timber management and economic analysis

a case study

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Introduction

IN THE economics of forestry, one of the major subject areas for research is timber production. During the past few years a number of economic analyses have dealt with this subject. For example, Buckman and Lundgren (1961), King, Stoltenberg, and Marty (1960), Lundgren (1961), Marty and Allison (1960), McMahon (1961), and Wikstrom and Wellner (1961) have made economic analyses of timber-production problems.

In their purposes these analyses differ somewhat, yet they all have much in common. In broad terms they have two interrelated objectives. First, they are designed to determine the relationship between benefits and costs for various timber-management opportunities, thus guiding timber-management funds toward those opportunities that promise the largest benefits relative to costs. Second, they may also be designed to identify the breaking point between those opportunities that are justified and those that are not. Identification of this breaking point may aid in the determination of budgets. In short, these analyses serve to arrange timber-management opportunities into a scale of priority, and they may also serve to identify the point on this scale beyond which management should not try to go.

Have these analyses reached their mark? In what kinds of timber-management decisions have they been useful? Where, specifically, have they fallen short? Can we define both the usefulness and limitations of economic analyses as a guide to timber management?

The usefulness and limitations of economic analysis for this purpose have been discussed in a number of publications. Stoltenberg (1956), Stoltenberg, Marty, and Webster (1961), Newport (1962), and Webster, Marty, and Skok[1] emphasized the usefulness of such analysis. Dowdle (1962) and Marty[2] discussed limitations as well as usefulness. These investigators

[1] Webster, Henry H., Robert J. Marty, and Richard A. Skok. FORESTRY PRACTICE, BIOLOGICAL RESEARCH, AND ECONOMIC ANALYSIS. Article submitted to Journal of Forestry, 1962.

[2] Marty, Robert J. TIMBER INVESTMENT DECISIONS: A STUDY OF ECONOMIC DECISION-MAKING UNDER UNCERTAINTY IN FORESTRY. Unpublished manuscript, Northeastern Forest Experiment Station, Upper Darby, Pa.

pointed out that economic analysis is a powerful device for viewing timber management from the viewpoint of people and their objectives; for comparing opportunities (i.e., alternative courses of action) as means of achieving these objectives; and for pulling together many different kinds of information to make these comparisons. They also pointed out that economic analysis is a somewhat less-than-perfect device since less-than-perfect information must be used.

These articles were general in the sense that they discussed economic analysis on a conceptual level. They did not attempt to directly trace the usefulness and limitations of particular analyses in terms of decisions made in particular geographic areas, or by particular forest land-management agencies.

Attempts to trace directly the usefulness and limitations of particular economic analyses would be valuable, as a pragmatic approach. Such an approach would lend substance to conceptual appraisals of the usefulness and limitations of economic analysis. Distinctions between theory and practice are much overworked, and often false. Nevertheless such an approach would provide a more practical view. And a more practical view might help several groups.

Suppose the usefulness and limitations of a number of economic analyses were traced. This might help forest managers to interpret the results of other economic analyses of timber-management opportunities. They would have a better frame of reference both for formulating their problems and for asking "Where and how might these analyses be useful to me?" A more practical view might also help researchers to direct their work toward those timber-management decisions where economic analysis can make a major contribution. And finally, it might help many, particularly students, to understand the relationship between forest management and forestry research, particularly research in forest economics.

This paper is an attempt to trace the usefulness and limitations of economic analysis as a guide to timber management. It builds upon an earlier analysis of major timber-management opportunities in Pennsylvania (Webster 1960), applying the results

to a particular area in the State. It attempts to view the analysis through the eyes of a perceptive forest manager, asking where and how this analysis has been useful and where and how has it fallen short.

This is a report on a case study. It deals with a particular economic analysis applied to a particular situation. It is in no sense a definitive treatment of the usefulness and limitations of economic analysis as a guide to timber management. Definitive treatment would require many additional cases involving other analyses directed toward other geographic areas, other product objectives, and decisions involving opportunities other than stand improvement. Nevertheless this case is a first step in a pragmatic appraisal of economic analysis as a guide to timber management.

The Management Situation

The management unit considered is the Elk State Forest in Pennsylvania, which is administered by the Pennsylvania Department of Forests and Waters as part of the Department's Administrative District 13. Its management group includes the District Forester assigned to District 13 and the Chiefs of the Divisions of State Forest Management and Forest Advisory Services in the headquarters of the Department of Forests and Waters. They jointly make management decisions, which are then carried out under the supervision of the District Forester.

