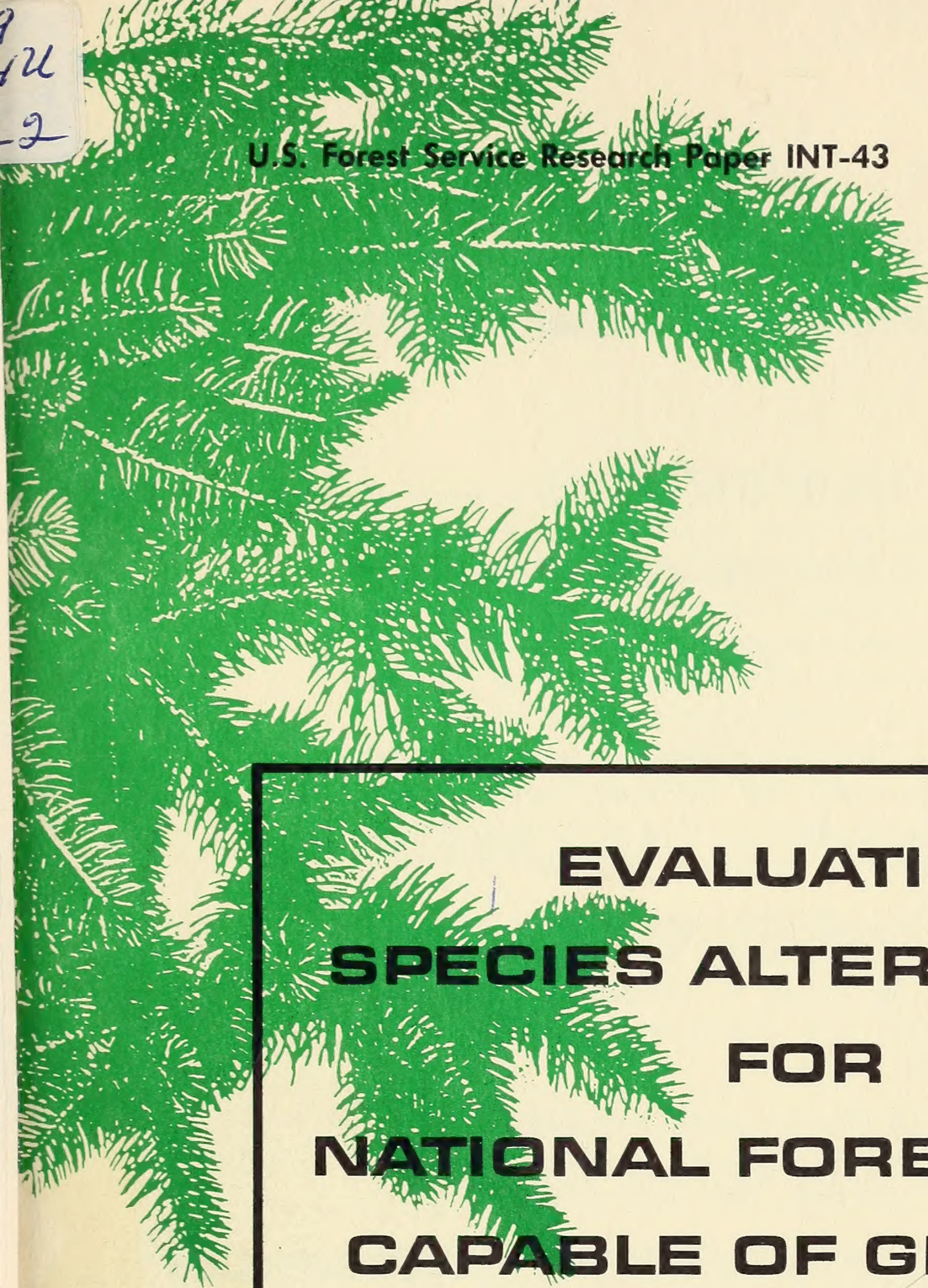


U.S. Forest Service Research Paper INT-43 1967

EVALUATING SPECIES ALTERNATIVES FOR NATIONAL FOREST LAND CAPABLE OF GROWING WESTERN WHITE PINE

by

Alan W. Green and Jack R. Alley

INTERMOUNTAIN FOREST AND RANGE EXPERIMENT STATION
Ogden, Utah

This Research Paper is one of a series of publications by the Intermountain Forest and Range Experiment Station. The series reports results of a study started in 1962 to evaluate management alternatives on lands capable of growing white pine within National Forests in eastern Washington, northern Idaho, and western Montana. The study was done in cooperation with the Northern Region of the U.S. Forest Service. The series of publications includes the following items:

Relations between western white pine site index and tree height of several associated species, by Glenn H. Deitschman and Alan W. Green. U.S. Forest Serv. Res. Pap. INT-22, 1965.

Market trends for western white pine, by Robert E. Benson and Larry L. Kirkwold. U.S. Forest Serv. Res. Note INT-65, 1967.

