ECONOMIC EVALUATION OF INTERMEDIATE OPERATIONS IN OAK STANDS

by HENRY H. WEBSTER *and* JOHN C. MEADOWS, JR. *respectively Head, Department of Forestry, and Assistant Professor, Department of Forestry, Iowa State University, Ames, Iowa.*

ABSTRACT. Economic evaluation of forest-management opportunities is a vital ingredient of effective forestry programs. Choices among management opportunities are necessary because opportunities inevitably exceed funds available, and they are important because opportunities commonly range from highly productive to decidedly unproductive. Economic evaluation in oak stands shows a wide range in productivity. Primary factors influencing this range include site-productivity, length of the investment period, and division of costs between private owners and public assistance programs such as the Cooperative Forest Management and Agricultural Conservation Programs.

ECONOMIC EVALUATION can be useful only if it is firmly based on adequately defined silvicultural relationships. And economic evaluation can enhance the usefulness of silvicultural and other biological knowledge. It can do this by linking silvicultural knowledge more directly to at least some of the human purposes for which forests and related resources are managed.

Economic evaluation is important for this reason, and for more specific reasons. A first specific reason relates to budgets—always an important topic and currently an unusually difficult one in many organizations. It is almost universally true that in any ranger district, woodland management work unit, or other administrative unit, there are—and always will be—many more opportunities to undertake intermediate operations or other forms of intensified management than there are funds to meet the costs. This same excess of opportunities in relation to funds also occurs at higher organizational levels.

It can be illustrated in many different ways and at many different levels. Though they involve many matters other than oak stands, estimates developed by Robert Marty and Walker Newman *(1969)* for the National Forests as a whole are particularly striking. They found that $210 million dollars could be invested in intensified timber management on the National Forests with promise of making at least a 7-percent annual return—a respectable return even in this time of high interest rates. In sharp contrast, funding for such management at the time Marty and Newman made their estimate was only $17.5 million per year. Thus it would take nearly 15 years to carry out current opportunities, to say nothing of new opportunities that would develop over this period in response to new markets, new technology, and changes in the composition of the forest resource. Though specifics would differ, the same would be true in more restricted situations involving smaller administrative units, or a single forest type such as oak stands. The essential point is that many choices among opportunities are necessary.

And these choices are important—a second specific factor making economic evaluation important. Intermediate operations (and other specific opportunities to apply intensified management) differ greatly in terms of results in relation to efforts. These differences can be illustrated at several different levels. At a national level, Marty and Newman found that rates-of-return on investments in intensified timber management on the National Forests would range from more than 15 percent per year down to zero. Comparisons for oak stands in Pennsylvania made several years ago illustrate the same point *(Webster 1960)*. Probable costs and returns from a program of intensified management of oak stands on three progressively poorer site classes were analyzed. Rates-of-return were 9 percent, 6 percent, and 1 percent. Thus returns for management in a single type range from good to wholly inadequate.

Economic evaluation is important because choices among opportunities are unavoidable, and because these choices greatly affect the results achieved in relation to efforts. Economic evaluation—used in an appropriate manner—can help forest managers to more consistently choose opportunities that promise a large measure of desirable long-range results in relation to costs and associated efforts required to carry out these opportunities.

METHODS OF ECONOMIC EVALUATION

Economic evaluation is concerned with the comparison of results in relation to efforts or inputs. Its value lies in helping managers to identify and select efficient courses of action. Implicitly, efficient courses of action are those that yield the greatest results or outputs in relation to the inputs.

In management of oak stands, many intermediate operations constitute stand improvement. Such operations involve goals or outputs that occur at some point in the future. Associated with the choice of pursuing each goal may be additional costs or returns. To provide the manager with a means of assessing the economic efficiency of given choices among the many possible choices relating to stand improvement, the economist must weight inputs and outputs according to the time at which they are expected to occur.

Two common elements in this weighting are: (1) the contribution such choices make to present net worth, and (2) the internal rate of return associated with such choices. As measures of relative efficiency among the possible stand-improvement alternatives, these two time-weighted criteria provide a basis for choice.

In some situations, either of these criteria will yield good results. In some situations these criteria will yield similar results, ranking opportunities in entirely the same order. This is most likely when there are no restrictions on movement of assets in or out of the particular organization.

