HARVARD FOREST

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ECONOMIC ANALYSIS OF FARM FOREST OPERATING UNITS

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FOREWORD

This study grew out of a project on the rural economy of New England which has been a major undertaking of the Seminar in Agriculture, Forestry and Land-Use Policy of the Graduate School of Public Administration at Harvard University since this seminar was organized in 1938. The first major publication growing out of this project was "The Rural Economy of New England" (14). It was early decided to follow up this general study with more detailed work on the two principal uses of the land of New England, dairy farming and forestry. The Charles H. Hood Dairy Foundation has financed the dairy farming work since 1946 by a grant to the Committee on Research in the Social Sciences of Harvard University, and a report on this is well on its way toward publication.

The central feature of the dairy farming study is a planning analysis of 241 dairy farms in fourteen areas in 21 counties in the six states. On 211 of these farms that had 5 acres or more of forest land the woodlots averaged 107 acres. These woodlands were treated as an integral part of the farm business, and profitable woodland management alternatives were carefully evaluated. The yearly average farm sale of forest products during the transition period, while the woodland management plans were being put into effect, was estimated at $350 at 1949–51 farm prices, and labor inputs at 41 man-days. The comparable estimates for the longer run of 40 to 80 years were $680 for 69 man-days, assuming no relative rise in timber-product prices.

The Hood Foundation then financed the analysis of the nine farms in the agricultural fringe areas of New England which is reported in this bulletin. These farms have relatively more woodland and less dairying (one has beef cattle for comparison) than the 241 farms in the first study, and the woodland analysis is more detailed, the woodland production being estimated by 10-year periods for 90 years. Farms of this type are common in northern Europe, and it was thought worthwhile to explore their possibilities in similar situations in New England.

The planning of the woodlands on the 241 farms was done by Ernest Gould, and that of the nine farms by Gould and Solon Barraclough in company. It became apparent at the start that existing input-output data were highly inadequate for woodland planning analysis, and these two men began collecting additional information, and improvising procedures for its use. The Northeastern Forest Experiment Station recognized the relationship of these data to the U. S. Forest Service research program, and during 1951–1952 engaged Dr. Barraclough (now Associate Forester, University of Tennessee Agricultural Experiment Station) to explore and assemble all the forest input-output data that he could locate anywhere in the Northeast. This bulletin reports what he found, in combination with the results of the analysis of the nine fringe-area farms. Much of the final task of analyzing the data and preparing this report has been financed jointly by the Northeastern Forest Experiment Station and the Harvard Forest, where Dr. Gould is now stationed as Forest Economist. The Hood Foundation project and the Harvard Forest are sharing the publication expense.

In order to arrange the subject matter of the bulletin conveniently it is divided into seven chapters, the first three covering farm analyses and the second three forest planning data. The seventh chapter includes a brief summary and conclusions.

In Chapter I plans for a dairy-woodland farm are discussed in detail to show how alternative operating plans can be evaluated by the budget method. As a further illustration similar budget analyses for eight other farms are summarized in Chapter II. Because all nine farms are in areas where agricultural activity has declined, some tentative conclusions about the problems and opportunities for profitable farm and forest management in such "fringe areas" make up Chapter III. The nature of the input-output relationships needed for budgeting is discussed in Chapter IV, and the next two chapters include data on forest management-yield relationships and on performance rates in forest operations. This information is applicable to New England conditions, and the discussion includes some suggestions for future biological and engineering research. Finally, Chapter VII contains a brief summary of the principal points developed in this study and an outline of the broad contours of a research program in the field of forest production economics.

The information presented in this bulletin has several objectives. First, the discussion of the nine farms illustrates a method of analysis that has wide application to the management opportunities and problems of forest and farm operating units. Second, some broad generalizations can be based on the analysis of these farms. Third, forest planning data which may be useful to persons concerned with budgeting alternatives are presented. And fourth, the weaknesses and gaps in these data are made more obvious, and research is suggested to remedy these deficiencies.

The authors have found that whenever budget analyses of forest-management alternatives are discussed, some people question the input-output relationships used and want further information about them. On the other hand, some find it difficult to see the necessity for collecting input-output data until shown how they are used in a concrete case. The content of this bulletin has been designed to answer both kinds of questions.

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INTRODUCTION

In 1754 this bulletin would have had little meaning. Two hundred years ago forest owners were confronted with a seemingly endless supply of standing timber. The leading forestry question of the day was how to utilize profitably this abundant natural resource.

Twenty decades of national growth, however, have brought about great changes in the economic climate affecting the way owners use their forests. Some statement of the present situation seems necessary, not only as a background to the discussion that follows, but also to see why we have focused our attention on the economic problems of forest production.

Future Forest Requirements If the desires of an increasing population for an improved standard of living in the United States are to be satisfied, the nation's output of goods and services will have to double between 1950 and 1975. This estimate amounts to an average increase of about 2½ percent each year. And an even greater increase in output may be needed to meet additional demands for armament and foreign aid.

We shall have to use more of our natural resources, both renewable and non-renewable, to produce more and more goods in the future. To do this it will be essential that we as a nation utilize all of our resources wisely and efficiently.

As the United States' economy expands, so will its demands for most timber products. The President's Materials Policy Commission Report (87) has emphasized a need for greater total production even though less wood may be used for some products than formerly. In addition, the use of our forests for recreation, wildlife production, and watershed protection should increase rapidly. The long-run outlook is one of increasing demands for nearly all the products of the forest.

But this does not mean that forest resources will automatically furnish more timber and other values in the future. Greater use depends on increasing forest production economically so that wood can be supplied at prices competitive with those of imports and of other products that may be used as substitutes. If timber prices rise too high, people will be encouraged to use other materials such as plastic, steel or brick instead of wood, and to develop new substitutes. After this, even with a subsequent decrease in its relative price, timber might not fully recover its former markets.

Production Adjustments Any permanent and economical expansion of forest production will require a gradual reorientation of the forest economy. In the past, timber products have been cut largely from the virgin and second-growth stands that nature provided. Usually little thought has been given to other forest values or to growing forest crops for the future. The drain on good quality sawtimber under this system now far exceeds current replacement.

Because the way that we use our forests today will largely determine the timing and kinds of product they will yield in the future, we now need to take steps designed to obtain a desirable long-term level of production.

It is often stated that achieving more forest production is merely a matter of increasing the volume and quality of forest growing stock because high-quality sawtimber can be produced only from well-developed stands, and the continued yield of any timber product is directly related to the growing stock maintained. In addition, watershed, recreational, and many other forest benefits may depend on keeping vigorous stands of sizable trees on much of the forest area.

At first glance the problem of building up growing stock seems to be a simple one that can be solved in purely quantitative and biological terms. Much current thinking is to the effect that this objective can be achieved simply by waiting a few years longer than is now the practice before cutting, protecting the forest from fire and other injuries, and by taking steps to promote more adequate regeneration. Partial cutting alone will frequently increase production and avoid delays in reproducing new forest stands. And the whole process of growing desirable trees may often be speeded up by using cultural practices such as thinnings and improvement cuttings.

But the goal of more and better growing stock is a deceptively simple generalization. Even if we knew all about the methods that would increase forest production, which we do not, there are a great many complex economic problems that have to be solved before people will apply them.

The Role of Landowners In the Northeast, for example, there are over 750,000 separate forest owners, each with his own problems. Seven tenths of the region's 72,000,000 acres of commercial forest is owned privately in holdings of less than 5000 acres. Although the average size of these small holdings is only 66 acres, those between 50 and 1000 acres include the bulk of the total forest area (8) (102).

These forest owners are the ones in position actually to increase long-run productivity by improving forest practices. In the final analysis, they make the management decisions that affect land use. But many of their present decisions are not conducive to increasing or even maintaining forest production. In addition, there are strong reasons to believe that most of these owners are not taking full advantage of their opportunities to utilize profitably their forest resources.

Formulating effective public policies to deal with these small holdings depends partly on knowing more about what landowners can do with their woodlands profitably and what forest practices they can use in their own interest. At present little is known about the economic sacrifices that might be forced on private owners if they were compelled to follow specified forest practices. And we have only a hazy notion of the practices owners would follow if they clearly understood the full consequences of their management decisions.

This kind of information can be obtained by evaluating alternative management programs for individual forest operating units. After enough forest ownerships have been analyzed in this way it will be possible to see patterns of adjustment that are needed to bring forest land under desirable and profitable management and to answer such questions as what natural resources, labor, materials, technical assistance, and credit will be required, and what forest production is likely to result.

Research is needed to show exactly what forest management has to offer an owner in his particular case. To do this, the findings of silvicultural and engineering research must be related to the problems of individual owners. In the process of coordinating and translating technical knowledge into a basis for private and public action, economic analysis plays an indispensable part. The principal purpose of this bulletin is to increase our understanding of forest production problems by applying available technical information in economic analyses at the forest operating unit level.

Chapter I

PLANNING ONE WOODLAND-DAIRY FARM

All too often owners make their forest and other management decisions knowing very little about what will result or about what courses of action are open to them. The problem of converting these decisions into a rational choice among alternatives whose consequences are known is, therefore, a matter of considerable interest. This chapter and the next contain some specific cases where farmers have systematically considered their management opportunities in order to make well-informed decisions.

The first farm is discussed in considerable detail in this chapter to clarify the meaning and the mechanics of budgeting — a process for planning an operating unit that can lead to rational management decisions. Although only case studies of farms have been used in this bulletin, budgetary analysis is equally applicable to the management problems of other holdings, whether they are large industrial ownerships, small residential farms or government forests.

Farm A — A Hill Farm in a Nearly Abandoned Town

The owner of this farm is a young man dealing in an unusual way with a difficult situation commonly found in the more remote areas of New England. He is a skillful and energetic farm operator with a varied background of vocational training and work in agriculture and logging. A flexible imagination is a great help to him in planning the development of what was once a typical "run-down" farm.

The owner has worked successfully in better developed areas, but a few years ago decided to return to this small town. The family likes the location and they have worked together to remodel the house into a comfortable home despite the lack of a telephone and electricity and the probability that such conveniences will not be available in the near future.

The farm has a good deal of value to the family as a residence, and they get considerable pleasure from merely owning the land. But it is also necessary to develop the income-producing capacity of the operating unit so that they can continue living here.

Until recently the operator has spent at least half of his time working off the farm, but now he wants to look ahead and see what the farm opportunities are and how he can best develop them. He has long been convinced that forest production has a promising future, and he has added to his woodland holdings whenever purchases could be made cheaply.

To date the operating unit that he has assembled and the improvements he has made in it have been aimed at building up crop, livestock, and forest enterprises that will support his family and in the long run have value for his children.

The Town and Markets The alternative ways in which these enterprises can be developed are limited to some extent by factors outside the farm. The town itself is nearly abandoned, and many public services are at a minimum level. Fortunately, the expense of these services is not great and the tax burden does not fall heavily on the residents; most of the taxes are paid by non-residents who own a great deal of the property. This situation seems likely to continue.

The farm is located on a gravel road 18 miles from the nearest creamery and 8 miles from the nearest milk truck route. Road maintenance and timely snow removal are therefore important to the successful marketing of farm and forest products. The long distance to a wholesale milk outlet and the lack of electricity handicap expanding the dairy enterprise.

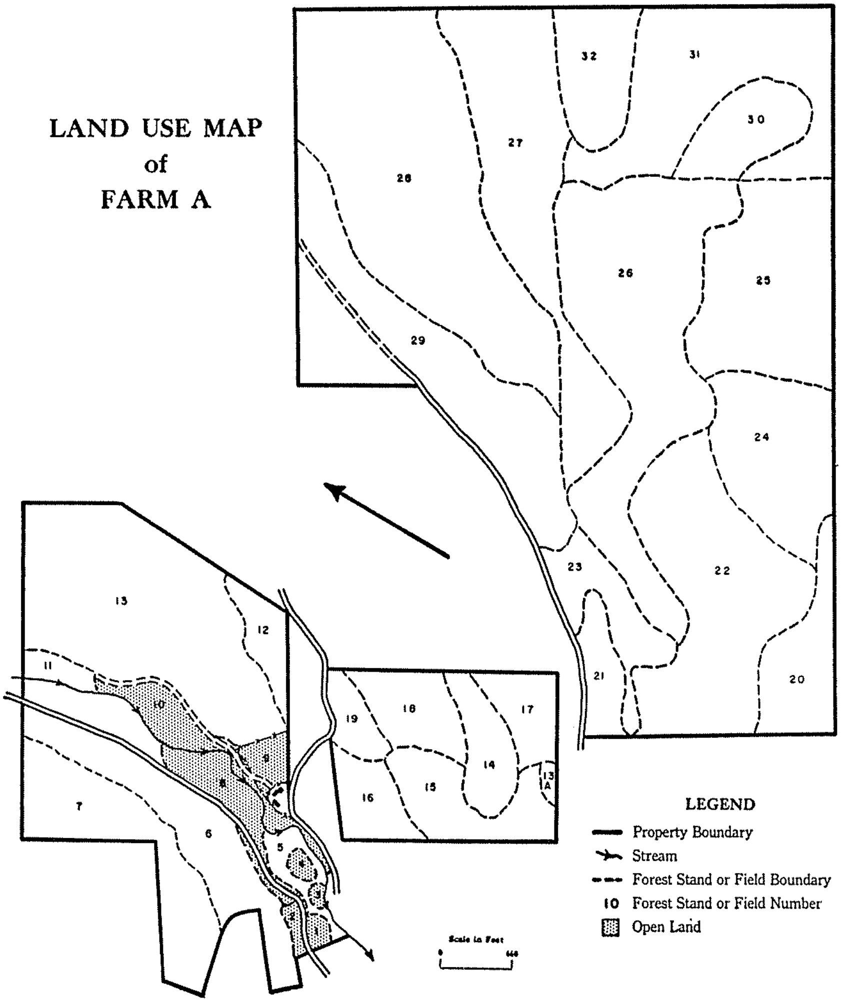
However, markets for all kinds of wood products, delivered at the roadside, are fairly steady and buyers are plentiful. The long-term outlook for selling forest products appears favorable. A county forester, Soil Conservation Service technician, and extension agent are also available to help the owner with his forest and farm management problems.[1]

The Farm Until recently the land resources of the farm included 833 acres of woodland, much of it purchased after it had been clear-cut or high-graded. There were also 18 acres of cropland, 4 acres of improved pasture, 8 acres of open pasture, and 3 acres of other land. A current purchase has added 9 more acres of open land and about 36 acres of woodland which are not worked at present. This makes a total of 911 acres to be operated in the future. (See Maps 1 and 2.)

Buildings include a 36 x 45-foot main barn with 10 tieups and a young-stock pen. An adjoining shed provides fertilizer storage, contains a tub of running water for the stock, and an old milk room. A horse barn and three cabins are located about a quarter of a mile from the homestead. The cabins are rented. A horse, used primarily for woods work in rough terrain, is kept in the barn.

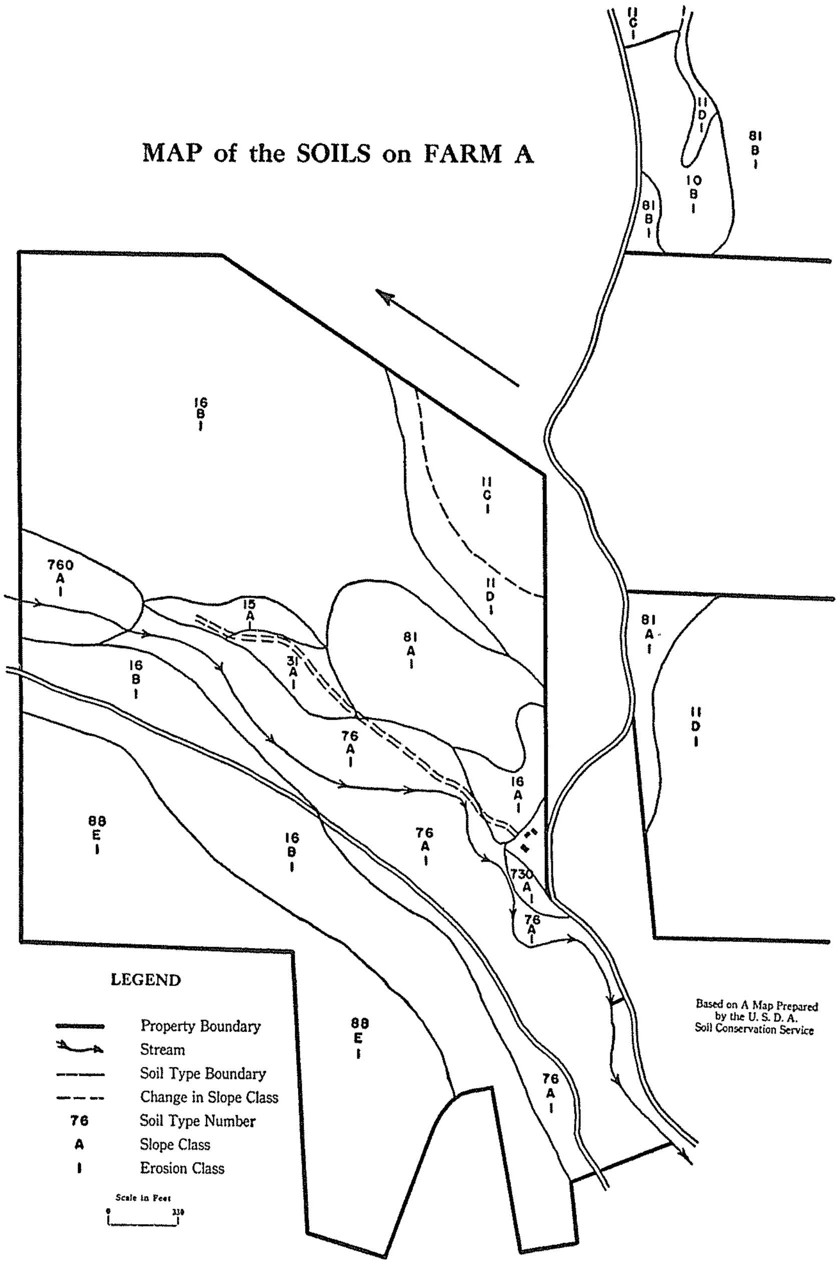
The farm is equipped with a new rubber-tired tractor, plow, harrows, cultivator, mower, and a manure spreader. The dairy barn has a hay fork. Other equipment includes a dump rake, low-bed wagon, 1941 pick-up truck, and 1935 dump truck.

[1] In some states county foresters are called service foresters or farm foresters. They are employed under the Federal Cooperative Forest Management Act of 1950 in cooperation with the states.



MAP No. 1 LAND USE MAP OF FARM A
The open fields and forest stands on Farm A. Field and stand numbers are those used in the discussion of management suggestions.

MAP No. 2 MAP OF THE SOILS ON FARM A
See Soil Notations for explanation of the number and letter symbols used.



SOIL NOTATIONS USED ON MAP OF FARM A

Soil Type Numbers	*Soil Name and General Characteristics*
10	Berkshire loam — a deep, well drained soil from acid rock.
11	Berkshire stony loam — a deep, well drained, stony soil from acid rock.
15	Woodbridge loam — a deep, slightly imperfectly drained soil from acid rock, with a tight compact subsoil at 1½′–2′ which makes for seepy spots.
16	Woodbridge stony loam — a deep, slightly imperfectly drained stony soil from acid rock, with a tight compact subsoil at 1½′–2′ which makes for seepy spots.
31	Sudbury fine sandy loam — imperfectly drained sands or gravels.
76	Podunk fine sandy loam — imperfectly drained bottom land soil — usually subject to flooding by normal high water — acid.
81	Leicester stony loam — a poorly drained stony soil from acid rock (granite, etc.).
88	Rough stony land — rough, non-agricultural areas best suited to woodland.
730	Ondawa fine sandy loam, high phase — well drained bottom land soil — above normal high water — acid.
760	Rumney fine sandy loam — poorly drained bottom land soil — usually subject to flooding by normal high water — acid.

Slope Symbol

- A level or nearly level
- B gently sloping
- C moderately sloping
- D strongly sloping
- E steep
- F very steep

Erosion Symbol

- 1 slight erosion
- 2 moderate erosion
- 3 severe erosion

Present Operations The herd of Jersey cows has been built up to five, and some promising heifer calves have been purchased. Considerable reseeding and moderate fertilization have already greatly improved roughage production. The operator has fed little grain, since only a small amount of milk can be sold locally. Each year he makes about 500 pounds of butter and sells half of it in the neighborhood; the balance of the milk is used by the family or given to the calves or pigs. Production per cow has been about 4500 pounds of milk with 4.8 percent butterfat on about 700 pounds of grain feeding. Two pigs and a beef animal are kept for home use.

The operator has also carried on some woods work, cutting the equivalent of about 96 cords of pulpwood each year in addition to fuelwood. Most of these operations have been patch cuttings in small stands of older trees and reproduction has become established promptly. The owner has been able to hire most of this work done and to pay part of the wages in the form of cottage rent and milk.

Problems and Possibilities

The situation on this farm and on farms generally can be stated something like this: The owner has certain natural resources of farm land and forests. He also has a supply of capital goods such as buildings, livestock, machinery, and equipment; this supply he can sometimes change, especially if he can borrow money. In addition, he has the use of his own labor and managerial ability, and perhaps some family or hired help.

The owner can use all three of these factors of production — land, labor, and capital — in any number of ways to produce farm income. He may develop his livestock and crop enterprises, his forest enterprise, or perhaps all three; but he will ordinarily strive for a balance that will make the most satisfactory return for the combined use of all his factors of production. This will not ordinarily call for getting "maximum production" from any one enterprise.

Of course, there are many operating plans that the owner of Farm A might use. In this instance three general farm programs appear most feasible, and although they do not exhaust all the possibilities, they do seem to cover fairly well the range of practical alternatives.

Plan I The owner's first alternative is to continue operating as he is at present. Under such a program most of his receipts come from off-farm work, and the livestock enterprise is on a part-time basis geared to supply home needs and the local milk and butter markets. Active woods management is limited by the amount of labor that the owner can spare from his other activities or can hire locally. This has resulted in cutting that will keep his stands growing without long delays for reproduction. He has so far been unable to harvest all of the material that could be cut and marketed in any given year.

Plan II A second plan is to give up outside employment entirely and expand both the livestock and the forest enterprises. The possibilities of keeping the present herd of five milk cows and raising about six fresh heifers for sale each year seem attractive. Sufficient roughage can be produced for such an enterprise, and little change in barn arrangements will be necessary. The local milk and butter market will continue to absorb some of the milk not used at home. Success in such a venture will depend to a large extent on the operator's skill in buying and selling stock as well as on his ability to produce good heifers. It may also be possible to buy and raise a few veal calves when market conditions are favorable.

Plan III Alternatively, it will be possible under a third plan for him to give up outside work, produce wholesale milk, and expand the forest enterprise. This will use about the same amount of roughage as Plan II. Success will depend on overcoming several difficulties. First, the milk must be delivered to a truck route eight miles away. Second, it will be necessary to get facilities for cooling milk, and a new stable and milk room may eventually be needed to meet sanitary regulations.

The agricultural parts of any one of these three programs could be undertaken on the basis of present cropland and pasture acreages. But without off-farm work neither the heifer nor the wholesale milk enterprises alone would provide profitable full-time employment for the owner. However, more work could be done in the woods as a part of each plan to round out the farm business. There would be no great conflict in the timing of farm and forest operations. The chief woodland problems would be those of hiring exrta labor and ensuring continued markets for the relatively low-grade materials that could be cut during the next few decades. It would also be necessary to lay out the woods operations carefully, since saleable stands are now quite scattered. Some lost time and inefficiencies would be unavoidable, and care would be needed to make cuttings even moderately profitable.

Proposed Plans

Having reviewed the situation and outlined the owner's alternatives, the next step is to analyze the advantages, disadvantages, and probable results of each major plan in more detail so that he can see which one is most desirable. Before doing this, however, we must turn aside for a moment and consider the basic information needed for any such analysis.

Input-Output Data To begin with, we must know a good deal about how any proposed management practice will work out and what will be needed to put it into effect. We shall have to know such things as the amount of milk each cow will produce if fed a given ration; the amount and kind of wood that can be cut under a given silvicultural program; and the amount of labor and other materials needed to operate according to each plan.

Input and output figures of this kind have to be based on the best information available. As far as farm management practices are concerned, we have a good many specific input-output studies and a large store of knowledge based on farm experience with animals and crops over many years. These provide such a fund of planning data that a skillful operator can project future inputs and outputs with considerable confidence.

In the field of forest production knowledge is much less complete. We have only a few input-output studies, and many of these do not apply directly to specific operating units. We also have less experience with growing trees and are only beginning to know how fast wood can be produced by various kinds of management. Also, we do not have much firm knowledge about how to harvest stands in order to promote desirable natural reproduction. This and other information is essential before we can analyze confidently how proposed plans will work out.[1]

All this means that in order to make analyses such as we are discussing, it is necessary to rely on whatever data can be assembled on forest production. The value of planning will be sharply limited by the validity of these data and the skill and ingenuity used to manipulate scanty information. We have used the best data and judgment available to us, but the results must always be interpreted with caution. Wherever possible, our basic assumptions have been stated.

Unit-Cost and Price Rates Figures on the probable production and consumption of goods and services are not enough to help an owner make a wise choice between plans. These quantities must be converted to the dollar values that make up receipts, expenses, and net farm income. This can be done by multiplying quantities by probable unit-costs or prices.

In this study each budget was based on a set of prices which it was thought in 1946 could serve as a reasonable guide to determine profitable changes during the next five to ten years. The expenses used were at the 1943–45 level, and the prices received were believed reasonable in relation to these unit-costs and the general outlook. These values were not set up as forecasts of actual prices in any one year but were intended to reflect cost-price relationships likely to prevail. However, within two years, prices and costs had been inflated to levels far above the 1943–45 average, and the down-turn in 1949 was more than offset by subsequent events in Korea. In 1953 rough pulp sold for $12 to $15 a cord at the roadside in New Hampshire, as compared with the long-range budget price of $9. Farm wages in 1953 had risen by about half over 1943–45 levels. Other

[1] For a more complete discussion of this problem and the data to be used in these analyses see Wheeler (110), Brown (16), Gould (42), Social Science Research Council (93).

prices and costs had also risen, but relationships between prices and costs were remarkably close to those postulated under the original budget price assumptions. If refigured at current prices, net farm incomes would be about 25 to 30 percent above the ones calculated originally, but the relative gains from the proposed changes would be only slightly increased or decreased.

Plan I — Continue Present Off-Farm Work

The management program needed to continue the owner's present farm operation was pretty well covered in the description of the present farm situation. Further details will be found in the Crop and Livestock Summary and in the Financial Summary. No major land-use adjustments are proposed. The desirability of this plan will depend largely on the kind of off-farm work available and the amount of money it will bring in. This plan will serve as a known bench mark with which the other plans can be compared.

Plan II — Heifer Program with Intensified Forest Production

In order to sell fresh heifers and expand the forest enterprise, a number of adjustments are needed. The agricultural changes can be fully effective within the next five years. To build up a heifer program the milking herd will be kept at five cows, and enough heifer calves will be bought to start a total of about seven each year. This will provide six fresh heifers for sale each year and one for herd replacement. Young stock in excess of the main barn capacity will be put in the shed adjoining the barn. The present local sales of milk and butter will continue. A side-delivery rake and hayloader will be purchased to speed hay harvesting.

Open Land Plan Reseeding will be at the rate of about four acres per year, and fertilization will be stepped up. The following table describes the condition and proposed use of the open fields.

Field No.	*Acres*	*Dominant Soil Types*	*Land Use*
8, 10 1,2,3,4, (newly bought)	18 9	Podunk fine sandy loam (imperfectly drained bottom land soil, subject to flooding); Sudbury fine sandy loam (imperfectly drained terrace)	Legume hay and pasture mixture
9	4	Woodbridge loam and Woodbridge stony loam (deep, slightly imperfectly drained stony soil with a tight compact subsoil at 1½ to 2 feet which makes for seepy spots)	Fertilized permanent pasture

Field No.	*Acres*	*Dominant Soil Types*	*Land Use*
12	8	Brushy pasture. Berkshire stony loam (deep, well drained, stony soil)	Allow to revert to woodland. If satisfactory natural seeding does not result, planting can be done.

Annual fertilizer and lime purchases will be approximately equivalent to the following materials:

6 tons of lime	at	$ 6.00	per ton
½ ton of superphosphate for reinforcing manure	"	29.00	" "
3 tons of 8–16–16 for topdressing hayland and pasture	"	50.00	" "
1 ton of 0–20–20 for topdressing hayland and pasture	"	48.00	" "
4 cwt. of muriate of potash for seeding legumes	"	46.00	" "

With top-quality pasture available for five or more summer months, with heavy fertilization of cropland seeded to desirable species of legumes and grasses, and with earlier harvesting of these crops, some increase in the average quality of roughage consumption will result; an increase in milk production or a decrease in grain feeding should follow. Whether or not to maintain the present rate of grain feeding will depend on how well the cows respond to the additional nutrients provided. The plan assumes that milk production per cow can be increased 200 pounds annually with no change in grain feeding.

Estimated milk and butter sales and grain purchases would be as follows:

50 cwt. of milk	at	$5.58	per cwt.
250 pounds of butter	"	0.50	" lb.
35 cwt. of cow grain	"	3.00	" cwt.
142 " " other grain	"	3.00	" "

Woodland Plan Within the limits of technical knowledge, the level of production reached in the farm forest enterprise will depend on how the owner applies labor and capital to his woodland over the years to produce successive crops of primary forest products for sale at the roadside or on the stump. The outputs realized will depend on the silvicultural program used, and on how successful it is; while the input required will be governed by the number and kind of forest treatments or cuttings needed, and the operating efficiency achieved in making them.

