their relationships, the foregoing view of the evaluation process should suffice.

Results from these modal project analyses (table 1) show that immature timber stands on above-average sites would logically get priority for timber-stand-improvement funds; first in areas where only sawtimber markets are available, then where there are markets for both sawtimber and pulpwood. Having a pulpwood market for intermediate cuttings reduces the additional value to be gained by undertaking stand-improvement projects.

Where oak timber stands are more than 60 years old it is doubtful if expected rates of return are sufficient to justify stand-improvement projects. This is also the case for stands where high costs and low returns are anticipated because of stand conditions and location.

Furthermore, under current financial conditions, adequate rates of return for type-conversion projects on medium oak sites (site

Table 1.—Rates of return for project opportunity classes[1] according to market availability and cost-return options

Project opportunity class	Class definition (main stand)					Internal rates of return					
				Basal area		Sawtimber market only			Sawtimber and Pulpwood markets		
	Site index	Stand age	Average d.b.h.	Total	Growing-stock level[2]	Ave. cost, ave. return	Low cost, high return	High cost, low return	Ave. cost, ave. return	Low cost, high return	High cost, low return
	Feet	*Years*	*Inches*	*Sq. ft.*		%	%	%	%	%	%
A — Thinning	71+	41- 60	5.0-10.9	81-100	>B	7.5	11.2	4.6	6.7	6.0	4.6
B — Thinning	51 - 70	41- 60	5.0-10.9	81-100	>B	6.8	13.7	1.2	6.5	0.1	1.2
C — Thining & weeding	51 - 70	21- 40	5.0-10.9	101-120	>B	4.5	7.9	0.5	3.2	4.4	0.5
D — Thinning	71+	21- 40	5.0-10.9	101-120	>B	4.2	5.2	2.7	0	0	2.7
E — Thinning	51 - 70	41- 60	5.0-10.9	101-120	>B	3.5	7.1	1.1	1.9	1.6	1.1
F — Thining & weeding	51 - 70	41- 60	1.0- 4.9	61- 80	>B	3.4	5.8	0.9	3.5	6.2	0.9
G — Thinning	51 - 70	61- 80	5.0-10.9	101-120	>B	2.3	3.7	0	2.4	3.5	0
H — Thinning	51 - 70	61- 80	5.0-10.9	81-100	>B	1.2	0.6	1.7	1.6	0.4	1.7
I — Thining & weeding	51 - 70	21- 40	1.0- 4.9	81-100	>B	0	7.1	2.1	0	7.0	2.1
J — Thinning	51 - 70	21- 40	5.0-10.9	121-140	>B	0	0	0.3	0	0	0.3
K — Thinning	31 - 50	61- 80	5.0-10.9	81-100	>B	0	3.0	0	0	1.4	0
L — Thinning	31 - 50	41- 60	5.0-10.9	81-100	>B	0	1.0	0	0	0	0
M — Thining & weeding	31 -50	41- 60	1.0- 4.9	81-100	>B	0	0	0	0	0	0
N — Conversion	51 - 70	101-120	11.0-16.9	101-120	<C	3.8	6.1	0	4.2	6.2	0
O — Conversion	51 - 70	121-140	11.0-16.9	81-100	<C	3.7	5.8	0	4.1	6.5	0
P — Conversion	51 - 70	41- 60	5.0-10.9	61- 80	<C	3.5	5.6	0	4.0	6.2	0
Q — Conversion	31 - 50	121-140	11.0-16.9	81-100	<C	0	2.8	0	0.3	2.8	0
R — Conversion	31 - 50	41- 60	5.0-10.9	81-100	<C	0	2.5	0	0.2	2.6	0
S — Conversion	31 - 50	101-120	11.0-16.9	121-140	<C	0	2.6	0	0.4	1.9	0

[1] See appendix for complete description of each project opportunity.
[2] Refers to stocking-guide levels in figure 2.

index 51–70) appear rather limited. These projects would probably be confined to low-cost—high-return situations, favoring locations where both sawtimber and pulpwood could be sold to minimize the initial cost of conversion. And unless nontimber benefits are important, projects to convert oak stands to pine probably would not be undertaken where oak site index is less than 50 feet. Investment analyses for these conversion opportunities indicate that the return on investment would be, at best, less than 3 percent.

DISCUSSION

Evaluations of modal project opportunities are intended to give expected rates of return on investment for each project considered. These rates of return then permit this group of projects to be ranked according to economic desirability. Therefore, consequent project ratings represent only the modal conditions of opportunities that were evaluated. They do not give adequate information for accurately predicting where other sets of stand conditions might fit into this group. However, we can rationalize why certain project opportunities apparently rank above or below others.

Interaction of Timber-Stand Characteristics

Timber-stand characteristics influence each project's cost, value added, and interval between investment and return. How they interact determines the project's economic desirability. And how well a project ranks according to economic desirability depends on what other combinations of timber-stand characteristics are represented in the in group of projects being evaluated.

A long period of time until harvest can minimize benefits from stand treatment done early in the rotation. Such extended timespans increase the probability that commercial timber sales alone will accomplish desired stocking, species composition, and grade structure changes in untreated stands. Also, where time between investment and return varies from one project to another, the value growth rate (rate of return) for equal treatment expendi-

tures will be less on a project requiring a longer period of time to accomplish similar changes in value.

When crop-tree diameter goals are used to determine rotation length, as in this study, the beginning modal diameter-class of a project opportunity influences the time period until final harvest. This means that, given similar project expenditures and changes in value, projects in stands with larger diameter trees yield a higher rate of return. Furthermore, if crop-trees on the more productive sites have larger diameter specifications for final harvest, the project investment interval might be longer than on projects on poorer sites. In such cases, despite the greater timber growth rate possible on a good site, a project on a medium site could yield a higher return to treatment because of its shorter period of investment.

Effect of Opportunity Costs

Some projects classified as low cost on the basis of invested funds might not be classed as low-cost projects if opportunity costs (income foregone in the untreated timber stand), are included with direct costs. Rates of return are usually highest for project opportunities in low-cost—high-return situations. However, exceptions occur if the opportunity cost, compared to value resulting from stand treatment, is proportionately greater in the low-cost—high-return option than in other cost-return options for the project. For example, under a high-cost—low-return combination an untreated timber stand might have insufficient value to justify a commercial timber-cutting operation. In this case the rate of return for a stand-improvement project simply reflects the treatment expenditure and return value of the treated stand—opportunity cost is zero. As a result, a high-cost—low-return combination can give the best rate of return for some projects.

On the other hand, anything tending to give the untreated timber stand greater value, such as having markets for pulpwood as well as sawtimber, usually increases the opportunity cost. Consequently, an investment in stand improvement normally has the greatest impact where intermediate removal of timber volume by sale of products, such as pulpwood, is not possible.