The present net worth is the discounted stream of appropriately valued inputs (costs) and outputs (returns). It is measured in dollars. It reflects the impact on the present net worth of the organization that is expected to ensue from the flow of outputs and inputs associated with a particular choice. If the present net worth of the anticipated returns is greater than the present net worth of the anticipated costs, the implication is that the particular project should be undertaken.

To apply this criterion, inputs, outputs, and their values, along with the times of their occurrence, must be known. In addition, the appropriate rate of discount must be specified. The appropriate discount rate is frequently referred to as the alternative rate of return, or the rate of return that the organization could earn on its next best investment opportunity.

Unfortunately, the next best investment may be poorly defined. This is especially true in large organizations where budgets are specified with slight emphasis on their earnings potential in many parts of the organization. Large organizations are also likely to have overall objectives that are so interrelated as to make the use of market rates of interest inappropriate even if measurable. Under these circumstances, the internal-rate-of-return approach has distinct advantages for those segments of organizations that are concerned with allocating budgets among the various alternative opportunities available.

The internal rate of return measures the rate at which an investment and its associated incomes and costs grow into a final value. As a measure of the rate of growth, the internal rate of return is most frequently expressed as an interest rate. The internal rate of return is calculated by determining the rate of interest that would equate the time streams of the various costs and returns (initial, intermediate, and final) if all are discounted to the present. The application of the method implies that there is one interest rate that is appropriate for money received in returns and money borrowed to defray costs; but, in view of the difficulties of the alternatives, this assumption is not too difficult to surmount.

Generally, application of this criterion involves a ranking of the various alternatives in terms of the internal rate of return. Those alternatives with the higher rate of growth are to be preferred to those with a lower rate of growth. The budgets available are then allocated sequentially, beginning with those with the higher rates of return. When investments must be made in discrete segments, due consideration must be given to the size of the investment.

To efficiently choose among the various possible intermediate stand treatments on the criteria of either present net worth or internal rate of return, distinct types of information are needed:

1. The cost of choosing to carry out each particular choice.
2. The change in quality, amount, and timing of the biological response attributable to each particular choice in terms of output that the manager seeks to maximize—for example, additional cords or board feet.
3. The appropriate value measures, generally at some future time, that are to apply to the change in biological response.

In assessing the information needs, the emphasis should be placed upon the added cost and added biological response, appropriately valued, rather than upon the total cost and total biological response. It is with the additional inputs and their commensurate outputs that decisions are concerned. This is especially clear in intermediate operations, where the obvious impact of any decision is to modify the currently anticipated outcome.

Among the decisions to be made, a distinction should be drawn between those that relate to choices in a particular stand and those that relate to choices between stands. If the choice of one alternative, say thinning to 60 square feet of basal area, precludes another choice, say thinning to some other intensity as measured by basal area, then these two choices should not be considered in the same ranking of opportunities because they cannot physically be carried out on the same stand at the same time. It is much more likely that one opportunity will preclude another on choices within a particular stand than in choices where several stands are involved. Choices where one course of action does preclude another require particularly careful selection of a criterion. It is here that present net worth will frequently be preferable to internal rate of return—despite difficulties of actually using present net worth. This is true for a simple reason: a lower *rate* of return, but a larger *absolute* return, will often be preferable when a direct choice must be made. This can occur, for example, when relatively small investments in managing an existing stand are compared with larger investments involved in converting that stand to more valuable species.

Economic analysis helps the decision-maker to choose efficient courses of action. Inputs and outputs are weighted to reflect their occurrence at different times. The typical means of weighting the costs and outcomes of forest operations are the present-net-worth method and the internal-rate-of-return method. For most intermediate operations, especially in large organizations, the internal rate of return is an appropriate means of weighting the inputs and outputs. Decisions based on either criteria should emphasize the incremental changes that result from a choice. Particular care should be taken to avoid including within the same ranking choices that preclude one another. Application of either of the time-weighting methods, or for that matter any managerial decision, requires information in terms of the cost, physical response, and value associated with each choice.

COMPARING OAK MANAGEMENT OPPORTUNITIES

Several analyses have been made using these methods of economic evaluation to directly compare oak management alternatives. These analyses have been directed primarily toward intermediate operations. We will draw primarily on three such analyses.