Forest Management Intensity

Thus if the owner of Farm A wants to fit a high level of forest production into his business he will use relatively intensive forest management based on a silvicultural program that calls for using a large amount of labor, capital and managerial effort over the years on each acre of woodland, relative to the capacity of that land to utilize such inputs. Or if a medium or low level of forest production is satisfactory he will use less intensive management including a simpler silvicultural program that on the average over time will require relatively smaller amounts of the variable factors of production per acre. Each intensity of forest management will be based on what is known of the biological realities of the forest situation, and on probable operating efficiency.

The physical and biological factors inherent in forest production will, of course, place definite limits on the returns that this farmer can realize from any given intensity of management. But, in addition, his skill and ability as a manager may limit the probable success of some intensities more than others. Also, such factors as markets, transportation, the owner's ability to borrow money, the availability of labor for exchange or hire, the preferences of the owner for doing certain kinds of work and his ultimate aims and ambitions may make one intensity more attractive and feasible than another.

Despite the complexities of these interacting variables, it is usually possible to see several action programs that could be used to integrate the forest enterprise into the farm business. The initial steps toward such a rational use of resources seem to be defining and evaluating alternative programs in such a way that the owner can pick out the most desirable one to follow. We have concentrated attention in this bulletin on the problem of analyzing forest alternatives and have merely outlined the technical requirements of each forest management intensity. In order to bring out the advantages and disadvantages of each farm plan it is assumed that they will be applied with an efficiency that seems likely under prevailing conditions.

Foresters will see that this kind of planning is quite different from a forest management plan that concentrates on detailed ways of using labor and capital efficiently in carrying out a given intensity of management. In this bulletin an array of forest management intensities is analyzed, rather than just one for each farm, without any preconceived ideas about which will turn out best. The owner may choose any plan, and its provisions will be flexible enough to allow him a wide latitude in laying out his work. The owner can thus adjust his day-to-day management to make the most of current situations because, with his intimate knowledge of the locality, the farm, and his own capabilities he is usually the person best suited to make these on-the-spot adjustments.

To illustrate the range of possible ways that the forest enterprise on Farm A can be used to round out the farm business we have analyzed three intensities of forest management.

a. *High Intensity of Forest Management* assumes cultural treatments at 5- to 15-year intervals throughout the life of the stand. These treatments will include weedings, thinnings, and improvement cuttings when they seem silviculturally desirable. Harvest cuttings will also be made in a way to promote prompt and valuable reproduction. This silvicultural program is designed to take full advantage of the productive capabilities of the woodlands, and trees will be harvested when they have reached their most profitable development.

b. *Medium Intensity of Forest Management* assumes that trees will be harvested when they have reached their most profitable development and will be cut in a way to promote prompt and valuable reproduction but that no other cultural operations will be made during the life of the stand. In exceptional cases, however, weeding will be done if it seems likely to make a marked improvement in the forest cover that will take over an area.

c. *Low Intensity of Forest Management* assumes that stands will be clearcut or high-graded whenever they contain enough value to attract a buyer. No special attempt will be made to improve production during the life of the stand or to promote reproduction.

Forest Growing Stock

Table 1 shows the present growing stock on Farm A classified by forest cover type and age class. Nearly 80 percent of the stands are northern hardwood, and about

TABLE 1

DISTRIBUTION OF FOREST ACREAGE ON FARM A BY AGE CLASS AND FOREST COVER TYPE

Forest Cover Type	*Age Class* 0–20	21–40	41 & over	*All Ages* Area	Percent
			—ACRES—		
Northern Hardwood	516	110	61	687	79.2
Northern Hardwood and Spruce-Fir	10	12	20	42	4.7
Spruce-Fir	128	—	12	140	16.1
Total	654	122	93	869	100.0
	Percent of Total Acreage				
All Types	75.3	14.0	10.7		100.0

75 percent of the acreage supports young stands less than 20 years old. With such a scarcity of older trees, a fairly long growing period is needed before any large amount of harvest cutting can be done. This will be true regardless of the forest management program followed. However, the highest intensity of management does call for some intermediate cuttings that will yield saleable products before the stands are fully grown.

Forest Treatments Table 2 shows the number, acreage, and present condition of each forest stand on Farm A. The "suggested treatment" shows the forest practices that would be required to carry out a program of high management intensity on each group of similar stands. These suggestions were made after a ground survey and inspection of the entire property; they are more condensed than those written out in the owner's plan. Variations in treatments for medium or low intensity management were also discussed with the owner.

TABLE 2

Outline for a Program of High Intensity Forest Management on Farm A

Stand No.	Acres	Present Stand Condition	Suggested Treatment
6 7	39 37	Uneven-aged northern hardwood stand 0–60 years old. Area has been culled for veneer logs and upper side is badly hurricane-damaged. Much of the understory is 20–40 years old and contains some spruce, fir, and poplar. About 40 maples along the road tapped for home use.	Make partial cuttings at 10-year intervals to salvage veneer logs. Girdle wolf trees and favor the best hardwoods and spruce for sawlogs at 16″–18″ d.b.h. Smaller hardwood thinnings and poplar can make pulpwood. Cut to develop groups of softwoods and of hardwoods rather than a mixture of both.
5 11	10 4	Predominantly alder run along river, plus some hardwoods.	No treatment.
13	78	Uneven-aged, 20–60 year old stand of northern hardwood, spruce, fir and some hemlock. Medium to high density with some openings due to blow-down and high-grading. Good reproduction. Eastern edge has about 10 M.b.f. of mature hemlock.	Make partial cuttings every 10 years to remove sawlogs at 16″–18″ d.b.h. and poorer trees that crowd crop trees. Some sawlogs and pulpwood can be cut soon. Develop groups of softwoods and hardwoods. Favor spruce, hemlock, and best hardwoods for sawlogs. Harvest hemlock gradually.
13A	2	Even-aged, 40–60 year old spruce and fir stand. High density and no reproduction.	Harvest gradually for pulp if trees appear windfirm. Open gradually to promote good reproduction. Cut fir for pulp and favor spruce for sawlogs.

Stand No.	Acres	Present Stand Condition	Suggested Treatment
14 15 16 19	12 21 12 8	Even-aged, 40–60 year old northern hardwood stand with considerable poplar. Medium to high density and good reproduction. Stands 16 and 19 have been partially cut to remove poplar and some other hardwoods. No. 14 contains some spruce and fir groups.	Continue partial cuttings every 10 years. Cut poplar at about 12″–14″ d.b.h. Favor best maple and ash for sawlogs at 16″–18″ d.b.h. Wherever possible develop groups of softwoods and groups of hardwoods. Do not remove over ⅓ of the volume at any one cut.
17 18 25	11 14 50	Even-aged, 20–40 year old stand of hard maple, beech and birch. Good quality trees of medium density. Good reproduction.	Make partial cuttings every 10 years to favor best maple for sawlogs, birch for turning bolts and to reduce the proportion of beech. Much of this area can develop into a sugar bush by leaving 50 mature maples per acre.
20 22 29	22 65 67	Uneven-aged stand of northern hardwood with many old residual trees. Stands 20 and 22 cut over in 1946, leaving an uneven-aged overstory of birch, maple and beech. Medium density and good reproduction.	Salvage merchantable trees and girdle wolf trees. Make partial cuttings every 10 years to favor best trees for sawlogs.
21 23	10 17	Old field seeding in to poplar, soft maple and some spruce and fir.	No treatment until usable products are available; then start partial cuttings. Develop groups of softwoods and groups of hardwoods.
24 26 27 28 32	35 79 68 111 21	Even-aged, 0–20 year old cut over stand of hardwood with some spruce and fir groups. Stand 27 recently cut to a 10″ diameter limit leaving many openings and groups of low quality hardwoods. Good reproduction of medium to high density.	Start partial cuttings whenever usable products are available. Some residual trees can be salvaged and wolf trees girdled. Develop groups of hardwood and groups of softwood.
30 31	19 57	Uneven-aged stand of northern hardwood cut to a 14″ diameter limit two years ago. Low density overstory of residual trees and good reproduction. Some spruce and fir groups present. Stand 30 cut more lightly than 31.	Make partial cuttings every 10 years to remove poorest trees and mature trees at 16″–18″ d.b.h. Favor best maple and spruce for sawlogs, cut birch for turning stock and rest for pulpwood. Girdle wolf trees.

During the field inspection the amount and kind of wood to be cut from each stand in the next decade was estimated, assuming that each of the three forest management programs might be followed. Thus the yield estimates for the next ten years are based on present volumes of wood plus an allowance for growth during the decade. These are therefore more reliable yield figures than the estimates for successive decades which include larger and larger growth allowances, with increasing possibilities for error. The reader should keep this fact in mind when interpreting yield estimates.

Future Yields Based on the present growing stock, full application of the treatments proposed above will result in average annual sales during the next ten years of about 171 cords of fuel and pulpwood and 27 M.b.f. of sawlogs. About 10 man-months of labor will be needed to make this cut. The heifer program, Plan II, will leave the owner with about five months of labor that can be used in the woods; an equal amount of hired woods help will therefore be needed in addition. The above amounts of cutting and hired labor are included in the Financial Summary.

Even at the assumed cost-price relationships, the first 10-year period of this program of forest management can provide favorable returns for labor not used in the dairy enterprise. However, additional benefits will accrue in later decades as the management practices become more fully effective. The volume of wood to be harvested, and the amount of labor needed, decade by decade, will indicate the trend of probable returns over later years. Long-run estimates of this kind are not needed for the agricultural enterprises since most of the benefits accruing from changes will be realized within the next decade. But the forest enterprise presents a special problem that requires a long-term analysis to indicate the rate at which future gains are likely to accumulate.

In this plan we have projected forest returns 90 years into the future. By using a planning period of this length we have been able to include estimates of not only the early costs but also of most of the later benefits from various intensities of forest management applied to even the youngest stands. The length of the planning period used will depend on how many years are needed to realize these benefits, and on how far the owner wants to look into the future. In this planning we provide the best estimates we can of future returns and let the owner discount them as heavily as he wants. Without specific estimates of future returns, the owner has no option but to ignore them, or to make guesses which may not be consistent with the other estimates.

Section A of Table 3 shows estimates of the annual cordwood and sawlog sales and the yearly labor inputs necessary to carry out the high intensity forest program during each of the next nine decades. Improvement cuttings during the early years of this program will yield a substantial volume of low-grade products. If these do not find favorable market outlets, or if hired help is extremely scarce and high-priced, one of the less intensive systems of forest management may prove more advantageous. Section B of the table shows probable sales and labor inputs under a medium intensity of forest management.

Section C of the table indicates probable sales and labor requirements under a low intensity program when stands are clear-cut or high-graded at 70–80 years of age. Annual cuts will be erratic, and we have assumed that the residual stands will have a lower density and contain a higher proportion of low value species than those under medium or high intensity programs. A 5- to 10-year delay in establishing enough valuable reproduction to form a new stand is also assumed under the low intensity program.

TABLE 3

PROBABLE YEARLY FOREST PRODUCT SALES AND WOODS LABOR REQUIREMENTS ON FARM A[1]

Item	*Average Yearly Sales and Labor by Decades in the Future*									*Cu. Ft. Vol. per Acre Left After 90 Years*[2]
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	
A. *High Intensity of Forest Management*										
Cords	171	362	165	507	402	226	261	138	312	1,403
M.b.f.	27	65	46	43	107	89	240	230	417	
Mo. of Labor	11	24	11	30	25	15	24	18	32	
B. *Medium Intensity of Forest Management*										
Cords	4	70	23	23	162	55	251	191	235	1,627
M.b.f.	4	56	26	22	66	60	185	195	284	
Mo. of Labor	1	7	3	3	12	6	23	20	28	
C. *Low Intensity of Forest Management*										
Cords	6	57	14	49	184	0	390	40	448	322
M.b.f.	6	69	5	45	84	0	302	71	546	
Mo. of Labor	*	6	1	5	14	0	38	5	55	

[1] Estimated average annual sales and labor requirements during each of the next nine decades, under different intensities of forest management, on 869 woodland acres; and the average volume of standing timber per acre left at the end of the planning period.

[2] The estimated volume per acre left after 90 years of medium intensity management includes a considerable quantity of poorly formed trees that would ordinarily be cut out in the intermediate treatments that make up a program of high intensity management.

* Less than 1 man-month of labor.

Maintained Yield Levels Table 3 shows no two decades with identical amounts of forest products planned for sale. However, average sales during the fifth through the ninth decades have leveled out somewhat and may be indicative of yield levels that could be maintained under the higher management intensities. With intensive management, average annual sales from the whole property during this period are estimated at about 220 M.b.f. of sawlogs and 270 cords of fuel or pulpwood. With medium management, average sales during this period are estimated at 160 M.b.f. and 140 cords. The level of yield that might be maintained under the low management intensity is best indicated by the 9-decade average — only 120 M.b.f. and 130 cords. Sawlog quality is also assumed to be lower under the less intensive management. The average sales and labor input level per acre that could be maintained are summarized in Table 4.

TABLE 4

MAINTAINED AVERAGE ANNUAL SALES AND LABOR INPUTS PER ACRE

	Intensity of Management		
Item	*High*	*Medium*	*Low*
		Volume per Acre	
Sales — Board Feet	250	180	140
and additional Cords	.30	.20	.15
		Labor per Acre	
Labor (man-days)	.65	.50	.40

Long-run Income Possibilities So far inputs and outputs have been discussed in terms of labor, sawlogs, and cords of wood. But what long-run income possibilities do these figures indicate for the owner of Farm A? It is obvious that the forest enterprise is likely to make a variable contribution to net farm income each year during the next nine decades. Table 5 shows the average annual stumpage value of the products to be cut and sold in each decade under the three intensities of management. These figures are of course merely the amount of wood products scheduled for cutting each year multiplied by an appropriate stumpage price. The schedule of prices used in this estimate is shown at the bottom of Table 5.

Stumpage Values These stumpage returns are an indication of the minimum probable contribution of the forest enterprise to net farm income. Additional income will be earned when the owner can do some of the woods work himself, using equipment not otherwise employed. A large share of the cutting in the first decade will be done in this way; the amount of time available in later decades will depend on progress in developing the livestock enterprise. The cutting schedule can be adjusted to make full use of any available labor by shifting scheduled operations for as much as several years. To the extent that labor must be hired for cutting, however, net returns to the operator will not greatly exceed the stumpage value shown in the table. The estimated contribution of the forest enterprise to income on Farm A during the next decade is shown in Table 8, the Financial Summary.

TABLE 5

ESTIMATED YEARLY STUMPAGE VALUE OF FOREST PRODUCTS SOLD ON FARM A, BY FUTURE DECADES[1]

Management Intensity	*Decades in the Future*									*Value of residual standing sawtimber*	*Total value for period*	*Maintained annual stumpage value*[2]
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*			
				Sec. I. Assuming Constant Sawlog Prices[3] *Dollars*								
High	453	1005	694	1249	1646	1185	2604	2305	4383	37,017	192,257	2413
Med.	31	455	234	204	770	544	1815	1787	2530	24,007	107,707	1497
Low	46	511	54	353	817	0	2475	494	4038	2,000	89,880	981
				Sec. II. Assuming Rising Sawlog Prices[3] *Dollars*								
High	453	1005	694	1507	2488	1719	5484	5065	9287	86,373	363,393	4834
Med.	31	455	234	336	1166	904	4034	4127	5938	62,420	234,670	3393
Low	46	511	54	623	1341	0	6099	1346	10590	6,000	212,100	2481

[1] Average annual values under different management intensities and alternative price assumptions. The stumpage values of the residual standing sawtimber and of the maintained level of annual sales are also included.

[2] Prices are those assumed for the third three decades.

[3] Stumpage values used in this table are at long-term levels consistent with other prices and costs used in the Financial Summary. The comparable rate for harvest labor is $6.00 per day. Sales of cordwood stumpage are valued at $1.50 to $2.00 per cord throughout the period, but no allowance is made for the value of cordwood in the residual stand. Section I assumes a stumpage price of $6.00 per M.b.f. for average quality sawlogs throughout the period, whereas Section II assumes an upward trend in sawlog prices during the next 90 years. The following prices for average quality sawlogs are assumed in Section II, a comparable roadside value is also shown:

Period	*Stumpage Value*	*Roadside Value*
First three decades	$ 6.00 per M.b.f.	$18.00 per M.b.f.
Second " "	12.00 " " " "	24.00 " " " "
Third " "	18.00 " " " "	30.00 " " " "

It is further assumed that after 20 years of medium or high intensity management, the quality of sawlogs sold will improve enough to bring a quality premium of $1.00 to $3.00 per M.b.f.

From these figures it is clear that the woodland can be an important farm asset if it can be operated in conjunction with the rest of the farm business. The present discounted value of future woodland stumpage returns averages about $29 per acre under high management as compared with $7 under low management, assuming constant sawlog prices and a 3½ percent discount rate. With rising sawlog prices, these values will be $44 per acre for high management or $19 per acre for low management.

The level of annual stumpage returns that can be maintained under high intensity management exceeds that of low intensity management by $1,432 if constant sawlog prices are assumed; or by $2,353 with sawlog prices rising as assumed in Section II of Table 5. This $4,834 stumpage return will nearly double the net farm incomes shown in the Financial Summary for Plans II and III.

Stumpage returns throughout the period will be greatest if the high intensity management program can be followed. The cut will be larger and returns will be more regular, yet the value of the growing stock will also increase more rapidly. This is because it is planned to leave high quality trees to grow under favorable conditions and to sell some materials that would otherwise die and be wasted. This improvement in the volume and quality of the growing stock should be reflected in the cash value of the woodland long before the end of the 90 years.

Plan III — Wholesale Milk with Intensified Forest Production

Plan III is based on giving up outside work and wholesaling the milk from an 11-cow dairy herd. Before such a move can be made, arrangements must be completed for getting the milk delivered. The added cash costs and time involved driving 18 miles to the creamery indicate that it will be most advantageous to deliver only the 8 miles to a truck route. A method of cooling milk satisfactorily without high-line electricity will have to be found, and a new stable may have to be built to meet sanitary regulations. A milking machine, side-delivery rake, and a hayloader will also be purchased.

Because roughage requirements will be slightly less than if heifers are raised, the same crop land plan with slightly less purchased fertilizer than in Plan II will meet the needs of the dairy herd. The possibilities of ensiling unchopped legumes in a trench silo will also be explored.

Some further increase in the average quality of roughage fed can be expected, and with a market for fluid milk, heavier grain feeding will be advantageous. The plan assumes that average production per cow will be 6,000 pounds of 4.8 percent milk on grain feeding of 2,000 pounds.

Estimated milk sales and grain purchases will be as follows:

575	cwt. of milk	at	$3.80
220	" " cow grain	"	3.00
82	" " other grain	"	3.00

The woodland programs outlined for Plan II can also be combined with the dairy enterprise. About seven months of hired labor will be required by the entire farm business if a high intensity of forest management is used. The Financial Summary is based on the assumption that this is done.

The increase in investment under Plan III is estimated as follows:

Stable	$1,000
Milking machine and cooler	800
Increase in livestock inventory	650
Hayloader and side-delivery rake	700
	$3,150

The increase in the herd can take place gradually as extra young stock are raised and as roughage production is expanded. The amount of credit necessary will depend upon the rate at which the plan is put into effect and on the amount of current income which the operator is willing to put back into the business. A practical plan for financing the investment should take account of the estimated year-by-year needs for credit and the expected year-by-year earnings available for repayment of indebtedness after meeting minimum family living expenses.

TABLE 6

CROP SUMMARY — FARM A[1]

	Present — Plan I		*Plan II*[2]		*Plan III*[2]	
Crops	*Acres*	*Production*	*Acres*	*Production*	*Acres*	*Production*
Legume hay and pasture	18	24 Tons hay 8 Tons pasture	27	37 Tons hay 21 Tons past.	27	37 Tons hay 19 Tons past.
Fertilized perm. pasture	4	6 Tons pasture	4	6 Tons past.	4	6 Tons past.
Other pasture	8	3 Tons pasture	—		—	
New legume seedings	(3)		(3)		(3)	
Woodland	833		877		877	

[1] Pasture production measured in tons of hay equivalent.

[2] Nine acres of cropland and 36 acres of woodland recently purchased are included under Plans II and III but not under the present plan.

TABLE 7

Livestock Summary — Farm A

Livestock	Present — Plan I		Plan II		Plan III	
	No.	Production	No.	Production	No.	Production
Cows of milking age	5	225 cwt. milk	5	235 cwt. milk	11	660 cwt. milk
Calves started each year	2		7		2	
Beef animals	1	Home use	1	Home use	1	Home use
Horse	1		1		1	
Pigs	2	Home use	2	Home use	2	Home use

Advantages and Disadvantages The budget statement and yield projections just presented, together with the discussion of the problems and possibilities of each plan, will take much of the guesswork out of deciding which general program or management intensity to adopt. Of course, the final figures are no more reliable than the estimates on which they are based — but at least they have been consistently considered so that the estimates are as nearly as possible compatible one with the other.

The Financial Summary shows that about 40 percent of the farm receipts under the present plan of operation come from off-farm work. This has been replaced in part by receipts from work on the farm and in part by income from the forest enterprise in Plans II and III. A large portion of the planned income is derived from woods work. Making the estimated relative gains in net farm income during the next decade will therefore depend not only on achieving the proposed changes efficiently but also on maintaining relative forest product prices at least as favorable as those used in these estimates.

Following a high intensity of forest management, in addition to producing more wood immediately, will also allow greater flexibility for the owner to make later adjustments to changing price relationships. If relative forest prices improve, he will have a larger inventory of high-quality products maturing. If price relationships get temporarily worse, he can dip more heavily into this inventory to maintain farm income for a time.

If he decides finally to sell his farm, then the improved growing stock resulting from more intensive management should add to the value of the farm. If the value of the forest growing stock is not properly reflected in the sale of the farm, he can probably recoup his investment by liquidat-

TABLE 8

FINANCIAL SUMMARY — FARM A[1]

		Plan I Present		Plan II Including High Forest Mgt. Intensity[2]		Plan III Including High Forest Mgt. Intensity[2]
Receipts						
Milk		$ 279		$ 279		$2,185
Cows		100		50		100
Calves		4		16		24
Heifers		—		810		—
Butter	(250 lbs.)	125	(250 lbs.)	125		—
ACP refund		28		28		28
Pulpwood	(90 cds.)	810	(171 cds.)	1,539	(171 cds.)	1,539
Sawlogs	(3 M.b.f.)	54	(27 M.b.f.)	486	(27 M.b.f.)	486
Rent of cottages		250		250		250
Off-farm work		1,050		—		—
TOTAL		$2,700		$3,583		$4,612
Expenses						
Grain		$ 207		$ 531		$ 906
Labor	(6 Mo.)	780	(5 Mo.)	650	(7 Mo.)	910
Seed		35		45		45
Calves		—		30		—
Other stock		10		10		10
Misc. dairy		50		50		110
Fertilizer and lime		88		257		211
Gas, oil and grease		100		150		250
Other truck & tractor exp.		25		25		25
Bldg. upkeep and repairs		100		100		100
Equip. upkeep and repairs		80		90		180
Taxes		217		230		230
Insurance		21		21		26
Interest		—		54		142
Deprec. horses		15		25		25
Deprec. machinery		100		125		125
TOTAL		$1,828		$2,393		$3,295
NET FARM INCOME		$ 872		$1,190		$1,317

[1] Using the original long-term planning prices. If prices closer to 1953 levels had been used, net farm incomes would be about 20 per cent higher.

[2] Sales of forest products under Plans II and III are based on the average cut under high management intensity during the coming decade. The wood sales of Plan I are based on current cuttings that follow an intensity of management between "high" and "medium." The long-run increase in forest productivity under these plans promises larger returns in later decades especially if in the future prices rise as outlined in Section II of Table 5. The total return under Plan I depends primarily on the amount of income received from off-farm work. A minimum figure has been used in this budget, based on the past few years' experience.

ing it at that time. Thus the higher intensities of management seem to provide this owner with greater security and flexibility of operation in the future than the lowest intensity that liquidates all values as they mature.

Low Income To the owner perhaps one of the most important points brought out by this analysis is the relatively low income that he can expect from his operating unit under current conditions, even if he uses the highest intensity of farm and forest management analyzed and allows for a higher current price level. The operator can clearly see that as a consequence of holding so much young growing stock, a relatively long period must pass before he can get much income from his forest enterprise, no matter what kind of management he uses. Even with a high intensity of forest management, stumpage returns are estimated at generally less than $1,000 a year for the next three decades. And the farm's limited agricultural opportunities suggest that net farm income will be fairly low for a number of years.

Owner's Plan In light of the broad alternatives spelled out in this analysis, and with the owner's special knowledge of the local situation, he has devised a program for operating the farm that will lead him toward Plan III. He has gotten a better paying off-farm job, but he has also worked out a scheme with a neighbor for delivering milk to the wholesale pick-up route. In addition, he is moving as far toward a high intensity of forest management as he is able to do with hired labor working under his supervision. Thus he hopes finally to give up off-farm work, sell wholesale milk, and use intensive forest management. The present arrangements will carry him at least part way through the growing period necessary to build up the size of his forest enterprise.

Many other owners of similar farms face this same problem of maintaining a reasonable net farm income while the productive capacity of their property is being built up by more intensive management. In the long-run probable income looks more promising, but in the meantime the owner may need help if he is going to stay in business.

Chapter II

ALTERNATIVES ON EIGHT OTHER FARMS IN THE FRINGE AGRICULTURAL AREAS OF NEW ENGLAND

The last chapter laid out some of the alternative ways in which one farmer could operate a combined dairy and woodland farm and showed how budgetary analysis of his operating unit could help him make rational management decisions. This chapter contains brief summaries of eight additional cases that further illustrate this planning process and the diversity of problems facing forest owners.

All nine of these cases are in localities where many surrounding farms have gone out of business; some of the towns, in fact, are almost abandoned. This general situation has a marked effect on economic activity in such areas and may limit the business opportunities of the remaining landowners. It is worthwhile, therefore, before taking up the rest of the cases to get a better idea of conditions in these sections that lie on the fringe between lands devoted primarily to forest and those that support a well-developed agriculture. First, what has been the history of these "fringe agricultural areas"?

Over the years New England has gained a reputation for being stable and conservative. The record shows, however, that the region has changed continuously in the course of the development and growth of the country. Adjustments in land use have been particularly striking.

Ebb and Flow of Farming In the early days a great deal of land was cleared to produce food and fiber. Farming spread far up into the hills and into the remote corners of the region. But this trend was reversed as improved transportation opened the rich western lands and as industrial centers developed. Many farm products were brought here cheaper than they could be raised at home, and people left their rocky New England land for better opportunities elsewhere.

In the region as a whole farm abandonment on a large scale got under way between 1850 and 1870 and continued even into the present century. Trees promptly seeded in on most of the old fields, and it is estimated that about 9,000,000 acres of open land reverted to woods. The fact that this is a larger acreage than now remains in agricultural use, according to the last census, gives some idea of the magnitude of land-use change.

Very little "abandoned" land actually became tax delinquent. Someone was usually willing to own it. What really happened was that intensive agricultural use of the soil was given up; farming frequently tapered off and stopped as the young people moved away.

Much of the land best suited to modern agriculture is still being farmed wherever conditions are favorable. A great deal of the area in the coastal plain, the river valleys, and the foothills is now in commercial farms. But agriculture has generally withdrawn from the hilliest, roughest, and most inaccessible places.

Fringe Areas Today there are transition zones between the localities primarily devoted to agriculture and those primarily forested. These lands on the edges of the best farming sections may be thought of as "fringe areas" where commercial agriculture has disappeared from the majority of the once-numerous upland farms.

Map 3 shows a generalized pattern of land use in the region. In addition to the land around the "predominantly agricultural and urban" areas, land within the smaller segments of "predominantly forest land" is really fringe agricultural land.

Most of this fringe area was once farmed, and it continues to be in relatively small ownerships. Some of these units now operate at a subsistence level, some are summer residences, and many belong to non-residents. Scattered through these zones, however, there are still a number of farms where operators are attempting to conduct successful businesses.

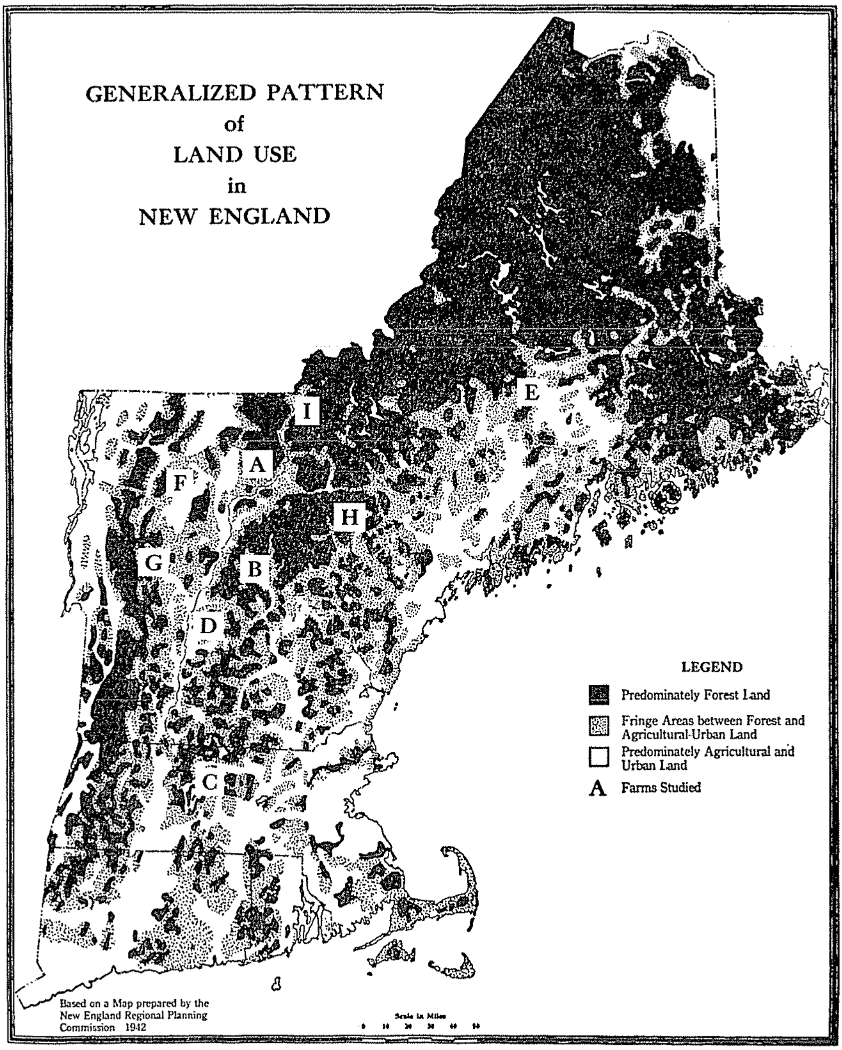
Table 9 shows the distribution of the forest ownerships in 23 New England towns by size-of-holding. This pattern of ownership is about the same in the fringe areas; about one-third of the owners, with holdings of over 100 forested acres, control around three-fourths of all the woodland. Nearly half of the owners have 10- to 49-acre holdings and they control less than 10 percent of the total forest area.