The Elk State Forest (fig. 1) is located in north-central Pennsylvania. District 13, of which the Elk State Forest is a part, includes portions of Cameron, Elk, Potter, Clinton, and McKean Counties. This is a predominantly rural area, containing several towns of 5,000 to 10,000 population, but none larger. It is extensively forested: the 5 counties contain some 2.3 million acres of commercial forest land out of a total acreage of 2.7 million acres. Some 35 to 40 percent of the commercial forest land here is publicly owned (U. S. Forest Service 1958). The Allegheny National Forest is located in this general area, as are

several State Forests and areas of State Game land. Industrial holdings are also large.

A variety of market outlets for timber are found here. According to the most recent tally, some 85 sawmills operate in the 5-county area (Pa. Dept. Forests and Waters 1960). A dozen of these mills produced more than 1 million board feet of lumber each in 1960. Two large pulp mills obtain part of their wood supplies from this area. In addition, there are outlets for veneer logs and for material suitable for handles, baseball bats, and a variety of other products. Sawtimber-size timber is readily saleable here. But pulpwood-size material is less saleable because so much of it is available in relation to current use.

The Elk State Forest itself is an area of 187,000 acres. Most of it is relatively undeveloped. Some 6,000 acres are in developed parks, roads, and streams. Another 17,000 acres have been leased as a special industrial site.

The Forest contains some 287 million board feet of sawtimber and some 142 million cubic feet of additional timber in trees of less than sawtimber size. It also contains three rather highly developed recreational areas, as well as a number of additional areas that might be developed for recreational purposes at some time in the future.

Timber management on the Forest has been undertaken rather recently. A timber-management plan for the Forest was completed in 1954, and accomplishments since then have been sig-

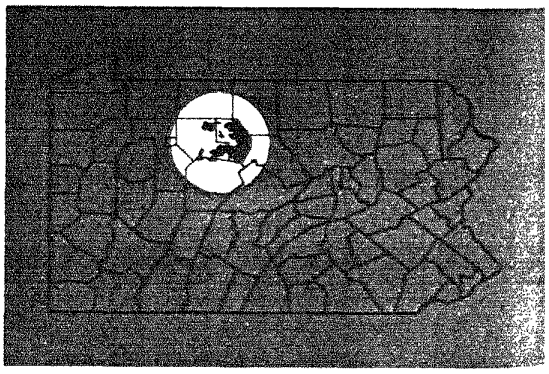

Figure 1.—Elk State Forest in north-central Pennsylvania, where a case study was made through economic analysis of timber-management opportunities.

nificant. Nearly 13 million board feet of sawtimber and some 6,000 cords of smaller material have been harvested. At the same time, many low-value trees have been removed to upgrade the forest. Receipts have totaled $440,000.

Objectives

The objectives of the Pennsylvania Department of Forests and Waters (1955) in managing the Elk State Forest have been stated as follows:

- To produce the greatest possible sustained supply of timber products.
- To improve species composition and quality of existing stands and provide for adequate residual growing stock as well as reduce the damage caused by insects and diseases.
- To regulate the cutting of timber so that the supply and flow of products from the Forest will be constant and adequate. This will tend to stabilize wood-using industries and the employment and communities dependent upon them.
- To develop and preserve the recreational values of the Forest.
- To protect the watersheds from erosion and obtain from them the maximum yields of usable water.
- To harvest timber in such a way that an adequate, uniform supply of wildlife food and cover is produced.

An economist might phrase it in slightly different terms. For example, he might place greater emphasis on minimum-cost production of various forest products. He might also make more explicit provision varying rates of production over time in response to changes in demand. And he would probably discuss the conflicts that are likely to develop as a result of attempts to simultaneously produce several forest products.

Language differences aside, this statement clearly establishes that the Department of Forests and Waters is interested in producing a variety of forest products on the Elk State Forest. Timber, water, wildlife, and recreational services are specifically mentioned.

Elsewhere in the management plan for the Elk State Forest it is established that management for production of these products is still in an early stage. At this stage, relationships between these products are more nearly complementary (or at most neutral), not competitive. For example, production of recreational services reduces opportunities for timber production on only a few carefully delineated areas. Therefore, production of the various products can be treated separately to some degree in terms of many decisions.

Specific guidelines to decisions logically follow statements of objectives. The Department of Forests and Waters has guidelines that are operationally useful although not explicitly stated in the plan. It is clear that the necessity of choosing among alternative courses of action within a fixed budget is well appreciated, as is the merit of choosing the most productive courses of action first.

Efficiency in producing additional timber values is clearly one of the Department's objectives. They intend to produce additional timber values at minimum cost; that is, to obtain the greatest pos-

Table 1. — *Land cover and use classifications, Elk State Forest*

Land classification	Area
	Thousand Acres
Poletimber	139
Small sawtimber	17
Large and medium sawtimber	2
Saplings	4
Plantations, plantable areas, etc.	1
Recreation areas	5
Special industrial site lease	17
Roads	2
Total area	187

Source: Pa. Dept. Forests and Waters. FOREST MANAGEMENT PLAN FOR THE ELK STATE FOREST, 1955.

sible value response from funds invested in timber management.