However, the effect of opportunity cost (income foregone) on stand-improvement projects differs from its effect on conversion projects. Both types of projects generally face higher opportunity costs where markets are available for other timber products in addition to sawtimber. But because these markets enable harvesting more of the hardwood stand they also reduce the initial treatment cost for conversion projects. Therefore, despite the higher opportunity cost, investments in timber-stand conversion usually earn a better rate of return where both sawtimber and other timber products can be sold.

It should be noted that several major considerations underlie the evaluation of conversion opportunities:

- First, markets are assumed to be available for the pine sawtimber and pulpwood produced on the areas converted from hardwoods.
- Next, present stand conditions are assumed to be representative of what the area produces as a hardwood stand without additional investment.
- Finally, rates of return for conversion opportunities are considered to be measured at maximum levels because the cost and values expected from conversion to pine are compared with values expected from the understocked hardwood stand.

The resulting rates of return are partial analyses for type-conversion projects. They can be used to guide policy decisions to convert poor oak site areas to pine rather than have them recur as less productive hardwood stands. But conversion rates of return alone do not necessarily indicate the optimum investment for an area—for this purpose they must be weighed against other alternatives such as investing to establish a productive hardwood stand on the area.

Limitations of Return-Rate Estimates

Obviously the reliability of return-rate estimates involves the relative strengths and weaknesses of the data used to determine them. Cost data, output-response data, and dollar prices for converting output responses to a common basis will not always be

exactly correct or unaffected by time. Thus the rate-of-return estimates for modal projects are not likely to be exactly correct—although they accurately establish relative priority among projects.

Long-term studies will eventually provide better and more complete information for accurate prediction of output responses. Until then decision-making must rely on the best evidence available at the time.

Moreover, product prices and processing costs may change in time; and differential price and cost changes could have a direct effect on comparisons among projects. That is, if harvesting and processing efficiency or product demand change more rapidly for some kinds of timber than for others, then projects yielding more of the favored timber than other projects would have a greater change in value of additional yield relative to present prices. But again, decision-making must be based on current prices until more reliable projections of future prices are available.

Finally, return-rate estimates for modal projects are based on dollar costs and returns of timber production. In this respect they measure only the net effect of tangible costs and returns to projects. For some projects, however, intangible or unmeasurable aspects can have important and even overriding influence on their desirability. For example, timber-stand improvement or conversion may occasionally cause gains or losses to wildlife habitat, watershed, and scenic values in the area being treated. However, judging the effect of these intangibles on specific projects is left to those who apply the modal project evaluations.

PROCEDURES UNDERLYING THESE ANALYSES

Estimating Yield

The first task in estimating value gained by stand treatment is to determine anticipated timber yields. Timber yields for the modal stands were projected both with and without prescribed treatment from the initial stand conditions to the final harvest. To determine when stand projections attained rotation age, the

following guideline relating crop-tree diameter goals to site quality for the oak forest type was used:

Site-index class (feet)	*Rotation d.b.h. class* (inches)*
40	14
60	20
80	26

*Weighted by species composition.

The projection of stand volume was done in terms of basal area, using a 10-year growth and inspection cycle. Stands were projected over each 10-year period at normal growth rates estimated to be the result of intensive management. These growth rates were developed with a modification of Meyer's *(1937)* method for estimating normal mortality and gross yield, using the following normal yield tables: Schnur *(1937)* for hardwoods, and Schumacher and Coile *(1960)* or Frothingham *(1914)* for pine. In addition, if stand treatment or commercial thinning reduced stocking down to B-level all normal mortality was considered "pre-harvested" for the next growth period, and was added to the period's normal growth rate to estimate gross response. When stands contained more than B-level basal area, they were projected at normal growth rates but the addition of normal mortality was reduced in proportion to the position of their stocking between B-level and normal stocking.

Basal area removals indicated in these stand projections were converted to gross volumes per acre by applying volume/basal-area ratios for each stand's average d.b.h. and merchantable height at the time of scheduled cutting.

Next we obtained separate estimates for losses to insects, disease, and planting failures based on the judgment estimates of research foresters. Fire losses were estimated from the probability of having a killing fire during the rotation (*Webster 1960*). These loss estimates for each projected stand, together with cull estimates based on the stand's timber merchantability and soundness classification projected from inventory data, were deducted from gross volumes to get estimates of net volume output.

Species composition.—Initial species composition for the modal

stands was obtained from George Washington National Forest timber-inventory data. These data give species by percent of net cubic-foot volume per acre for growing-stock trees 5.0 inches d.b.h. and larger. Species composition goals and the consequent changes required in modal stands to attain these goals were based on Forest Service timber-management guides (table 2).

The amount of change toward a species-composition goal for the final harvest was estimated by the relative amount of growing-stock basal area removed from the stand during intermediate cutting. For example, differences between the initial and desired species compositions shown in table 2 for oak forest type, site index 60 stands, amount to an overall change of 21 percent. Removing at least 21 percent of the growing-stock basal area, either in one cut or cumulatively, was considered sufficient to both remove undesirable species and cause subsequent growth to be distributed so as to fully attain the goal. Cutting, say, 10 percent of the growing-stock basal area would only achieve approximately

Table 2.—Initial and desired species composition by site index class, oak forest type, in percent[1]

Species or species group	Species composition for —					
	Site index 40		Site index 60		Site index 8(	
	Initial[2]	Desired	Initial[2]	Desired	Initial[2]	Desir
Red oak	3	3	6	10	15	23
Black oak	9	9	13	20	19	19
White oak	4	4	13	20	16	24
Chestnut oak	49	50	33	25	26	18
Scarlet oak	14	7	12	9	11	5
Yellow poplar, basswood, cucumber tree	—	—	2	4	1	2
Sugar maple, black locust, black cherry	1	1	2	2	1	2
Red maple, black birch, beech	1	0	2	0	5	0
Hickory	3	0	7	0	1	0
Black gum	1	0	1	0	1	0
White pine	—	—	1	2	3	6
Yellow pine	15	26	8	8	1	1
Total	100	100	100	100	100	100

[1] Percent of net cubic-foot volume per acre of growing-stock trees 5.0 inches d.b.h. and lar
[2] From George Washington National Forest, 1954-59 inventory.

half the desired change. The initial species composition of the stand was applied to yields from intermediate cutting.

Log-grade distribution.—Log-grade distribution for hardwood butt logs in the initial stand condition was also obtained from George Washington National Forest timber-inventory data. Butt-log grade distributions reported by Trimble *(1965)* were considered attainable at final harvest with an intensive hardwood management program. Both log-grade distribution tables appear in appendix A.

Changes in butt-log grade distribution were gaged according to the relative proportion of desirable versus acceptable growing-stock basal area in the stand initially and at rotation age. Removing all the acceptable basal area from the stand by intermediate cutting—that is, leaving only desirable basal area in the stand—produced a butt-log grade distribution as shown by Trimble *(1965)*. Removing less than the full amount of acceptable growing stock resulted in proportionately less of a move from the initial to the desired grade distribution.