Figure 1 shows that only about 12 percent of the forest land is owned by full-time farmers, and that less than a quarter of it is held by the owners of wood-using plants.

A large portion of New England's somewhat scanty natural resources is included in these fringe areas. Therefore it is important to work out efficient land-use adjustments designed to take advantage of the potential productivity of the land. One approach to this problem is to work with a variety of operating units where improved production techniques can be tried out to see if a new combination will enable the owner to make a return comparable to the one he might reasonably expect elsewhere. One logical place to start looking for operating units that can make profitable changes is on the few remaining active farms.

MAP No. 3 GENERALIZED PATTERN OF LAND USE IN NEW ENGLAND

Although the characteristics of the "fringe areas" vary considerably there are many problems of land use adjustment common to such areas throughout the region.



Remaining Farms Farms in the fringe areas are usually characterized by large acreages of woodland, a few small open fields with soils and topography suitable for crops or pasture, and considerable areas of brush pasture. Buildings and equipment on most of these farms tend to be in poor repair or obsolete. Although dairying is frequently the principal enterprise, the herds are small, grain feeding usually is light, and milk production per cow is low. Many are located far from regular milk routes so that it is difficult and costly to take milk to market. As we have seen on Farm A, these factors may combine to limit sharply the profitable alternatives for farm management.

TABLE 9

DISTRIBUTION OF FOREST LAND ACREAGE AND OF FOREST LAND OWNERS IN 23 NEW ENGLAND TOWNS, ACCORDING TO SIZE-OF-HOLDING CLASS [1]

Size-of-Holding Class (Acres)	Forest Land	Owners	Percentage Distribution: By Single Classes, Acreage	Percentage Distribution: By Single Classes, Owners	Percentage Distribution: Cumulative, Acreage	Percentage Distribution: Cumulative, Owners
	Acres	*Number*	*Percent*	*Percent*	*Percent*	*Percent*
5,000 & over [2]	54,292	8	19.5	0.4	19.5	0.4
2,500 to 4,999	13,277	4	4.8	0.2	24.3	0.6
1,000 " 2,499	30,195	21	10.9	1.0	35.2	1.6
500 to 999	20,838	30	7.5	1.4	42.7	3.0
250 " 499	33,691	97	12.1	4.6	54.8	7.6
100 " 249	66,141	448	23.8	21.3	78.6	28.9
50 to 99	34,842	509	12.5	24.1	91.1	53.0
10 " 49	24,765	989	8.9	47.0	100.0	100.0
Total	278,041	2,106	100.0	100.0	——	——

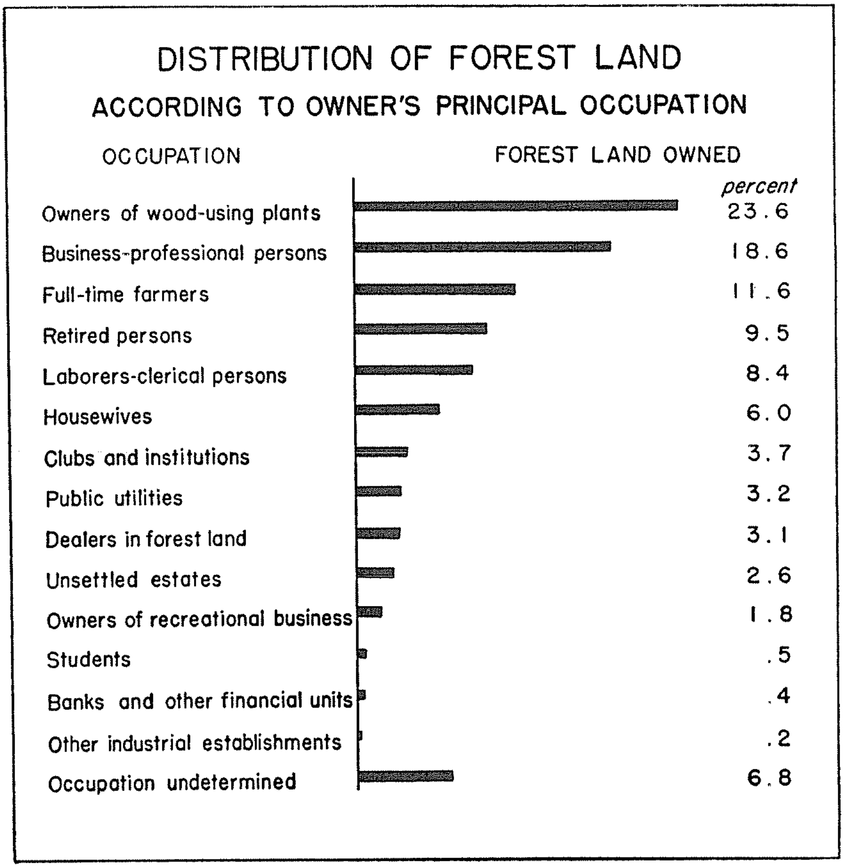
[1] The Ownership of Small Private Forest-Land Holdings in 23 New England Towns, (8).
[2] In these towns there was no private holding that contained more than 12,000 acres.

The operators of these farms are often experienced woods workers, and they frequently depend on woods work on their own land or elsewhere for part of their cash income. Forest land makes up the major part of the farm area, and adjacent woodlands usually can be acquired at reasonable cost. Under these circumstances the possibilities of combing forest production and dairying on such units need to be thoroughly investigated. Adjustments toward this end may be of vital importance to the people trying to earn a living from the land in the fringe areas.

Of course, many other kinds of land use also should be analyzed. Other agricultural enterprises may prove desirable and, as we have seen, over half of the fringe area land is not in active farms. The absentee

FIGURE 1

From The Ownership of Small Private Forest-Land Holdings in 23 New England Towns, (8).



owners, rural and summer residents who control a large part of the land, may use it only for recreation, residential purposes, water and wildlife conservation, or merely to satisfy their desire to own land. Forest production or any other use of the land for profit may be of minor importance to them, and their interest in making land-use changes may be correspondingly less.

The Study Farms We chose to study nine farms whose owners were in position to explore the possibilities of combining considerable forest production with dairy farming. These cooperators were picked to illustrate a range of problems and possibilities. Map 3 shows that they are scattered over the region, including many different crop and forest growing conditions and market situations.

These and many other farm owners have most of the resources required to combine forestry and dairying, but they need to be shown the economic feasibility of making the land-use and management adjustments needed for this sort of "combined operation."

Each of the operating units that we shall discuss presents a unique combination of circumstances that can be met by no single plan of development. However, these fringe area farms do have some common characteristics. In general, the owners are trying to build up the earning capacity and value of their property. Farm A and the next three farms have a limited amount of cash and labor, their buildings are small and in poor repair, and their agricultural enterprises are generally small. They also have only small acreages of arable land and relatively large acreages of forest land.

These cases are discussed in some detail since they illustrate the use of the budget analysis, with particular emphasis on forest problems. On farms of this kind the contribution of the forest enterprise may be an important part of farm income, and production opportunities must be very carefully considered.

The last five farms have more arable land, better buildings and equipment, and relatively less forest land. Their problems are somewhat different from those of the first four farms and making satisfactory management adjustments depends less heavily on forest production. These analyses are discussed briefly.

The fact that the farms presented first have the most limited income possibilities does not indicate that these are the most typical situations in the fringe area. In fact, farms like the last five are probably much more numerous. However, the nine farms seem to cover the general range of operating units found in the fringe areas.

Farm B

A HILL DAIRY FARM THAT THE OPERATOR EVENTUALLY WANTS TO SELL

This farm is superficially similar to Farm A, but there are some differences that affect the business opportunities. One of the most striking of these differences appears in comparing the two operators. This farm is not owned by the operator but by his elderly parents who want to live out their lives here in their home town. However, the burden of running the farm falls on their son. He is unmarried, a high school graduate, and a lifetime farmer. But during a tour of duty with the Army he traveled a good deal and now feels that he would like to leave the place that his family has owned for three generations.

This operator is anxious to build up a business that will support the family during the next few years; but he hopes to sell the farm eventually and use the money to buy one with larger opportunities for developing a dairy enterprise. Thus he differs considerably from the first owner who is determined to stay and build up the income and long-run value of his farm.

Town and Markets As in the first town farming in this town has nearly stopped, but many of the old farms are used as summer residences. A fair amount of extra labor can be hired at reasonable rates, especially during the winter when the summer people do not need local help. A wholesale milk pick-up route runs by the house, and the farm has both a telephone and electricity.

Although agricultural markets generally favor farm expansion, forest product markets are not quite as favorable as those on Farm A. Low-grade products, especially poorer hardwood logs, do not have steady outlets, and some ingenuity will be needed to sell at a favorable price all the wood that can be produced.

The Farm The resources of this farm include 25 acres of cropland, 34 acres of rough hillside pasture, and 706 acres of woodland. Power equipment, including horses, a new jeep for transportation and drawbar work, and a one-man chain saw, is adequate for the present operation. But some other equipment will be needed before milk can be wholesaled, and the barn will need extensive repairs, especially a new floor under the stanchions.

While the operator was in the Army, all the livestock was sold. The herd now includes one grade Holstein cow, two heifers and two Milking Shorthorn heifer calves. A flock of 13 ewes and a ram are also kept, and about 16 lambs are sold each year. Additional livestock includes two horses and a sow. Fertilizing and reseeding have been at a moderate level but stones make plowing difficult over a large part of the fields. Usually enough roughage has been raised to meet livestock needs.

Forest products normally harvested include about 130 gallons of maple syrup that are usually sold to mail-order customers, about $250 worth of Christmas greens, and about 30 M.b.f. of sawlogs. In general the woods have been cut carefully for many years, leaving behind many well-formed smaller trees to grow for harvesting another time. Some improvement cuttings have also been made in the younger stands. Unfortunately, a great many older pine stands were lost in the 1938 hurricane, but the present hardwood stands appear more wind-firm. Extra labor is hired to help with logging, and the operator is interested in doing woods work.

He also does a small amount of off-farm work and is under G. I. training, receiving about $600 for subsistence.

Problems and Possibilities

Present Plan The operator is handicapped by the fact that most efforts to augment farm income will require a considerable investment in buildings, livestock, land improvements or equipment. The present plan of operation is not really a permanent program that the owner wants to continue. It is merely a stage that has been reached in the process of developing the farm after its war-time decline. However, the present plan does provide a basis with which any proposed adjustments may be compared.

Veal Calves Buying, raising and selling veal calves is one livestock enterprise that the operator could undertake without much improvement in present resources. However, he is concerned over the possibility of introducing calf diseases into his barn and losing his present stock. He is also skeptical of his chances, in this remote locality, of buying good calves when they are needed. Consequently, this alternative has not been budgeted.

Wholesale Milk As a goal to be approached gradually, the operator wants to build up a herd of about 10 Milking Shorthorn cows. Fattened animals culled from the herd would provide more beef sales than usual for a dairy herd of this size. He also wants to keep two sows and expand the sheep flock to about 20 ewes.

When this plan is analyzed it appears that some additional enterprise will still be needed to round out the farm business. An analysis of the woodland growing stock indicates a sizeable opportunity for expanding forest production to form an important segment of the farm business with little added cash investment.

Proposed Plan

Agricultural Adjustments In order to implement the wholesale milk program outlined above, a stable will be added to the main barn. This work is already under way. Water bowls and a hayfork will be installed. A milk room will be built along with the new stable, and a milking machine and cooler will be purchased. A side-delivery rake and hayloader will be added to the present haying equipment. The operator feels that by using farm labor and materials as much as possible, the added investment will amount to about $5500; and that most of this can be recovered by sale of the property, or the items can be moved to a new farm when necessary.

To provide roughage for the livestock, reseeding and fertilizing of the hayland will be stepped up and about 16 of the better acres in the open pasture will be top-dressed. Three acres of silage corn will be planted. If excess roughage is available, the operator may choose to start more young stock for beef animals or for sale as dairy replacements.

Woodland Plans This farm has 447 acres of timber in the older age classes, while Farm A has only 215 acres. Here only 259 acres (36%) support stands less than 21 years old, while on the first farm 654 acres (75%) have very young stands. The larger acreage of middle-aged and older growing stock will provide Farm B with a more regular flow of forest products than is possible on Farm A.

But data about the present growing stock are most useful to this owner after they have been translated into probable future wood sales. Three general intensities of forest management are also open to this owner. Although he is more interested in probable income during the next decade than he is in long-run forest productivity, figures like those in Table 10 will help him choose among these broad alternatives.

High Intensity During the next decade annual sales under a program of high intensity forest management will be about 129 cords of fuel and pulpwood and 55 M.b.f. of sawlogs (Section A of Table 10). The forest practices required will be substantially those used in the past, but a greater area will be worked-over each year in order to utilize the whole woodlot more completely. However, a large amount of the material cut will not attract a stumpage buyer, and the operations probably can be done only if the farmer is willing to direct the cutting and do some of it himself. The county forester will give any technical assistance needed.

By working in the woods, time not needed for the dairy enterprise will yield a moderate cash return, together with the benefits of stand improvement and increased future yields. During the next decade, high forest management intensity combined with a 10-cow dairy will fully occupy the operator's time and will require in addition about 8½ months of hired labor each year.

If the operator decides to stay on the farm, the level of cutting during

TABLE 10

PROBABLE YEARLY FOREST PRODUCT SALES AND WOODS LABOR REQUIREMENTS ON FARM B[1]

Item	*Average Yearly Sales and Labor by Decades in the Future* 1	2	3	4	5	6	7	8	9	*Cu. Ft. Vol. per Acre Left After 90 Years*
A. High Intensity of Forest Management										
Cords	129	261	207	129	561	296	209	241	167	2,258
M.b.f.	55	90	167	28	147	131	158	178	95	
Mo. of Labor	9	18	18	8	36	21	18	21	13	
B. Medium Intensity of Forest Management										
Cords	3	19	116	93	80	83	85	88	37	2,496
M.b.f.	7	18	109	87	110	114	128	131	57	
Mo. of Labor	1	2	12	10	10	10	11	11	5	
C. Low Intensity of Forest Management										
Cords	7	23	160	0	157	0	157	0	53	1,463
M.b.f.	14	14	157	0	216	0	247	0	78	
Mo. of Labor	1	2	18	0	20	0	22	0	7	

[1] Estimated average annual sales and labor requirements during each of the next nine decades, under different intensities of forest management, on 706 woodland acres; and the average volume of standing timber per acre left at the end of the planning period.

the second decade of high intensity forest management will allow an expansion to a two-man business. Although future sales will vary somewhat, this size of business can generally be maintained by adjusting harvest cuts as much as several years. Seeing these future possibilities clearly may have some bearing on the operator's final decision on whether to move or to keep his present farm.

The financial success of cutting in the first decade will depend heavily on a pulpwood market, but the increasing proportion of sawlogs in later decades will permit more diversified marketing.

The program of high forest management intensity is presently attractive to the owner because it offers the greatest promise of immediate income combined with the greatest long-range increase in growing stock value. This increase in value probably will be reflected in the farm sale price later. Or, if not, the growing stock can be liquidated to help pay for a new farm.

Medium and Low Intensity If forest markets are not favorable, or if help is scarce and high-priced, a less intensive system of forest management may prove advantageous. The owner will have to to build up both the current income and long-term value of their operating unit.

In the past this farmer has experienced some difficulty in the timely execution of necessary work. He feels that considerable improvement can be expected on this score if he concentrates his efforts on fewer enterprises and gives up peddling poultry products and vegetables.

Town and Markets This farm is in central New England within a short driving distance of several industrial centers. Although there are prosperous farms in the general area, agriculture has generally been discontinued in the immediate vicinity. Many of the old homesteads are now residence or part-time farms for mill workers or are used as summer homes. The town is well-populated and represents a variant of the fringe area different from those we have discussed so far. Roads are in good condition, and maintenance and snow removal are performed promptly.

The local markets for farm products are well established and dependable, especially the market for wholesale milk. But forest products do not have steady outlets. Pine sawlogs of all qualities can be sold either at the roadside or on a stumpage basis, but there is a demand for only the better grades of hardwood logs. There is no market for either softwood or hardwood pulpwood, although one promises to develop within a few years. Fuelwood has no stumpage market but the owner can probably sell about 100 cords a year at a roadside price that will pay him going wages for harvesting it.

This situation is different from that of the other two farms and generally favors the development of agricultural enterprises much more than it does an expansion of forest production.

The Farm The farm includes about 35 acres of crop and pasture land and 603 acres of woodland. The buildings and equipment are adequate for the present enterprises although the horse barn floor needs repair before any more stock are housed in it. Both a farm tractor and team of horses are kept. Livestock includes 12 purebred and grade Guernsey cows, young stock for replacements, a sow, two pigs, and about 70 laying hens.

Pasture and cropland reseeding has been fairly frequent, and a moderate amount of fertilizer has been used. Very little wood has been cut beyond a few sawlogs for farm maintenance, and desirable young trees have become established rapidly in these patch cuttings.

ns

The o[illegible]ner has decided, in light of his past experience, his resour[illegible]s, and local markets, that he will first build up his mi[illegible]king herd as much as possible without making any vestmen[illegible]s. He will expand the number of milkers to 19 and resent b[illegible]rn. If no large amount of woods work is contem- near fu[illegible]ure, it will also pay him to drop his team and use and ba[illegible]n space to raise two fresh heifers for sale each year. nough r[illegible]oughage for the expanded dairy enterprise he will ove abo[illegible]t 10 acres of the most accessible brush pasture. The reseede[illegible]l more frequently and more lime and fertilizer will

gram of [illegible] management can be put into effect over a 5-year ly witho[illegible]ut hired labor and without much cash investment. tments h[illegible]ave been completed the owner will have as much as of his ti[illegible]me that can be spent in woods work.

lans Se[illegible]veral forest production programs could be combined w[illegible]th the above crop and livestock plan to help round ne farm [illegible] business. About half the forested acreage presently xed soft[illegible]wood stands, about two-thirds of which are very other h[illegible]f of the stands are hardwood, and nearly two-thirds reache[illegible] pole size. Only 1 percent of the whole area supports ands, si[illegible]ce most of the older pine was destroyed in the 1938 Many of [illegible] these stands on the dryer sites are growing up to Sawtim[illegible]er now occurs mostly in small groups or as a scat- ory.

uction [illegible]Of course it is physically possible for the operator to [illegible]se any of the three forest management intensities [illegible]e have already discussed. The probable average and the [illegible] labor required during each of the next nine decades n the fir[illegible]t three sections of Table 12.

e prese[illegible]t forest market and labor supply conditions, how- ns inad[illegible]sable to carry out the high intensity program of t. Proba[illegible]bly two-thirds of the cordwood could not be sold at l much [illegible] of the hardwood sawlog material would not meet ket speci[illegible]ications.

logs sche[illegible]duled for cutting under either medium or low inten- ment, o[illegible] the other hand, could be sold on current markets at or on t[illegible]e stump. Stumpage sales probably could be concen-

TABLE 12

PROBABLE YEARLY FOREST PRODUCT SALES AND WOODS LABOR REQUI

Item	Average Yearly Sales and Labor by Decades in the Future							
	1	2	3	4	5	6	7	
A. High Intensity of Forest Management								
Cords	318	134	126	175	305	171	522	[illegible]
M.b.f.	40	65	90	198	290	279	210	[illegible]
Mo. of Labor	23	13	11	18	30	21	50	
B. Medium Intensity of Forest Management								
Cords	0	0	0	84	459	75	114	3
M.b.f.	2	3	49	155	273	58	177	3
Mo. of Labor	*	*	2	11	39	7	12	
C. Low Intensity of Forest Management								
Cords	0	0	0	56	535	0	292	1
M.b.f.	4	0	98	63	351	0	226	2
Mo. of Labor	*	0	5	6	47	0	24	
D. Medium Management Intensity on 52% of the Area, High I on 48% of the Area								
Cords (rdsd.)	96	82	75	111	92	128	267	2
M.b.f. "	14	28	24	106	127	141	203	2
M.b.f. (stpg.)	2	3	46	88	169	58	0	
Mo. of Labor	8	9	5	11	10	13	27	

[1] Estimated average annual sales and labor requirements during decades, under different intensities of forest management, on 603 wc average volume of standing timber per acre left at the end of the plannir

* Less than 1 man-month of labor.

trated in one cutting each decade rather than spread c as in Table 12. However, the cut on a yearly averag about the same as that shown in the table.

No cordwood is scheduled to be cut for about thr either medium or low intensity, and it seems likely t pulpwood markets will have developed. However, e' plans seem feasible under current conditions, neither management intensities will add more than about $50 t net farm income during the next decade or two, assum have used previously.

Compromise Program Another alternative might add more i better advantage of present forest mar plan farm labor will be used to give th stands high intensity management, leaving 52 percent of the area managed with a medium intensity using periodic marked-stumpage sales. This program will produce about all of the sawlogs and cordwood that can currently be sold. The sales and labor for this program are shown in section D of Table 12. During the next decade about six months of hired labor or the equivalent in family help will be needed. This program will also pave the way for a wider application of a high intensity of forest management when conditions are more favorable.

Future Returns Woodland income will gradually increase under any of the forest programs as the stands grow older. If a high, medium, or a combination of high and medium management intensity is used, income will more or less even out after about 30 years to a level that probably can be maintained. Table 13 shows the stumpage value of this maintained average annual sale of wood. Returns under low intensity will vary a great deal over the years. An average of stumpage values over the whole 90-year planning period is probably a fair indicator of the level of probable returns that can be maintained.

TABLE 13

STUMPAGE VALUE OF MAINTAINED AVERAGE ANNUAL FOREST PRODUCT SALES FROM FARM C[1]

Forest Management Intensity	*Dollars*
High	$2,350
High and Medium	1,850
Medium	1,600
Low	950

[1] Assuming the constant level of stumpage prices previously described in footnote to Table 5.

In so far as woods labor is hired, these stumpage values indicate the probable eventual contribution of the forest enterprise to net farm income. When the growing stock is older, if forest markets are well-established and extra labor is available, the woodlands can make up a very substantial part of this farmer's income, especially if he uses any of the higher intensities of management.

Orderly Development It seems likely that the operator should develop this combination of agricultural and forest enterprises gradually. The first step would be to build up his dairy enterprise. While this is going on he could probably gain most in the long-run by using a medium intensity of forest management that would make few demands on his time and management ability. When agricultural adjustments are less pressing he could adopt a combination of medium and high intensities even if present wood markets had not improved.

This schedule of making land-use adjustments will allow the operator to concentrate his attention, and will give him a maximum of flexibility for making future adjustments as market conditions change and the family grows up. Probable yearly receipts, expenses and net farm income during the next decade after the proposed adjustments have been made are shown in Table 14.

TABLE 14

CONDENSED FINANCIAL SUMMARY — FARM C[1]

	Present Plan		Proposed Plan Including Med.-High Forest Mgt. Intensity		
Receipts					
Agricultural Enterprises		$2,936			$5,104
Forest Enterprise[2]					
Cordwood (Roadside)	$0		(96 cds.)	$864	
Sawlogs (Roadside)	0		(14 M.b.f.)	252	
Sawlogs (Stumpage)	0		(2 M.b.f.)	12	
Total		0			1,128
Total Farm Receipts		$2,936			$6,232
Expenses					
Farm and Forest Enterprises		$2,476			$3,747
Hired Labor		0		(6 Mo.)	780
Total Farm Expenses		$2,476			$4,527
NET FARM INCOME		$ 460			$1,705

[1] Using the original long-term planning prices. Refiguring the budgets using prices closer to 1953 levels would show net farm incomes somewhat lower than those above.

[2] Sales of forest products under the proposed plan are based on the average cut of the first decade under a combination of medium and high forest management intensity. The contribution of the woodlands to income will gradually increase due to the effects of management and growth, especially if the relative values of forest products increase.

Income Limits Net returns are unlikely to increase much more than the estimated $1300 without a fairly heavy investment of borrowed money in the agricultural enterprises. And larger forest returns depend on growth and better markets, which are largely beyond the owner's control. Despite the relatively modest estimated net income, the owner believes that he can follow this plan of development if price relationships are at least as favorable as those used.

Of course the compromise woodland plan of using both medium and high intensity forest management carried out by stumpage and roadside sales could be used on any of the other farms. However, it is not so clearly needed on the first two farms because markets and the labor supply are more favorable. The returns in any case would probably fall between those of high and medium management as they do on this farm. It should perhaps be emphasized, however, that as a method, the operating unit budgetary analysis is flexible enough to include many intensities of management other than the three chosen here to illustrate the range of possible alternatives.

Farm D

A HILL DAIRY FARM WITH SPECIAL PROBLEMS THAT LIMIT BUSINESS EXPANSION

The Owner The young man who owns this farm comes from a professional family and has had university training. He has inherited a strong conviction that owning and operating land is a desirable way of life. So, after holding several farm jobs, he acquired the present farm and has set out to build it into a two-man business based on agricultural and forest production.

However, he wants to develop the farm slowly so that he can spread out any necessary cash investment and gradually acquire more management experience. Over the next decade or so he hopes to build up an operating unit that will yield satisfactory returns to the family and be increasingly valuable to his children.

Town and Markets Although many of the surrounding farms have been abandoned, the town still contains some well-developed agricultural areas. There are several small industrial centers nearby and the local roads are fairly well maintained. A wholesale milk pick-up route comes to the house, even though it is at the end of a gravel road. Ready outlets for practically all forest products seem likely to continue.

The Farm The resources of the farm include 72 acres of crop and pasture land and 451 acres of woodland. In addition, the operator's father owns 527 acres of adjoining forest, and he appears willing to work out some agreement to let his son use this land as a part of the farm operating unit. The following plans assume that this is done.

The present barns are adequate for the operator's six Jersey cows, replacement young stock, and 300 chicks that are sold when ready to lay.

Some additional haying equipment is needed, and if much woods work is done, a small crawler tractor will have advantages over the present rubber-tired tractor. In the past the operator has exchanged a good deal of labor with his neighbors and has spent about four months doing custom work with his tractor and chain saw.

Currently he is harvesting about 50 thousand board feet of white pine sawlogs from his own woodland. Most of the trees he is cutting are of poor quality and their removal will effect a considerable improvement in the residual stand. The indications are that little more work will be available on the home woodlot for about 10 years. However, if the father's land can be used under some reasonable arrangement, there will be a considerable opportunity for woods work and income.

Proposed Plans

12-cow Herd In order to take full advantage of the present barn space the milking herd can be increased to 12; and 5 calves can be started each year. These will provide normal herd replacements, a beef animal for home use, and about 2 fresh heifers for sale each year. Two pigs can be raised for home use and the present poultry enterprise continued.

If somewhat more lime and fertilizer are used the 42 acres of improved land can provide enough roughage for the above livestock. The other 37 acres of open pasture can revert to woodland unless further farm expansion is planned later. The cash investment needed should not exceed $2900, including an exchange of the present tractor.

The operator, however, wants to give up custom work and if this is done, the above program will not fully occupy his time. If he combines this farm work with a high intensity of forest management, the farm business will then take up all of his time plus about four months of hired labor each year during the next decade.

30-cow Herd Alternatively, it would also be possible to take full advantage of the farm land production with a herd of about 30 cows. But an investment of over $10,000 in buildings, land improvements, machinery and livestock would be needed. The owner prefers to approach this goal slowly as he gathers more experience and capital.

However, this expanded agricultural enterprise might be combined with a high intensity of forest management a decade from now. The probable returns from such a farm business are shown as Plan II in the Financial Summary.

Forest Production So far little has been said about forest production possibilities. Over 40 percent of the 978 acres of woodland supports middle-aged or older stands, and 65 percent of the acreage contains northern hardwoods. Nearly 300 acres of pine are reaching the stage where thinnings can be profitable, and more than 100 acres are over 40 years old and nearing commercial maturity. This distribution of age classes indicates that a sizable amount of material can be cut without too long a delay for growth, although most of the older stands are on the father's land.

It seems likely that the three intensities of forest management already discussed will also adequately cover the range of practical alternatives open to this owner. Table 15 shows the probable average annual yields and labor required to carry out any of these three plans of action.