Obviously this is not the Department's only objective. At the risk of oversimplifying, we can list at least three additional objectives: (1) to produce forest products other than timber in an efficient manner; (2) to keep the complexities of management to a tolerable level; and (3) to maintain satisfactory relations with legislators, other governmental agencies, and the citizenry of Pennsylvania.

The interrelationships between these objectives have not been specified. The Department (like nearly all agencies and firms) has not stated how much of one objective it would give up to move one degree nearer to achieving another.

Opportunities

Forest management for production of additional timber values on the Elk State Forest might include a variety of activities. Four major activities might be: (1) harvesting mature timber; (2) protecting timber stands from fire, insects, and diseases; (3) establishing new stands both in areas presently occupied by commercially valuable timber and in open areas, and in areas occupied by brush and low-value timber; and (4) management in existing immature stands, including both type conversion and management within the context of a given forest type.

Both the timber resource and the nature of going programs influence the decisions now faced in managing the Elk State Forest. Special measures for protection of timber stands are carried out under special plans. These activities, particularly fire protection, are generally believed to be operating in a reasonably satisfactory manner. Therefore they can be assumed to continue at present levels and need not be explicitly considered.

The timber resource is concentrated in a relatively few stand classifications. Poletimber stands occupy the bulk of the area, well over 80 percent. Small sawtimber stands (average d.b.h. 12 to 15 inches) occupy most of the remainder (table 1). Though harvesting mature sawtimber is certainly a first-priority activity, this large area in poletimber and small sawtimber constitutes a

major management opportunity. Management of these stands could greatly influence the kind of timber that can be harvested from the Elk State Forest in the future. Thus some of the major opportunities are in management of existing immature stands.

These opportunities can be defined further in respect to the composition of poletimber and sawtimber stands. The Elk State Forest is in hardwood country. Hardwood types occupy virtually all of the 156,000 acres in poletimber and small sawtimber (table 2); and more than 90 percent of the timber volume on the Forest is in hardwood species (table 3). The area is divided about equally between oak and northern hardwood stands. Softwood types and mixed types (the latter particularly suitable for type conversion) occupy extremely limited areas.

Table 2. — *Forest types on Elk State Forest*

Forest type	Area
	Thousand acres
Hardwood types:	
Oak	80
Northern hardwood	67
Aspen	7
Mixed types:	
Oak-hard pine	1
Softwood types:	
White pine hemlock	1
Total area in poletimber and small sawtimber stands	156

Source: Pa. Dept. Forests and Waters. FOREST MANAGEMENT PLAN FOR THE ELK STATE FOREST, 1955.

Three principal management practices might be suitable in the oak and northern hardwood poletimber and small sawtimber. (1) Thining, skillfully applied, would improve timber quality and species composition and would hasten production of mature timber in virtually all of these stands. In some stands, thinning

might reduce the oak component in favor of northern hardwood species. (2) Release might also be a possibility in some of the younger, lower-quality oak poletimber stands. A small number of these oak stands have understories of white pine that could be released. (3) Finally, complete type conversion from hardwood to softwood would be a possibility in some of the poorest oak

Table 3. — *Timber volumes on Elk State Forest*

Species group	Sawtimber volume	Additional poletimber volume
	Million bd. ft.	*Million cu. ft.*
Hardwoods	263	141
Softwoods	24	1
All species	287	142

Source: Pa. Dept. Forests and Waters. FOREST MANAGEMENT PLAN FOR THE ELK STATE FOREST, 1955.

stands. This would involve killing the oaks and then planting white spruce or larch, species generally immune to deer browsing.

These statements concerning practices that would increase timber values help to define the opportunities that are available. They do not indicate which opportunities should be undertaken. To undertake them all would be simply too big a job. For example, if pre-commercial thinning costs roughly $10 per acre, it would cost more than $1½ million dollars to thin the 156,000 acres in poletimber and small sawtimber stands. Some of this area might be thinned without cash cost if saleable products could be produced. Still, the total cost would be large, many times any foreseeable budget for timber-stand improvement. Pertinent questions are: Where might stand improvement best begin? Where would benefits be large in relation to costs? Where would they be small? Also, how large a sum might profitably be spent on stand improvement?

The opportunities to be considered can be classified further in terms of forestry practices and stand conditions. It has already been shown that thinning is probably the most widely suitable practice, and that release and type conversion are other possibilities for some stands. Both the costs and response to thinning and other practices are affected by a wide variety of factors. Species composition (as reflected in forest types) and site productivity are two of these factors. (Accessibility might be another). These factors can be used as a simple basis of classification even though the bulk of the Elk State Forest is in one particular site-productivity class. The major stand conditions found on the Elk State Forest, together with area estimates for each, are listed in table 4.