Marty and Newman *(1969)* analyzed opportunities for intensification of timber management on the National Forests as a whole. The oak-hickory type was one of those explicitly considered. "Package programs", involving several management practices, were evaluated for oak-hickory (as for other types) on each of several site-productivity classes. Webster *(1960)* evaluated management opportunities that were applicable in a specific but sizable geographic area, namely Pennsylvania. Separate evaluations were made for individual practices that are applicable at different stages in stand development. Manthy *(1970)* carried analysis further for essentially the same area and practices considered by Webster. He analyzed these practices as parts of the Cooperative Forest Management and Agricultural Conservation Programs. He made separate calculations of investment returns to the landowner and to the agencies administering these public programs.

Rates of return that were calculated in these three analyses are shown in tables 1 to 4. These rates measure return on additional investment needed to carry out the specified practices.

We might note several items concerning these rates of return. First, we see that re-

Table 1.—***Rates of return for selected intermediate operation and reforestation opportunities on the National Forests***

Timber type group	Site-productivity class	Intensification rate of return
		Percent
RELEASE AND PRECOMMERCIAL THINNING OPPORTUNITIES		
Oak-hickory	1	8.2
	2	7.0
	3	3.6
	4	3.0
Maple-beech-birch	1	[1]
	2	6.4
	3	4.0
REFORESTATION OPPORTUNITIES		
Red-white pine	1	10.0
	2	8.8
	3	7.8
	4	5.9
Fir-spruce (eastern)	1	[1]
	2	6.7
	3	5.5

Source: Marty and Newman *(1969)*.
[1] No estimate.

Table 2.—***Return on additional investment in timber-management practices in Pennsylvania***

Management opportunity	Rate of return compound interest
	Percent
OAK	
Thin poletimber, site 1	8.6
2	6.8
3	1.1
Clean seedlings & saplings, site 1	6.0
2	4.7
3	[1]
NORTHERN HARDWOODS	
Thin poletimber, site 1	11.2
2	10.3
Clean seedlings & saplings, site 1	7.8
2	7.2
COVE HARDWOODS	
Thin poletimber, site 1	12.0
2	9.8
SOFTWOODS	
Plant bare land, site 1	5.3
2	4.6
3	2.3

Source: Webster *(1960)*.
[1] No estimate.

Table 3.—*Summary of potential financial yields of ACP-CFM-supported plantings at financial maturity and for TSI practices for public, private, and total establishment investments, by site-productivity class.*

[In percent, compound interest]

Practice	Site I	Site II	Site III
PUBLIC INVESTMENT			
Planting:			
White pine	[1]6.9- 8.2	5.8- 7.0	3.1- 3.9
Red pine	7.3- 9.3	6.7- 7.6	6.1- 6.9
Larch	8.9- 9.4	7.3- 7.7	5.6- 5.9
Norway spruce	7.8- 9.0	5.8- 6.5	—
Cleaning and liberation:			
Oak	5.4	4.1	1.0
Northern hardwoods	7.3	6.3	—
Thinning:			
Oak	7.9	6.0	1.0
Northern hardwoods	11.1	10.2	—
Cove hardwoods	12.2	9.9	—
PRIVATE INVESTMENT			
Planting:			
White pine	11.5-12.9	9.6-10.8	4.8- 5.7
Red pine	12.8-14.1	11.9-13.2	10.6-11.6
Larch	15.5-17.6	13.2-13.7	9.6- 9.9
Norway spruce	15.9-17-1	10.6-11.3	—
Cleaning and liberation:			
Oak	8.3	7.1	3.2
Northern hardwoods	10.3	9.7	—
Thinning:			
Oak	12.1	10.2	4.4
Northern hardwoods	16.7	15.7	—
Cove hardwoods	18.0	15.5	—
TOTAL INVESTMENT			
Planting:			
White pine	6.6- 7.9	5.6- 6.8	2.9- 3.8
Red pine	7.1- 8.0	6.5- 7.4	5.9- 6.8
Larch	8.6- 9.0	7.9- 7.4	5.4- 5.7
Norway spruce	7.4- 8.6	5.5- 6.2	—
Cleaning and liberation:			
Oak	5.1	3.7	1.0
Northern hardwoods	7.0	5.9	—
Thinning:			
Oak	7.4	5.4	1.0
Northern hardwoods	10.5	9.5	—
Cove hardwoods	11.7	9.2	—

[1] The high and low interest rates for planting are rates earned under the high-and low-stumpage price assumptions.