Stumpage Returns In so far as hired woods labor is used, stumpage values will give a fair indication of the forest contribution to net farm income (Table 16). The owner can earn extra returns by working in the woods with farm equipment that might not otherwise be in use. He will be able to do a good deal of this in the next decade,

TABLE 15

PROBABLE YEARLY FOREST PRODUCTS SALES AND WOODS LABOR REQUIREMENTS ON FARM D[1]

Item	*Average Yearly Sales and Labor by Decades in the Future*									*Cu. Ft. Vol. per Acre Left After 90 Years*
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	
A. *High Intensity of Forest Management*										
Cords	103	503	236	444	421	316	293	422	351	1,464
M.b.f.	65	30	134	110	475	348	465	517	302	
Mo. of Labor	9	26	18	27	42	30	37	45	32	
B. *Medium Intensity of Forest Management*										
Cords	11	26	30	37	227	158	266	291	182	1,387
M.b.f.	1	53	54	82	295	192	255	290	189	
Mo. of Labor	2	4	4	6	24	16	27	29	19	
C. *Low Intensity of Forest Management*										
Cords	0	68	0	83	304	0	533	21	324	684
M.b.f.	0	93	0	165	354	0	501	34	311	
Mo. of Labor	0	8	0	12	32	0	51	2	31	

[1] Estimated average annual sales and labor requirements during each of the next nine decades, under different intensities of forest management, on 978 woodland acres; and the average volume of standing timber per acre left at the end of the planning period.

but if he expands the herd to 30, he will have to hire more labor for woods work.

The maintained level of stumpage returns shows that the forest enterprise can form a substantial part of the net income of this forest-farm operating unit, especially if sawlog prices go up over the years. The relative advantage of the more intensive management system is not fully apparent, however, without the value of the residual standing sawtimber at the end of the planning period. These values will affect the sale value of the farm long before the 90 years are up.

TABLE 16

YEARLY STUMPAGE RETURNS OF FUTURE FOREST PRODUCT SALES ON FARM D[1]

Intensity of Management	*Average Annual Stumpage Returns in Next Decade*	*Indicated Maintained Average Annual Stumpage Returns*	*Value of Residual Standing Sawtimber 90 Years Hence*
Section I — Assuming Constant Sawlog Prices:			
		DOLLARS	
High	565	4,420 [2]	34,380
Medium	35	2,210 [2]	20,120
Low	0	1,220 [3]	3,230
Section II — Assuming Rising Sawlog Prices:			
High	565	8,470 [2]	80,450
Medium	35	4,560 [2]	53,000
Low	0	2,700 [3]	11,000

[1] Estimated average annual stumpage returns during the next decade, level of annual stumpage sales that can be maintained, and stumpage value of residual standing sawtimber on 978 acres of woodland. Stumpage prices are those described in the footnote to Table 5.

[2] Values based on an average of returns during the 5th through the 9th decades.

[3] Values based on an average of returns during all nine decades.

Farm Income The budgeted net farm incomes (Table 17) indicate that the owner can expand his dairy enterprise gradually and use intensive forest management to make satisfactory returns, provided some scheme can be worked out to let the operator use all 978 acres of forest land. About two-fifths of gross farm receipts will come from the forest enterprise during the next decade under Plan I.

TABLE 17

CONDENSED FINANCIAL SUMMARY — FARM D[1]

	Present Plan			Plan I 12-cow Dairy and High Forest Mgt. Intensity			10 to 20 Years Hence: Plan Ia 12-cow Dairy and High Forest Mgt. Intensity			10 to 20 Years Hence: Plan II 30-cow Dairy and High Forest Mgt. Intensity		
Receipts												
Agricultural Enterprises			$2,582			$3,595			$3,595			$7,696
Forest Enterprise[2]												
Cordwood, cds.	(18)	234		(103)	927		(400)	3,600		(400)	3,600	
Sawlogs, M.b.f.		0		(65)	1,170		(30)	540		(30)	540	
Total			234			2,097			4,140			4,140
Total Farm Receipts			$2,816			$5,692			$7,735			$11,836
Expenses												
Farm and Forest Enterprises			$2,343			$3,341			$3,541			$ 6,186
Hired Labor, man months		(1)	130		(4)	520		(15)	1,950		(24)	3,120
Total Farm Expenses			$2,473			$3,861			$5,491			$ 9,306
NET FARM INCOME			$ 343			$1,831			$2,244			$ 2,530

[1] Using the original long-term planning prices. Refiguring the budgets using prices closer to 1953 levels would show a smaller net farm income under the present plan and net farm incomes about 20 percent higher under the proposed plans.

[2] Plan I includes the average cut under high intensity forest management during the next decade. Plans Ia and II include a cut slightly smaller than that possible with the same management during the second decade.

Actual Adjustments Since this study was made the father has died and his forest land is now being cut under an accelerated schedule of medium management intensity to make a settlement with the heirs. The land will eventually go to the owner of Farm D, but present cutting will probably reduce the amount of future returns. At the same time, however, some additional capital may be provided for farm improvements. It seems likely that a more rapid development of the agricultural enterprises will be possible than the one contemplated here, and that the long-run results will not be much different from those discussed.

The Last Five Farms

The farms discussed so far are ones that are likely to be thought of as run-down when seen from the road. They have problems that are especially prevalent on other "poor" farms in the fringe area, particularly in towns that are nearly abandoned.

There are other farms in the fringe areas, however, that look better to anyone driving by. Buildings are larger and in better repair, fields are bigger and include less brush pasture, and the farms have a greater air of prosperity despite an isolated location on a back road. Even though they are in a fringe area these farmers frequently have more resources to work with and seem to be getting better returns from their farm enterprises than the operating unit owners we have taken up so far.

The next five farms have more resources and their problems and objectives are somewhat different from those of the first group. These last farms will be treated in a summary fashion merely to bring out the major problems of adjustment, and to show that alternative forest management plans can be integrated into the total farm operation. The reader should remember that initially all of these operating units were analyzed as completely as Farm A.

Farm E

A DAIRY, CANNING CROP AND WOODLAND FARM

The Situation This young, unmarried owner has been successfully operating a 20-cow dairy-canning crop farm on the edge of the "North woods" ever since he graduated from high school. The farm includes 290 acres of woodland and 106 acres of crop and pasture land. It is well equipped with machinery and buildings, so no large additions will be needed to carry on the present scale of operation efficiently. Although farm income has been fairly satisfactory, the work on a one-man dairy farm is very confining. The owner would like to expand his enterprises in order to hire a full-time assistant; so far he has hired the equivalent of only three man-months of extra help each year.

In the past, occasional stumpage sales have been made with little attention to their effect on forest productivity. In a recent 200-cord pulpwood sale no farm labor was used, even though the difference between the stumpage and roadside prices was enough to pay going wages for cutting and skidding.

About 80 percent of the woodlot supports spruce-fir and mixed softwood-hardwood stands. Over 90 percent of these stands are middle-aged, and they contain a considerable amount of merchantable pulpwood and some sawlogs. If the operator uses farm labor to produce forest products for roadside sale, he may follow any of the basic intensities of management that we have outlined so far. However, the highest intensity will not only yield the greatest amount of wood in the next decade — and in the long-run — but it is also the only intensity that calls for enough labor to warrant hiring an extra year-round man.

The operator could clear a good deal of land and make the other improvements necessary to have a 40-cow, two-man farm. A large investment would be needed, however, and the operator does not want

TABLE 18

CONDENSED FINANCIAL SUMMARY — FARM E[1]

		Present Plan			Proposed Plan Including High Forest Mgt. Intensity	
Receipts						
Agricultural Enterprises			$3,808			$6,238
Forest Enterprise[2]						
Pulpwood	(200 cds. stpg)	500		(240 cds.rdsd)	2,160	
Sawlogs		0		(20 M.b.f.rdsd)	360	
Total			500			2,520
Total Farm Receipts			$4,308			$8,758
Expenses						
Farm and Forest Enterprises			$2,261			$3,205
Hired Labor		(3 mos.)	400		(18 mos.)	2,400
Total Farm Expenses			$2,661			$5,605
NET FARM INCOME			$1,647			$3,153

[1] Using the long-term planning prices. Refiguring the budgets using prices closer to 1953 levels, shows net farm incomes about 20 percent higher than those above.

[2] The wodland sales shown under the proposed plan are based on cutting during the next decade under a high intensity of forest management. Woodland values will increase as the management program becomes fully effective, especially if the relative value of forest products increases.

to borrow this much. Moreover, moderate improvements in roughage production and feeding promise a large increase in milk from the present herd at little added investment. Even if he makes these farming adjustments he still will not have enough profitable work to hire an extra full-time man. The forest land offers good possibilities for rounding out an integrated business.

Income Possibilities During the next decade, if the agricultural enterprises are improved and a high intensity of forest management is used, about 18 months of hired labor will be needed. Under this plan there should be enough profitable work on the farm to maintain a two-man organization indefinitely.

Table 18 shows the receipts, expenses and net farm income that may be expected during the next decade at the price level we have previously assumed.

Under the circumstances the owner can reach his goals of a larger income and bigger operation by combining improved farming with a high intensity of forest management. This will require only a small cash investment and will leave him in a position for further expansion if he wishes it at a later date.

Farm F

A HILL DAIRY-WOODLAND FARM

The Situation The operator of this farm has some problems in common with the last owner. This young man, however, has worked at city jobs part of the time since he graduated from high school. Recently he brought his wife and two children back and rented the home farm from his father. He has also been working substantially alone, with only about two months of hired help, and wants to expand his farm business to improve net income and get away from the confinement of a one-man dairy farm. However, his opportunities for adjustment are quite different from those on Farm E.

This farm contains 116 acres of woodland and 90 acres of crop and pasture land. It is located in a fringe area with good roads and good markets for farm and forest products. But the owner has already intensified his farming enterprise about as much as possible, maintaining a herd of 15 high-producing Jersey cows. Although he can sell his bull, use artificial insemination, and keep three more milkers, further farm expansion is limited by steep rocky land and the lack of any arable land for sale in the neighborhood. Roughage production can be somewhat increased on the 30 acres of cropland and 60 acres of open pasture by more frequent reseeding and greater fertilization. Although farm income will be increased by these agricultural adjustments, they will not make up a two-man operation.

Forest Production In the past, except for making 60 to 70 gallons of syrup each year from his 16-acre sugar bush, the owner has not gotten much return from the rest of his woodlot. The syrup enterprise can be expanded profitably to use about 3½ man-months of labor and produce about 380 gallons of syrup by renting an adjoining sugar bush. Most of the 100 acre woodlot supports stands of northern hardwood and pasture spruce-fir that are currently almost merchantable. More intensive use of this part of the forest land, together with the agricultural and syrup enterprise adjustments suggested above, seems to offer a way of expanding farm income and size of business.

Speed up Cutting Unfortunately, as Table 19 indicates, even with the most intensive kind of forest management analyzed, there will only be about 20 cords of pulpwood and 40,000 board feet of sawlogs to cut during each of the next ten years if the cutting is spread out evenly. This lack of profitable woods work could be temporarily taken care of by a speed-up in cutting the merchantable timber scheduled to be operated under the high intensity of management. Thus the cut for the next decade could be done during the next five years without much

TABLE 19

FUTURE YEARLY FOREST PRODUCT SALES AND WOODS LABOR REQUIREMENTS ON 100 ACRES OF WOODLAND ON FARM F[1]

	Intensity of Forest Management		
During the Next 10 Years:	*High*	*Medium*	*Low*
Sales of Cordwood, Cds.	22	0	1
Sales of Sawlogs, M.b.f.	40	14	18
Labor Requirements, Man-months	3.1	0.5	0.7
Estimated Maintained Levels:			
Sales of Cordwood, Cds.	33[2]	11[2]	10[3]
Sales of Sawlogs, M.b.f.	49	33	29
Labor Requirements, Man-months	4.5	2.5	2.2

[1] Probable average annual woodland sales and labor requirements during the next decade and estimated level of average annual sales and labor requirements that can be maintained under different intensities of forest management.

[2] Average of sales and labor during the 5th through the 9th decades in the future.

[3] Average of sales and labor during the 1st through the 9th decades in the future.

affecting estimated yields in later decades. This would allow expanding to a two-man farm and increasing farm income.

Net Farm Income The Condensed Financial Summary includes the income effects of an accelerated program of cutting during the next five years under high forest management intensity. The coordinated adjustments in farm and forest production outlined above will make it possible to add a full-time hired man and increase net farm income by about $1000 a year during this period.

TABLE 20

CONDENSED FINANCIAL SUMMARY — FARM F[1]

	Present Plan			Proposed Plan Including High Forest Mgt. Intensity		
Receipts						
Agricultural Enterprises			$3,872			$4,650
Forest Enterprise[2]						
Syrup	(60 gals.)	180		(380 gals.)	950	
Pulpwood (rdsd)		0		(44 cds.)	396	
Sawlogs (rdsd)		0		(80 M.b.f.)	1,440	
Total			180			2,786
Total Farm Receipts			$4,052			$7,436
Expenses						
Farm and Forest Enterprises			$2,702			$3,671
Hired Labor	(1½ mos.)		200	(12 mos.)		1,560
Total Farm Expenses			$2,902			$5,231
NET FARM INCOME			$1,150			$2,205

[1] Using the long-term planning prices. Refiguring the budgets using prices closer to 1953 levels, shows net farm incomes about 35 percent higher than those above.

[2] Proposed woodland sales are based on an accelerated schedule of cutting under high forest management intensity.

Buy Forest Land Although the probable net income of the proposed plan is attractive to the owner, any permanent form of business expansion based on woods work will depend on buying additional forest land. This seems like a feasible adjustment since more of this kind of land is available at reasonable cost adjoining the present woodlot. It seems likely that at least 150 acres of land with a growing stock similar to that already owned will be needed to round out a permanent two-man forest-farm.

FARM G

A HILL FARM COMBINING BEEF AND WOODLAND ENTERPRISES

The Situation To illustrate the range of possible enterprise combinations, let us look at a 387-acre hill farm with a herd of 20 beef cows. In addition to beef, sales include some local milk, Christmas greens, maple syrup and about 40 cords of pulpwood each year.

The owner is a life-time farmer who left a large valley farm during the 30's. He is now enthusiastic over the possibilities for keeping remote hill farms productive by raising beef and forest products. He has built up his present business despite the fact that both he and his hired man are partly disabled. He estimates that the two of them do work about equivalent to that of one vigorous man. The owner wants to continue building up the value of his property and increasing its earning capacity without making large cash investments.

The owner took over this operating unit after it had been abandoned for a few years and the town road was about to be discontinued. With a small cash investment he has gradually built up the farm business so that the town has reversed its previous policy and the main road is now being improved and extended to reopen the area beyond the farm.

Integrated Adjustments One immediate problem is to increase the productivity of the 111 acres of open land on the home place so that it will no longer be necessary to rent 40 acres of adjoining pasture. This could be done by using more fertilizer and more frequent reseeding; to date neither of these farming practices has been used very extensively. The owner feels that these changes will save a good deal of labor now spent running back and forth and moving the cattle around.

Net cash returns under such a stepped-up program will be slightly less than present returns if no further changes are made; but concentrating roughage production on the home farm and dropping the rented land will increase efficiency and make more labor available for woods work. Net farm income could then be increased despite added seed and fertilizer costs. This is clearly a case where interdependent farm and forest enterprise adjustments lead to greater total net returns.

Forest Production The 276 acres of woodland support stands of northern hardwood and spruce-fir that are mostly even-aged. About half the stands are over 40 years old. Table 21 shows the probable average annual woodland sales during each of the next four decades under three alternative intensities of management, and the labor required under each. The level of sales and labor that could be maintained and the volume of residual standing sawtimber at the end of nine decades are also shown.

TABLE 21
ESTIMATED YEARLY FOREST PRODUCT SALES AND WOODS LABOR REQUIREMENTS ON FARM G

Item	*Average Annual Sales and Labor by Decades in the Future*				*Maintained Average Annual Sales and Labor*	*Cu. Ft. Vol. per Acre Left After 90 Years*
	1	*2*	*3*	*4*		
A. *High Intensity of Forest Management*						
Cords	108	180	146	99	64[1]	1,000
M.b.f.	27	28	14	14	86	
Mo. of Labor	7	11	8	6	7	
B. *Medium Intensity of Forest Management*						
Cords	20	42	22	0	60[1]	1,140
M.b.f.	17	32	16	0	64	
Mo. of Labor	2	4	2	0	6	
C. *Low Intensity of Forest Management*						
Cords	20	64	0	0	43[2]	180
M.b.f.	17	47	0	0	46	
Mo. of Labor	2	6	0	0	5	

[1] Sales and labor based on an average of 5th through 9th decade.
[2] Sales and labor based on an average of 1st through 9th decade.

Farm Income Either of the lower intensities of management can be carried out by the present labor force. However, after changes in the beef enterprise, income will not be much greater than at present and the two men will not be fully occupied. If the highest intensity of forest management is used, income will be greater than at present; but in addition, about two months of extra labor will have to be hired. The following condensed financial summary shows the probable receipts, expenses, and net farm income from the present plan and from intensive use of the open land combined with a high intensity of forest management.

The owner could carry out a medium intensity of management on all or a part of his woodland. This would give him the benefit of more regular returns than the low intensity and would help to increase the long-run value of his farm. In this instance the same amount of cutting is scheduled during the next decade under either low or medium management intensity.

TABLE 22

CONDENSED FINANCIAL SUMMARY — FARM G[1]

			Present Plan			Proposed Plan Including High Forest Mgt. Intensity
Receipts						
Agricultural Enterprises			$2,563			$2,563
Forest Enterprise[2]						
Pulpwood	(40 cds.)	360		(108 cds.)	972	
Sawlogs		0		(27 M.b.f.)	486	
Xmas Greens		300			300	
Syrup	(65 gals.)	162		(65 gals.)	162	
Total			822			1,920
Total Farm Receipts			$3,385			$4,483
Expenses						
Farm and Forest Enterprises			$1,788			$2,017
Hired Labor			40		(2 mos.)	250
Total Farm Expenses			$1,828			$2,267
NET FARM INCOME[3]			$1,557			$2,216

[1] Using the long-term planning prices. Refiguring the budgets using prices closer to 1953 levels, shows net farm incomes about 25 per cent higher than those above.

[2] Proposed woodland sales are based on cutting during the next decade under high forest management intensity. Forest sales will gradually increase as management becomes fully effective, especially if relative forest product values increase.

[3] Neither the operator nor the present regular hired man perform vigorous fulltime work; therefore wages of the hired man are not included in labor expense, and net farm income includes the return for the efforts of both workers.

Milking Herd It seems probable that a younger and more vigorous man might carry out this entire farm program with only a small amount of part-time help in woods work. Beef animals require a less rigid program of care and attention than dairy cows and thus permit a more flexible work schedule. This flexibility makes it possible to do more woods work on a forest-beef farm than on a forest-dairy farm. If this farm, however, were to support a herd of 20 milkers rather than 20 beef cows, net farm income could be increased by about $200 a year, even though about six months of hired labor would be needed.

FARM H

A HILL FARM COMBINING TOURIST, DAIRY AND FOREST ENTERPRISES

The Situation This operating unit illustrates a peculiar combination of enterprises developed by an ingenious operator on a fringe-area farm. The owner is now a middle-aged man, and he has operated his 425-acre farm since he graduated from college. By taking advantage of a large farmhouse in a pleasant setting he has built up a selected "house guest" or tourist trade.

He has developed modest agricultural enterprises on 37 acres of open land and uses most of the produce for guests. He has also used a medium or low intensity of forest management on his 388-acre woodlot. The returns of this business have been adequate, providing about all the profitable work the owner wants to do. However, his son may soon want to work full-time in the business; so the owner wants to explore the ways of expanding his whole operation into a two-man enterprise.

Agricultural Adjustments To fill the barn the herd can be increased from its present size of 8 Jersey cows up to 12, plus enough young stock for replacements. More frequent reseeding and more fertilizer will produce enough roughage on the present open land to support this milking herd, replacement young stock, and two fresh heifers for sale each year. Further expansion will require a sizable investment in buildings, land clearing, and other improvements that the owner does not want to make right now.

Forest Production The above changes in the agricultural enterprises alone will not provide enough profitable work for an added man. But more intensive forest management can help to round out a two-man operating unit. The growing stock is fairly evenly distributed between young, middle-aged, and old stands, and under a high intensity of management about 70 cords of pulpwood and 44 thousand board feet of sawlogs can be cut each year during the next decade. Sawlog sales can be further increased later and will level off at around 100 M.b.f. per year. About six man-months of woods work will be needed during each of the next ten years.

TABLE 23

PROBABLE ADDED RECEIPTS, EXPENSES AND NET FARM INCOME DUE TO ADOPTING THE PROPOSED PLAN FOR FARM H[1]

Added Receipts	$2,685
Added Expenses	$1,436
Added Net Cash Income	$1,249

[1] Using the long-term planning prices. Refiguring the budgets using prices closer to 1953 levels, shows that the added net cash income would be about 20 percent more than that above.

A lower intensity of management would provide less income in the long-run and the more erratic yields form a less stable basis for a two-man business.

Table 23 shows the probable receipts, expenses and net farm income that would be added by adopting the proposed program of expanded farming and intensive forest management combined with the tourist business. Receipts include the returns from 70 cords of pulpwood and 44 M.b.f. of sawlogs sold at the roadside.

Farm I

A LARGE FOREST AND DAIRY FARM

Most of these farms have had limited income possibilities that might not tempt many enterprising farmers to make the effort needed to run this kind of fringe-area operating unit. One more case will show that when enough resources can be gathered together the opportunities on a fringe-area farm may compare favorably with those elsewhere.

TABLE 24

Future Yearly Forest Product Sales and Woods Labor Requirements on Farm I[1]

Item	*Average Yearly Sales and Labor by Decades in the Future*									*Cu. Ft. Vol. per Acre Left After 90 Years*
	1	2	3	4	5	6	7	8	9	
A. *High Intensity of Forest Management*										
Cords	253	848	486	530	671	386	178	548	600	2,040
M.b.f.	71	70	117	182	123	254	99	213	184	
Mo. of Labor	17	39	27	32	37	30	13	36	36	
B. *Medium Intensity of Forest Management*										
Cords	15	180	302	190	734	592	199	89	260	1,710
M.b.f.	7	50	86	108	100	210	13	36	23	
Mo. of Labor	1	10	17	14	38	38	10	6	12	
C. *Low Intensity of Forest Management*										
Cords	25	275	342	16	1152	229	9	14	0	1,280
M.b.f.	7	111	68	48	250	0	27	43	0	
Mo. of Labor	2	17	17	3	64	10	2	3	0	

[1] Estimated average annual sales and labor requirements during each of the next nine decades, under different intensities of forest management, on 880 woodland acres; and the average volume of standing timber per acre left at the end of the planning period.

The Situation This operator's family has owned land in the vicinity for many years. The present owner has added to the operating unit since he graduated from the state university. Although the farm is located deep in the woods of northern New England, there are good markets for milk and most other farm products, including all kinds of forest products. Roads are well maintained and the owner takes a vigorous part in the town government.

The Farm This farmer owns most of the bottom land in a narrow valley and much of the broad ridge to the west. This land was once held in three separate farms. He has 108 acres of crop land in the valley; 190 acres of open upland pasture extending over the ridge, and about 880 acres of woodland. He also has three large barns that house a herd of 40 milkers, young stock for replacements and 10 veal calves each year, 30 ewes, and three teams of horses. The livestock enterprises are well suited to present land-use and building capacities.

The owner has used only a moderate amount of fertilizer and has reseeded his fields only infrequently. Haying has also been slowed by using a large amount of hand labor. A moderate increase in the fertilizer

TABLE 25

CONDENSED FINANCIAL SUMMARY — FARM I[1]

	Present Plan			*Proposed Plan Including High Forest Mgt. Intensity*		
Receipts						
Agricultural Enterprises			$11,317			$10,648
Forest Enterprise[2]						
Pulpwood		0		(250 cds.)	2,250	
Sawlogs		0		(71 M.b.f.)	1,278	
Syrup	(100 gals.)	300		(100 gals.)	300	
Total			300			3,828
Total Farm Receipts			$11,617			$14,476
Expenses						
Farm and Forest Enterprises			$ 7,009			$6,400
Hired Labor	(6 mos.)		600	(21 mos.)		2,362
Total Farm Expenses			$ 7,609			$ 8,762
NET FARM INCOME			$ 4,008			$ 5,714

[1] Using the long-term planning prices. Refiguring the budgets using prices closer to 1953 levels, shows net farm incomes about 40 percent higher than those above.

[2] Cutting under the proposed plan is based on average sales during the first decade of high forest management intensity. Values will be greater as management becomes fully effective, especially if the relative prices of forest products increase.

used, more reseeding, and a hayloader, together with a few other minor changes would considerably increase the efficiency of the agricultural enterprise. This would be a desirable goal since one of his problems has been that of hiring enough part-time labor to help him, his grown son, and other family labor get the farm work done.

Forest Production No large-scale cutting has been done in the woodland for about 30 years, and a good deal of material is reaching a merchantable stage. The owner hopes to start some forest cutting with the farm labor force soon. The stands are mostly spruce-fir and northern hardwoods, and nearly 60 percent of the area has trees over 40 years of age. Table 24 shows the probable average annual sales and labor required for each of three intensities of forest management.

Either the medium or low intensity of forest management could be carried out by stumpage sales. But probably many of the operations that make up the high intensity could only be done by farm labor or at least under the owner's close supervision. It seems likely that at least one more man could profitably be added to the regular farm labor force if intensive

TABLE 26

ESTIMATED YEARLY STUMPAGE RETURNS OF FOREST PRODUCT SALES ON FARM I[1]

Intensity of Management	*Average Annual Stumpage by Decades in the Future* 1	2	3	4	*Indicated Maintained Average Annual Stumpage Returns*	*Value of Residual Standing Sawtimber 90 Years Hence*
Section I — Assuming Constant Sawlog Prices:						
				DOLLARS		
High	806	1,692	1,606	2,160	2,024[2]	39,000
Medium	64	570	1,098	1,095	1,135[2]	23,100
Low	79	1,078	921	312	713[3]	9,200
Section II — Assuming Rising Sawlog Prices:						
High	806	1,692	1,606	3,252	3,667[2]	190,500
Medium	64	570	1,098	1,743	1,680[2]	115,700
Low	79	1,078	921	600	1,005[3]	78,400

[1] Estimated average annual stumpage returns during the next four decades, the level of returns that could be maintained, and the value of the residual standing sawtimber, under different intensities of forest management and assuming the constant level of stumpage prices or the rising schedule of prices described in the footnote to Table 5.

[2] Based on an average of annual returns during the 5th through the 9th decades.

[3] Based on an average of annual returns during all 9 decades.

silviculture were undertaken; in fact, a total of about 21 man-months of extra labor would be needed to carry out the proposed plan of more intensive farm and forest management.

Farm Income The Condensed Financial Summary shows the returns likely under the present plan and after the proposed adjustments have been made.

The stumpage returns of Table 26 are a minimum estimate of the forest enterprise's contribution to net farm income. But even these figures indicate that the woodlands can make up a substantial part of the farm business, especially after a decade. The schedule of rising stumpage values assumed in Section II of Table 26 shows even more favorable returns, especially for the higher intensities of forest management.

This owner feels that with his present income he can afford to practice at least a medium intensity of management, despite the necessity for postponing some cutting during the next decade that might otherwise be done under a low intensity. He would prefer, however, to use a high intensity of forest management whenever his labor supply and market opportunities permit.

Chapter III

FOREST-FARM PRODUCTION OPPORTUNITIES IN THE FRINGE AREAS

The nine farms just analyzed are not, of course, a satisfactory statistical base for any final conclusions about the future of forest and farm production in the fringe agricultural areas of New England. The farm operators, for example, were not selected in a random manner but were chosen because they met a variety of criteria. But the farm units themselves — the various combinations of cropland, woods and other resources, and the market situations — are fairly typical of many others in the fringe areas.

By a careful study of this small sample of nine farms it is possible to draw some general conclusions about profitable management adjustments on other similar holdings. Used in this way the case method may lead to valuable insights on the way a segment of the regional economy works. This kind of knowledge will provide a realistic background for any solution of the broader problem of using the region's resources.

Let us look at some of the inferences and tentative conclusions that can be drawn from these nine operating unit analyses.

Increasing Forest Productivity

As noted in the introduction, the ways and means of increasing forest production are vital national and regional questions. After analyzing over 5000 acres of woodland on the nine farms some provisional conclusions about future production in the fringe areas can be outlined. Some of these findings may apply more widely.

TABLE 27

Percentage Distribution of Forest Land Acreage by Age Classes

Forest Land	*Age Class* 0–20	21–60	61 & up
		Percent	
5078[1] Acres on 9 Fringe Area Farms	43	38	19
All New England Forest Land[2]	25	28	47

[1] Excluding 28 acres of sugar bush.

[2] Derived from U. S. Forest Service data.

Growing Stock First, Table 27 shows that the forest growing stock on these nine farms has less than the New England average amount of older sawtimber, and a correspondingly greater proportion of young and middle-aged trees. It appears that these private holdings may have been depleted more by past cutting than have the region's forest lands as a whole.

This relative lack of older growing stock available for cutting in the next few decades creates a serious problem on most of the nine farms; especially if the owners wish to increase forest production. The data in Table 28 show the estimated forest product sales during the next decade and the long-run levels of sales that could be maintained under the three forest management programs analyzed.

TABLE 28

ESTIMATED ANNUAL FOREST PRODUCT SALES PER ACRE FROM THE 5078 ACRES OF FOREST LAND ON THE NINE FARMS

Intensity of Forest Management Used (1)	*Average Annual Sales in the Next Decade* (2)	*Average Annual Sales That Can Be Maintained*[1] (3)
	Volume per Acre in Cord Equivalents[2]	
High	0.4	1.0
Medium	0.05	0.6
Low	0.1	0.4

[1] Estimates for high and medium intensities based on an average of sales during the 5th through the 9th decades. Estimates for low intensity based on an average of sales for all 9 decades.

[2] Includes the total volume of wood sold, whether as sawlogs, fuel or pulpwood.

Medium vs. Low Intensity It is estimated that a low intensity of forest management on the nine farms will lead to maintained woodland sales that average about 0.4 of a cord per acre per year; medium intensity promises a probable annual maintained average of about 0.6 of a cord per acre; while sales equivalent to about 1.0 cord per acre per year can be maintained by using a high intensity of forest management (column 3).