Table 4. — *Area in poletimber and small sawtimber stands, by site class*

(In thousands of acres)

Forest type	Site classes			
	1	2	3	All sites
Hardwood types:				
Oak	([1])	72	8	80
Northern hardwood	1	65	1	67
Aspen	—	7	—	7
Mixed types:				
Oak-hard pine	—	1	—	1
Softwood types:				
White pine hemlock	—	1	—	1
Total	1	145	9	156

Source: Pa. Dept. Forests and Waters. FOREST MANAGEMENT PLAN FOR THE ELK STATE FOREST, 1955.

[1] Less than 500 acres.

A Simplified Analysis

There are many timber-management opportunities on the Elk State Forest. The major ones are in improvement of the pole-timber and small sawtimber stands that occupy nearly the entire forest. The area in these stands is divided somewhere near equally between the oak and northern hardwood types, with a small area in aspen poletimber stands, and negligible areas in oak-hard-pine and white pine-hemlock stands.

Of the oak and northern hardwood types, which stands offer the best opportunities for stand improvement and where would benefits be large in relation to costs?

This is a complex question if *benefits* and *costs* are interpreted broadly, because the Department of Forests and Waters has not one, but several objectives. The question can be simplified by first concentrating on one objective and introducing the others later. This simplified analysis will concentrate on the Department's primary timber-management objective: to obtain the greatest possible value response from funds invested in timber management.

Timber-management opportunities in Pennsylvania as a whole were analyzed recently (Webster 1960). In this analysis, each of three sets of forestry practices applied under a variety of stand conditions were ranked. The practices were: (1) planting open or lightly stocked forest land, (2) cleaning and cull-tree removal in hardwood seedling-and-sapling stands, and (3) thinning in hardwood poletimber stands.

These rankings were in terms of value response per cost dollar. A number of factors were considered. They included: (1) the physical costs of carrying out the selected forestry practices under a variety of stand conditions; (2) cost rates for converting physical costs to dollars; (3) physical response that could be expected under various conditions (including changes in gross volume, losses to fire, insects, diseases, changes in species composition and timber quality, and changes in the number of years required to produce mature timber); and (4) the prospective value of the mature timber.

These rankings brought together many different types of information—silvicultural, entomological, pathological, economic. A wide variety of sources—published, unpublished, and personal consultation—were drawn upon.

The thinning portion of this analysis deals with some of the timber-management opportunities available on the Elk State Forest. It can be used to compare opportunities for thinning. No comparable basis is yet available for comparing opportunities for pine release and for type conversion in oak stands. Comparisons in terms of thinning will give a minimum estimate of the value response obtainable from appropriate forestry practices under each of a variety of stand conditions. In a few cases, value response from release or type conversion might be greater.

Rating the Opportunities

The major timber-management opportunities on the Elk State Forest were ranked, using value response and cost data from the earlier analysis (table 5). This ranking provides information concerning the relationship between benefits and costs for four different management opportunities in oak and northern hard-

Table 5. — *Rating of timber-management opportunities on the Elk State Forest*[1]

Management Opportunity	Rate of return on additional investment	Value response per cost dollar		Increase in present net worth per acre[2]
		Discount rate 6%	Discount rate 3%	
	Percent	*Dollars*	*Dollars*	*Dollars*
Thin, northern hardwood, site 1	11.2	5	16	46
Thin, northern hardwood, site 2	10.3	4	13	32
Thin, oak, site 2	6.8	1.40	5	3.6
Thin, oak or northern hardwood on site 3 and aspen site 2	1.1	.20	.71	—7

[1] Rate of return, value response per cost dollar, and increase in present net worth were all calculated using data from Webster (1960).

[2] Future values discounted at 6 percent.

Table 6. — *Accomplishment at various levels of expenditures*

Expenditure level	Management opportunities	Increase in present[1] net worth of Elk State Forest
$5,000	Thin approximately 500 acres, northern hardwood, site 1	$23,000
$10,000	Thin approximately 1,000 acres, northern hardwood, site 1	$46,000
$25,000	Thin approximately 1,000 acres, northern hardwood, site 1, and approximately 1,500 acres, northern hardwood, site 2	$94,000
$50,000	Thin approximately 1,000 acres, northern hardwood, site 1, and approximately 4,000 acres, northern hardwood, site 2	$174,000
$100,000	Thin approximately 1,000 acres, northern hardwood, site 1, and approximately 9,000 acres, northern hardwood, site 2	$334,000
$500,000	Thin approximately 1,000 acres, northern hardwood, site 1, and approximately 49,000 acres, northern hardwood, site 2	$1,600,000
$1,000,000	Thin approximately 1,000 acres, northern hardwood, site 1, and approximately 65,000 acres, northern hardwood, site 2 Thin approximately 34,000 acres, oak, site 2	$2,200,000
$1,500,000	Thin all poletimber and small sawtimber stands (total 156,000 acres)	$2,200,000