Grade distribution for the entire tree was expanded from butt-log distribution on the basis of d.b.h. and merchantable height in logs by using information developed at the Fernow Experimental Forest.[1] As with species composition, butt-log distribution for the output of intermediate cutting was the same as in the initial stand condition.

Estimates of grade distribution in the sawtimber yield from stands converted to white pine were based on Forest-Survey data *(Ferguson 1964)* modified to include more recent log-grading experience. The following white pine grade distributions were used:

Type of cut	*Stand age (years)*	*Log grade* 1 (%)	2 (%)	3 (%)
Thinning	50	—	—	100
Thinning	60	—	50	50
Thinning	70	20	30	50
Harvest	80	25	35	40

[1]Unpublished data on file at Northeastern Forest Experiment Station, Upper Darby, Pa.

Options Evaluated

Because of the variety of locations and physical settings in which a project opportunity can occur, each has a range of possible situations for cost of treatment, market availability, unit value of output, and timber sales preparation cost. The following options were included in the analyses:

1. Project costs.—Typical costs per acre for the prescribed stand treatment and, in addition, likely high and low levels of this cost are quantified for each project opportunity. Costs used were based on 1963 and 1964 operations. These costs were calculated for three levels of job difficulty. At each level we (1) used equations relating labor-time and chemical used to the sum of diameters of the trees treated; (2) added reconnaissance and transportation charges corresponding to the level of accessibility for getting men and materials to and from the projects; and (3) increased each field cost 15 percent to cover miscellaneous and overhead expenses. This provided three total treatment cost figures for each project.

No attempt was made to analyze the costs of different treatment techniques; rather, the three treatment cost levels for each project opportunity permit choosing one that would best reflect doing the job in a specific timber stand. Such factors as stand accessibility, steepness, and ground condition, as well as techniques, could determine which cost level should represent a particular stand.

2. Markets.—Market availability for hardwood species is divided into (1) sawtimber markets only, and (2) sawtimber and pulpwood markets. Further, under both categories markets are assumed to be available for pine pulpwood and pine sawtimber as well as for operable volumes of small hardwood sawtimber cut in intermediate treatments.

3. Timber values.—Timber yield is valued at the conversion-return level, using dollars per unit of output based on average sales value (fiscal-year 1962–64) by products, species, and where possible, by log grade. In addition, high and low conversion-return values were determined as influenced by corresponding low and high costs for harvesting and transporting forest products

Table 3.—Conversion-return values[1] for standing timber by species (group), product, and price level

Species or species-group	Log grade	Price level		
		Average	Low	High
	SAWTIMBER			
	Dollars per M board feet Int. 1/4-inch rule			
Red oak	1	74	53	107
	2	32	12	62
	3	4	(−14)	28
Black oak	1	48	30	71
	2	13	(−2)	32
	3	1	(−20)	21
White oak	1	85	69	104
	2	36	21	55
	3	9	(−7)	37
Chestnut oak	1	25	7	44
	2	5	(−12)	27
	3	3	(−20)	20
Scarlet oak	(*)	11	(−9)	31
Yellow-poplar, basswood, cucumber tree	1	70	50	90
	2	45	27	65
	3	31	13	60
Sugar maple, black cherry, black locust	(*)	26	(−6)	58
Red maple, black gum, black birch, beech, hickory	(*)	4	(−13)	30
Yellow pine	(*)	13	(−10)	38
White pine	(*)	19	(−4)	43
	1	38	—	88
	2	20	—	46
	3	10	—	23
	PULPWOOD			
	Dollars per cord			
Hardwood	—	0.60	(−3.10)	5.60
Pine	—	3.20	(−0.30)	7.50

[1] These values include the addition to income for both the stumpage producer and processor, and the increase of permanent asset value (system development roads) on the George Washington National Forest, fiscal-year 1962-64.

* Ungraded.

(table 3). Separate timber-yield values were computed for each of these price levels.

Table 3 includes a number of negative conversion returns. Since timber volume projections would be affected if trees with a negative value are not felled, these negatives were subtracted from the positives to get stand yield values for intermediate cuts.

These conversion-return values are appropriate for public programs because they approximate the total increase in income to the economy from harvest of public timber *(Marty and Mott 1964, p. 22; Marty 1966, p. 12)*. They include the addition to income for both the stumpage producer and processor, and the increase of permanent asset value (system development roads) on the National Forests.

Again as with treatment costs, selecting an appropriate price level for a specific timber stand depends upon the stand's location and physical characteristics.

4. *Timber-sale preparation expenses.*—The alternative timber-management programs (with treatment or untreated) result in different amounts of volume per acre to be harvested. It follows that costs per acre for timber-sale preparation will also differ. Timber marking and associated travel costs at $1.30, $2.20, and $0.65 per thousand board feet were used to compute corresponding average, high, and low timber-sale preparation costs for each timber sale's yield per acre.

Computing Rate of Return

The costs and added values for each modal project were used to compute the projects' rate of return. Income and expense schedules for each stand-management program were cast into a "marginal" schedule, which indicated the difference between the treated and untreated programs. Incomes in this schedule were those received in the treated-stand program beyond those available in the program without treatment, or any expenses in the untreated program that would be avoided in the treated program. Similarly, expenses in the marginal schedule were either those incurred in the treated program or incomes foregone in the untreated program (opportunity costs). The computer program

described in Marty et al. *(1966)* was used to measure the rate at which investment in each project grows towards the return it eventually generates, taking into account the amount and timing of costs and returns.

SUMMARY AND CONCLUSIONS

The system of analysis described here is designed to provide an investment-opportunity guide for timber-stand-improvement and conversion work on National Forests in the Appalachian Mountains. The project opportunities are for modal site-stand condition classes selected because of their importance on the George Washington National Forest. Low, average, and high cost and price options for each project are considered with markets available for both sawtimber and pulpwood, and for sawtimber only. The investment guide for each project is internal rate of return per acre resulting from treatment. Forest administrators can use these guides to rank the relative economic desirability of alternative project opportunities.

In terms of individual project-opportunity classes, the relative desirability of stand treatment varies according to the stands' physical aspects regarding accessibility and job difficulty, and its location with respect to timber-product markets. Timber-stand-improvement projects undertaken where markets are available for both pulpwood and sawtimber nearly always return less to treatment than the same project undertaken where only sawtimber can be sold. This is because intermediate cuttings for pulpwood give untreated stands greater value, which in effect narrows the benefit that stand treatment can achieve beyond that available without treatment.

With timber-type-conversion projects, however, pulpwood cutting is not so important for the added value it gives untreated stands, but rather for the reduction of initial treatment cost that results from being able to harvest more of the original timber stand. Consequently, in contrast to timber-stand-improvement projects, conversion projects nearly always return more to treat-

ment when undertaken where markets exist for both pulpwood and sawtimber.