Cost control in timber growing on the National Forests of the Northern Region, by J. H. Wikstrom and J. R. Alley. U.S. Forest Serv. Res. Pap. INT-42, 1967.

Ranking of treatment opportunities in existing timber stands on white pine land in the Northern Region, by J. H. Wikstrom and Jack R. Alley. U.S. Forest Serv. Res. Pap. 46. (In preparation)

U.S. Forest Service Research Paper INT-43 1967

EVALUATING SPECIES ALTERNATIVES FOR NATIONAL FOREST LAND CAPABLE OF GROWING WESTERN WHITE PINE

by
Alan W. Green and Jack R. Alley

INTERMOUNTAIN FOREST AND RANGE EXPERIMENT STATION
Forest Service
U.S. Department of Agriculture
Ogden, Utah 84401
Joseph F. Pechanec, Director

THE AUTHORS

ALAN W. GREEN joined the U.S. Forest Service in 1955 as a Research Forester in silviculture and regeneration at the Central States Station office in Carbondale, Illinois. Three years later he was transferred to Iowa, where he was Superintendent of the Amana Experimental Forest. In 1961 he was reassigned to Foreign Forestry Services in the Washington Office. In 1964 he joined the Timber Production Economics project at Intermountain Station in Ogden. He holds both bachelor and master of science degrees in forestry from Purdue University.

JACK R. ALLEY is Chief of the Branch of Timber Management Planning in the U.S. Forest Service Regional Office in Missoula, Montana. A 1940 graduate of the University of Idaho, he joined the Forest Service in 1946. His career has included assignments as Assistant Ranger and District Ranger on the Colville, Flathead, Nezperce, and Clearwater National Forests. In 1958 he joined the valuation section of the Timber Management Branch in Missoula, and he later served the Regional Office in Ogden in a similar capacity. Until 1966 he was a special cooperator with the Intermountain Forest and Range Experiment Station in a study of the management of white pine lands in the Northern Rocky Mountains.