The larger sales estimated for medium and high intensity management will eventually contain a high proportion of good quality sawlogs that will help to meet national requirements for more wood products. But it is also apparent that these increased sales of higher quality materials will not be realized for several decades.

In the meantime, average annual woodland sales on the nine farms will be much less; the figures in column 2 of Table 28 show estimates for low, medium and high management intensities equivalent to about 0.1, 0.05, and 0.4 of a cord per acre per year during the next decade. These estimates reflect the present preponderance of young stands. They also suggest that if the farm owners adopt programs of medium rather than low management intensity, they will have to reduce current cutting by about half. Five decades hence, medium intensity management will lead to a maintained cut about 50 percent larger than under a low intensity. Even if these figures are not entirely accurate, some sacrifice of this kind seems inevitable because the assumed long-run gains of medium management come mostly from allowing selected trees to grow larger and from establishing better reproduction than is customary under low management intensity.

Under these conditions short-run private interests in woodland management may not always be compatible with the longer-run aim of higher forest productivity. Without some form of assistance many owners cannot afford to postpone returns in the near future in order to build up somewhat larger returns several decades later. This difficulty needs to be considered before adopting a public policy to impose minimum cutting standards that give results similar to a medium intensity of forest management.

High vs. Low Intensity If an owner can adopt high intensity management rather than low intensity, the situation may be different. If the nine farmers use the highest intensity of forest management that is apparently feasible, it is estimated that average annual sales during the next decade will be about four times greater than those of a low intensity. Of course this larger volume of sales does not imply that net cash returns will be proportionately increased. In fact, some of the cuttings proposed under high intensity will barely pay wages for doing the work (under the assumed cost-price relationships); and a few operations will make no immediate return at all. But on the nine farms alternative employment is generally lacking or unattractive, and net farm incomes can be increased by using farm labor and equipment to make these cuttings.

Under high intensity forest management average annual sales will eventually reach a level that can be maintained about 150 percent higher than that of low intensity. These owners can gain in both the short-run and the long-run by adopting high intensity forest management; and their private interests then seem to coincide more nearly with the aims of public policy.

This being so, what conditions will make high intensity management an attractive alternative for the owners of these nine farms? These conditions may indicate promising areas where public and private action can help create circumstances that favor a higher level of forest production.

Markets and Public Services

All nine farms are located in areas where farming has retreated considerably. Farms A, B, and D are at one extreme, located in towns that are almost abandoned. Public services, especially roads, are poorly maintained; and marketing farm products under these circumstances may be difficult. But usually most forest products can be sold easily.

Farm C is at the other extreme near a small central New England industrial town where agriculture has been abandoned in the immediate locality. Here agricultural product markets are more favorable and public services are adequate. However, only softwood sawlogs, the best grades of hardwood sawlogs, and a small amount of cordwood can be sold.

The other farms are in localities with characteristics somewhere between these two limits; but most of them have better forest product markets than Farm C.

Forest Markets Needed The situations on all nine farms indicate that without markets for all forest products, especially for such items as fuel and pulpwood, the operators cannot seriously consider using a high intensity of forest management. They must be able to sell most of the small products of improvement cuttings and thinnings. Otherwise, these operators may have to use a medium or low intensity of forest management. The owner of Farm C, for instance, can only afford to use a high intensity of management on a part of his stands because of a limited market for fuelwood. When he can sell more fuelwood or pulpwood it may be advantageous to use more intensive forest management.

Price Relationships

A discussion of markets has little meaning without also considering unit-costs and prices (26). The budgets in this study are based on an assumed cost level of production factors equal to the 1943–45 average, and on comparable forest product prices. These prices are assumed to remain substantially unchanged throughout the planning period.

In addition, a second set of figures was prepared, assuming that roadside sawlog prices would increase by one-third after 30 years and by an additional one-third after 60 years. Other costs and prices were assumed to remain unchanged except for increased stumpage prices. Some upward trend of this kind is not unlikely as our stocks of virgin timber are depleted and our expanding economy continues to demand high-quality wood products.

The farm analyses show that in the long-run forest returns will be greatly increased if the relative value of sawlogs goes up in this manner. High and medium management intensities that produce more sawlogs than low intensity will be especially favored. These farmers could benefit far more from increasing their forest management intensity if sawlog prices increased in this way than they could if price relationships remained constant.

But it must be remembered that this expectation of future gains will not solve the immediate problem of increasing farm income during the next decade. In fact, if sawlog prices should start up now, these owners could make short-run gains by liquidating their older growing stock. The attractiveness of this alternative would also be increased if the owners anticipated a later decline in the relative price of timber. However, most of them expected present prices to be maintained or increased over the years. The important role that price expectations can play in determining the attractiveness of forest management alternatives is illustrated by the farm analyses.

Of course, if all the forest owners in the region should start using high-intensity management, the present fuel and pulpwood markets would probably be flooded by the products of thinning and improvement cuttings. However, due to the rather specialized conditions needed to make this kind of management attractive to forest owners, the chances of such an over-supply materializing are rather remote.

Farm Labor

The amount of labor that can be hired in the fringe areas may also limit the size of the farm business. In general, part-time workers are available, especially during the winter. But most of these farmers thought that they would be able to get more satisfactory help if they could offer year-round work. This whole problem may be less acute in northern New England than it is farther south where factory jobs are more plentiful. Also, most of the northern farmers exchange a good deal of work with their neighbors.

Table 29 summarizes the hired labor requirements on the nine farms under both the present and proposed plans. Only Farm G is presently using a full-time hired hand, but he is partly disabled. Farm H can be run with family and exchange labor under either the present or the proposed plan, while Farms E, F, G, and I will need at least a year-round man. Farms A, B, C, and D, however, will still need only part-time help.

Analyses showed that labor-saving equipment, and the more efficient organization of woods and farm work that these machines make possible, will be advantageous on most of the farms, especially if a high intensity of forest management is undertaken.

TABLE 29

LABOR HIRED EACH YEAR TO CARRY OUT PRESENT AND PROPOSED FARM PLANS

Farm	*Labor Hired Each Year under Present Plan*	*Labor Hired Each Year under Proposed Plan*[1]
	Man-months of Labor	
A	6	7
B	2.5	8.5
C	0	6
D	1	4
E	3	18
F	1.5	12
G	12	14
H	0	0
I	6	21

[1] During the next decade. Later increases in forest production will require more hired labor.

Property Taxes

Although property taxes have seldom been very burdensome on these farms, the forest yield tax law in New Hampshire has certain advantages. Payment of a yield tax, especially when it is coupled with an abatement for "improved forest practice," rather than a tax based on periodic assessment of the growing stock, will generally help owners to adopt more intensive forest management. How this new law will affect farm income on some of these farms was analyzed in detail in "A Preliminary Appraisal of New Hampshire's Forest-Yield Tax" (9).

But even if markets, prices, labor, transportation, and taxes are favorable, the development of fringe-area farms depends on the resources of the operating unit and the ability and aims of the operator.

Farm Resources and Their Use

For simplicity, the nine farms may be divided into two main groups with similar resources, incomes, and opportunities for development. A third group of two farms with unusual characteristics is also set off in Table 30.

TABLE 30

LAND AREA, NET FARM INCOMES AND GROSS RECEIPTS, BOTH PRESENT AND PROPOSED, ON THE NINE FRINGE AREA FARMS [1]

Farm	*Land Area* Open	*Land Area* Forest	*Net Farm Income from:* Present Plan	*Net Farm Income from:* Proposed Plan [2]	*Percent of Gross Receipts from Woodland under:* Present Plan	*Percent of Gross Receipts from Woodland under:* Proposed Plan [2]	*Proposed Plan Will Add to Gross Receipts from:* Agri.	*Proposed Plan Will Add to Gross Receipts from:* Forest
	Acres		Dollars		Percent		Dollars	
Small Farms with Large Woodlots:								
A	39	869	872 [3]	1,317	32	44	751	1,161
B	59	706	246 [4]	1,389 [4]	29	40	1,945	1,611
C	35	603	460	1,705	0	18	2,168	1,128
D	72	978	343	1,831	8	37	1,013	1,863
Larger Farms with Smaller Woodlots:								
E	106	290	1,647	3,153	11	29	2,430	2,020
F	90	116	1,150	2,205	4	37	778	2,606
G	111	276	1,557	2,216	24	43	0	1,098
Miscellaneous Farms:								
H	37	388	122 [5]	1,371 [5]	10 [5]	32 [5]	1,449	1,236
I	298	880	4,008	5,714	3	26	−669	3,528

[1] Income and expenses based on long-term planning prices about equal to 1943–45 average.
[2] During the next decade.
[3] Forty percent of gross receipts come from off-farm work.
[4] $600 a year from G. I. training not included.
[5] Figures do not include tourist enterprise income.

FARMS WITH SMALL AGRICULTURAL ENTERPRISES AND 600 TO 1000 FOREST ACRES

The first four farms fall in this group; development of the agricultural enterprises is limited by a lack of suitable land, livestock, buildings, and capital or credit. Estimated net farm incomes for the present plans on these operating units range from about $250 to $900, using long-term planning prices. The woodlands presently contribute only a small part of the gross receipts; only on Farm A does as much as one-third come from woodland sales. This group also includes the farms in the most remote and nearly abandoned towns.

Agricultural Adjustments Table 31 indicates that the milking herds on these farms and Farm H can be considerably expanded, together with total milk production. The increase in milk production can be achieved not only by keeping more cows and feeding them more grain, but also by growing and feeding more high quality roughage. A substantial part of these assumed gains will be due to more frequent reseeding with desirable legumes and grasses, heavier fertilization, and more timely harvesting.

TABLE 31

LIVESTOCK NUMBERS AND MILK PRODUCTION UNDER PRESENT AND PROPOSED FARM PLANS[1]

Farm	*Number of Milking Cows*		*Total Farm Milk Production*	
	Present Plan	*Proposed Plan*	*Present Plan*	*Proposed Plan*
			Hundredweight	
A	5	11	225	660
B	1	10	40	600
C	12	19	624	1,060
D	6	12	300	740
H	8	12	400	732

[1] The proposed plan used here for Farm A is Plan II; all others are Plan I.

The analyses of these operating units indicate that net farm incomes can be increased to between $1300 and $1800 ($1200 to $2100 at 1953 prices) during the next decade by using better farm practices, expanding agricultural enterprises as much as seems practicable without a prohibitively large cash investment, and stepping up forest production by more intensive management. About one-fifth to one-half of the gross receipts will come from woodland sales during this period, and an even larger proportion later when the growing stock has been built up.

Integrated Adjustments A net increase in farm woodland income in the near future will depend largely on using farm labor and equipment that would not be otherwise profitably employed. Even if only a small amount of stumpage value is realized, the owners will benefit from the wages earned and also from the long-run increase in productivity. It is primarily this possibility of integrating the agricultural and forest enterprises, and the lack of more profitable alternative work, that makes a high intensity of forest management desirable at the present time on these farms.

Owners' Objectives The operator of Farm C, on the other hand, has only a short-run interest in his farm. He wants to sell out eventually and buy a larger dairy farm. His objectives are unlikely to be met by a medium intensity of forest management that postpones cutting to obtain a long-run increase in productivity and value.

All of these farmers will have a greater flexibility of choice for adjusting their businesses to future conditions if they use the higher intensities of management, rather than liquidate their growing stock as rapidly as possible. But none of them has enough current income or resources to afford any large investment in forestry.

The owner of Farm H, it may be noted in passing, also has a relatively small agricultural enterprise and only about 400 acres of forest land. This operating unit illustrates the possibilities of developing a recreational enterprise in combination with farm and forest production in a fringe area.

Farms with Larger Agricultural Enterprises and 100 to 300 Forested Acres

The three farms in this second group are characteristic of many others in the fringe area. They have about 100 acres of open land and 100 to 300 acres of forest land. Their livestock enterprises are fairly well developed, and the owners are making moderate net farm incomes which range from $1100 to $1600 ($1500 to $2000 at 1953 prices).

These three men want to continue running their farms, to improve their incomes, and also to get away from the confining life of a one-man dairy farm. Better farm practices and an expansion of the agricultural enterprises promise more returns, but land or capital is too limited to build up a two-man business on this basis alone. Intensive forest management on the woodlands of Farms E, F, and G, however, will round out a larger business.

Table 32 indicates that little if any expansion of the livestock enter-

TABLE 32

Livestock Numbers and Milk Production under Present and Proposed Farm Plans[1]

Farm	Number of Mature Cows		Total Farm Milk Production	
	Present Plan	Proposed Plan	Present Plan	Proposed Plan
			Hundredweight	
E	20	20	854	1560
F	15	18	900	1080
G	19	19 (Beef Cows)	0	0
I	40	40	3200	3200

[1] All proposed plans are those discussed as Plan I.

prises has been proposed on these farms. Increased milk production is achieved largely by better dairy practices and by feeding more and better roughage. On Farm I this should lead to an actual reduction in the amount of grain fed.

Incomes can be increased to between $2200 and $3100 ($2200 to $3500 at 1953 prices) with 29 to 43 percent of the gross receipts coming from woodland sales in the next decade. Later the forest enterprises will contribute between 30 and 50 percent of gross receipts.

Integrated Adjustments Farm G illustrates the necessity for making integrated adjustments in agricultural and forest production if farm income is to be maintained or increased. Creating a more efficient beef enterprise by eliminating the rented land will allow more labor to be used in forest operations. Gross agricultural income will not increase, but more intensive forest production will raise gross receipts by about $1000, and net farm income will go up by about $650 a year in the next decade.

The owner of Farm F will have to buy more woodland if he wishes to maintain his income at the proposed level. Although his present 116-acre woodlot contains a large amount of older timber, it is not a large enough base for the kind of forest enterprise he needs to round out a two-man dairy-woodland farm. Under similar circumstances this adjustment might be profitable on many other farms that lack land resources.

Farm I illustrates the opportunities that exist in the fringe area for creating a larger operating unit. The chief problem is to get enough labor to work the farm and carry out a program of high forest management intensity. If this obstacle can be overcome, about a fourth of the farm's gross receipts can come from woodland sales in the next decade and a much larger proportion later.

In summary, these general situations were found on fringe-area farms: First, the men with very small livestock enterprises and large woodlots have the smallest income possibilities in the next few decades until their forest enterprises can be built up. They will need considerable ingenuity and some help to get through this period. Second, the one-man farms with larger herds and more open land are in a more comfortable situation. Higher intensities of forest management may offer an opportunity to round out a larger two-man business with more income. Third, if a large dairy is combined with a large woodlot, a scarcity of labor may make a medium intensity of forest management more desirable than a high intensity.

The Human Element and Ownership Objectives

In the final analysis the successful application of any of the proposed plans will depend on the farm operator's ability and ambition. In this connection it may be significant that eight of these nine men are young or early middle-aged. And what the one older man may lack in vigor is made up, perhaps, by his determination to show that a combination of beef and woodland enterprises can successfully rehabilitate fringe area farms.

All of these owners are high school-educated, two of them have had university training, and one other has had a good deal of vocational training and business experience. They generally do not feel that they have been trapped in a declining area and must make the best of a bad situation. They seem, rather, to have a realistic but generally sanguine view of their opportunities. Their many problems appear as a challenge to their skill and ability as land-owners and operators.

Land Ownership Values The probable net farm incomes budgeted for those farms with limited opportunity for agricultural expansion are comparatively low. If 1953 price relationships had been used instead of 1943–45 prices, most of the incomes would seem more attractive. In comparing these figures with urban incomes a fairly liberal allowance must be made for the non-cash values of family living derived from the farm. The present level of living of each of these families includes adequate housing and a car, for instance.

In addition to the production values of the farm, these operators apparently realize a good deal of subjective value from owning their land and following their own way of life. These benefits might be called the consumption values of their operating units to distinguish them from the production values outlined above.

In addition to the consumption and production values of land, the owner of Farm C took account of possible speculative gains. At least one reason for buying his 275-acre separate tract was the belief that a highway might be put through it and that this would increase his land value.

These owners also attached considerable weight to the fact that over the years they were not only earning a living from their farms but were also building up the value of their estates. Improved forest management was often the most practical way of increasing their net worth.

Time Preference These nine owners appear to have a strong preference for immediate returns over future returns only up to a point where their net farm income is large enough to support their present standard of living. Once this point has been reached — and it seems to be reached at a relatively low level of net cash income — possible future returns become relatively more valuable than before. In other words, they seem consistently to discount future returns at a high rate until total current income increases to a minimum level; thereafter their rate of discounting future income drops sharply. This attitude might be taken into account in any credit or other assistance policies designed to help these owners.

Assistance Needed to Make Land-use and Management Adjustments

Agricultural Credit Needs Some of the nine farms will need a small amount of short-term production credit in order to adopt the proposed plans. Most of this credit will be needed to make land improvements or to step up fertilization. Some intermediate credit may also be needed for buildings, equipment, and the like. The first group of "run-down" farms in abandoned towns generally require more building, equipment, and livestock investment than the other farms (Table 33).

TABLE 33

ESTIMATED ADDED CASH INVESTMENT REQUIRED TO ADOPT THE PROPOSED FARM PLANS [1]

	Added Investment Required for:				*Total*
Farm	*Buildings*	*Equipment*	*Livestock*	*Land Improvements*	*Added Cash Investment*
		DOLLARS			
A	1000	1500	650	. . .	3150
B	2000	1550	1800	200	5550
C	. . .	300	1000	640	1940
D	500	1500	800	150	2950
E	. . .	1000	. . .	500	1500
F	. . .	2100 [2]	300	1600 [3]	4000
G	. . .	1000	. . .	600	1600
H	. . .	1660	500	. . .	2160
I	. . .	300	. . .	. . .	300

[1] Investment estimated at prices prevailing when the plans were made; only cash outlays are included.

[2] Includes $1200 for sugar bush equipment.

[3] Includes $1500 for buying 150 acres of woodland.

The added investment in livestock can of course be made gradually as more replacement youngstock are raised. The amount of credit actually required will depend upon the rate at which the plan is put into effect and on the amount of current income which the operator is willing to put back into the business. Most of the probable credit needs can be met by existing credit agencies.

Forest Credit Needs However, even under the proposed plans, all of these farms will have lower incomes for the next one to four decades than they will have after forest productivity is built up. And the investment of labor and growing stock necessary to achieve greater forest returns later could be much more attractive if long-term forest credit were available at relatively low rates. Then a forest owner could enjoy during his lifetime some of the benefits of increased productivity that would ordinarily accrue later. These loans might not have to be large in view of the present owners' time preferences. Both private and public effort might usefully be put into developing adequate long-term forest credit.

Subsidy Program Some of the need for immediate assistance might be met by a program of subsidies to help meet the added costs of higher forest management intensities that lead to greater productivity. The New Hampshire yield tax law, with a 30 percent abatement of the tax for owners who follow cutting practices similar to those of "medium intensity," recognizes this need for some public assistance. A direct subsidy to cover part of the costs of specific forest practices, such as the payments made in some states by the Agricultural Conservation Program, should also stimulate farmers to use more intensive forest management.

Other Aids Owners frequently need help to plan their farm business, and many of them also need technical assistance to carry out any chosen plan. The county agents, county foresters, and Soil Conservation Service already provide much of this service. But some additional public aid is needed to help owners learn how to make analyses similar to those we have discussed. A concerted effort is needed to bring together all the results of farm and forest research so that landowners can solve their operating unit problems.

Work is also needed to promote more efficient and stable forest product markets, especially for the lower grades of wood. Certainly better marketing information is needed, and the possibilities of cooperative marketing and long-term sale contracts with buyers should be explored. An effort is needed especially to minimize present uncertainty about the capacity of existing markets to absorb future wood production without drastic fluctuations in prices.

Budgetary Analysis So far we have concentrated attention on the owner's problem of choosing a general policy to govern his forest operations. However, the reader should keep in mind that the same method of analysis is equally useful for appraising the possibilities of other more limited and detailed alternatives in forest production. Such questions as whether to cut a stand now or to wait until later, choosing the most advantageous way of harvesting a stand or of organizing a crew, and similiar short-term alternatives can be budgeted, provided enough data of the right kind are available. Black (13), Wheeler (111), and Gould (43).

Chapter IV

INPUT-OUTPUT RELATIONSHIPS FOR FOREST PRODUCTION

This chapter contains a general discussion of the kinds of data needed to analyze landowners' forest production problems as was done in the first two chapters. The presentation in this and the next two chapters is designed primarily for people doing forest and agricultural research; but it may be useful to practicing foresters and landowners. Therefore, the problems of securing needed input-output information are laid out with a minimum of specialized terms.

Let us begin by discussing some of the questions commonly raised when economists start talking in terms of "input" and "output." Because the subject cannot be completely covered here, the reader who wants more information should look up some of the references cited in the text.

Why Are Dollar Cost Figures Inadequate?

If the primary use of input-output or planning data is to estimate costs and returns, why not concentrate on finding this information directly in monetary terms? Why not study forest operating units and see how many dollars were spent to produce a cord of wood or thousand board feet of sawlogs, how many dollars were returned by selling these products, and then generalize from this information?

Usually owners want foresters to describe the costs of any forestry proposals in money terms. Numerous studies have been made to find the "average unit-costs and returns" or the "costs of production" of forest operations or management programs in monetary terms (50), (96), (117). At first glance this approach seems to be a direct and simple way of finding needed information in a form ready to be used; why it is inadequate is certainly a fair question.

Cost Components Why a seemingly indirect approach is needed to find cost and return data applicable to any forest operating unit may be partially explained by considering the nature of these figures. Cash cost is determined by the quantity of inputs multiplied by the value paid (unit-cost) for each item; and cash returns equal the quantity of output times the price received for each item. The unit-cost paid and the prices received by any owner are likely to vary considerably over a period of time. Unit-costs and prices are also likely to vary from place to place and may sometimes be uniquely determined for each owner by such things as accessibility and bargaining skill. Thus the values experienced on one property may not be universally reliable guides to future values elsewhere.

Separate Data Needed Therefore, if dollar values and quantity data on inputs and outputs are kept separately in any study, it will be possible to make more realistic estimates of future costs and returns. Unit-costs and prices can be used that seem best suited to the problem at hand, together with the quantity of inputs and outputs likely to be realized considering probable efficiency, the "state of the arts" and known biological limitations. Projections of this kind may be impossible on the basis of simple dollar figures.

Cost Concepts There are other limitations to using dollar cost figures. The whole concept of cost needs careful scrutiny because at best it is an ambiguous term. Merely to list some of the different cost concepts used will illustrate how loose a term it is: total cost, average cost, fixed cost, variable cost, necessary cost, joint cost, opportunity cost, and historical cost, all have their particular meaning — and this list does not exhaust the variations.

A forest owner can use cost data in appraising alternatives, but only if these data have a clearly defined concrete meaning. If cost of production figures are to be useful to an owner in making management decisions, he must be able to relate them to his particular operating unit, to a given period, and to a specific output. The following will illustrate why this is so.

Average Total Cost Consider for a moment the average total cost per mile of operating an automobile. Gasoline, oil, tires, and repairs may cost about 3 cents per mile. But is that the cost of operating a car? Hardly. There are still interest on the investment, depreciation, and rent for the garage to consider. If these items amount to $600 per year and the car is driven 10,000 miles a year, this will add 6 cents per mile, and the total average cost will be 9 cents per mile. But if, instead, 30,000 miles are driven during the year, the total average cost will be 5 cents per mile; while driving only 2,000 miles will make the total average cost 33 cents per mile. But does that mean it will cost $33.00 to drive 100-miles? No indeed; the additional expense will be little more than a $3 outlay for gasoline.

It is easy to see that the simple statement "It costs an average of 9 cents per mile for a 1950 Ford owner to operate his car" has little meaning to a car owner. First there must be a lot of explanation and clarification of that 9 cent figure. The same is true of the statement that "It costs a forest owner in Maine an average of $6 per cord to produce spruce pulpwood." And the complications behind using this average cost figure are even more serious than those behind the average cost per mile for operating a car.

Dividing total costs by total output to obtain a figure of average cost per unit of product does little to make the data more usable. And averaging the costs realized on several different forest properties merely obscures the data still farther, insofar as other owners who wish to use them as a guide are concerned.

What Are Input-Output Relationships?

In any process of production certain resources (inputs) are combined in a given way to result in certain useful products (outputs). All production can be regarded as resulting from various input-output combinations. Hence a knowledge of the relationship between input and output is basic to an analysis of economic activity (48).[1]

Production Recipes There is nothing mysterious about input-output data. Fannie Farmer's cookbook, for example, is merely an extremely useful collection of one type of input-output relationships. But there is a great deal more to being a good cook than knowing several specific recipes. The housewife needs to know what will happen to her product if she varies the proportions called for or makes some substitutions. What, for instance, will happen to her cake if she uses one egg instead of two, and uses lard instead of butter and increases the amount of flour or milk? Knowing answers to such questions, she can adjust her recipes to the materials she has on hand, to her pocketbook, and to her family's tastes.

The forest owner's job is not so very different, but it may be more complicated. Instead of just one product there are usually several. He may be producing pulpwood, sawlogs, veneer logs and cordwood all as part of the same operation. His inputs are the man-hours, machine-hours,

[1] Physical imput-output coefficients may be required for a single technical unit of production such as a homogeneous acre or machine or they may be required for a single firm or for a whole region or country. Relationships for technical units, however, are basic. Input-output relationships are usually found for single processes of production. Production processes are arbitrarily defined and where the line is drawn is a matter of convenience. In forestry the most relevant production process is the establishment, growing and harvesting of continuous forest crops, but for some problems it is convenient to consider a single rotation or cultural operation as a separate process of production (15).

hours of supervision, quantities of gasoline and the like used on the job; his outputs are the quantities of the various products.

In order to plan his activities and to make rational decisions he needs to have at least a rough idea ahead of time about the quantities of materials and labor he will require, and the quantities of products that probably will result.

But like the housewife and her cooking, he also should have some idea of how his output is likely to be affected if he changes the proportions of input used. What will be the effect on the quantity of product and the time necessary to produce it if he employs an additional laborer, substitutes horses for a tractor, buys a chain-saw or alters the way in which he selects trees to cut?

Perhaps if he buys one chain-saw, efficiency will increase enough for the saw to more than pay for itself, but then what will be the effect of buying two chain-saws? Perhaps he will also need another man to operate the second saw, or more men to help handle the timber. Knowing something about these quantitative relationships of inputs and outputs, he can adjust his operations toward greater efficiency.

Input-output combinations are seldom simple ones involving a single product and one or two inputs. Changing the quantity or manner of using one input may call for adjustments in the quantities and uses of several others, and changes in the scale of operations may alter everything. Certain inputs, however, will always tend to go together in very nearly fixed proportions, for example horses and teamsters, or axes and choppers. Others may be varied within rather wide limits around some starting organization such as the number of men in a felling crew or the number of men used on the whole job. For any given job the ways in which the operator can alter his inputs and outputs may be fairly limited. What he needs to know is what these possible adjustments are in terms of actual quantities of inputs and outputs.

Curvilinear Relationships Output will seldom respond proportionally to changes in the amount of an input. The "laws" of increasing and diminishing returns also apply to forest production. For example, adding another man to a one-man felling crew might increase daily output by 1500 board feet. A third man, however, might add only 900 board feet per day to the crew's production, while a fourth man added to the same crew might not increase output at all. In more technical terms: input-output relationships are often curvilinear; if straight-line relationships exist they will hold good only for a limited range of variation.

Another illustration is the familiar curve showing the increase in volume of an even-aged forest stand over its life cycle. This is an input-output relationship in which the number of years of growth serves as an index of a complex of inputs, and volume of timber is the output. Volume growth is not directly proportional to the age of the stand; instead it is slow in early years, picks up rapidly as the stand begins to have merchantable volume, and then gradually slacks off as the stand approaches old age.

Conditions Affecting Production Input-output relationships are valid only if the initial conditions affecting the production process in question are clearly stated, and then only if these conditions remain constant during the process of production. It is for this reason that relationships derived by averaging data from diverse operations are often completely useless to an individual owner wishing to apply the data to his unit. Averaging data on dissimilar operations or stands tends to obscure the effects of the initial conditions. This makes it hard for the owner to know how closely these conditions correspond to those of his own operation or stand, and consequently he cannot tell how applicable the data will be.

For instance, it is of little help to an owner to know that on the average it took ten man-hours per M.b.f. to harvest white pine logs if he does not know how closely his stand resembles the average, and whether his methods of operation will be comparable with those where the data were taken.

Applying any input-output relationships is bound to contain an element of error. The more completely estimates can be limited and defined the more valuable such data will be. It is not enough to express average or typical relationships, but the range and reliability of the data should also be indicated. Naturally, the longer the projections the more uncertain the estimates are likely to be.[1]

[1] Data on the relationships of inputs to outputs in specific situations for specific forest areas are basic to economic analysis of management plans for individual forest operating units. Frequently some supplementary input-output data of a slightly different type are needed for making analyses of aggregates including large numbers of operating units. In such aggregative studies it is useful to relate various stocks of productive materials, such as growing stock and capital equipment, to flows of inputs and flows of outputs. For example, to produce an annual flow of so many tons of pulp, the industry requires a stock of standing trees and operating and processing facilities; it also requires a flow of a number of man-hours of labor devoted to harvesting, silviculture, and processing operations, and a flow of a number of tons of fuel, thousands of saws, barrels of gas, etc. In other words, knowledge is needed of stock-flow ratios such as the average annual growth per M.b.f. of growing stock.

The relationships of stocks and the flows of inputs and outputs are most usefully expressed in terms of the physical quantities involved, although money values must sometimes be used. Data may have to be bundled together for many diverse operations and stands; however, if the information can be related to distinct conditions and economic activi-

What Forest Input-Output Data Are Important?

Forest input-output information can be divided conveniently into two parts. First, there is information about biological possibilities — the yield or output of forest stands over long periods of time in response to various kinds of management. Second, there is information about input-output relationships in performing the operations involved in the various management systems — the labor and materials required to do logging, pruning, road building and the like.