Among the projects evaluated, priority for program funds would logically go to stand-improvement projects in immature timber stands on above-average (site index 71+) sites. Next follow projects on medium (site index 51–70) sites where, along with stand improvement in immature stands, a few worthwhile opportunities occur for type conversion in low-cost—high-return situations. Rates of return are generally inadequate to justify timber-stand-improvement projects for oak timber stands over 60 years old or in situations where high costs and low returns are anticipated. Similarly, unless non-timber benefits are important, type-conversion projects probably would not be undertaken where oak site index is less than 50 feet.

Timber-stand characteristics influence each project's cost, value added, and interval between investment and return. How they interact determines the project's economic desirability. And how well a project ranks according to economic desirability depends on what other combinations of timber-stand characteristics are represented in the group of projects being evaluated.

This group of projects or alternative courses of action are important to the managers of a National Forest. And the relative project priority can also apply elsewhere if similar conditions exist. The analyses are directed toward assisting the decision-maker—their main role should be to sharpen his intuition and judgment for making long-range planning decisions in timber-stand-improvement and stand-conversion programs.

■

LITERATURE CITED

Ferguson, Roland H.
1964. THE TIMBER RESOURCES OF WEST VIRGINIA. U. S. Forest Serv. Res. Bull. NE-2. 123 pp., illus. NE. Forest Exp. Sta., Upper Darby, Pa.

Frothingham, E. H.
1914. WHITE PINE UNDER FOREST MANAGEMENT. U. S. Dept. Agr. Bull. 13. 70 pp., illus.

Marty, Robert.
1966. ECONOMIC GUIDES FOR BLISTER-RUST CONTROL IN THE EAST. U. S. Forest Serv. Res. Paper NE-45. 14 pp., illus. NE. Forest Exp. Sta., Upper Darby, Pa.

Marty, Robert, and Gordon D. Mott.
1964. EVALUATING AND SCHEDULING WHITE-PINE WEEVIL CONTROL IN THE NORTHEAST. U. S. Forest Serv. Res. Paper NE-19. 56 pp., illus. NE Forest Exp. Sta., Upper Darby, Pa.

Marty, Robert, Charles Rindt, and John Fedkiw.
1966. A GUIDE FOR EVALUATING REFORESTATION AND STAND IMPROVEMENT PROJECTS. U. S. Dept. Agr. Agr. Handbk. 304, 204 pp., illus.

Meyer, Walter H.
1937. YIELD OF EVEN-AGED STANDS OF SITKA SPRUCE AND WESTERN HEMLOCK. U. S. Dept. Agr. Tech. Bull. 544. 86 pp., illus.

(Roach, Benjamin A., and Samuel F. Gingrich.)
1962. TIMBER MANAGEMENT GUIDE FOR UPLAND CENTRAL HARDWOODS. U. S. Forest Serv. Central State Forest Exp. Sta. 33 pp., illus.

Schnur, G. Luther.
1937. YIELD, STAND AND VOLUME TABLES FOR EVEN-AGED UPLAND OAK FORESTS. U. S. Dept. Agr. Tech. Bull. 560. 87 pp., illus.

Schumacher, F. X., and T. S. Coile.
1960. GROWTH AND YIELDS OF NATURAL STANDS OF SOUTHERN PINES. 115 pp., illus. T. S. Coile, Inc., Durham, N. C.

Trimble, George R. Jr.
1965. IMPROVEMENT IN BUTT-LOG GRADE WITH INCREASE IN TREE SIZE FOR SIX HARDWOOD SPECIES. U. S. Forest Serv. Res. Paper NE-31. 15 pp., illus. NE. Forest Exp. Sta., Upper Darby, Pa.

Webster, Henry H.
1960. TIMBER MANAGEMENT OPPORTUNITIES IN PENNSYLVANIA. U. S. Forest Serv. NE. Forest Exp. Sta., Sta. Paper 137. 37 pp., illus.

APPENDIX

A

Table 4.—Current distribution of butt-logs in growing-stock trees in the oak type by species and 2-inch d.b.h. class[1]

(In percent)

D.b.h. class (inches)	Species or species group											
	Red oak, black oak			White oak			Chestnut oak			Yellow-poplar, basswood, cucumber tree		
	Butt-log grade			Butt-log grade			Butt-log grade			Butt-log grade		
	1	2	3	1	2	3	1	2	3	1	2	3
12	—	—	100	—	—	100	—	—	100	—	—	100
14	—	25	75	—	30	70	—	14	86	—	34	66
16	—	40	60	4	40	56	2	25	73	1	44	55
18	2	52	46	8	48	44	3	37	60	9	43	48
20	12	54	34	12	52	36	4	48	48	16	42	42
22	21	53	26	21	52	27	12	51	37	22	41	37
24	29	52	19	30	51	19	22	51	27	28	40	32
26	37	51	12	40	50	10	34	50	16	34	40	26

[1] From George Washington National Forest 1954-59 inventory.

Table 5.—Butt-log grade distribution considered attainable at final harvest through intensive management, by species and 2-inch d.b.h. class[1]

(In percent)

D.b.h. class (inches)	Species or species group											
	Red oak, black oak			White oak			Chestnut oak			Yellow-poplar, basswood, cucumbertree		
	Butt-log grade			Butt-log grade			Butt-log grade			Butt-log grade		
	1	2	3	1	2	3	1	2	3	1	2	3
12	—	—	100	—	—	100	—	—	100	—	—	100
14	—	24	76	—	40	60	—	62	38	—	45	55
16	19	17	64	21	39	40	60	22	18	17	51	32
18	34	13	53	38	31	31	67	18	15	45	33	22
20	54	16	30	52	23	25	75	13	12	66	20	14
22	72	17	11	62	19	19	81	9	10	80	10	10
24	86	12	2	71	14	15	86	6	8	90	4	6
26	96	4	—	81	10	9	91	3	6	97	0	3

[1] From Trimble 1965; U. S. Forest Service Res. Paper NE-31.

APPENDIX B

All projects discussed are for the oak timber type identified as having 50 percent or more of net cubic-foot volume in white, black, scarlet and chestnut oaks, with which hickory, yellow-poplar, yellow pine, white pine, and maples are commonly associated.

Each project is described below together with its schedule of costs and returns. The schedules identify (1) treatment cost, (2) timber value of the untreated stand (income foregone or opportunity cost as discussed here), (3) timber value resulting from the stand treatment (income), and (4) changes in timing of timber removal or rotation age caused by stand treatment.

For example, in the schedule for Project A under the average cost-return combination, treatment at stand age 50 costs $11.40 per acre. With markets for sawtimber only, income foregone from the untreated stand management program amounts to $17.15 at age 80 and $338.70 at age 120 for intermediate and final harvests per acre respectively, net of average costs for timber-sales preparation. The management program with stand treatment results in corresponding incomes of $10.90 at age 70 and $446.30 at age 100, indicating that treatment enables intermediate cutting 10-years sooner and shortens rotation length 20 years.