[1] Future values discounted to present at 6% compound interest.

wood poletimber and small sawtimber stands. The relation of benefits and costs can be expressed in several different units: rate of return on additional investment, value response per cost dollar, and increase in present net worth. Rates of return range from a high of 11.2 percent for thinning northern hardwoods on site 1 to a low of only 1.1 percent for thinning oaks or northern

hardwoods on site 3 or aspen on site 2. The other profit measures give similar rankings.

These rankings constitute a priority schedule for timber management. If the data are correct, the greatest possible increase in timber values will be obtained by undertaking management opportunities in the order listed. For example, it is estimated that $10,000 dollars spent thinning northern hardwood stands on site 1 will increase the net value of the Elk State Forest by some $46,000 dollars (table 6), while the same amount spent for thinning oak stands on site 2 will increase the value by only $3,600.

Application

A schedule of priorities (table 5) can be used to guide management to the most productive opportunities. The managers of the Elk State Forest could use it to start management where benefits would be largest in relation to costs, and to proceed down the scale step by step.

However, additional information is required before such a schedule of priorities can be used. Many different kinds of stands are intermixed in the forest. Management planning could focus first on northern hardwoods on site 1. However, it would be extremely inefficient to actually thin all of these stands, and then go back and thin all the northern hardwood stands on site 2, and so on. Under many circumstances it would be more efficient to do all the work that is to be done in a given area before moving on to another area. What is the total job to be done at any given time? Or, how far down the schedule of priorities will any given budget reach?

The management opportunities that might be undertaken at a number of levels of expenditure (table 6) range from a very modest $5,000 to $1½ million dollars. For example, $5,000 could be used best to thin approximately 500 acres of northern hardwoods on site 1. Other opportunities would have to be ignored for lack of funds. With $50,000, it would be possible to thin all 1,000 acres of northern hardwoods on site 1 and also to thin 4,000 acres of northern hardwoods on site 2. Similar

Table 7. — *Cost schedule*

Management opportunity	Area	Average variable cost per acre	Total cost	Cumulative total cost
	Thousand acres	*Dollars per acre*	*Thousand dollars*	*Thousand dollars*
Thin, northern hardwood, site 1	1	10.50	10.5	10.5
Thin, northern hardwood, site 2	65	10.50	682.5	693.0
Thin, oak, site 2	72	9.00	648.0	1341.0
Thin, oak or northern hardwood on site 3, or aspen on site 2	16	9.00-10.50	160.0	1301.0

determinations could be made for any other level of expenditure, using the acreage and per-acre cost data in table 7.

But just what would be accomplished by taking advantage of the package of management opportunities that could be undertaken at any given budget level? How much would the additional timber be worth?

The increases in the present net worth of the Elk State Forest that would be produced by spending various sums in accordance with our schedule of priorities are listed in the last column of table 6. For example, expenditure of $10,000 to thin some 1,000 acres of northern hardwoods on site 1 would produce additional net values equal to $46,000 when discounted back to the present at 6 percent. Determinations for levels other than those listed can be made by using the value-increase data in the last column of table 5 and the acreage data in table 7.

How Big a Budget?

So far we have dealt with problems to be faced in the management of the Elk State Forest. In essence, we were concerned with how to spend a given budget. But there is a larger problem that must also be dealt with, at some higher level. That is the problem of how much money should be spent on timber

management on the Elk State Forest. How big should the budget be?

Economic theory provides one framework for answering this question. The greatest net benefit will be obtained from timber management on the Elk State Forest (or any other activity) if management is extended just to the point where an additional dollar spent will return an additional dollar in benefits. This point can be identified by using the rates of return for various management opportunities shown in table 5.

Suppose that other opportunities open to the Department of Forests and Waters are good enough that 6 percent is a minimum acceptable rate of return. In that case, all oak and northern hardwood poletimber and small sawtimber stands, except those on site 3, should be thinned. Thinning in all these stands promises returns greater than 6 percent. Therefore each dollar spent promises a return of more than a dollar. These stands occupy slightly less than 140,000 acres. If thinning costs about $10 per acre, a budget of $1.3 to 1.4 million would be justified (table 6).

Now suppose that other opportunities are somewhat better. Suppose that they are so good that 11 percent is the minimum acceptable return. Only thinning in northern hardwood stands on site 1 proimses a return greater than 11 percent. Therefore our analysis suggests that it is the only opportunity that should be undertaken. This would call for a much smaller budget. Some 1,000 acres would be involved, and a budget of approximately $10,000 would suffice (table 6).