Forest Yields Finding adequate input-output data bearing on forest management-yield relationships (including growth and regeneration) is one of the most difficult and challenging problems in forest research. There are similar problems in agriculture. A simple example is that of finding corn production over time when different crop rotations or variable amounts of fertilizer and other inputs are used. But agricultural yield data involve projections for a few seasons at most, and good estimates usually can be obtained after a few years of research. Also we have many years of experience in managing field crops and livestock.

Forest management-yield data, on the other hand, often cover forest growth and regeneration for a period of many decades. It may take 100 years or more to establish a stand and bring it to saw timber size, while the cutting cycle in all-aged stands may be twenty years or more. Under these circumstances it is not surprising that there is no large fund of accumulated experience with growing trees.

But data are still needed to indicate not only what products can be harvested and the period when they can be cut, but also the nature and value of any stand throughout the planning period. We should be able to estimate the yields from diverse sites and stands handled under different types of silvicultural programs.

Variables Affecting Yields For many owners the principal problem is to find out how yields from any particular stand will be affected by different silvicultural programs not only in the present but also far into the future. Both the absolute quantity and quality of forest products produced and the relative levels of production under vari-

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ties, it will be much more realistic. These data are particularly necessary for understanding the dynamic processes of economic growth and contraction (67). Broad statistical information usually gives coverage representative of an industry or region, but it is deficient in detail. Information derived from specialized studies of operating units is seldom representative for the broader problem at hand, but it provides the necessary technical information to understand the detailed structure of the production process.

ous programs are important. Unfortunately, silviculture is not the only factor that determines forest yields. There are also many variables associated with forest site, growing stock, risks of damage from cataclysms and the like.

It is not necessary to know all the more technical biological aspects of forest production in order to analyze alternatives, provided the data relate forest yields to recognizable differences in the major variables so that this information can be applied to any given area. Only then can alternatives be analyzed for any ownership, watershed or state. To find the effect on yields of just site or just growing stock or just management, ignoring the other factors that affect growth and regeneration, is not enough.

Work Performance Data The problem of estimating relationships between accomplishments in various forest operations and labor and material inputs is in some respects less complex. It is analogous to the problem agriculturalists have in finding the labor and material inputs going into taking care of cows, or crops, or poultry.

It must be recognized that in forest production the amount of labor and material inputs needed for a given operation is changing over time with the development of new machinery and methods. The input-output relationships of these operations that take only a short time to complete, change much more rapidly than the biological relationships affecting long-run forest yields.

Utilization Standards Closely connected with these two types of information are data on utilization possibilities. Long-run yields should indicate the volume, shape, and size of trees through some objective measures so that changing utilization standards over the years will not leave the data obsolete. Cubic foot volumes and tree-grading rules have been developed as partial answers to this problem.

What Data Are Now Available?

A review of the literature shedding light on forest input-output relationships shows a wide variety of research. Forest yields over the years have been studied in many ways; yield tables and growth formulae have been developed to measure the production of forest areas, stands, and individual trees during a rotation. The work performance rates of different ways of carrying out forest operations such as planting, pruning, and thinning have also received a good deal of attention.

Research Data Incomplete Much of this research, however, has been spotty, and provides incomplete data of the kinds discussed. Data on the yield of fully-stocked stands under natural conditions have been accumulated, for example, but there is little companion information on the yield of understocked stands or of those handled under various systems of management. And although the short-run input-output relationships of some operations like pruning have been thoroughly investigated, relatively little work has been done to find similar data about other operations like harvesting hardwood logs.

Although some studies have been made primarily to assemble input-output data, more often these relationships have been neglected. If measured at all, they have been noted only as incidental to other primary objectives of the research project. Consequently, data are often incomplete and no consistent research methods or standard ways of presenting input-output information have been developed. The data collected in one study seldom can be compared with those of another.

Past research bearing on input-output relationships has also been deficient in other respects. It is not enough to know what relationships to look for; the investigator should also know how the data will be used. Hazy thinking on this score often has resulted in ineffective research design and in a confused presentation of findings. For example, data on a few widely divergent situations have frequently been averaged together in such a way that the figures represent neither a reliable average of the situation in the field, useful in macroeconomic work, nor inputs and outputs that can be applied to individual operating units.

Consequently it is now impossible to assemble a complete handbook of the input-output data that a forest owner can use for making management decisions. Only bits and snatches of information are available and much of this must be rearranged and re-analyzed to get it into a usable form.

Information Assembled In 1951 a project was set up to assemble forest input-output data applicable to New England from both published and unpublished sources. The records of private and public forest owners who had been managing their lands for several years were reviewed. It was hoped that records could be found of what actually had happened in different specific situations. Knowing what an owner's inputs of labor had been, what sort of management he had followed, his yields, and what his growing stock was at the beginning and end of any period, would provide a start toward a set of forest input-output data concerning that particular situation.

Practically every experimental forest in New England and New York was visited together with about 100 owners who had forest records. But not many appropriate data were found.

Records Unsatisfactory The records of private owners tended to be incomplete; there was always something missing, such as a description of the original growing stock. Owners frequently skipped record keeping for a period or changed their standards of measurement over the years. Or else the records were simply inscrutable; everything might be there but the records were not in a form that could be analyzed readily.

This was not too surprising on private ownerships, but the experimental forest records sometimes were even less applicable. One reason for this seems to be that the people at experimental forests have not been primarily interested in finding the kind of input-output data described here.

The difficulties of using dollar cost data have been discussed. This survey illustrated these problems very well. Owners and the operators of experimental forests sometimes kept dollar cost and return records on different operations but these data were little help in finding physical relationships and the variables affecting inputs and outputs. Most of the cost accounting used was rather laborious, and resulted in a figure of the dollars returned by the forestry enterprise. This figure had little meaning for other properties, and where overhead was arbitrarily allocated it frequently did not have much analytical value even to the owner who kept the accounts.

Economists apparently have a responsibility to set forth clearly the kind of data they need in order to make useful economic analyses of forest production. It seems that so far they have been unsuccessful in this endeavor, which may partly account for the fact that to date research has not been completely adequate.

Chapter V

NEW ENGLAND FOREST MANAGEMENT-YIELD DATA

A handbook of forest input-output data would be valuable to foresters, landowners, extension workers, and economists who work with the economic problems of forest production. Probably a separate compilation would be needed for each major forest region of the country. Bulletins containing input-output and other planning data for agriculture, such as "A Handbook of Standard Performance Rates for Haying Equipment Commonly Used in the Northeast" by Fellows (37), "Input-Output Relationships in Milk Production" by Jensen (58) and "Farm Management Reference Manual" by Frick and Burkett (40) illustrate how these data might be presented.

This chapter and the next outline some of the quantitative input-output relationships that would make up any handbook of planning data on forest production. Wherever feasible, this is illustrated with findings taken from the survey of forest input-output information in the New England area. Forest yields will be discussed first.

Forest Yields Forest management-yield data should make it possible to estimate the timing, volume, and quality of successive forest crops from any forest area, property or region. Ordinarily, the relevant production period is a full rotation — a working division that includes the time necessary to establish, grow and harvest a crop of trees. The term rotation is least ambiguous when it is applied to even-aged stands, but the concept of a rotation period is still useful when one is finding input-output relationships for all-aged forests.

It is necessary to keep in mind the use that will be made of forest management-yield data, namely, to show a forest landowner the costs and returns he will probably realize if he handles all or a part of his property according to any of the known forest management techniques. He needs to have these estimates projected not only into the near future but also to know their probable variation over a long period of time. Because the full value of many forest practices may not accrue for several decades, comparisons of yields that include these postponed effects may have to cover a rotation or more.

Thus the nine farm owners we have discussed, needed to know what returns they could expect from their forest enterprises during the next decade or so in order to see their immediate income prospects under different kinds of management. They also needed to see what sort of returns could be expected in the long-run in order to gauge the eventual development of their operating units. And finally they needed to trace the probable course of returns during the intervening years when their forest enterprises were being developed.

Forest yield data will furnish the quantitative estimates on which to base projections of this kind. In view of the changing standards of utilization, volume yield should be measured in some fixed unit such as cubic feet of wood. Volume figures alone, however, are not enough. Ideally they should be supplemented by a description of the size, form, species and other attributes that will determine merchantability for different uses. These data are needed before wood volume can be evaluated in terms of the products into which it can be converted.

Management-yield data should make it possible to estimate the volume and quality characteristics of the trees a forest area will contain at any time during the planning period as the result of a given management program. Output is measured by the volume and quality figures, while knowing what operations are called for by the specified management program makes it possible to estimate the inputs associated with these outputs.

Yield Projection Methods Over the years a large number of methods have been developed for projecting future forest yields. These may be put into two general classes. First, there are systems suitable only for estimating the probable future production of large areas of forest land in a particular region. Second, there are systems for projecting the yields of smaller specific forested areas such as a forest stand. Some of the methods in this group are suited to projecting yields for only a few years, while others furnish a basis for estimates over a full rotation period. Ordinarily, some combination of methods will have to be used to make the economic analyses discussed in this bulletin.

Yield Estimates Based on Large General Forest Areas

Rules of Thumb Rules of thumb usually show yield levels that can be realized over a period of years and are characterized by simplicity, generality, and ease of application. They may be derived from accumulated experience and folklore or from scientific research findings. In any event, they are most useful in the hands of an experienced practitioner; simple rules are never adequate substitutes for judgment and experience.

The most common rules of thumb are used only for estimating probable yields from large forest properties or regions. These rules are of almost no value for estimating yields from a specific forest stand; but over a large enough area there is usually a combination of high- and low-producing sites and stands that allows yields to be estimated by use of an average relationship or a range of relationships. Some rules of thumb can also be applied to generalized forest cover types, but even these ordinarily will give satisfactory estimates only when a large acreage of the cover type is involved.

General Area Rules In New England there seems to be fairly general agreement among foresters that a large forested area will produce an average of about ¼ to ½ a cord of usable wood per acre per year. Another rule estimates annual saw timber production as equivalent to about 50 to 100 board feet per acre per year. Still a third rule for pulpwood production postulates that the combined spruce and fir growth on an average Maine township is equal to about 0.15 of a cord per acre per year.

These estimates indicate the level of production that can be averaged over a period of years from a large area and give no indication of how cutting may be distributed over time. Only if a property has a "normal distribution of age classes" — an equal area of young, middle-aged and old trees — is it assumed that the estimated yield can be cut regularly over the years; and even then there are other criteria that must be met.

Adjustment for Management All of the above "rules" assume the low intensity of management commonly practiced in the New England area. And since these rules are derived from past experience they also assume past utilization practices. A supplement to the ¼ to ½ cord and the 50 to 100 board feet per acre per year rules is that these yields can be about doubled over a long period by using "good" forest practices. These practices would include silvicultural treatments when desirable, such as improvement cuttings, weedings, and thinnings; and they imply harvest cuttings designed to stimulate growth and encourage desirable reproduction.

Confirmation of Rules There are some data confirming the general applicability of these rules for large tracts over long periods. Since the rules are largely derived from the experience of landowners who have bothered to keep records, it is not surprising that some large companies have generally realized yields of ⅒ to ¼ cord of pulpwood per acre per year from their extensive holdings. Of course their reports are generally based on softwood utilization only. Many lumber-men cite the 50 to 100 board feet per acre per year rule, and the experience of farm and consulting foresters definitely points to average total yields equal to ¼ to ½ a cord per acre per year.

The forest survey of New Hampshire and Vermont (100) (101) found an average net growth of about ½ a cord per acre per year, but there are many reasons why the survey figures for net growth may have been higher than yields actually realized in the past. First the survey standards of merchantability were more lenient than those that had prevailed in the past. Also, net growth was based on the most recent five-year period and did not give a picture for a full rotation; over a longer time the average age distribution and mortality from catastrophic losses can reasonably be expected to be considerably different from those taken account of in the survey.

Case Histories In the search for New England input-output data several case histories of forest properties were found that tend to confirm these "rules" and their supplement. The forest management programs used on each property were classified as high, medium or low intensity according to the criteria already discussed. The productivity realized was estimated from the recorded yield and the original and present growing stock volumes. Any difference between the starting and ending inventory of growing stock was accounted for in estimating the average annual yield. Historic utilization standards must be kept in mind when interpreting these data. Some of these cases are described below:

One 50-acre pine lot on a good old-field site in Vermont had yielded 650 board feet per acre per year during 75 years of intensive management. These yields are considerably better than would have been estimated by blind application of the rule; but fully stocked old-field pine stands on good sites have sometimes shown yields as much as 1000 board feet per acre per year even without management, and may be regarded as something of an exception. This case also illustrates the danger of trying to apply the "rule" to a single stand instead of to a large property containing several stands.

A 1200-acre mixed hardwood property in Connecticut yielded an average of 0.6 cords plus 30 board feet per acre per year during 30 years of intensive management. Another 4000 acres of pine and hardwood types (including some pine plantations) in Connecticut showed yields of 1/3 cord plus 95 board feet per acre per year during about 30 years of intensive management.

A 2000-acre old-field pine and hardwood area (now mostly hardwood) in Massachusetts yielded about 120 board feet plus 1/3 cord per acre per year after being intensively managed for about 45 years. A 35-acre pine-hardwood farm woodlot on a wet site in central Massachusetts showed yields under medium intensity management of 100 board feet plus 1/3 cord per acre per year over 30 years.

A 600-acre holding of mixed hardwood and old-field pine in central New Hampshire showed an average yield of about 100 board feet plus 1/5 of a cord per acre per year during 50 years of medium management intensity. A 200-acre pine stand contained in this same holding, on an outwash Merrimack soil and under slightly more intensive management, yielded 130 board feet per acre per year.

A 95-acre farm woodlot of spruce-fir, hemlock, pine and hardwood types in northern New Hampshire under medium to intensive management for 40 years yielded an average of 1/2 cord plus 100 board feet acre per year.

Table 34 summarizes these crude yield relationships. The classification of management intensity is open to question and may be too high when the management used over the entire property is considered. There is

TABLE 34

YIELDS PER ACRE REALIZED ON SEVERAL FOREST TRACTS IN NEW ENGLAND UNDER DIFFERENT MANAGEMENT INTENSITIES[1]

Management Intensity[2]	*General Forest Cover*	*Acres*	*Number of Years Covered by Records*	*Ownership*	*Average Yields per Acre per Year*[3]
Above medium	Pine	50	75	Farm	650 bd.ft. +0.0 cds.
	Hardwood	1200	30	Estate	30 " " +0.6 "
	Pine–Hardwood	4000	30	Water Co.	95 " " +0.33 "
	Pine–Hardwood	2000	45	Institution	120 " " +0.33 "
	Spruce–Fir–Hardwood	95	40	Farm	100 " " +0.5 "
Medium	Pine	35	30	Farm	100 " " +0.33 "
	Pine–Hardwood	600	50	Farm	100 " " +0.2 "
	Pine	200	50	Farm	130 " " +0.0 "
	Hardwood–Spruce–Fir	100	50	Farm	100 " " +0.75 "
Low	Hardwood–Spruce–Fir	100	50	Estate	50 " " +0.25 "
	Pine	75	60	Farm	150 " " +0.0 "
	Pine–Hardwood	300	45	Lumber Co.	50 " " +0.3 "
	Hardwood	150	50	Estate	20 " " +0.4 "

[1] Data collected from forest records and interviews with forest owners.

[2] Management intensities are those used in the farm analyses. Actually none of the cases represented "high" intensity management over the whole property.

[3] Yields include adjustments for estimated increases or decreases in the volume of growing stock.

no stratification by stands or sites, but nonetheless, the range of yields does tend to show the validity and limitations of the rules of thumb.

The variation in the yields of the cases summarized in Table 34 illustrates the limited utility of accumulating great masses of forest yield data from large heterogeneous forested tracts. Unless each case is carefully documented describing the site, initial growing stock, management and other variables, these data have little value for use in projecting yields for other tracts. If the cases were carefully described and recorded, however, they could be used to indicate possible yields from other properties that resemble them closely.

Comparing Yields Two properties found in central New Hampshire illustrate still another use for general case history yield data. Yields were available for two similar tracts that had had identical histories in almost every respect except for the intensity of management; the differences in yield may therefore be ascribed largely to the management factor. And if enough such cases were available, valid generalization might be made about the effect of management on yields in various situations.

A 100-acre farm woodlot of mixed hard and softwood types growing partly on an intervale of the White Mountains and partly on a lower mountain slope yielded nearly 100 board feet plus ¾ of a cord per acre per year over 50 years of medium management intensity. An adjacent 100-acre lot, that had a practically identical history until 1900, has since yielded 50 board feet plus ¼ cord per acre per year under low intensity management. Site, markets, and original growing stock were roughly similar on the two properties. This is an illustration of the "rule" that yield can be approximately doubled through management.

But, of course, even rules of thumb based on a carefully documented series of cases that show yield levels eventually attained under different kinds of management programs, still leave unsolved the problem of estimating probable yields from any property both in the near future and then later while the forest stands are being built up.

Forest Cover Type Rules Another type of rule of thumb has gained some currency in New England. These rules are designed for use on large areas of rather loosely-defined forest cover types; and like the rules we have discussed, they indicate average annual yields per acre attainable over a long period of time. One rule states that the combined spruce and fir growth suitable for pulpwood equals about ⅕ of a cord per year per acre on "softwood land" and ⅙ of a cord on "mixed growth land." "Softwood land" is that covered by practically pure spruce and fir stands, while "mixed growth land" supports hardwoods, spruce and fir.

Another form of these rules states that spruce increases its volume at a rate of about 2 percent and fir at about 3 percent per year in pure stands; pine grows at 5 percent, poplar at 5 percent, and hemlock at 2 percent. The percent form of a rule may be most useful for projecting growth during the next decade or so and relating the level of growth to a volume of growing stock. But for making rough long-range estimates the volume increase per acre per year rule seems superior.

Other Case Histories Other records and case histories show yields for smaller areas and plots during short periods of five or ten years. Many of these data are published; for examples, see reports by Adams and Chapman (2), Hough (55), Jensen (61), Recknagel and Abel (1), Recknagel and Westveld (90), and Ray (89). Other cases exist in the unpublished records of research forests. Some of these fragmentary data would, if extrapolated for a large area for a full rotation, show much higher yields than are indicated by the various rules of thumb or by the cases cited above because the small plots selected for remeasurement were not representative of average sites and densities over large areas or because remeasurements were made during the most productive periods of the stand's life.

Case histories recording yields for softwood plantations are numerous, but ordinarily these include only the first 20 or 30 years of the plantation's life. Baldwin reports on some plantation records kept for a longer period (7), and there are published reports on plantation yields in other sections of the country (103). The records seem to indicate that the average production of these plantations, even without much management, has been in the neighborhood of 1 cord per acre per year. This figure must be tempered by the fact that few records are available for the plantations that failed or did poorly on inferior sites.

No complete records were found showing yields from hardwood plantations. However, one case history covering a long period is reported by Holst (52). In 1820, Zachariah Allen, one of the earliest American forestry enthusiasts, planted about 40 acres of chestnut in Rhode Island. By 1877 he had cut and sold about 21 cords per acre from this area and another 8 cords per acre remained standing. This amounts to an average yield of about ½ a cord per acre per year over a 57-year period.

Refining Yield Estimates Plans like those for the nine farms comparing forest management alternatives frequently require more detailed yield estimates than are possible using rules of thumb. This need is generally met by dividing a forest area into segments that seem likely to have similar, more or less homogeneous production schedules, at least during the present rotation. The yields over time from these separate sectors can then be totaled to get an estimate of yield from the whole property. This separation procedure is similar to that used in rules of thumb based on forest cover types; but more refined methods generally make allowances for additional variables such as site and growing stock.

Yield Estimates Based on Small Specific Forest Areas

Even the best yield estimates are not highly dependable for long-range projections but the degree of uncertainty may be lessened in various ways. Estimates of production from specific forest stands for only a few years into the future offer the fewest difficulties. These short-term forecasts are useful for making many kinds of management decisions, such as whether to harvest a stand now or to wait a few years. They may not be much help, however, in choosing between alternative forest management intensities.

Short-Term Forecasts Many methods have been developed for making short-term yield forecasts or estimates, and most mensuration textbooks discuss these systems in detail; Spurr (95), Meyer (75), and Chapman (25). More complete treatments of the subject will be found in bulletins by Buell (18), Meyer (73) and Wahlenberg (107). It will be sufficient here merely to point out some of the advantages and disadvantages of these methods for use in economic analyses.

All of the systems are designed to be applied to specific stands. They are "direct projection" systems in the sense that the past growth of a forest stand during some period of time is used as a guide to the growth of that particular stand during a similar period in the future. Growth in the recent past may be gauged by stem analyses, remeasurement of plots, or continuous inventories of larger areas. Stand table projection, percent growth calculations, and various other methods may be used to convert these data into forecasts.

The major disadvantages of these systems are, first, the limited future period to which past growth may serve as a guide; and second, the assumption that future growth conditions will be the same as those of the past. This assumption of static conditions makes it impossible to estimate changes in growth due to such things as different management practices, for instance. A third disadvantage seems to be that all of these systems require considerable field and office work — they are not easy to use.

Perhaps the outstanding advantage of these short-term projection systems lies in the fact that such variables as site need not be measured or defined. The forest stand itself is used as a gauge to weigh and interpret all of the factors that have affected growth, so they need not be explicitly recognized. This is a great advantage, considering the present state of knowledge about forest growth, but these estimates are still limited to the near future under static conditions and do not provide all of the data that are needed about more distant yields.

Long-Term Forecasts Forecasting long-term yields is more hazardous than projecting growth for only a few years into the future. But such estimates are necessary before choosing between forest management programs of various intensities. Most of the methods that have developed for making long-term yield projections are "indirect methods" in that the yields experienced on some specific stand are used to project the growth of another stand. It is assumed that if two stands are similar in various measurable ways, they will follow the same schedule of production, at least over one rotation. But this assumption makes it necessary to recognize and measure the essential features affecting growth. At least the principal variables must be identified before much progress can be made toward refining long-term yield forecasts.

As yet there is little agreement concerning which of the many factors that apparently influence yields should be considered as most important, and what the relative effect is of each. Management intensity, site, growing stock, and risk have been mentioned as general categories of variables that should be considered. Before proceeding with illustrations of long-run forest yield data these should be discussed in a little more detail.

Management Programs The kind of management program used is one variable that a forest owner can choose. We have defined three management intensities each of which represents a broad "level of inputs." This seems to be a fine enough breakdown of the management variable for analyzing many economic problems, at least for the time being. However, it is difficult to define even three management intensities objectively in terms of a specific series of silvicultural treatments because the same management intensity often will call for divergent treatments depending on site, product objectives, stand condition and the like.[1]

Nevertheless, if we keep in mind the general concept of management intensity as being the relative quantities of variable inputs (labor, capital, etc.) applied over time to a fixed unit of input (an acre of forest land), then a reasonably acceptable classification by intensities of management is possible.

[1] One input to consider is "management" in the entrepreneurial sense. The problem of defining management intensity is further complicated because there is little agreement about how to obtain the maximum level of long-run output from a given level of inputs. Forest management is still in the trial and error stage of determining how effective various long-term management programs may be.

Forest Site What site factors are and how they affect forest productivity is not completely certain, but soil, slope, and aspect are generally presumed to be important (49). The thinking among many people working on the problem in New England seems to be that soil moisture regimes are usually a most critical factor. Studies by Stout (97) and others support this hypothesis. For estimating long-run yields as a basis for economic decisions, three or four gradations of site based on species suitability and on growth potential are probably sufficient.

Growing Stock The condition of the growing stock or stand, including species composition, age, volume, quality, density, and stand structure, greatly affects the course of future development and yields. We do not know how necessary it may be to consider each one of these variables separately since they certainly are not independent of each other, or for that matter, of site and management. Probably each of them should at least tentatively be regarded as a necessary datum when estimating yields for long periods.

Risks and Uncertainties Quite apart from the risks and uncertainties of an economic nature, such as markets and prices, there are the physical and biological risks that the stand may be wholly or partially destroyed by wind, fire, insects or disease.

Fire risks have been studied by Shepard (92), and although they change over time, they probably can be dealt with objectively through actuarial procedures when estimating long-range yields. We know less about the importance of the other kinds of risks or of their relationship to various intensities of management.[1]

One thing seems quite certain: the cumulative effects of all these physical and biological risks are likely to be great. As soon as better data are available it may be possible to classify stands and localities as "high risk" and "low risk." When risks can be reduced materially through management it seems likely that this fact can also be taken into account. Meanwhile, these risks should be allowed for through judgment, experience, and a knowledge of local conditions.

Different methods of making long-term estimates take account of factors affecting growth in varying degrees. Let us discuss two groups of these methods — yield tables and stand analysis — and some of the available data.

[1] A distinction should be made between "risk" and "uncertainty." Risks can be measured on an actuarial basis and can be predicted. Uncertainty is always present and cannot be estimated on the basis of statistics relating to past events.

Normal Yield Tables Many early American foresters such as Pinchot (86), Graves (44), and Fernow (38) recognized the need for making long-term yield estimates, and almost without exception these pioneers resorted to yield tables to furnish a partial basis for management decisions.

Early research efforts along this line were quite naturally directed at constructing so-called "normal" yield tables since these did not require waiting to remeasure growth on permanent sample plots. Normal yield tables are statistically compiled for different species or cover types from numerous "fully-stocked" sample plots of various ages. Most tables recognize two or three site classes and presume no silvicultural treatments. The resulting data purport to describe the development of a fully-stocked "wild" forest stand from its establishment to harvest.

Normal yield tables based on New England forest stands include among others those of Tarbox and Reed for white pine (98), Murphy (82) and Meyer (76) for red spruce, and Schnur for central hardwoods (91). Tables of this kind have several well-recognized shortcomings. They tend to exaggerate the yields expected from a natural forest because few stands are "fully-stocked" in the normal yield table sense. Also, the data are for "even-aged," "pure" stands while may forests depart from this ideal. Finally, and most important, the tables are for "wild" stands and do not recognize differences in yield due to forest management practices or programs.

Despite their limitations, when properly used, normal yield tables are often the most ready source of information for estimating long-term yields from stands managed under a medium or low management intensity. Adjustments have to be made for site differences, density, age, composition, and quality. Duerr and Gevorkiantz have suggested using Gehrhardt's formula to take account of the approach of understocked stands toward "normality" (33), (34), and use of this formula probably helps in making better approximations. Yield tables applied with skill and judgment can result in more useful and realistic yield estimates than those derived from rules of thumb or by short-range projection methods alone.

Second Rotation Yields A few words are needed to point out the problems of forecasting growth during the second rotation. The analyst must determine what kind of stand will result from the different harvesting methods used, and when it will become established. Success in this endeavor requires considerable skill in assessing seed source, soil capabilities, land-use history, plant successions, and the like. When adequate data are lacking, as is frequently the case, one alternative may be to assume that a low management intensity will usually result in a longer delay in regeneration and a lower degree of stocking than will a medium or higher intensity. In planning the nine farms it was assumed that often the tree species in a new stand would be of less desirable quality if low intensity management were used. These are only assumptions, however, and little evidence has been gathered to support them.

Often foresters are tempted to discard yield tables because they have so often been used fallaciously to support grossly over-optimistic forecasts. However, these tables are easy to use, and the major variables affecting growth can be allowed for. Therefore it seems that more reliable and realistic tables of this kind are needed as guides for making projections. Fortunately some progress is being made in this direction.

Empirical Yield Tables Westveld (109) and Mulloy (81) have developed empirical yield tables based partly on remeasurement of permanent sample plots, and taking explicit account of forest types, site, composition, and density. Allowances are made for changes in density and composition with the passage of time. Westveld's tables for spruce-fir areas in the Northeast are probably the best expression for any forest cover type in the region of long-range forest yields under prevailing management practices.

"Managed" Yield Tables Yield tables would be much more valuable if the kind of management were included as an explicit variable. This step is badly needed to aid the economic analysis of management alternatives. "Managed" yield tables based on both empirical data and on "normal" plots have been in use for some time in Europe; for an example, see Vanselow (106). Similar tables could be developed here to show forest management-yield relationships.

In New England we found that data and methods were woefully inadequate for making estimates of long-term yields under intensive forest management. Most records relating silvicultural treatments to yields are fragmentary and usually deal with a single silvicultural practice. Almost every experimental forest has a backlog of unpublished and often unanalyzed records of this kind, but the data shed little light on the problem of estimating yields under a series of related treatments over a full rotation.

The compartment experiments now being carried on by the Northeastern Forest Experiment Station are designed in part to find answers to this general problem of determining yields under alternative management intensities. However, it will be many years before long-term yield data will be available from these experiments, and additional studies will be needed.

Synthesizing Yield Tables Yield tables for managed stands can be synthesized from available data, although the reliability of such tables is open to question. In 1950 the authors had to devise some stopgap method to estimate yields from stands under intensive management, or else abandon their budgetary analyses of forest alternatives on New England dairy farms. The system finally adopted is mentioned here only because it may be suggestive of what can be done until better data are available, and because we believe the resulting estimates were considerably better than could have been made by rules of thumb or short-term projection methods alone.

Actually a combination of projection methods was used for different phases of the budget analyses. Cutting during the next decade under all three intensities of management was estimated in the field using short-term projection methods to allow for growth during the decade. Yields during succeeding decades from stands managed under medium or low intensities were estimated from normal yield tables, with all of the modifications and reservations previously mentioned. Westveld's empirical tables were used for estimating yields under these conditions from cut-over spruce-fir stands. For projecting long-term yields under high intensity management, however, we were forced to improvise a method.

First, it was necessary to construct a "managed" yield table, and a supplementary table showing individual tree development, for each major forest cover type found on the sample farms. These tables served as guides to estimating long-run yields from various sites under intensive forest management; and a stand table method was used to take account of present stand condition and structure. Allowances were also made for quality changes and prospective markets.