Under the high-cost — low-return column the schedule shows that only a final harvest is possible at these prices. And undertaking treatments at ages 50 and 70 shortens the rotation 20 years and triples income compared to the yield value for an untreated stand (both values minus high-level costs for timber-sales preparation).

PROJECT OPPORTUNITY A

Class title: Thinning well-stocked poletimber and small sawtimber stands on good sites.

	Class definition	*Modal stand conditions*	*Prescribed initial treatment*
Site index (oak at 50 years)	71+	80	Thinning and cull-tree deadening to remove 27 square feet of basal area per acre.
Age (years)	41-60	50	
Average d.b.h. (inches)	5.0-10.9	9.6	
Basal area (square feet)	81-100	93	
Growing stock basal area	$\geq$ B	88	

SCHEDULE OF COSTS AND RETURNS PER ACRE FOR PROJECT A

Item	Stand age (years)	Markets for sawtimber only			Markets for sawtimber and pulpwood		
		Average cost, average return	Low cost, high return	High cost, low return	Average cost, average return	Low cost, high return	High cost, low return
Cost:							
Treatment	50	$ 11.40	$ 7.00	$ 17.50	$ 11.40	$ 7.00	$ 17.50
	70	—	—	15.05	—	—	15.05
Income foregone	60	—	—	—	.70	43.15	—
	80	17.15	92.75	—	16.40	70.85	—
	110	—	—	—	361.15	716.20	—
	120	338.70	706.90	82.75	—	—	82.75
Income:	70	10.90	58.05	—	10.90	58.10	—
	100	466.30	845.20	249.90	471.40	858.70	249.90

PROJECT OPPORTUNITY B

Class title: Thinning well-stocked poletimber stands on medium sites.

	Class definition	*Modal stand conditions*	*Prescribed initial treatment*
Site index (oak at 50 years)	51-70	60	Thinning and cull tree deadening to remove 26 square feet of basal area per acre.
Age (years)	41-60	50	
Average d.b.h. (inches)	5.0-10.9	8.0	
Basal area (square feet)	81-100	91	
Growing stock basal area	$\geq$ B	69	

SCHEDULE OF COSTS AND RETURNS PER ACRE FOR PROJECT B

Income and cost items	Stand age (years)	Markets for sawtimber only			Markets for sawtimber and pulpwood		
		Average cost, average return	Low cost, high return	High cost, low return	Average cost, average return	Low cost, high return	High cost, low return
Cost:							
Treatment	50	$ 8.60	$ 4.80	$ 14.20	$ 8.60	$ 4.80	$ 14.20
	60	—	—	—	1.10	28.00	—
Income foregone	100	16.80	67.85	—	31.10	78.25	—
	120	172.10	375.35	58.90	157.75	451.10	58.90
	70	10.90	53.75	—	10.90	53.75	—
Income:	100	211.65	470.65	—	213.09	483.45	—
	110	—	—	80.55	—	—	80.55

PROJECT OPPORTUNITY C

Class title: Thinning and weeding well-stocked poletimber and sapling stands on medium sites.

	Class definition	*Modal stand conditions*	*Prescribed initial treatment*
Site index (oak at 50 years)	51-70	60	Thinning, weeding, and cull tree deadening to remove 38 square feet of basal area per acre.
Age (years)	21-40	30	
Average d.b.h. (inches)	5.0-10.9	6.3	
Basal area (square feet)	101-120	105	
Growing stock basal area	$\geq$ B	77	

SCHEDULE OF COSTS AND RETURNS PER ACRE FOR PROJECT C

Income and cost items	Stand age (years)	Markets for sawtimber only			Markets for sawtimber and pulpwood		
		Average cost, average return	Low cost, high return	High cost, low return	Average cost, average return	Low cost, high return	High cost, low return
Cost:							
Treatment	30	$ 12.20	$ 7.25	$ 19.05	$ 12.20	$ 7.25	$ 19.05
Income foregone	40	—	—	—	1.25	31.30	—
	70	16.45	74.15	—	4.15	10.45	—
	100	—	—	—	156.35	417.70	—
	110	115.50	360.05	7.40	—	—	7.40
Income:	50	—	—	—	1.45	37.30	—
	60	11.35	58.30	—	—	—	—
	80	20.05	69.55	—	—	—	—
	90	179.15	389.20	31.15	202.20	449.05	31.15

PROJECT OPPORTUNITY D

Class title: Thinning well-stocked poletimber stands on good sites.

	Class definition	*Modal stand conditions*	*Prescribed initial treatment*
Site index (oak at 50 years)	71+	80	Thinning and cull tree deadening to remove 32 square feet of basal area per acre.
Age (years)	21-40	30	
Average d.b.h. (inches)	5.0-10.9	8.4	
Basal area (square feet)	101-120	109	
Growing stock basal area	≥ B	105	

SCHEDULE OF COSTS AND RETURNS PER ACRE FOR PROJECT D

Income and cost items	Stand age (years)	Markets for sawtimber only			Markets for sawtimber and pulpwood		
		Average cost, average return	Low cost, high return	High cost, low return	Average cost, average return	Low cost, high return	High cost, low return
Cost:							
Treatment	30	$ 12.95	$ 8.15	$ 19.45	$ 12.95	$ 8.15	$ 19.45
	60	—	—	18.50	—	—	18.50
Income foregone	40	—	—	—	.65	45.25	—
	50	11.30	70.05	—	—	—	—
	60	—	—	—	14.10	60.60	—
	70	18.30	67.10	—	—	—	—
	90	—	—	—	41.80	125.85	—
	110	441.40	799.70	67.95	477.05	834.35	67.95
Income:	40	—	—	—	.70	35.70	—
	50	8.80	53.35	—	—	—	—
	60	—	—	—	13.10	57.25	—
	70	21.70	71.25	—	—	—	—
	80	—	—	—	35.80	106.65	—
	100	528.70	924.90	227.65	476.10	832.60	227.65

PROJECT OPPORTUNITY E

Class title: Thinning well-stocked poletimber stands on medium sites.