Making the Decisions

Our analysis of major timber-management opportunities on the Elk State Forest is relatively simple. It ranks major opportunities, thereby supporting the proposition that timber management should start with those northern hardwood stands on highly productive sites and proceed, by stages as more money becomes available, down a scale ending with those oak stands on sites of low productivity. It measures the differences between opportunities in terms of benefit—cost relationships. Thus it

provides a basis for estimating the opportunity costs that would be incurred if opportunities were taken up in some other order.

The simplicity of the analysis stems from a number of assumptions made in carrying it out. There are three or four major assumptions. The first is that the sole objective of management is to produce additional timber at minimum cost; that is, to obtain the greatest possible value response from funds invested in timber management. There is a corollary to this assumption: that any complexity of management is acceptable so long as it increases value response per cost dollar. The second major assumption is that thinning in hardwood poletimber and small sawtimber is the only major timber-management opportunity. The third major assumption is that all data used in the analysis are perfect. The fourth major assumption (or perhaps a corollary to the third) is that all costs are readily measurable in terms of the inputs used in timber management.

How reasonable are these assumptions? Where do they depart from reality? And how might these departures affect timber-management decisions?

Allocating a Given Budget

The first three major assumptions affect allocation of a given budget. All depart from reality to one degree or another. The Department of Forests and Waters has not one but several objectives. Thinning in various kinds of hardwood stands is not the only timber-management opportunity available. And this analysis, like all others, uses information that is imperfect.

In addition to minimum-cost production of timber, the Department's objectives include efficient production of other forest products, keeping complexities of management to a tolerable level, and maintaining good relations with legislators, other agencies, and citizens. Furthermore, concentration of work in areas of limited employment opportunities is either another objective or perhaps a means of maintaining good relations.

The effects of other objectives are clearest in the case of wildlife production. During the fall and winter of 1961-62 the Pennsylvania Game Commission made thinnings and other

cuttings on some 5,800 acres for the primary purposes of providing additional deer browse in food-shortage areas. This acreage included some 800 acres on State Forest lands. The Department of Forests and Waters and the Game Commission selected stands for treatment on State Forest land. If these thinnings had been made to produce additional timber values at minimum cost, they would have been concentrated in northern hardwood stands on productive sites. It is here that benefits from timber production are largest in relation to costs (table 5).

However, the fact is that the stands thinned have been roughly half oak and half northern hardwood. Many food-shortage areas have been in locations where oak stands predominate. In these situations the Department of Forests and Waters and the Game Commission try to select for treatment oak stands on the more productive sites. Thus, the Department tries to pursue its primary timber-management objective but within restraints imposed by its wildlife-management objective. The objective of producing wildlife in an efficient manner has modified management on a relatively small area. If the Game Commission were able to expand its scale of operation, this objective might modify management on much larger areas.

Since the effects of other objectives are not so clear-cut, specific cases cannot be cited. It is apparent, though, that the effects are important. Given funds for management of immature stands, the Department of Forests and Waters would try to direct work toward areas of unemployment or limited employment opportunities. While this objective would primarily influence distribution of work among districts or other major sections of the State, it might also have some influence on distribution of work among sections of particular state forests like the Elk. There is obviously no reason for expecting the most profitable timber-management opportunities to coincide with areas of unemployment.

The objective of maintaining good relations has somewhat similar effects. Concentration of work in areas of unemployment may be one means of maintaining good relations. But, in any case, the interest of individuals and groups of citizens does have some effect on the location of work in Pennsylvania or in any

other state or jurisdiction. Almost any activity, including timber management, is more likely to be successful if it is undertaken in areas where people are interested in it. Thus the Department operates within an additional restraint in selecting the timber-management opportunities it will undertake. And this restraint probably influences distribution of work within Administrative Districts and State Forests, as well as between them.

Timber management may be influenced by the existence of other opportunities as well as other objectives. Thinning is not the only forestry practice that might be applied in predominantly oak and northern hardwood poletimber and small sawtimber. Release of understory pines and complete type conversion from hardwoods to softwoods are also possibilities in some of the poorer oak stands. These practices might bring about somewhat greater returns than thinning (table 5). This would decrease the differences in the returns promised by various opportunities. As a result, management of oak stands might appear somewhat more favorable than it does in our simplified analysis. Some parts of relatively small budgets might be devoted to management of these stands.

Finally, the information used in the analysis is imperfect. Both the response and cost data (Webster 1960) and the area estimates for the Elk State Forest are subject to error. Both types of data were obtained by sampling. In addition, the response and cost data were developed by combining information from a number of studies, and gaps were filled by using judgment estimates supplied by experienced foresters familiar with Pennsylvania conditions. As a result, both the profit measures used to rank timber-management opportunities and the auxiliary data used in other calculations might be represented better by either probability distributions or range estimates rather than by point estimates. Unfortunately the information necessary to calculate distributions or ranges is not readily available.