The tables were made in this way: Because the volume and quality of the forest products in any stand depend on the number, dimensions, and form of the component trees, these were taken as the basic building blocks for estimating yields. The system used for doing this was to determine what the average crop tree in a stand would look like at different ages, as it developed under an intensive management program. Once the average dimensions had been set up the trees could be combined to synthesize stand tables from which could be derived at least first approximations of expected yields.

It was assumed that under favorable conditions maximum yields would result if the entire area was covered by dominant and codominant crop trees. Data on the development of dominant and codominant trees in wild and in managed stands were used as guides. With the crown diameter estimated for a given age, simple arithmetic indicated the number of trees necessary fully to occupy an acre.

It was assumed that partial cuttings would reduce the number of stems at the beginning of a cutting cycle to the number required for complete stocking at the end of each cycle. Cutting cycles of five, ten, or fifteen years were assumed, depending on forest cover type and site. The effects of this kind of management on quality and on product volumes were then estimated from the probable form and dimensions of the trees.

In the course of using these tables, and later while making the New England input-output survey, some empirical check was made on the data. As indicated, little verification based on actual historic yields could be obtained. Several sample plots in managed stands of various ages were measured, however, and compared with the tabular data. The tables were adjusted slightly to take account of any major discrepancies.

This approach is, at best, highly theoretical and inadequate. The important thing is that until better data are found this or some other makeshift method will have to be used for estimating long-term yields under a high degree of management intensity. Synthetic tables of this kind can be set up and corrected later as field evidence is collected. The data developed for northern hardwoods are shown in Tables 35, 36 and 37 as examples of the procedure just described.

Growing Stock and Stand Structure The analysis of growing stock and stand structure is another promising approach to forecasting long-term yields under alternative management intensities. Some European foresters have placed a great deal of emphasis on the so-called "method of control" for regulating cut and estimating growth; for examples, see discussions by Favre (36), Huber (57), Knuchel (65), and Meyer (75). Meyer has suggested ways of extending this approach to include stand structure as a variable in analyzing yield problems (74).

The possibilities of making long-term yield estimates by developing this general approach seem to be great. Perhaps it can be used to extend and improve some of the "direct projection methods" that are now useful only for making short-term estimates.

Optimum Stocking There has been some research designed to find the optimum stocking for a forest stand or property. While valid for some economic problems, the optimum stocking approach does not appear very well adapted for choosing between various management intensities because it does not lead to long-term yield estimates for different management programs. Some investigators such as Duerr (35) explicitly recognize that the silvicultural system and stand structure both have to be assumed as given before optimum stocking investigations can be very

TABLE 35

Estimated Crop Tree Dimensions and Volumes, in Stands under High Forest Management Intensity, by Successive Five-Year Periods[1]

NORTHERN HARDWOODS

Site II

5-Year Periods	Starting D.b.h. 4″ D.b.h. Inches	Ht. Feet	Volume Bd.ft.	Volume +Cds.	Starting D.b.h. 6″ D.b.h. Inches	Ht. Feet	Volume Bd.ft.	Volume +Cds.	Starting D.b.h. 8″ D.b.h. Inches	Ht. Feet	Volume Bd.ft.	Volume +Cds.
0–5	4.0	38.5	..	.022	6.0	52.0	..	.064	8.0	59.0	..	.106
5–10	4.7	46.2	..	.037	7.7	58.0	..	.100	9.3	63.0	35	.070
10–15	6.3	53.0	..	.071	9.1	62.3	32	.070	10.0	65.4	48	.070
15–20	8.0	59.0	..	.106	9.8	65.0	45	.070	10.7	67.5	64	.070
20–25	9.3	63.0	35	.070	10.5	67.0	60	.070	11.3	69.4	78	.070
25–30	10.0	65.4	48	.070	11.1	69.0	75	.070	11.7	70.8	90	.070
30–35	10.7	67.5	64	.070	11.5	70.4	87	.070	12.0	72.0	102	.070
35–40	11.3	69.4	78	.070	12.0	71.8	100	.070	12.3	73.2	115	.070
40–45	11.7	70.8	90	.070	12.3	73.0	113	.070	12.6	74.2	126	.070
45–50	12.0	72.0	102	.070	12.6	74.0	124	.070				
50–55	12.3	73.2	115	.070								
55–60	12.6	74.2	126	.070								
	Starting D.b.h. 10″				Starting D.b.h. 12″							
0–5	10.0	65.4	48	.070	12.0	72.0	102	.070				
5–10	10.7	67.5	64	.070	12.3	73.2	115	.070				
10–15	11.3	69.4	78	.070	12.6	74.2	126	.070				
15–20	11.7	70.8	90	.070								
20–25	12.0	72.0	102	.070								
25–30	12.3	73.2	115	.070								
30–35	12.6	74.2	126	.070								

Number of Crop Trees per Acre for Full-Stocking

Age in Years	30	35	40	45	50	55	60	65	70	75	80
No. trees per acre	460	245	189	165	149	139	130	126	122	120	120

[1] Adapted from Harvard Forest Paper No. 2, (51) and Harvard Forest Bulletin No. 2, (94).

TABLE 36

ESTIMATED YIELDS FROM FULLY-STOCKED STANDS UNDER HIGH FOREST MANAGEMENT INTENSITY [1]

NORTHERN HARDWOODS

SITE I

Age in Years	Crop Tree Height Feet	Crop Tree D.b.h. Inches	Leave: No. tr. per Acre	Leave: Volume Cu. ft.	Leave: Volume Bd. ft.	Leave: Volume Cds.	Cut [2]: No. tr. per Acre	Cut [2]: Volume Cu. ft.	Cut [2]: Volume Bd. ft.	Cut [2]: Volume Cds.
25	48.0	5.0	360	1116	...	15.7	370	1147	...	16.2
30	56.5	7.3	200	1500	...	18.0	160	1200	...	14.4
35	62.5	9.1	150	1875	4,950	10.5	50	625	1,650	3.5
40	68.0	10.8	130	2444	8,840	9.1	20	376	1,360	1.4
45	72.0	12.0	116	2830	11,948	8.1	14	342	1,442	1.0
50	75.5	13.1	109	3270	15,042	7.6	7	210	996	.5
55	78.0	14.0	102	3519	17,034	7.1	7	242	1,169	.5
60	81.0	14.8	95	3886	19,095	6.7	7	286	1,407	.5
65	83.5	15.6	90	4140	20,880	6.3	5	230	1,160	.4
70	86.0	16.3	86	4489	22,532	6.0	4	209	1,048	.3
75	88.5	17.1	83	4897	24,900	5.8	3	177	900	.2
80	91.0	17.7	...	...	...	...	83	5561	27,888	5.8
					Total Yield			10,605	39,020	44.7
					Intermediate Yield			5,044	11,132	38.9

SITE II

Age in Years	Crop Tree Height Feet	Crop Tree D.b.h. Inches	Leave: No. tr. per Acre	Leave: Volume Cu. ft.	Leave: Volume Bd. ft.	Leave: Volume Cds.	Cut [2]: No. tr. per Acre	Cut [2]: Volume Cu. ft.	Cut [2]: Volume Bd. ft.	Cut [2]: Volume Cds.
30	47.9	5.0	460	1380	...	19.5	272	816	...	11.6
35	54.6	6.7	245	1470	...	19.6	215	1290	...	17.2
40	60.0	8.4	189	1909	4,158	13.2	56	566	1,232	3.9
45	63.4	9.4	165	2211	6,270	11.6	24	322	912	1.7
50	65.8	10.2	149	2369	7,748	10.4	16	254	832	1.1
55	68.0	10.8	139	2599	9,452	9.7	10	187	680	.7
60	69.6	11.2	130	2730	10,400	9.1	9	189	720	.6
65	70.9	11.7	126	2848	11,466	8.8	4	90	364	.3
70	72.2	12.1	122	3050	12,932	8.5	4	100	424	.3
75	73.4	12.5	120	3240	14,400	8.4	2	54	240	.1
80	74.4	12.8	...	...	...	...	120	3420	15,480	8.4
					Total Yield			7,288	20,884	45.9
					Intermediate Yield			3,868	5,404	37.5

[1] Adapted from Harvard Forest Paper No. 2, (51) and Harvard Forest Bulletin No. 2, (94).

[2] Trees removed in intermediate cuttings plus final yield that will be harvested gradually to promote prompt and valuable reproduction.

TABLE 37

DATA USED FOR COMPUTING YIELDS FROM MEDIUM AND LOW FOREST MANAGEMENT INTENSITY

NORTHERN HARDWOODS

Present % of Stocking	10	20	30	40	50	60	70	80	90
% of Normal Growth during Next 10 Years[1]	17.2	32.8	46.8	59.2	70.0	79.2	86.8	92.8	97.2

NORMAL YIELD TABLE VALUES[2]

	Site I					Site II				
Age Years	No. Trees per Acre	Av. Ht. of All Trees Feet	D.b.h. Av. Tree	Vol.[3] per Acre Cu. ft.	Next 10-yr. Vol. Increment Cu. ft.	No. Trees per Acre	Av. Ht. of all Trees Feet	D.b.h. Av. Tree	Vol.[3] per Acre Cu. ft.	Next 10-yr. Vol. Increment Cu. ft.
20	1250	27.1	3.11	1041	1109	...	...	...	...	...
25	1120	33.0	3.86	1625	1103	1360	27.8	2.84	982	816
30	1010	37.5	4.41	2150	908	1235	31.8	3.40	1380	800
35	900	41.5	4.94	2628	867	1125	34.8	3.86	1798	736
40	800	45.0	5.46	3058	840	1030	37.4	4.25	2180	648
45	700	48.2	6.05	3495	803	940	39.8	4.66	2534	584
50	610	50.7	6.69	3898	779	855	41.5	4.94	2828	547
55	525	53.1	7.37	4298	770	775	42.8	5.43	3118	520
60	450	55.4	8.14	4677	785	700	44.2	5.85	3375	520
65	390	57.8	8.91	5068	765	630	45.3	6.31	3638	508
70	340	59.8	9.72	5462	738	565	46.3	6.79	3895	495
75	300	61.9	10.51	5833	...	500	47.0	7.36	4146	...
80	270	64.0	11.25	6200	...	440	47.6	7.98	4390	...

Site I: Final Yield Conversion Factors[4]		Site II: Final Yield Conversion Factors[4]	
Board Feet	— 3.77	Board Feet	— 3.50
Cords	— .0044	Cords	— .0052

[1] From Gehrhardt's Formula when K = .8.

[2] Harvard Forest Bulletin No. 2, (94), Table II, "All Trees 2 Inches D.b.h. and Over."

[3] Volume of merchantable stem to a 2-inch diameter at the center of the stick, outside bark.

[4] Number of board feet and cords per cubic foot of final yield. Same values as those of original Normal Yield Tables. Conversion Factors used: 6 b.f. = 1 cu. ft., 80 cu. ft = 1 cord.

meaningful. Statements by others concerning optimum stocking (116), however, seem to have ignored the management intensity problem altogether.

Optimum stocking studies do furnish some refined input-output relationships for a particular management intensity. However, putting first problems first, major emphasis in New England might well be placed on finding the perhaps cruder relationships exemplified by long-term yield estimates for different management intensities.

This concludes a brief review of the available New England data for estimating future yields. For many purposes rough rules of thumb, tempered by considerable judgment, may be as satisfactory as anything; however, making budget analyses now requires a variety of projection methods. Short-term methods seem adequate for estimating yields in the near future, while some kind of yield table or a rule of thumb is needed to estimate the level of productivity that eventually can be reached. In order to fill in probable yields during the intervening period, something like a yield table approach that takes account of the present condition of the growing stock on any property will be needed.

Research Problems This discussion of forest management-yield relationships would be incomplete without some suggestions for research to get the data needed for budgetary analyses. Past and current forest research has already gone a long way toward defining the various forests and diverse growing conditions found in New England. Many of the factors affecting forest yields have been recognized and more information is being assembled as silvicultural studies continue. However, there is a need for some research aimed primarily at measuring the productivity of forests in a way that will be directly useful for economic analysis. Although a study of this kind can not be divorced from silvicultural research, it seems likely that there is now enough technical knowledge to make such a project possible.

The best source of data for predicting the probable yields of an established forest is probably in the yields recorded from other similar forests handled under various silvicultural programs. Likewise, records of experience are needed to forecast the kind of forest likely to become established on new land or following the removal of an old woods. A research project set up on selected areas to measure yields as they accrue and to record regeneration as it becomes established would eventually supply this need. However, some additional research to get quicker results seems desirable. A three-part research program is suggested, first to get provisional measures of forest reproduction and yields that can be used temporarily for economic analysis, and then gradually to improve and perfect these estimates by accumulating more data over a long period of time.

The first phase of this program is aimed at a preliminary assessment of the reproduction likely to become established when existing forest stands are harvested. It is suggested that in a region like New England enough stands have been cut in the past five to ten years to sample most of the significantly different forest cover types, and furthermore that commercial operations have been so diverse in their character that most of the feasible cutting practices have been used in one way or another. Several thousand of these operations are available for inspection, and the established reproduction could be assessed. By taking full advantage of any available records and of the evidence on the ground itself, the nature of the stand before cutting, the kind of cutting done and the regeneration actually established could be fairly well described. Open land planted to forest or seeding in naturally could also be included in this phase of the research program.

A large number of specific case histories could be organized to show modal situations that have given significantly different results. The differences that would probably show up between cases that were seemingly similar might also suggest fruitful areas for further research, and meanwhile these first approximations would be used for economic analysis.

The second phase of this program would be a project similar to the above but aimed at measuring the rate at which established forest stands have produced yields in the past. Stands of various ages, structures, densities, species composition, etc., could be measured and described. Then the condition of these stands five to ten years ago could be reconstructed from any available records and from the evidence on the ground and in the forest itself. From these data it would be possible to get preliminary estimates of stand development and yield production over a short period of time.

If enough of these cases were assembled and analyzed, it would be possible to stratify them according to pertinent factors. The data on similar cases could be linked together to form provisional yield tables for modal forest stands and situations. Such tables could recognize differences in yield associated with silvicultural programs and other measurable forest conditions.

The final phase of this coordinated research program would be to improve the provisional data assembled in the first two phases by checking them against the yields and reproduction actually realized over a long period of time on specific forest areas. A number of forest stands or plots could be measured and marked on the ground, yields could be recorded over time and the stands remeasured periodically.

Probably a large number of these areas would be needed to sample adequately the forests of New England or of any smaller subregion and to allow for normal losses over the years. Therefore, the record system should be simple, and once the plots have been established they should require a minimum of technical maintenance.

It is suggested that these sample areas be relatively homogeneous stands of convenient size located on a wide variety of forest ownerships. The initial measurements and periodic remeasurements should be made by technical personnel. The owners could use any silvicultural practices they pleased and would have to cooperate only by describing any operations done and recording the total volume and quality of products removed from the sample area. Special effort will be needed to include enough areas under purposeful forest management.

If standardized records were kept, these simple case histories could be easily compared and supplemented by the more detailed records from experimental forests and from silvicultural experiments. This would be essential in order to test silvicultural programs not ordinarily used. Over a period of years this recorded experience would provide a fund of information for revising the provisional yield tables and estimates of reproduction associated with various stands and management programs. A mass of these cases would also be a prolific source of research problems that could inspire special projects of a more specific and detailed nature.

The results of this "three-pronged" research program would have to be assembled into forest management-yield tables, formulae and rules of thumb that have regional and local application. Although a great many knotty problems would have to be solved in defining forest yields, cover types, stands, and the like, this project to relate measurable aspects of the forest itself and its management to rates of production and reproduction should lead to immediately usable results, make provision for further improvements, and be a constant source of research ideas. Most important, it would soon be possible to make more informed estimates of long-term forest production under different forest management intensities.

CHAPTER VI

PERFORMANCE RATES IN NEW ENGLAND FOREST OPERATIONS

Relationships between management programs and yields represent one important category of input-output data needed for comparing forest management alternatives. Another category includes input-output data relating inputs of labor and other resources to accomplishments in the individual practices which make up forest management programs.

Piece-Work Rates If labor is to be hired on a piece-work basis, the "going rate" provides an easy way of estimating the additional costs of a proposed forest operation. Any timber operator who pays his men on a piece-work basis, for instance, can estimate the cost of cutting a given amount of sawlogs or pulpwood. His figures are in dollar terms, to be sure, but these serve his purpose so long as he plans for only the near future. As price levels change he can adjust his current estimate of piece-work rates accordingly.

Actually, although practical woods operators and laborers talk of dollar values, they usually have a fairly good idea of the labor and machinery inputs used for any operation. And piece-work rates tend to be adjusted so that woods workers can earn what they consider to be a reasonable day's wage. Thus dollar piece-rates are actually based on quantitative input-output estimates and prices.

Estimating the costs of an operation on the basis of piece-work rates is subject to many of the pitfalls that are found in using average cost data, especially if these rates are projected far into the future. While these rates are based on quantitative inputs and outputs, the amount of information that any one operator has is generally limited to that gained from his own experience in using currently popular operating methods. He is likely to have little factual knowledge about the requirements of new or different operating methods.

Also this body of knowledge has never been collected or codified so that a landowner can use it for estimating costs and returns. Many operators consider their inputs and outputs to be trade secrets that they do not want publicized.

Quantitative Data Needed A necessary step toward obtaining data that can be widely used for determining costs is to gather information about the timing and quantities used of such inputs as labor, machinery, supplies and the like. This will make it possible to estimate the inputs needed to carry out the various steps required in any forest management program; each operation can be visualized, and estimates made of the inputs needed. For example, if the program calls for a weeding operation on 20 acres five years hence and for a partial cutting of 50,000 board feet of sawlogs on 80 acres ten years hence, the man- and machine-hours needed to perform each of these operations can be forecast. Probable prices for each of these inputs can then be determined separately.

Performance Rates Often these short-run input-output relationships are expressed as performance rates — the number of man- and machine-hours and the quantities of supplies needed per unit of product or per acre. These rates can be used to make the forecasts involved in long-range forest planning as well as in making day-to-day decisions about current operations.

Each forest cultural operation is essentially short-run in the sense that it will be completed within a few days or months from the time it is started. Relationships between inputs and immediate product output, and even the kinds of input used, will change over the years due to new operating methods and technological advances. Consequently, for making day-by-day short-run operating decisions work performance data must be kept constantly up-to-date.

On the other hand, each short-run operation is also an integral part of a longer-run management program. The total effect of an operation on long-term yields can only be determined in relation to the whole management program. For long-range planning purposes each operation must be evaluated in this context.[1]

Work Performance Data Used to Analyze Long-Term Management Programs

Comparing long-range alternatives requires estimating the inputs for numerous forest operations that will be started during future decades.

[1] A confusion in terminology inevitably seems to arise when one is talking about short-run forest input-output relationships. Each arbitrarily-defined production process has a unique set of input-output data. Each short-run operation in combination with a sequence of other short-run operations over a rotation period influences yields. There are, however, distinct short-run input-output relationships, such as so many man-hours per cord for a harvesting operation or so many machine- and man-hours per mile to build a woods road, that can be determined quite apart from any long-run considerations.

Work performance data used in this way are subject to the same kind of uncertainty as management-yield data. This does not invalidate their use, however, in making economic comparisons over long periods since technological changes will usually affect the quantity of input needed for carrying out different management programs in a roughly proportional manner. Also, the general direction of technological change can often be foreseen and allowed for in estimates. But these uncertainties do indicate that approximations of input and output may be about as satisfactory for long-range planning purposes as more refined estimates.

At present, inputs must be calculated separately for each operating plan on any property. If the problem were only less complex it might be possible to relate inputs directly to a given kind of management program and apply these relationships to any area or ownership; some European yield tables have done this for major forest cover types.

Kinds of Forest Operations Short-run forest operations can be divided for convenience into three broad categories. First, is a large group of operations associated with harvesting. Thinning and some improvement cuttings can also be included in this category since they are similar in most ways to harvest cuttings but are usually done in younger stands.

A second group of operations yield no immediate usable product and may be put in a category of forest treatments. These operations are done chiefly to improve the growing stock, and it is expected that future harvests will be increased sufficiently in value to repay the extra outlay of time and materials for the treatment. The operations in this group include planting, girdling, poisoning, and cleaning or weeding and the like.

A third, rather miscellaneous group can be called forest aids and improvements. Typical operations are cruising, mapping, marking, scaling, and road construction. Relationships found for these operations would include the input required per bridge or mile of road; inputs per acre mapped or cruised; and inputs per M.b.f. of sawlogs or per cord of pulpwood marked or scaled, and the like.

Operations and Separate Jobs Each of these operations can be thought of as made up of numerous component jobs — harvesting, for instance, includes such jobs as swamping, felling, limbing, bucking, peeling, yarding, skidding and trucking. Each operation has its own unique set of conditions, and so does each job. The exact amount of input needed for a complex operation can seldom be found merely by adding up the average input required for each component job. However, when this procedure is tempered with judgment and experience it is a means of finding the approximate total input for an operation. Therefore, when collecting input-output information an effort should be made to find data not only for the total operation but also for the individual jobs.

Sources of Data Many of the above forest operations have been made thousands of times, and a vital financial interest and a desire to use labor and machines efficiently has caused men to study these operations most carefully. A considerable backlog of knowledge has thus accumulated to create a folklore about the costs and returns of the most commonly used forest operations.

Many "cost and return" studies have also been made of forest operations. These are usually detailed time studies to relate tree size and other variables to production per man-hour, and they have contributed a great deal to a better understanding of the factors affecting production rates. Time studies have also helped to improve the efficiency of performing forest jobs and operations.

Variables Affecting Efficiency From the general body of folklore and from various special studies we have accumulated a long list of the factors that can affect production rates on many short-run forest operations. In fact, there are so many of these factors and they constitute such an "embarrassment of riches" that it is difficult to arrive at usable data. Once an operation has been defined, however, the following groups of variables need to be considered:

a. Material worked on and working conditions: here are included such things as the tree species, their size, and distribution over the area, the slope, stoniness, hauling distance, roads, and the like. Also, such working conditions as rain, the amount of snow, cold, etc., may have an effect on working speed and effectiveness.

b. Men and material used: certain qualities of the labor force such as age, skill, intelligence, and experience will affect input-output relationships. Also, whether payment is made as straight wages, for piece-work, or on some incentive plan, may be important. The kind of tools and machinery used will affect production as well as the skill displayed in operating them.

c. Management and scale of operation: the way that labor is organized into crews and equipped with tools and machinery, the timeliness of each job, the quality and amount of supervision, and the like will all affect the rate of production. The general size of the operation also influences input-output relationships.

Many other items could be listed but these are probably enough to illustrate the range of factors that must be considered in studying short-run operations. Some of these factors, like tree size, are easily measured, while others such as "skill" are more intangible. But if all these factors enter in, it is easy to see why the compiling of "planning data" has gone slowly. The picture is further complicated by interaction between factors.

Harvesting Operations

The process of harvesting forest products involves several related jobs, usually performed in sequence. Any particular harvesting operation may include all or only a few of these individual jobs. Thus the problem is to develop input-output data for the entire operation and also for its most important component jobs. These jobs usually include felling the timber, limbing and bucking it and bringing it to a drivable road. Some of these jobs may be essentially the same whether the operation is a thinning, improvement cut, or final cut.

Rule of Thumb A rule of thumb for typical small farm operations using conventional hand tools and logging methods is that harvesting takes about 2 man-days per thousand board feet of sawlogs, and 1.25 man-days per cord of rough pulpwood, cut and moved about 400 feet to a roadside. Larger commercial operations may be more efficient. In southern New England 1.5 man-days per cord may be more representative because of the preponderance of hardwood and the relative inexperience of farm woods labor.

Most New England operations fall within a range of from a little less than 1 man-day per thousand board feet to about 3 man-days per thousand. For cordwood and pulpwood the range would be from about ½ man-day per cord to about 2 man-days per cord. Of course labor is only one input, but other inputs can be considered as roughly proportional in this type of calculation.

These data were obtained by talking with foresters, landowners and operators throughout New England. Those interviewed were unanimous in warning that no single rule of thumb, simple or complex, would result in a completely reliable estimate of inputs for a particular operation. They did agree, however, that inputs for most operations would fall within the range cited above.

About a dozen cases with some written records of physical inputs and outputs for harvesting operations tended to affirm the validity of the above rules. Regional averages such as those derived from the 1950 Manpower and Equipment Survey (104) also show these figures to be representative of average input requirements.

Effect of Important Variables Refining these crude relationships so that more realistic estimates can be made for specific operations by taking into account the effect that major variables may have on input is a complex task. A good many efforts have been made, however, ordinarily using "time and motion study" techniques. The effect of tree size on logging costs, for instance, has received a good deal of attention.

Tree Size Costs per unit of product for felling, limbing, bucking and skidding all decrease as the diameter of the tree increases; up to a point where the tree becomes too large to handle easily. This appears to be a clear-cut input-output relationship that anyone with a diameter tape and a stopwatch can verify. Hundreds of foresters have done so, and the literature is replete with reports of their findings. Many of these reports, such as those by Kirkland (63), Jensen (59), Belotelkin (11), Koroleff (66), Hart (45), Ostrom (84), Cunningham (29), and Ferree (39) have application under New England conditions.

Once the way that labor input varies with tree size is known — with labor skill, logging method, logging chance, volume cut per acre, etc., remaining constant — this relationship can be taken into account in estimating inputs or analyzing the efficiency of a particular operation. Tables 38 and 39 are based on Jensen's studies of non-mechanized pine sawlog

TABLE 38

LABOR INPUTS FOR HARVESTING SPRUCE PULPWOOD [1]

Average D.b.h. of Tree Inches	*Man-hours per Cord for Felling, Limbing, and Bucking in the Woods*	*Man-hours per Cord for Yarding 400 ft.*	*Total Man-hours per Rough Cord*	*Man-hours per Cord for Peeling*	*Total Man-hours per Peeled Cord*
4	12.40	3.88	16.28	3.60	19.88
5	10.39	3.08	13.47	2.97	16.44
6	8.66	2.25	10.91	2.37	13.28
7	7.30	1.28	8.58	1.83	10.41
8	6.45	.92	7.37	1.42	8.79
9	5.98	1.13	7.11	1.23	8.34
10	5.76	1.37	7.13	1.12	8.25
11	5.68	1.42	7.10	1.05	8.15
12	5.72	1.48	7.20	1.00	8.20
13	5.82	1.54	7.36	.97	8.33

Source: Adapted from Cost of Producing Pulpwood on Farm Woodlands of the Upper Connecticut River Valley, (59).

[1] Man-hours of labor required by 1-man crew to produce spruce pulpwood; bucking in the woods and yarding 400 feet to a driveable road on an average logging chance.

TABLE 39

LABOR INPUTS FOR HARVESTING WHITE PINE SAWLOGS [1]

Average D.b.h. of Tree Inches	*Man-hours per M.b.f. for Felling, Limbing and Bucking*	*Man-hours per M.b.f. for Skidding 400 Feet*	*Total Man-hours per M.b.f.*
6	8.05	4.62	12.67
8	6.25	3.53	9.78
10	4.91	2.90	7.81
12	4.18	2.50	6.68
14	3.81	2.25	6.06
16	3.66	2.07	5.73
18	3.64	1.95	5.59
20	3.68	1.84	5.52
22	3.75	1.75	5.50
24	3.84	1.69	5.53
26	3.97	1.68	5.65
28	4.14	1.70	5.84

Source: Adapted from Cost of Producing White Pine Lumber in New England, (60).

[1] Man-hours of labor required by average crew to produce white pine sawlogs; bucking in the woods and skidding 400 feet to a driveable road on an average logging chance.

TABLE 40

LABOR INPUTS FOR CUTTING PULPWOOD [1]

D.B.H. (I.B.)	*Total Time in Man-Hours per Cord*	
	Spruce	*Balsam Fir*
3"	8.4	16.9
4"	6.5	5.4
5"	3.6	3.7
6"	2.9	2.9
7"	2.6	2.6
8"	2.3	2.1
9"	2.1	2.1
10"	2.1	1.9
11"	2.1	2.1
12"	2.1	2.0
13"	2.3	1.6
14"	. .	2.0
15"	2.3	. .

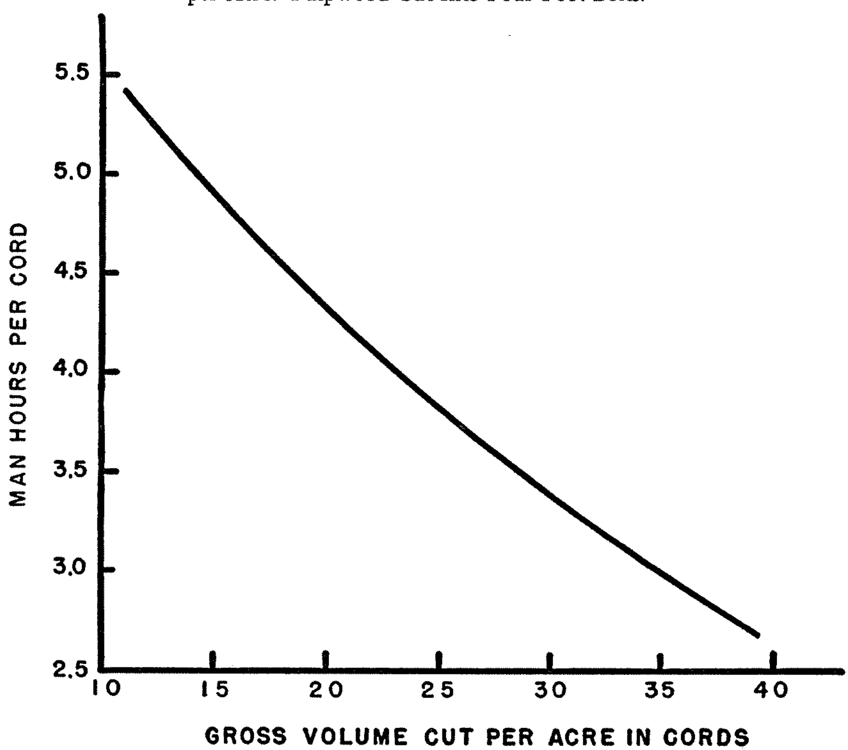
[1] Adapted from Pulpwood Cutting: Efficiency of Technique, (66). Time required in man-hours per cord to cut trees of different diameters into 4-foot bolts, using bow saw and axe. Time includes: moving to tree, felling, branching, measuring, bucking, and butting for defect.

and spruce-fir pulpwood operations in northern New England (60), (59). Labor inputs might increase by an average of about 20 percent on hardwood operations.