	Class definition	*Modal stand conditions*	*Prescribed initial treatment*
Site index (oak at 50 years)	51-70	60	Thinning and cull tree deadening to remove 35 square feet of basal area per acre.
Age (years)	41-60	50	
Average d.b.h. (inches)	5.0-10.9	8.0	
Basal area (square feet)	101-120	105	
Growing stock basal area	$\geq$ B	95	

SCHEDULE OF COSTS AND RETURNS PER ACRE FOR PROJECT E

Income and cost items	Stand age (years)	Markets for sawtimber only			Markets for sawtimber and pulpwood		
		Average cost, average return	Low cost, high return	High cost, low return	Average cost, average return	Low cost, high return	High cost, low return
Cost:							
Treatment	50	$ 15.70	$ 10.45	$ 22.65	$ 15.70	$ 10.45	$ 22.65
	60	—	—	—	1.50	47.85	—
	90	—	—	—	14.30	59.80	—
Income foregone	100	19.10	73.55	—	—	—	—
	110	—	—	—	175.60	382.65	—
	120	161.45	387.70	29.70	—	—	29.70
	80	14.80	62.75	—	14.80	62.75	—
Income:	100	—	—	84.65	—	—	84.65
	110	220.55	480.42	—	222.05	493.55	—

PROJECT OPPORTUNITY F

Class title: Thinning and weeding well-stocked poletimber and sapling stands on medium sites.

	Class definition	*Modal stand conditions*	*Prescribed initial treatment*
Site index (oak at 50 years)	51-70	60	Thinning, weeding and release to remove 27 square feet of basal area per acre.
Age (years)	41-60	50	
Average d.b.h. (inches)	1.0-4.9	2.9	
Basal area (square feet)	61-80	69	
Growing stock basal area	≥ B	39	

SCHEDULE OF COSTS AND RETURNS PER ACRE FOR PROJECT F

Income and cost items	Stand age (years)	Markets for sawtimber only			Markets for sawtimber and pulpwood		
		Average cost, average return	Low cost, high return	High cost, low return	Average cost, average return	Low cost, high return	High cost, low return
Cost:							
Treatment	50	$ 16.15	$ 9.80	$ 24.70	$ 16.15	$ 9.80	$ 24.70
	100	9.70	5.65	15.45	—	—	15.45
Income foregone	130	57.75	187.05	—	59.70	221.00	—
Income:	100	—	—	—	1.20	32.85	—
	110	159.80	348.70	58.65	150.40	361.85	58.65

PROJECT OPPORTUNITY G

Class title: Thinning well-stocked poletimber and small sawtimber stands on medium sites.

	Class definition	*Modal stand conditions*	*Prescribed initial treatment*
Site index (oak at 50 years)	51-70	60	Thinning and cull tree deadening to remove 28 square feet of basal area per acre.
Age (years)	61-80	70	
Average d.b.h. (inches)	5.0-10.9	10.7	
Basal area (square feet)	101-120	102	
Growing stock basal area	$\geq$ B	86	

SCHEDULE OF COSTS AND RETURNS PER ACRE FOR PROJECT G

Income and cost items	Stand age (years)	Markets for sawtimber only			Markets for sawtimber and pulpwood		
		Average cost, average return	Low cost, high return	High cost, low return	Average cost, average return	Low cost, high return	High cost, low return
Cost:							
Treatment	70	$ 10.50	$ 6.35	$ 17.65	$ 10.50	$ 6.35	$ 17.65
Income foregone	80	16.85	59.45	—	16.85	58.45	—
	110	56.30	184.65	—	58.30	214.90	—
Income:	110	115.60	384.60	—	119.05	398.70	—

PROJECT OPPORTUNITY H

Class title: Thinning well-stocked poletimber and small sawtimber stands on medium sites.

	Class definition	*Modal stand conditions*	*Prescribed initial treatment*
Site index (oak at 50 years)	51-70	60	Thinning and cull tree deadening to remove 28 square feet of basal area per acre.
Age (years)	61-80	70	
Average d.b.h. (inches)	5.0-10.9	9.0	
Basal area (square feet)	81-100	88	
Growing stock basal area	$\geq$ B	84	

SCHEDULE OF COSTS AND RETURNS PER ACRE FOR PROJECT H

Income and cost items	Stand age (years)	Markets for sawtimber only			Markets for sawtimber and pulpwood		
		Average cost, average return	Low cost, high return	High cost, low return	Average cost, average return	Low cost, high return	High cost, low return
Cost:							
Treatment	70	$ 10.95	$ 6.65	$ 16.95	$ 10.95	$ 6.65	$ 16.95
	100	9.60	—	—	9.60	—	—
	90	—	—	—	1.60	40.05	—
Income foregone	100	16.65	70.85	—	—	—	—
	120	110.75	298.75	—	124.00	350.90	—
Income:	120	163.40	387.45	38.50	163.40	402.85	38.50

PROJECT OPPORTUNITY I

Class title: Thinning and weeding well-stocked sapling and poletimber stands on medium sites.

	Class definition	*Modal stand conditions*	*Prescribed initial treatment*
Site index (oak at 50 years)	51-70	60	Thinning, weeding, and cull tree deadening to remove 45 square feet of basal area per acre.
Age (years)	21-40	30	
Average d.b.h. (inches)	1.0-4.9	4.2	
Basal area (square feet)	81-100	97	
Growing stock basal area	$\geq$ B	62	

SCHEDULE OF COSTS AND RETURNS PER ACRE FOR PROJECT I

Income and cost items	Stand age (years)	Markets for sawtimber only			Markets for sawtimber and pulpwood		
		Average cost, average return	Low cost, high return	High cost, low return	Average cost, average return	Low cost, high return	High cost, low return
Cost:							
Treatment	30	$ 18.30	$ 11.85	$ 26.85	$ 18.30	$ 11.85	$ 26.85
Income foregone	70	—	—	—	1.20	27.50	—
	80	9.30	48.30	—	—	—	—
	100	—	—	—	20.00	78.75	—
	120	211.05	471.85	7.35	197.55	439.15	7.35
Income:	60	12.65	66.05	—	12.65	66.05	—
	80	15.70	67.90	—	15.70	67.90	—
	100	200.55	440.00	115.25	201.90	452.20	115.25

PROJECT OPPORTUNITY J

Class title: Thinning well-stocked poletimber on medium sites.

	Class definition	*Modal stand conditions*	*Prescribed initial treatment*
Site index (oak at 50 years)	51-70	60	Thinning and cull tree deadening to remove 50 square feet of basal area per acre.
Age (years)	21-40	30	
Average d.b.h. (inches)	5.0-10.9	8.8	
Basal area (square feet)	121-140	126	
Growing stock basal area	$\geq$ B	82	

SCHEDULE OF COSTS AND RETURNS PER ACRE FOR PROJECT J

Income and cost items	Stand age (years)	Markets for sawtimber only			Markets for sawtimber and pulpwood		
		Average cost, average return	Low cost, high return	High cost, low return	Average cost, average return	Low cost, high return	High cost, low return
Cost:							
Treatment	30	$ 14.30	$ 9.30	$ 20.95	$ 14.30	$ 9.30	$ 20.95
	40	—	—	—	1.20	30.75	—
	50	12.05	51.65	—	—	—	—
	60	—	—	—	9.30	48.30	—
Income foregone	70	12.00	51.50	—	—	—	—
	80	—	—	—	18.15	68.30	—
	100	196.30	427.90	7.95	197.35	438.85	7.95
	40	—	—	—	1.35	30.80	—
	50	10.80	51.45	—	—	—	—
	60	—	—	—	12.00	51.50	—
Income:	70	17.95	67.15	—	—	—	—
	80	154.50	335.80	—	162.25	331.90	—
	90	—	—	31.80	—	—	31.80

PROJECT OPPORTUNITY K

Class title: Thinning well-stocked poletimber and small sawtimber stands on poor sites.