Nevertheless imperfections in the data can be recognized in a useful manner. When we inspect the rates of return promised by various timber-management opportunities, we see that they are 11.2, 10.3, 6.8, and 1.1 percent (table 5). Comparing

adjacent rates, which differences might be insignificant and which might remain even when data imperfections are taken into account? We cannot be sure, but we can probably make some informed guesses. The first two rates (11.2, 10.3) are particularly close, and the differences become progressively larger the rest of the way down the scale of priorities. We might be justified in concluding that the difference between the returns promised by the first two opportunities are insignificant, but that the other differences are significant, particularly the yawning gap between the last two opportunities on the list.

After reaching such a judgment, we could combine some of the opportunities. In this case, thinning northern hardwoods on sites 1 and 2 could be combined into a single opportunity, and the rest of the scale of priorities could be left as it is. Such combinations would simplify the manager's job in some respects, and would make it more complex in others. It would no longer be necessary, at low levels of expenditure, to find a small area of northern hardwoods on site 1, in the midst of a large area of northern hardwoods on site 2, and other kinds of stands. On the other hand, it would be less clear, in terms of planning, where a small budget might best be spent. In any event, however, the manager would be using data that represent reality more closely than would be the case if he assumed that all differences in return are significant no matter how small.

Thus a number of factors not included in the simplified analysis would influence budget allocation. Existence of other objectives and other opportunities might cause some shifting of priorities. Imperfect information would dull the analysis, giving a priority scale of only a relatively few opportunities.

Such an analysis will nevertheless be useful in allocating any given budget. Production of additional timber in an efficient manner is one of the objectives of the Department of Forests and Waters. Management for production of forest products other than timber is an important consideration on only relatively small areas of the Elk State Forest. And thinning in hardwood stands does encompass many of the major opportunities. Therefore this analysis can serve as a meaningful guidepost. It makes clear that

some timber-management opportunities are much better than others. And it provides a basis for separating the good opportunities from the poor ones that is more satisfactory than a one-aspect guide such as site-productivity. Imperfections in the available information mean that the guides are not so sharp as they might be. But some opportunities promise returns 10 times as great as those promised by others. Therefore a significant ordering of priorities has been accomplished.

Determining a Budget

Our analysis showed that modest budgets for timber management on the Elk State Forest would be justified even if a high return of more than 10 percent were the minimum acceptable. It further showed that truly large budgets would be justified if a moderate return of 6 percent were acceptable.

There is some evidence that the cost data used in this analysis are too low. It was assumed in the study on which this analysis was based that thinning would cost roughly $10 per acre. More recent information taken from operations of the Pennsylvania Game Commission suggests that roughly twice this figure—$20 to $25—might be more appropriate.[3] Higher costs would not change priorities because all of the management opportunities would be affected to the same degree. Their relative rankings would stay the same. But higher costs could influence budgets and the amount of timber management that could be accomplished. For example, suppose 6 percent were the minimum acceptable return and thinning cost $25 per acre. Under these circumstances, thinning in northern hardwood stands on sites 1 and 2 would still be justified (rates of return: 8.4 and 7.6 percent). But it would no longer be justified in oak stands on site 2 (rate of return: 4 percent). It so happens in this particular case that the budget would remain roughly the same.

[3] Thinnings carried out by the Game Commission have cost as much as $50 to $60 per acre. These costs were increased by factors that would not be present in thinnings carried out for timber rather than wildlife production: flattening of cut material, movement of brush, and performance of operations during periods of deep snow when deer food is particularly short. Straight timber-management operation might cost roughly half as much or less.

Higher costs per acre would offset a smaller number of acres, but obviously fewer acres could be treated and the resultant increase in the value of the Forest would be smaller. In other cases both the budget and the number of acres would decrease.

Even when higher costs are used, our budget calculations contrast sharply with the budget actually available. The managers of the Elk State Forest and other Pennsylvania State Forests now have no direct budget for management of immature stands. At present timber-management activities go little beyond sale of mature timber and related supervision. The only funds now available for management in immature stands are those available to the Pennsylvania Game Commission, and they are used primarily for wildlife-habitat improvement.

Why is there such an extreme contrast? One reason is that the overall budget for timber management in immature stands is beyond the control of the Department of Forests and Waters. When one is provided it will be done by the Governor and the Legislature. They will undoubtedly be influenced by the wishes and preferences of the citizens of Pennsylvania both as individuals and as organized groups. This is a higher level decision.