Source: Manthy *(1970)*.

Table 4.—*Summary of potential financial yelds of CFM-supported plantings at financial maturity and for TSI practices for public, private and total establishment investments, by site-productivity class.*

[In percent, compound interest]

Practice	Site I	Site II	Site III
PUBLIC INVESTMENT			
Planting:			
White pine	[1]8.3- 9.6	7.0- 8.2	3.9- 4.8
Red pine	8.9- 9.9	8.2- 9.2	7.4- 8.2
Larch	11.3-11.8	9.1- 9.5	6.8- 7.1
Norway spruce	10.2-11.4	7.2- 7.9	—
Cleaning and liberation:			
Oak	7.2	5.9	1.6
Northern hardwoods	9.2	8.4	—
Thinning:			
Oak	10.4	1.0	2.7
Northern hardwoods	14.5	13.5	—
Cove hardwoods	15.8	13.3	—
PRIVATE INVESTMENT			
Planting:			
White pine	7.5- 8.8	6.3- 7.5	3.4- 4.3
Red pine	8.0- 9.0	7.3- 8.3	6.6- 7.5
Larch	9.9-10.4	8.1- 8.5	6.1- 6.4
Norway spruce	9.8-10.0	6.4- 7.1	—
Cleaning and liberation:			
Oak	6.0	4.7	1.0
Northern hardwoods	7.9	7.0	—
Thinning:			
Oak	8.6	11.8	1.0
Northern hardwoods	12.1	11.2	—
Cove hardwoods	13.4	10.9	—
TOTAL INVESTMENT			
Planting:			
White pine	6.3- 7.6	5.4- 6.5	2.9- 3.6
Red pine	6.7- 7.7	6.2- 7.1	5.6- 6.2
Larch	8.2- 8.5	6.6- 7.1	5.1- 5.4
Norway spruce	6.9- 8.0	5.2- 5.9	—
Cleaning and liberation:			
Oak	5.2	3.9	1.0
Northern hardwoods	6.7	6.1	—
Thinning:			
Oak	7.5	5.6	1.0
Northern hardwoods	10.7	9.7	—
Cove hardwoods	11.9	9.4	—

[1] The high and low interest rates for planting are rates earned under the high-and low-stumpage price assumptions.

Source: Manthy *(1970)*.

turns range from approximately 12 percent per year down to essentially zero. This range is related to a considerable number of factors. It will be useful to examine these factors individually to the extent that available data permit.

Site productivity affects economic returns very sharply. The specific numbers differ from one analysis to another. The fact that Marty and Newman *(1969)* used a different measure of site productivity that did Webster *(1960)* and Manthy *(1970)* also complicates matters. Nevertheless, there are important common threads:

- With three broad site-productivity classes, the rate of return on investment in various intermediate operations is 5 to 8 or 9 *times* as great in stands in the top sites as on the poorest sites.
- The absolute difference between rates of return on best vs. poorest sites is consistently 4 to 7 percent annually over a range of specific practices and particular sources of information.
- Except under unusual circumstances, it seems unlikely that intermediate operations will fully pay for themselves (all costs considered) in stands below site index 60 (site 2) even if a fairly modest return is acceptable; and agencies or investors concerned with a moderately high level of efficiency in use of their budget dollars will find few opportunities attractive on site indexes lower than 80 (site 1).

All these common threads point the same direction: site productivity must be recognized as a crucial factor in choosing oak stands in which intermediate operations are to be carried out. In applying this, we should of course recognize that factors other than biological productivity may also contribute to the "goodness" of some sites and the "badness" of others. Proximity to markets, to transportation, and to concentrations of recreationists are obvious examples. Nevertheless biological productivity is extremely important.