	Class definition	*Modal stand conditions*	*Prescribed initial treatment*
Site index (oak at 50 years)	31-50	40	Thinning and cull tree deadening to remove 20 square feet of basal area per acre.
Age (years)	61-80	70	
Average d.b.h. (inches)	5.0-10.9	10.4	
Basal area (square feet)	81-100	88	
Growing stock basal area	$\geq$ B	73	

SCHEDULE OF COSTS AND RETURNS PER ACRE FOR PROJECT K

Income and cost items	Stand age (years)	Markets for sawtimber only			Markets for sawtimber and pulpwood		
		Average cost, average return	Low cost, high return	High cost, low return	Average cost, average return	Low cost, high return	High cost, low return
Cost:							
Treatment	70	$ 9.80	$ 5.75	$ 15.60	$ 9.80	$ 5.75	$ 15.60
Income foregone	90	24.85	103.95	—	27.00	136.95	—
Income:	90	29.20	114.30	—	32.55	144.40	—

PROJECT OPPORTUNITY L

Class title: Thinning well-stocked poletimber and small sawtimber stands on poor sites.

	Class definition	*Modal stand conditions*	*Prescribed initial treatment*
Site index (oak at 50 years)	31-50	40	Thinning to remove 27 square feet of basal area per acre.
Age (years)	41-60	50	
Average d.b.h. (inches)	5.0-10.9	7.7	
Basal area (square feet)	81-100	88	
Growing stock basal area	$\geq$ B	88	

SCHEDULE OF COSTS AND RETURNS PER ACRE FOR PROJECT L

Income and cost items	Stand age (years)	Markets for sawtimber only			Markets for sawtimber and pulpwood		
		Average cost, average return	Low cost, high return	High cost, low return	Average cost, average return	Low cost, high return	High cost, low return
Cost:							
Treatment	50	$ 13.90	$ 9.00	$ 20.50	$ 13.90	$ 9.00	$ 20.50
Income foregone	60	—	—	—	1.84	28.00	—
	90	30.95	146.85	—	27.50	123.45	—
Income:	90	35.80	160.05	—	35.80	160.05	—

PROJECT OPPORTUNITY M

Class title: Thinning and weeding well-stocked sapling and poletimber stands on poor sites.

	Class definition	*Modal stand conditions*	*Prescribed initial treatment*
Site index (oak at 50 years)	31-50	40	Thinning, weeding, and cull tree deadening to remove 33 square feet of basal area per acre.
Age (years)	41-60	50	
Average d.b.h. (inches)	1.0-4.9	3.4	
Basal area (square feet)	81-100	83	
Growing stock basal area	$\geq$ B	77	

SCHEDULE OF COSTS AND RETURNS PER ACRE FOR PROJECT M

Income and cost items	Stand age (years)	Markets for sawtimber only			Markets for sawtimber and pulpwood		
		Average cost, average return	Low cost, high return	High cost, low return	Average cost, average return	Low cost, high return	High cost, low return
Cost:							
Treatment	50	$ 15.60	$ 9.55	$ 23.85	$ 15.60	$ 9.55	$ 23.85
Income foregone	120	38.80	184.30	—	38.95	186.55	—
Income:	100	—	—	—	25.35	142.35	—
	110	41.80	185.20	—	—	—	—

PROJECT OPPORTUNITY N

Class title: Converting poorly-stocked sawtimber and poletimber stands on medium oak sites to pine.

	Class definition	*Modal stand conditions*	*Prescribed initial treatment*
Site index (oak at 50 years)	51-70	60	Conversion to white pine by: (1) harvesting 8.9 cords and 3 M board feet/acre (net) if markets exist; (2) killing residual hardwoods > 5 inches d.b.h.; and (3) controlling saplings that interfere with planting and early survival.
Age (years)	101-120	110	
Average d.b.h. (inches)	11.0-16.9	14.0	
Basal area (square feet)	101-120	102*	
Growing stock basal area	< C	42	

SCHEDULE OF COSTS AND RETURNS PER ACRE FOR PROJECT N

Income and cost items	Stand age (years)	Markets for sawtimber only			Markets for sawtimber and pulpwood		
		Average cost, average return	Low cost, high return	High cost, low return	Average cost, average return	Low cost, high return	High cost, low return
Cost:							
Site preparation	0	$ 17.50	$ 12.20	$ 24.65	$ 4.50	$ 1.75	$ 9.05
Planting	0	34.00	26.00	40.00	34.00	26.00	40.00
Regeneration release	3	8.00	5.00	11.00	8.00	5.00	11.00
	5	8.00	5.00	11.00	8.00	5.00	11.00
Income foregone	80	22.00	70.20	—	23.70	110.65	—
	30	19.05	53.80	—	19.05	53.80	—
	40	21.40	60.25	—	21.40	60.25	—
	50	38.70	105.40	—	38.70	105.40	—
Income:	60	65.00	165.20	—	65.00	165.20	—
	70	77.05	189.00	—	77.05	189.00	—
	80	703.50	1,719.85	—	703.50	1,719.85	—

*Plus 9 square feet of undesirable saplings.

PROJECT OPPORTUNITY O

Class title: Converting poorly-stocked sawtimber and poletimber stands on medium oak sites to pine.

	Class definition	*Modal stand conditions*	*Prescribed initial treatment*
Site index (oak at 50 years)	51-70	60	Conversion to white pine by: (1) harvesting 16.4 cords/acre (net) if markets exist; (2) killing residual hardwoods > 5 inches d.b.h.; and (3) controlling saplings that interfere with planting and early survival.
Age (years)	121-140	130	
Average d.b.h. (inches)	11.0-16.9	11.8	
Basal area (square feet)	81-100	92*	
Growing stock basal area	< C	26	

SCHEDULE OF COSTS AND RETURNS PER ACRE FOR PROJECT O

Income and cost items	Stand age (years)	Markets for sawtimber only			Markets for sawtimber and pulpwood		
		Average cost, average return	Low cost, high return	High cost, low return	Average cost, average return	Low cost, high return	High cost, low return
Cost:							
Site preparation	0	$ 24.70	$ 17.80	$ 33.55	$ 6.55	$ 3.25	$ 11.80
Planting	0	34.00	26.00	40.00	34.00	26.00	40.00
Regeneration release	3	8.00	5.00	11.00	8.00	5.00	11.00
	5	8.00	5.00	11.00	8.00	5.00	11.00
Income foregone	80	—	—	—	2.40	60.75	—
Income:	30	19.05	53.80	—	19.05	53.80	—
	40	21.40	60.25	—	21.40	60.25	—
	50	38.70	105.40	—	38.70	105.40	—
	60	65.00	165.20	—	65.00	165.20	—
	70	77.05	180.00	—	77.05	189.00	—
	80	703.50	1,719.85	—	703.50	1,719.85	—

* Plus 18 square feet of undesirable saplings.