But why haven't the Governor and the Legislature provided any money when opportunities look quite favorable? Two explanations might be advanced. First, governors, legislators, and citizens may be unaware of timber-management opportunities. After all, they are busy people with many other things to think about. Second, they may consider opportunities that are not included in our analysis. If so, our assumption that all costs can be measured in terms of inputs involved in timber management is unrealistic.

And it is clear that the Governor, the legislators, and the citizens do consider other opportunities, many of them far removed from forestry. There is presumably some reasonable consensus on budgets for the state government as a whole at any given point in time. Within the limit implied, many extremely diverse activities compete with one another. Timber-management opportunities do not compete with each other at this level. Rather they compete as a group with expenditures for edu-

cation, highway construction, and mental health programs—to name only three examples. Furthermore, political considerations are obviously important, and legitimately so.

The diverse nature of the opportunities compared at this level means that our analysis of timber-management opportunities can contribute relatively little to the details of budget determination. A much broader analysis would be required. Even then the contribution of formal analysis may be relatively limited. Obviously it would be difficult, if not impossible, to reduce to a common scale the benefits of timber management, public education, highway construction, and mental health programs. Formal analysis may identify extreme cases of budgets too high or too low. This case may be one of these. However, other criteria (more subjective and political) will necessarily be used in determining the dollar amount of budgets. From the viewpoint of the managers of the Elk State Forest, then, budget determinations will be made by other people, using criteria quite different from those that they might use.

Perspective

This paper traces the usefulness and the limitations of a particular kind of economic analysis as a guide to timber management. At the outset it was described as a case study. Therefore no sweeping conclusions can be drawn. However, one striking tendency can be noted: the usefulness of the analysis for spending a given budget and its lack of usefulness for determining that budget.

The analysis was found to be distinctly useful in ranking timber-management opportunities. Admittedly it did not consider all of the objectives of the Pennsylvania Department of Forests and Waters nor all of the opportunities open to the Department. Nevertheless it did consider some of the major ones. For that reason the Department could see the rankings based on rates of return or other profit measures rather directly. Therefore a given budget available for timber management could

be spent more efficiently with the aid of this analysis than without it.

On the other hand, the analysis was found to be of little use in determining budgets. The difference between the large budget that could be justified and the budget actually available was striking. Some part of this difference may be attributed to lack of information. Governors, legislators, and citizens may be unaware of timber-management opportunities. But the difference is so great that all of it can hardly be attributed to lack of information.

An earlier analysis considered much the same point in a quite different context. It examined, on a conceptual level, the usefulness and limitations of economic analysis as a guide to three types of watershed-management decisions (Webster and Hagenstein).[4] It contrasted least-cost, fixed-expenditure, and production-goal decisions. In broad terms, least-cost and fixed-expenditure decisions involve questions of method. How can given changes in the quantity, quality, and timing of water flows be obtained most cheaply? How can a given budget be best spent to obtain the greatest possible benefit from changes in water flows? These decisions do not require measures of the value of water. Therefore conventional techniques of economic analysis can be used to provide guides to them. On the other hand, production-goal decisions involve questions of scale. How large a budget for watershed management will give the greatest net benefit? Measures of the value of water are required to determine net benefits. And, since water is rarely bought and sold by the unit at the watershed, economic analysis is not likely to be very useful in terms of guides to production-goal decisions.

An interesting insight is provided when this case study and the earlier analysis are brought together. In the earlier analysis it appeared that lack of prices established in commodity markets was what limited the usefulness of economic analysis in budget determinations. In the case study we have seen, however, that

[4] Webster, Henry H., and Perry R. Hagenstein. ECONOMIC ANALYSIS OF WATERSHED-MANAGEMENT DECISIONS: WHAT SORT OF GUIDES FOR LAND MANAGERS? Article submitted to Journal of Forestry, 1962.

something else is also involved. Timber is the product in the case study. It is sold by the unit in commodity markets and therefore prices are established. Even so, economic analysis is not particularly useful in determining budgets. Why?

Budgetary and political factors are often cited. This is right as far as it goes, but it doesn't go very far. Why is economic analysis so outweighed by budgetary and political factors in budget determinations?

The fact is that determination of budgets for timber management, watershed management, or almost any other activity often involves comparisons of some extremely diverse activities. For example, in the case of state programs of timber management in Pennsylvania, the relevant comparisons might be with education, highway construction, and mental health programs. It would be difficult to reduce the benefits of these activities to a common scale. Allocation of a given budget involves a much narrower range of alternatives. This case study provides an example. The alternatives were various timber-management opportunities in a limited geographic area. The benefits of these opportunities can be more readily reduced to a common scale. Therefore economic analysis could be quite useful in allocating a given budget, and at the same time quite ineffective in determining the size of that budget.

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