The period between expenditure and returns—technically the "investment period"—also has a substantial effect on returns. Long investment periods reduce returns. Look closely at the analyses by Webster *(1960)* and Manthy *(1970)*. Rates of return for management that begins with thinning in 35-to-40-year-old stands are consistently 2 or 3 percent per year higher than those for management beginning with cleaning and liberation in 10-to-15-year-old stands. This runs counter to our urge to concentrate intermediate operations in young stands where more can be accomplished. It is true that more can be accomplished, but scarce funds are kept tied up much longer. This prevents uses of these same funds to carry out other desirable practices. The sense of the matter is as follows:

> Management regimes requiring heavy expenditure early in the rotation face a major cost disadvantage in comparison with those concentrating expenditure toward the end of the rotation. Therefore there is strong reason to favor a management program that concentrates expenditures toward the end of the rotation, if it will achieve the desired result. This argument applies even if somewhat larger expenditures are required later. For example, a 10-year delay in any management operation will increase profitability even if the cost increases by approximately one half, in most cases. (*Webster and Marty 1966*).

Cost sharing (of the type available to private landowners under the Agriculture Conservation Program) raises the return the owner receives on *his* investment in intermediate operations. This is true even though returns on overall investment are not affected. ACP currently pays on an average of 80 percent of the private owner's costs of carrying out approved practices. These costs are simply shifted from the owner to the administering agency. Manthy *(1970)* found that such cost-sharing increased returns to such private landowners an average of approximately 4 percent per year over returns otherwise obtainable. This 4 percent difference would, of course, change if the cost-share rate were changed, or if the overall rates of return on the practices involved were either appreciably higher or lower.

Now look beyond management of oak forests for a moment. How do oak forests compare with other associated forest types? Specifically, how do rates of return on intermediate operations compare? We will attempt only a capsule view, even though all three analyses bear on this point. So many comparisons could be made that it is difficult to go very far without becoming inundated in data. The analyses concerned with management opportunities in Pennsylvania indicate that returns on intermediate operations are somewhat lower for oak than for nothern hardwoods or cove hardwoods. On the other hand, they also indicate that intermediate operations in oak generally bring greater returns than does softwood plantation establishment in this region. These estimates of differences are partially contradicted by the analysis for the National Forests as a whole, but this may be more apparent than real. The relatively small acreage of high-site northern hardwoods in the National Forests, and relatively more optimistic assumptions about losses to fire and pests in softwood plantations, appear to be factors giving Marty and Newman *(1969)* a somewhat different ranking of opportunities.

We can use the analyses concerned with management opportunities in Pennsylvania to examine the extent of differences between forest types. We can do this even though it is difficult to generalize meaningfully. Nevertheless, it would appear that for intermediate operations on top-quality sites, northern hardwoods and cove hardwoods return an extra 2 to 4 percent annually as compared with oak. And the difference seems to be greatest for practices—like thinning in poletimber—that involve reasonably short investment periods. In contrast to top-quality sites, there is little if any difference in returns between types on relatively poor-quality sites (except for the obvious point that some of these types do not normally occur on poor sites).

ECONOMIC EVALUATION: USEFULNESS AND LIMITATIONS

The rates of return result from specific kinds of economic evaluation directly applied to intermediate operations in oak stands and associated forest types. We can also view them in broader perspective. Namely, what is the real usefulness, and what are the limitations, of economic evaluation of this kind? And how might these limits be pushed back to make this kind of analysis more useful?

Systematic analysis of this kind can help forest managers distinguish more objectively among their alternatives. Management alternatives differ greatly. It is important to distinguish among them. Doing so is the difference between resource management as a low-productivity field not likely to receive growing public and budgetary support, and resource management as a high-productivity field that will invite support.

Economic evaluation has at least three strong points.

1. It is directly oriented toward people, based on at least some of the objectives for which natural resources are managed. Therefore it suggests alternatives that are relevant.
2. It is concerned with quantitative comparisons of alternative courses of action. Thus it introduces a degree of objectivity and appeal to fact in comparing alternate courses of action.
3. Finally, economic evaluation is an integrating activity, pulling together several different kinds of knowledge. It can increase the value of silvicultural information by linking such information more directly to human objectives.

Economic evaluation also has at least four limitations. The first relates to the real objectives of forest managers. For purposes of analysis, we commonly postulate objectives that are relatively simple, well-defined, and consistent. But real objectives are frequently complex, not very well defined, and to some degree contradictory. Analyses can thus say that *if* a manager's objective is to produce additional timber values at least cost, or to create a particular environment as quickly as possible, *then* his best course of action is to do thus and so. Particular managers will have to consider how well the *if* matches their objectives and modify the *then* to take account of differences.