Table 40 presents comparable data reported by Koroleff for felling and bucking spruce and fir pulpwood (66). These figures were based on detailed time-studies of Canadian commercial operations and are included to show how much variation there may be between the inputs used on commercial and farm woods operations.

Volume Cut Per Acre Figure 2 shows another relationship suggested by Koroleff (66) that should also be considered in estimating inputs for a given operation. Apparently more and more labor is required to cut a cord of pulpwood as the volume cut per acre decreases. Several factors may help explain this, chief among them being the in-

FIGURE 2. Apparent Relationship of Cutter's Rate of Output to Volume of Wood Cut per Acre. Pulpwood Cut Into Four Foot Bolts.[1]



[1] Adapted from Pulpwood Cutting: Efficiency of Technique, (66). Ninety cubic feet assumed equal to one cord.

creased traveling and felling difficulties and the smaller trees that may have, on the average, made up the very light cuts recorded per acre.

Selective Cutting Many studies have been conducted to determine how selective cutting affects inputs per unit of output. This problem seems closely related to that of how input per unit of product varies with the volume cut per acre. Jensen found that although slightly more time is needed to make sawlogs on a partial-cutting basis, this is more than compensated for through easier skidding. And the extra time required for cutting pulpwood on a partial basis is more than offset by an increase in the average diameter of trees cut.

Belotelkin, Reineke, and Westveld have made detailed studies of partial-cutting and clear-cutting costs on the Gale River Experimental Forest (11). They found average cost per unit about the same under either method. And studies reported by Downs (32) in the South, Hasel in California (46), and Stott (96) in the Lake States resulted in similar conclusions. Hasel derived regression formulae for estimating the labor inputs of individual crews operating with clear and partial-cutting methods in ponderosa pine.

Despite the weight of this evidence, the general opinion and experience of many landowners and operators seems to indicate that partial-cutting is often much more time-consuming and expensive than clear-cutting. One reason for this belief may be unfamiliarity with partial-cutting techniques; another reason is perhaps the smaller volumes removed per acre.

Two operators in Vermont reported inputs of less than two man-days per thousand feet cut in thining operations; this compares quite favorably with some average clear-cutting labor input figures, but not with the clear-cutting inputs on other operations by these same operators. And a pulp company in New York has records showing a definite increase in labor inputs per cord on partial-cutting operations.

Even allowing for erroneous reporting methods and other special circumstances it appears that no definite prediction can be made concerning the way partial-cutting rather than clear-cutting will affect inputs in any particular instance. On the basis of present data we can only conclude that partial-cutting may require either more or less or the same inputs per unit of product as clear-cutting. Not even the general direction of the effect of partial-cutting on logging inputs can be predicted with assurance.

Skill and Efficiency The skill and effectiveness of individual workmen may influence work performance rates more than any of the other variables mentioned. Koroleff notes that the time required for different individual crews to perform identical jobs often varies by as much as 50 to 100 percent. House (56) kept records that indicate even wider variations among individual choppers' output. One of the authors went over the time sheets of employees in a logging camp in northern Vermont and found variations in the daily output of different workers on the order of 300 percent.

Mechanization and Technical Change That mechanization and new logging methods frequently have a large effect on labor accomplishments has been documented in many publications. Mechanization effects are discussed by Worthington (115), Wiesehuegel (112), Jones (62), Horncastle (54), Goodwin (41), Buell (17), Challenger (24), and Artman (5). Most of these data are not directly applicable in the Northeast because the studies were made elsewhere.

The authors talked with several New England operators who had adopted various mechanized devices such as chain saws, small tractors, and the like. According to them, labor accomplishments frequently can be increased from 10 to 50 percent over hand and horse logging methods if the new tools and equipment are used skillfully. However, a reorganization of operations is usually required at the same time and it is difficult to ascribe the resulting increased efficiency to any single machine or change.

Skidding, Yarding and Hauling Jensen has developed regression formulae for estimating skidding, yarding and trucking inputs on farm pulpwood operations in northern New England (59). The principal variables allowed for were distance, load volume and the log size. Archer (4) and Belotelkin, Recknagel, and Westveld (10) have also discussed labor costs for skidding and yarding.

Deficiencies in These Data The deficiencies in these data are pointed up by the fact that almost without exception the figures in the publications cited above are based on averages of the inputs and outputs recorded on several operations dissimilar in some important respects. Although some descriptive generality is achieved in this way, the resulting relationships have limited application to specific problems because the conditions influencing short-run inputs are complex and varied so much among the operations studied. Averaging input and output figures from divergent operations fails to provide data that represent any actual case, and anyone using the information is at a loss to know how it should be modified to fit the particular problem at hand.

Case Histories Required If each case history from which these averages were derived was presented separately, with all of the relevant conditions clearly stated, a start would be made towards accumulating sufficient reliable data for estimating inputs in specific situations. A great many of these case histories would have to be collected and grouped together into classes of similar operations according to various criteria. Modal and extreme relationships could then be determined for each group and the effects of the more important variables could be analyzed. Meanwhile, the case most resembling the one for which an estimate is required could be used as a guide.

A case study reported by Walters and Fox (108) is a good example of the kind of data needed. This study compares the inputs used in hand peeling fence posts with those of mechanical peeling. The authors carefully describe the methods used in making the tests and the conditions affecting them. The effects of the major variables on production are analyzed under different conditions. Finally, the authors present their results in quantitative terms, comparing the number of posts peeled per man-hour by each method under various conditions.

Reasonable estimates of input-output relationships for harvesting operations might be derived from cases by a series of successive approximations. And these might lead to improved rules of thumb or some other simple method for using the data. There is a great deal of room for improvement in our knowledge about this phase of work performance data.

Forest Treatments — Pruning

Pruning is a treatment that yields no immediate merchantable output. The operation can be completely evaluated only as part of an overall long-range management plan; on this basis the added costs of pruning can be balanced against expected added returns from clear lumber. However, an owner needs to estimate short-run pruning costs and these probably can be best expressed as man-hours and other inputs required per tree, per acre, or per linear foot of bole pruned.

Rule of Thumb A rule of thumb for estimating the labor input used to prune young softwood stands, using conventional hand-saw methods, is that one man-hour of labor is required per 100 linear feet of bole pruned. The range is from 50 to 200 linear feet per man-hour, depending on species, limb-size, stand density, topography, height of pruning, labor efficiency and the like.

Another rule of thumb is that it takes an average of 3 minutes per tree to prune the first 8 feet of bole and another 6 minutes for the second

8 feet. The range is from 1 to 6 minutes for the first 8 feet and 3 to 12 minutes for the second 8 feet.

Work performance data for pruning seem to be more adequately developed than those for almost any other forest operation. And there is considerable field evidence supporting the rules just cited. In addition, numerous studies are reported in the literature showing the effects on pruning input of the principal variables under different conditions.

Case Reports A Vermont owner estimated, on the basis of 50 years of experience in pruning white pine, that it takes about 4 minutes to prune the first 8-foot log and 6 minutes for the second 8 feet. This was for natural and planted pine on rough topography.

A New York owner had records on pruning 46,000 red pine and 5000 white pine in plantations. He pruned all crop trees to an 8-foot height and 1200 of them to a 17-foot height. The pruned trees were between 4 inches and 8 inches in diameter breast high. He estimated 100 feet of bole could be pruned per man-hour, or 3 minutes per tree for pruning the first 8 feet and 6 minutes per tree for the second 8 feet.

Two Connecticut owners and one New York owner pruned every tree in their plantations instead of only the crop trees. Their records show times required per foot of bole or per tree similar to those just mentioned. They justified the additional cost of pruning non-crop trees on the basis of greater accessibility and the increased value of later thinnings.

One of the best pruning studies from an input-output standpoint is reported by McLintock (72), although only about 150 spruce trees were pruned.[1] What makes it valuable is the way the study was set up, analyzed and reported. The conditions under which the job took place are well described and there is a careful description of the trees pruned, working conditions, and methods used. Multiple working hypotheses concerning the variables that might be important were tested through time studies. Quantitative data showing how various factors influenced pruning time were then recorded. Some of the relationships found in this study are given below:

	Min. : Sec.
Average pruning time per tree	6:17
Average walking time per tree	2:35
Total time per tree	8:52

[1] Tree height averaged 40 feet, and D.b.h. ranged from 3 to 8 inches. Hand pruning saws were used to a convenient height and 14-foot pole saws beyond that point to a total pruned height of 18 feet. 92 percent of the branches were dead. Mean diameter of branches removed was 0.56 inches. An average of 80 branches per tree were pruned. For comparison 50 white pine were also pruned.

	Min. : Sec.
Pruning time per tree as affected by number of branches pruned per tree:	
Fewer than 60 branches	4:43
60 to 99 branches	5:51
100 or more branches	8:39
Pruning time per tree as affected by average branch size:	
Small (¼″)	4:8
Medium (½″)	6:3
Large (¾″)	8:2

Of course these data are directly applicable only to cases similar to the one reported. But our knowledge of input-output relationships would be enhanced if there were a large file of similar case histories covering different conditions, methods, and operations.

Other Studies Cline and Fletcher (28), Hawley and Clapp (47), and Adams and Schneller (3) all give detailed information on pruning inputs in New England. They agree that the major variables affecting pruning time per tree are limb number and size and variations in the speed and skill of individual workers. A study in the South by Bull (21) found individual labor effectiveness to be the most important of all. Moss (79) investigated the pruning inputs used in natural stands of Connecticut hardwoods, and he also found limb size and numbers to be significant variables. Naturally, the actual relationships he found were different from those for pine plantations.

Mollenhauer (78) studied the efficiency of using various tools but his results were inconclusive. The Forest Products Laboratory (105) studied comparative inputs for power saws and hand saws in pruning, but the results so far are preliminary. Other references on pruning inputs are: Bull (19) (20), Canada Forest Service (23), Curtis (30), Davis (31), Mayer (71), Meyer (77), and Paul (85).

Forest-Treatments — Planting

Rule of Thumb A rule of thumb for hand-planting methods is that an average of from 500 to 1000 seedlings can be planted per man-day. Besides variations among individual workers, soil, topography, ground cover, tools used and planting crew organization help determine the inputs needed.

Other Studies Luther (69) reports extensive planting on his holdings in New York. In an experiment comparing two- and three-man mattock crews, he found two-man crews to be about 20 percent more efficient, planting 1058 trees per man-day. The planting site was level and sandy.

One of the most comprehensive studies of planting is reported by Kittredge (64). He does not, however, give much attention to input-output relationships in his bulletin. Holt (53) discusses machine planting but does not present any usable input-output data.

More good case studies of various planting operations are needed; and until such data are available and have been analyzed, approximations based on rule of thumb and experience will have to suffice.

Forest Treatments — Cleaning or Weeding

Rule of Thumb A rule of thumb states that it takes about 1 man-day per acre to weed typical young softwood stands in the Northeast. A range of from ½ to 2 man-days per acre is usually given.

Cline estimates 1 man-day per acre on the basis of his experience at the Harvard Forest (27). Inputs required for weeding on the Eli Whitney forest plantations varied from ½ to 2 man-days per acre. Several other owners reported average weeding times per acre within this range.

Kind, size and number of trees being released affect weeding times, as do the size, kind and number of trees being cut, weeding method used, site and topography, time of year and the individual workman's efficiency.

A Swedish study by Callin (22) presents an attempt to estimate inputs for a weeding operation by simultaneously considering several variables. A regression formula was developed with five independent variables. The cost of compiling enough data to make such an approach statistically sound seems almost prohibitive, and in addition, five variables do not begin to take account of all the possibilities. The case study approach again seems to be most desirable as a first step in accumulating adequate data.

Forest Treatments — Girdling

Rule of Thumb There are only a few data available for estimating girdling inputs. A simple rule of thumb states that girdling takes from 2 to 4 man-hours per acre. This assumes axe methods and treating 20 to 40 cull trees per acre.

The size of the trees being girdled, their proximity, and the ease of getting around in the stand all affect girdling time. Records were found for several commercial girdling operations, using axe methods, that killed cull hardwoods from 6 to 30 inches in diameter. The average times were from 3 to 8 minutes per tree, including walking time, when about 20 to 40 trees were girdled per acre.

One farm woodlot study of girdling 12-inch hardwoods showed 5 minutes actual girdling time per tree and 3 minutes walking time to the next tree. Baldwin (6) found the following average times required to girdle a 22-inch hardwood:

Method of Girdling	*Minutes Per Tree*
Notching	3.9
Peeling	4.2
Hacking	1.2

Poisoning Howard reports on experience in poisoning northern hardwood with sodium arsenite on the Pocono Experimental Forest. A total of 5951 trees were poisoned, and over 90 percent of these were between 8 and 10 inches in diameter. The timber stood on a 105-acre tract; 14.4 acres were to be clear-cut and the remainder of the area was marked for cutting on a selection basis. The poisoning was done in the summer by a two- to four-man crew of young, inexperienced men. One experienced woodsman worked with the crew as supervisor. Some generalized data concerning this operation were:

Trees girdled and poisoned per man-hour	11–14
100 cu. ft. of wood volume poisoned per gallon of sodium arsenite (Atlas A.)	17–41

A great deal of information is currently accumulating on chemical poisoning and weeding methods. Many of these data can be found in the Journal of Forestry, Proceedings of the Northeastern Weed Control Conference or in the house organs of the various chemical companies.

Forest Aids and Improvements

Marking A rule of thumb often heard is that a man can mark for cutting on a selection basis about 50 M.b.f. of standing sawtimber per day, using a paint gun. The range is from 15 M.b.f. to 100 M.b.f. per day, depending chiefly on tree size, species, volumes per acre, and the difficulties of getting around in the stand. One forester gave a rule of 10 cords per man-hour for marking spruce pulpwood. Nickerson (83) reports on pulpwood marking costs in New Brunswick.

Other Operations Road construction and numerous other operations have received some consideration from an input-output standpoint. Bennett (12) presents some data on inputs for woods road construction in Pennsylvania. Mulloy (80) reports on the direct costs of brush burning in Canada. As a generalization, however, there are very few data available on the inputs and outputs of operations of this type, although they are often needed in forest management.

No attempt has been made to include in this chapter a comprehensive survey of all the data available on work performance rates for every forest job and operation. Instead a few illustrations have been presented of the more important short-run relationships available from New England information. This has been done with the hope that some of the weaknesses and gaps in these data are now more apparent. It is also hoped that people needing such data in their work will be able to use the information presented and some of the references.

Research Problems

Estimates to compare the level of inputs under alternative forest management intensities on each of the nine farms were based on the rules of thumb and labor input curves just discussed. However, these data are not completely adequate for budgeting. It is always necessary to make adjustments to allow for the peculiarities of each operating unit, but arbitrary adjustments may lead to inconsistent and unrealistic results. Two general lines of research promise more ample work performance data.

Case Studies The commercial and experimental forest operations done each year are one fruitful source of information. The input and output experienced on many of these operations could be assembled into a case book if comparable records were kept. A significant number of case histories could be gotten in a relatively short time because so many kinds of forest operations, using various work methods, are done each year. Relatively simple records could be kept, at least at the start, so that with very little effort many forest owners and operators could cooperate in keeping case histories.

The usefulness of a case book on experience will depend on having comparable records that include careful notes on the major factors that affect work performance rates. A simple form such as that illustrated might be used, although the exact items to be enumerated could only be decided after giving the matter careful study. As case histories accumulate they could be divided into groups with similar input-output ratios and operating situations. New cases could be collected continuously to reflect changing technology, and although the forms might have to be revised from time to time, every effort should be made to keep them reasonably comparable over time.

SAMPLE FORM FOR RECORDING A CASE STUDY IN WORK PERFORMANCE RATES

Date: January 22–27, 1952.

Location: Chadwick Farm, Colebrook, N. H.

Kind of Operation: Cutting 4-foot rough pulpwood and piling it at the road. Cut spruce 8″ d.b.h. and above; fir 6″ d.b.h. and above. Cutting area about 60 feet wide by 400 feet long. A sled road was swamped along the middle of the strip. One man worked alone using axe and bow saw.

Operating Conditions: Gentle NW slope; stone-free; 6″ of snow on the ground; fair weather with only one day cold enough to interfere with work.

Stand Conditions: Uniform, 40–60 year old spruce-fir stand with scattered over story of residual hard maple and yellow birch. 30 cords of softwood per acre, of which 20 cords were cut.
Spruce: 3″–12″ d.b.h.; av. 9″; av. cut 10″; 75 trees per acre.
Fir: 3″–12″ d.b.h.; av. 10″; av. cut 9″; 80 trees per acre.
Hardwood: 12″–28″ d.b.h.; av. 20″; none cut; 20 trees per acre.

Unusual Delays: 4 man-hours lost because of broken axe.

Labor: 35-year-old experienced woodsman in good health and of average physique. Paid $9.00 per stacked cord; worked a 9-hr. day, plus an average of ½ hr. for lunch, etc.

Time and Production:	Jan. 22	9 man-hours	1.2 cords	
	Jan. 23	5 " "	.7 "	Broken axe.
	Jan. 24	9 " "	1.7 "	
	Jan. 26	9 " "	1.5 "	Very cold.
	Jan. 27	9 " "	1.7 "	
	Totals	41 man-hours	6.8 cords,	or 6 man-hours per cord

Improving Operating Methods

In addition to collecting the simple case histories suggested above, a parallel research project is needed to design improved operating methods. The owners of the nine farms, for example, were not only interested in estimating inputs under alternative forest management intensities but also wanted to find the most economical operating methods, machinery and equipment to use. Frequently careful analyses, using time and motion studies, are needed of each component job in a forest operation. The most effective methods and tools for doing each job can then be worked out and new operations synthesized to take advantage of any gains in efficiency. This general approach, sometimes referred to as "scientific management" (99), has often resulted in great savings in industry and agriculture.

The work done by Koroleff for the Pulp and Paper Institute of Canada and reported in "Pulpwood Cutting: Efficiency of Technique" (66), is an example of such research probably familiar to most foresters. A great deal of work along this line has also been done in Sweden. Luthman and Lundgren report on extremely detailed investigations of how output is affected by individual workers, tools, and methods (70). Lundgren also reports on an intensive study of the physiological effects of time schedule work on lumber workers (68). The "Agricultural Work Simplification News Letter" published by Purdue University tells about dozens of research projects investigating techniques for increasing efficiency in agriculture (88). Another example of this approach is a study of dairy barn efficiency by Woodworth and Morrow (113).

A series of projects to find better methods for doing forest jobs and operations in the Northeast would be worthwhile. Engineers, foresters and economists will have to work together to improve forest operating methods and machinery and to test the efficiency of different techniques.

Presenting the Data Although a collection of case histories and specific time and motion studies will be usable as they accumulate, the final step should be to collate all these data on some regional basis and to present them in such a way that they are of maximum value as planning guides. An article entitled "What Does it Cost to Practice Forestry in the South?" by Worrell (114) includes a compilation of this kind of planning guide. He includes several tables based on reports of

SAMPLE FORM

TIME REQUIRED TO PRODUCE A CORD OF 4-FOOT ROUGH PULPWOOD BY CLEAR CUTTING SPRUCE-FIR STANDS ON FARM WOODLOT OPERATIONS[1]

	Stand per Acre								
Av. D.b.h.	10 Cords			20 Cords			30 Cords		
of Trees Cut	*Good Time*	*Av. Time*	*Poor Time*	*Good Time*	*Av. Time*	*Poor Time*	*Good Time*	*Av. Time*	*Poor Time*
	MAN-HOURS PER CORD								
4"									
6"									
8"									
10"									
12"									
14"									
16"									

[1] These figures are for level to gently sloping terrain that causes no special delay in operation. Abnormal weather delays are not included. These figures are based on clear-cutting by strips and swamping a sled road. A 1-man crew of hired labor was used and paid a fixed rate for each cord piled at the sled road. Axe and bow saw were used.

actual commercial operations in the area, showing the mean inputs and the range of inputs required.

The preceding table shows, as an example, a summary form that work performance data about farm pulpwood operations in the spruce-fir region might take. Other factors than the ones noted might have a more important effect on performance rates; these major headings are used merely as illustrations. Similar tables, and other methods of presentation, could be worked out to summarize data on each kind of forest operation done under typical circumstances. The tables could be revised every few years in order to keep up with changing operating methods. Any summary material should also be accompanied by enough case histories to represent the range of results experienced in the field.

Chapter VII

SUMMARY AND CONCLUSIONS

A brief summary of a few major points may be useful in view of the wide range of subject matter that has been covered. At the root of this whole study is the thought that change is a dominant characteristic of the farm and forest economy of the Northeast. Landowners will always have to adjust their operations and tinker-up their businesses in the light of wars, depressions, changes in production and consumption patterns, shifting cost-price relationships and their own varying objectives of management.

Plans Necessary It is probably easier to run the day-to-day operations of a farm or forest than it is to devise a consistent and integrated plan for the development of a property when both technology and the economic situation change rapidly. Yet without a plan of some kind an owner will just drift and will have no control over future events. Of course, even with a plan he does not have complete control, but he can at least take some of the guesswork out of management and base more of his decisions on informed estimates and less on instinctive reactions.

The forest production analyses in this bulletin have been based on three simple facts. The first is that forest land, especially that in farm woodlots, is not managed in a vacuum. Woodlands are usually only part of a larger operating unit, and any proposed management adjustments must take this into account.

The second fact is that practically all forest production problems have several possible solutions. An owner is ordinarily able to use a wide variety of silvicultural programs and forest management practices on his land. Fortunately, for planning purposes the number of currently feasible alternatives is usually limited by outside conditions, previous commitments, and the like.

The last and perhaps most important fact is that usually the owner is the person best equipped to work out, evaluate and choose among alternative farm and forest operating plans, provided he has the right kind of technical assistance. If technicians work with a forest owner rather than plan for him, the operator is more likely to make well-informed decisions and put them into effect on the ground.

Although there are many tough technical problems inherent in this approach, foresters and other technicians are relieved of the far more difficult job of deciding what an owner should do. The whole philosophy of this approach to forest and farm problems was summed up recently by Dr. J. D. Black at the Harvard Conference on Forest Production. After a long discussion of various forest management programs that could be used in the Northeast, a forester asked Dr. Black, "Which would you advise an owner to use?" The answer was, "I never tell an owner what he should do; I like to help an owner lay out his alternatives and evaluate them, and then let him decide what he wants to do."

Operating Unit Budget Analyses The basic concept of budgeting the alternatives in a forest enterprise as a part of a total operating unit is the central theme of this study. The mental attitude suggested by the theme is much more crucial to successful planning than is any set of analytical techniques and data. Once the general idea is grasped, many ways can be devised to implement it. In our work on over 250 farms we have used several kinds of data to analyze alternatives in a variety of ways best suited to the problems at hand.

Integrated Adjustments We have used the budget method to make fairly elaborate evaluations of the economic opportunities for improved management on nine forest and farm operating units in the fringe agricultural areas of New England. Because all of these farms were in areas where farming had been largely abandoned, forest land made up a high proportion of the operating unit resources. Woodland income opportunities were correspondingly important. It was particularly desirable to use farm labor, equipment and management profitably in the woods during part of the year, and at the same time to maintain or improve agricultural efficiency.

Alternative management plans were analyzed on the basis of the physical and managerial resources of each unit, the input-output relationships that could be expected to prevail, and reasonable price and market conditons. The probable cash receipts and expenses were shown in an annual operating statement, and the difficulties and advantages of each plan were enumerated. After taking part in this planning process and considering the final figures, the owner chose the most advantageous plan in light of his preferences and objectives.

Management Opportunities A study of these nine farms gave valuable insights into farm and forest production possibilities in the "fringe areas," although the sample was inadequate for any final conclusions. Production was estimated under three levels of forest management intensity. It was found that a high intensity eventually would lead to sales at a level about two and one-half times as high as that maintained under a low intensity. Under medium intensity, sales eventually could be maintained about fifty percent higher than under low intensity. These higher production rates, however, would not be reached until after about forty years of medium or high intensity management had built up the growing stock. During the next decade or so annual sales under any plan would be low because of the preponderance of young stands; and sales under medium management would be least of all.

Despite greater yields it would not under all circumstances pay these owners to adopt high intensity forest management. Before this kind of management is feasible there have to be markets for all sorts of forest products, including the low-grade timber that often results from thinnings and improvement cuttings. The long-term market and price outlook for high-quality timber must also be favorable before most owners will seriously consider adopting long-range plans for intensive management. In addition, adequate woods labor must be available locally or on the farm, and forest taxes should not be too burdensome.

Income Possibilities Four of the farms had small agricultural enterprises and relatively large woodland areas. These owners could better than double their present net farm incomes by adopting the proposed plans. Whereas only about 20 percent of their gross receipts now comes from the sale of forest products, about 40 percent of gross receipts would come from the woodlands under the proposed plans.

The rest of the farms had larger agricultural resources and could also double their net incomes under the proposed plans. However, net returns tended to be much higher than those of the first group of farms, and a far larger proportion of their proposed gross receipts would come from farming rather than from forestry. Nonetheless, the relative contribution of the forest enterprise to farm income would be increased from less than 10 percent at present to over 25 percent during the first decade under the proposed plans.

Owner's Objectives The nine farm analyses show that the owner's objectives and capabilities are often deciding factors that determine what kind of forest management is most desirable. An interest in forest production and a relatively high value placed on future as well as immediate profits are essential if high intensity management is to appear attractive. In addition to profit from production, building up the value of the farm is often a major objective. Intangible values and satisfactions may also influence forest management.

Assistance and Credit These nine farms show that more productive forest management holds considerable promise of improving the returns of farms in the "fringe areas." If these possibilities are to be widely realized, forest owners will need technical help in planning integrated farm and forest adjustments and in applying any proposed plans of operation. There will also be a need for agricultural credit to reorganize and expand farm business, together with adequate long-term forest credit to help maintain a fair standard of living while growing stock is improved.

Input-Output Data Forest input-output data detail the physical and biological relationships of forest production. This technical information is the basis for practically all economic evaluations of alternative forest management proposals, and data in this form are especially needed for budgetary analysis.

Our main suggestion in this connection is that the establishment, growth and harvest of successive crops of trees be viewed as a single process of forest production. For research purposes it is useful to break this process down into two distinct though intimately related fields of knowledge — long-run forest management-yield relationships and short-run forest work performance rates.

The problems of estimating forest yields and work performance rates are different. The first is primarily a biological problem concerned with long-run growth and yield under various management programs, while the second is primarily a short-run engineering problem concerned with the use of labor and machines to carry out the forest practices that make up a management program. These basic differences should be clearly recognized and reflected in research.

Available Information Forest input-output data now available for New England have been reviewed and found in many respects inadequate for budget analysis. Gaps and deficiencies in this information suggest needed research to provide better data for the future. We have placed heavy emphasis on the role that case histories can play in providing adequate input-output data on both forest yields and work performance rates.

But forest input-output data are not ends in themselves. They make up the technical foundation on which analyses of forest production opportunities can be built. The chief reason for studying these relationships is to achieve a more desirable use of forest resources.

Planning Data Equally fundamental to budget analyses are the other "planning data" needed to evaluate possible courses of action; these include information on market outlook, laws and institutions affecting forest use, credit sources and interest charges, and the prices of goods and services bought and sold in the operation of a forest business.

Management Alternatives One of the most difficult and challenging research problems is to merge all of these planning data into analyses of production opportunities in forestry. The principal concern in this work is to help forest owners and policy makers evaluate alternatives on the basis of the best information available so that rational management decisions can be made.

Economic Problems There are many facets of this problem that await investigation. Operating units that can take the best advantage of technical possibilities will have to be found; and sometimes especially created. Research methods and procedures for evaluating alternatives should be adapted for general use to help owners make rational management decisions. Public policy makers need analyses showing how they can help create an environment more favorable to the kinds of forest management that are desirable from the public standpoint.

Studies similar to the farm analyses reported here should be made of a great many other operating units combining forest and various other enterprises. Financial opportunities through the management of various-sized forest enterprises should also be investigated; economies of scale are usually presumed to be great in forest production, but there is as yet little analytical evidence to support this. The degree of integration that is possible and desirable between forest production and the processing of forest products should also receive research attention.

Where feasible, economic research should deal with actual operating units like the nine fringe area farms. However, when studying the possibilities of establishing new units of various kinds and sizes it will often be necessary to construct synthetic forest operating units. These models should be based on actual forest and land-use situations in a specific area so that they may be as realistic as possible. Individual operating unit analyses are the first step toward widely applicable generalizations.

Pilot Operations It is not enough merely to analyze forest management alternatives. Proposed operating plans should be tested through continuing pilot operations on actual units. It may sometimes be necessary to subsidize these operations and to provide considerable guidance and direction in the early phases of getting new units established and new management plans put into effect. But records that are kept of such pilot operations will prove invaluable to an understanding of the economics of forest production.

A Research Program In conclusion, a broad forest production research program is suggested for the Northeast. First, a project is proposed to develop better input-output data. Second, a parallel project should be set up to develop price and market outlook and other planning data needed to analyze forest management alternatives. Concurrently a third, and perhaps most important, project should be directed at finding and testing various plans for managing forest operating units, using the best data that can be improvised at the moment.

There are two considerations in forest research that are so important that they subordinate all others. One is to keep in touch with biological and technical reality. The other is to use imagination in investigating production opportunities. If these are constantly kept in mind and acted upon, future progress should be rapid.

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