PROJECT OPPORTUNITY P

Class title: Converting poorly-stocked small sawtimber and poletimber stands on medium oak sites to pine.

	Class definition	*Modal stand conditions*	*Prescribed initial treatment*
Site index (oak at 50 years)	51-70	60	Conversion to white pine by: (1) harvesting 8.8 cords/acre (net) if markets exist; (2) killing residual hardwoods > 5 inches d.b.h.; and (3) controlling saplings that interfere with planting and early survival.
Age (years)	41-60	50	
Average d.b.h. (inches)	5.0-10.9	8.3	
Basal area (square feet)	61-80	78*	
Growing stock basal area	< C	35	

SCHEDULE OF COSTS AND RETURNS PER ACRE FOR PROJECT P

Income and cost items	Stand age (years)	Markets for sawtimber only			Markets for sawtimber and pulpwood		
		Average cost, average return	Low cost, high return	High cost, low return	Average cost, average return	Low cost, high return	High cost, low return
Cost:							
Site preparation	0	$ 34.55	$ 25.15	$ 46.04	$ 12.20	$ 7.25	$ 19.30
Planting	0	34.00	26.00	40.00	34.00	26.00	40.00
Regeneration release	3	8.00	5.00	11.00	8.00	5.00	11.00
	5	8.00	5.00	11.00	8.00	5.00	11.00
Income foregone	50	—	—	—	1.95	48.35	—
Income:	30	19.05	53.80	—	19.05	53.80	—
	40	21.40	60.25	—	21.40	60.25	—
	50	38.70	105.40	—	38.70	105.40	—
	60	65.00	* 165.20	—	65.00	165.20	—
	70	77.05	189.00	—	77.05	189.00	—
	80	703.50	1,719.85	—	703.50	1,719.85	—

* Plus 57 square feet of undesirable saplings.

PROJECT OPPORTUNITY Q

Class title: Converting poorly-stocked small sawtimber and poletimber stands on poor oak sites to pine.

	Class definition	*Modal stand conditions*	*Prescribed initial treatment*
Site index (oak at 50 years)	31-50	40	Conversion to hard pine by: (1) harvesting 14.2 cords/acre if markets exist; (2) killing residual hardwoods > 5 inches d.b.h.; (3) controlling saplings that interfere with planting and early survival.
Age (years)	121-140	130	
Average d.b.h. (inches)	11.0-16.9	15.9	
Basal area (square feet)	61-80	76*	
Growing stock basal area	< C	22	

SCHEDULE OF COSTS AND RETURNS PER ACRE FOR PROJECT Q

Income and cost items	Stand age (years)	Markets for sawtimber only			Markets for sawtimber and pulpwood		
		Average cost, average return	Low cost, high return	High cost, low return	Average cost, average return	Low cost, high return	High cost, low return
Cost:							
Site preparation	0	$ 18.30	$ 12.60	$ 25.90	$ 7.10	$ 3.60	$ 12.50
Planting	0	34.00	26.00	40.00	34.00	26.00	40.00
Regeneration release	3	8.00	5.00	11.00	8.00	5.00	11.00
Income foregone	60	—	—	—	2.20	34.65	—
Income:	40	12.55	35.65	—	12.55	35.65	—
	50	12.55	35.65	—	12.55	35.65	—
	60	33.15	99.75	—	30.15	99.75	—

* Plus 20 square feet of undesirable saplings.

PROJECT OPPORTUNITY R

Class title: Converting poorly-stocked poletimber and small sawtimber stands on poor oak sites to pine.

	Class definition	*Modal stand conditions*	*Prescribed initial treatment*
Site index (oak at 50 years)	31-50	40	Conversion to hard pine by: (1) harvesting 5.7 cords/acre (net) if markets exist; (2) killing residual hardwood > 5 inches d.b.h.; and (3) controlling saplings that interfere with planting and early survival.
Age (years)	41-60	50	
Average d.b.h. (inches)	5.0-10.9	6.7	
Basal area (square feet)	21-40	37*	
Growing stock basal area	< C	35	

SCHEDULE OF COSTS AND RETURNS PER ACRE FOR PROJECT R

Income and cost items	Stand age (years)	Markets for sawtimber only			Markets for sawtimber and pulpwood		
		Average cost, average return	Low cost, high return	High cost, low return	Average cost, average return	Low cost, high return	High cost, low return
Cost:							
Site preparation	0	$ 23.40	$ 16.30	$ 32.45	$ 10.50	$ 6.05	$ 17.02
Planting	0	34.00	26.00	40.00	34.00	26.00	40.00
Regeneration release	3	8.00	5.00	11.00	8.00	5.00	11.00
Income foregone	50	—	—	—	2.10	31.85	—
	40	12.55	35.65	—	12.55	35.65	—
Income:	50	12.55	35.65	—	12.55	35.65	—
	60	33.15	99.75	—	33.15	99.75	—

* Plus 46 square feet of undesirable saplings

PROJECT OPPORTUNITY S

Class title: Converting poorly stocked small sawtimber and poletimber stands on poor oak sites to pine.

	Class definition	*Modal stand conditions*	*Prescribed initial treatment*
Site index (oak at 50 years)	31-50	40	Conversion to hard pine by: (1) harvesting 15.5 cords/acre (net) if market exists; (2) killing residual hardwoods > 5 inches d.b.h.; and (3) controlling saplings that interfere with planting and early survival.
Age (years)	101-120	110	
Average d.b.h. (inches)	11.0-16.9	11.3	
Basal area (square feet)	121-140	136	
Growing stock basal area	< C	40	

SCHEDULE OF COSTS AND RETURNS PER ACRE FOR PROJECT S

Income and cost items	Stand age (years)	Markets for sawtimber only			Markets for sawtimber and pulpwood		
		Average cost, average return	Low cost, high return	High cost, low return	Average cost, average return	Low cost, high return	High cost, low return
Cost:							
Site preparation	0	$ 21.35	$ 15.30	$ 29.10	$ 3.40	$ .95	$ 7.60
Planting	0	34.00	26.00	40.00	34.00	26.00	40.00
Regeneration release	3	8.00	5.00	11.00	8.00	5.00	11.00
Income foregone	60	—	—	—	2.75	43.05	—
	40	12.55	35.65	—	12.55	35.65	—
Income:	50	12.55	35.65	—	12.55	35.65	—
	60	33.15	99.75	—	33.15	99.75	—