A second limitation relates to types of decisions. Many decisions are are concerned with methods; specifically, how best to spend a given budget? Other decisions are concerned with production goals and determination of the size of budgets. Budget decisions involve a much wider range of alternatives than do method decisions. At the highest level, public forest management may compete for funds with highway construction and expenditures for schools and mental hospitals, for example. For that reason, comparisons of costs and benefits via economic evaluation will necessarily be much less complete guides to budget decisions than they are to method decisions.

A third limitation relates to values that are not readily measurable. Recreational and watershed services are not commonly bought and sold by the unit. Economic evaluation can still contribute directly to many methods decisions. Many alternatives can be evaluated by direct comparisons of costs and physical outputs. However, nonmarket-determined values do pose a severe roadblock to budget analyses that seek to determine how much timber, water, recreation, and other forest products should be produced.

A fourth limitation relates to imperfect information. We frequently have some difficulty estimating the cost of particular management practices, considerable trouble predicting changes in physical output, and extreme difficulty in forecasting future prices or values. Three situations may occur under these circumstances. One alternative may be clearly better than the others despite imperfect information; it may have a good chance of being better; or it may be simply impossible to tell on the basis of the objective information available *(Marty 1964)*.

Efforts to increase the usefulness of economic evaluation relate closely to the quality of information that is available for use in these evaluations. Perfection vs. imperfection of information is a matter of degree.

Economic evaluation requires three types of information: costs, response, and value. Difficulties of locating high-quality information for use in economic evaluation increase in that order. Rather standard study procedures will produce accurate cost information. We have somewhat greater difficulty predicting biological responses despite 50 or 60 years of silvicultural research. And we have extreme difficulties predicting future values of products and services. Costs relate directly to actions to be taken now, so no major effort to foresee the future is required. Both physical responses and future values involve predicting events that will occur in the future. This is inherently difficult. However, prediction of biological responses is the easier of the two because biological relations are relatively stable. In contrast, future values depend substantially on people's preferences, which can change substantially in relatively short periods.

These differences in quality of information clearly indicate where efforts to improve information should be concentrated. Relatively small increases in the quality of information about use trends, utilization relationships, and other factors influencing values would greatly improve analyses of the type we have discussed—hence major efforts is called for. Improved predictions of biological responses also merit considerable effort because major improvement would seem within our grasp even though the deficiencies here are less striking than in the case of future values.

In conclusion, we would again underline the importance of economic evaluation as a means of systematically distinguishing between high-productivity management alternatives and low-productivity management alternatives. This is important for efficient production of products and services. Careful identification of high- and low-productivity management alternatives may also contribute in an important way to our forest resources in a distinctly naturalistic manner. This appears to be one of the things society is urgently demanding. Careful identification of high-productivity opportunities, and effective development of these opportunities in an intensive manner, may enable us to meet our commodity needs from a relatively modest part of our total forest land area—certainly less than would be needed with opportunities ineffectively identified and developed. Such concentration of effort would appear to us to be a major means of breaking a number of our serious resource-use conflicts. This, we think, is a major aspect of the usefulness of economic evaluation of management opportunities.

Literature Cited

Manthy, Robert S.
1970. An investment guide for cooperative forest management in Pennsylvania. USDA Forest Serv. Res. Paper NE-156. 59 pp. NE Forest Exp. Sta., Upper Darby, Pa.

Marty, Robert.
1964. Analyzing uncertain timber investments. USDA Forest Serv. Res. Paper NE-23. 2 pp. NE Forest Exp. Sta., Upper Darby, Pa.

Marty, Robert, and Walker Newman.
1969. Opportunities for timber management intensification on the National Forests. J. Forestry 67: 482-485.

McKean, Roland N.
1958. Efficiency in government through systems analysis: with emphasis on water resources development. A Rand Corporation Research Study. 336 pp. John Wiley and Sons, New York.

Webster, Henry H.
1960. Timber management opportunities in Pennsylvania. USDA Forest Serv. NE Forest Exp. Sta. Sta. Paper 137. 37 pp.

Webster, Henry H., and Robert J. Marty.
1966. Comparative analysis of costs and benefits of the various systems of silvicultural management. World Forestry Cong. Proc. 6: 2226-2230.

■