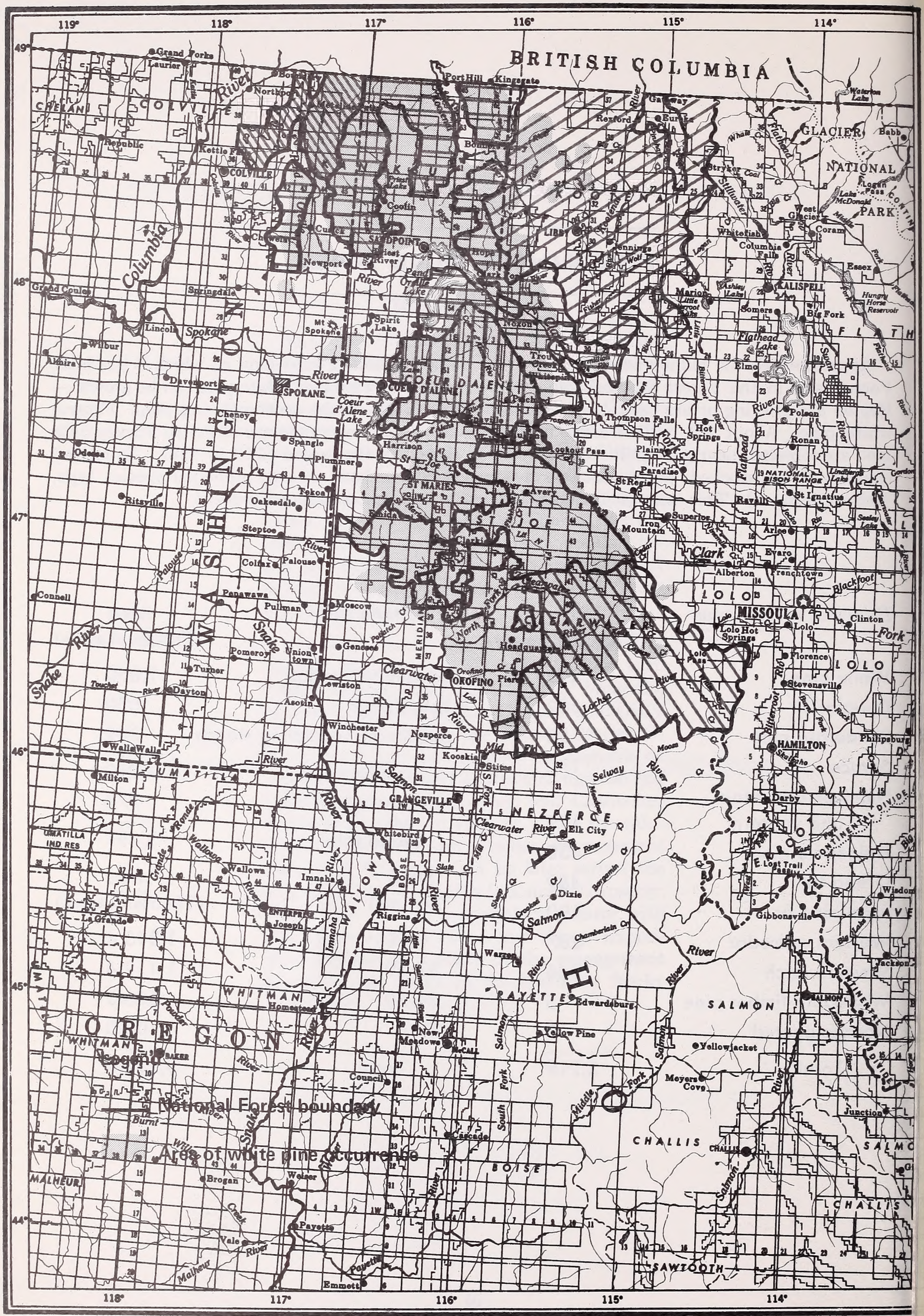
THE WHITE PINE AREA

Approximately 3.5 million acres of National Forest land in the Forest Service's Northern Region are growing or are capable of growing white pine. About 3.2 million acres of this land are forested; nearly 0.3 million acres were considered nonstocked when last surveyed (see appendix A). This estimate includes only the National Forest land on which it has been demonstrated that white pine can be grown — as shown in the accompanying map. Figures are based on a summary of Forest Survey data covering the period 1958 to 1962. Tabulated below is land area by principal species type, stand size, and slope percent.

Principal species type	*Area* (Thousand acres)
White pine	428
Douglas-fir	602
Ponderosa pine	98
Spruce	150
Hemlock (mountain and western)	179
Lodgepole pine	438
Grand fir	489
Subalpine fir	190
Western redcedar	287
Western larch	346
Whitebark-limber pine	5
Nondesignated	7
Total	3,219

Stand size	*Area* (Thousand acres)
Sawtimber stands	1,850
Pole stands	620
Seedling and sapling stands	749
Total forested	3,219
Nonstocked	278
Grand total	3,497

Slope (Percent)	*Area* (Thousand acres)
0-30	1,393.4
31-50	1,119.4
51-70	606.0
70+	100.0
Total	3,218.8



White pine zone in Northern Region

CONTENTS

THE WHITE PINE AREA iii
FOREWORD vi
INTRODUCTION 1
DETERMINING PRACTICAL SPECIES ALTERNATIVES 2
Site Suitability 2
Factors of Risk 4
ESTIMATING COSTS OF STAND ESTABLISHMENT 6
Variable Costs 6
Costs and Management Alternatives 6
ESTIMATING COMPARATIVE YIELDS AND VALUES 9
Yields 9
Values 9
MAKING ECONOMIC EVALUATIONS 11
MECHANICS OF AN EVALUATION – AN EXAMPLE 12
Preliminary Selection of Species 12
Preliminary Estimates 13
Evaluation Summary and Computer Analysis 14
SUMMARY 20
APPENDIX A: WHITE PINE LAND AREA SUMMARIES FOR NATIONAL FOREST LAND IN THE NORTHERN REGION 21
APPENDIX B: INVESTMENT ANALYSIS PROGRAMS 27

FOREWORD

The cutting of old timber stands presents management with a continuing problem — which species should be established to bring the land back into timber production? Frequently the choice of species or species mixtures to feature lies among many desirable species, such as those that grow together in the white pine zone on the National Forests of the Northern Rocky Mountain area.

In the past, choosing a species to feature in this region was relatively simple. White pine was an obvious choice on many areas because it produced large volumes of high quality wood per acre, could be regenerated naturally with relative ease, and could be sold at a higher price than its associated species. In recent years, however, production of white pine has suffered from increasingly heavy losses from blister rust *(Cronartium ribicola)* in young stands and from both rust and bark beetles in mature stands.

Recent surveys show that the best efforts made toward blister rust protection have been inadequate. An average of 48 percent of the white pine trees in stands less than 20 years old are lethally infected and there is a relatively constant infection rate of 1 to 2 percent per year. The heavy mortality and growth loss associated with blister rust, as well as the uncertainty of success attending efforts to protect white pine from the disease by either prevention or control, lead to only one conclusion: white pine must be eliminated from the regeneration plans of the Northern Region until such time as effective control measures are developed or disease-resistant stock that compares favorably with other species in terms of growth and cost of regeneration is available.

During the interim period, good utilization of these lands for timber production requires that managers choose from among the alternative species available those that seem likely to return the greatest net value yield per acre in view of the costs, yields, and risk of loss expected.

INTRODUCTION

The management of any operation requires frequent evaluation of alternative courses of action. Such evaluation defines a goal or objective and selects the best available method of achieving it. From all possible actions the manager sorts out those that are feasible in his situation and ranks or grades them for efficiency in terms of time and money. In this process a specific goal must be defined, since without it no real alternatives exist to be evaluated.

Forestry is an integrated operations business in which many kinds of activities are required for the production of a merchantable stand of trees. The allocation of an entire budget for timber growing cannot be based on a choice between regeneration or thinning; to evaluate these two kinds of work as alternative means of spending money is meaningless. Obviously both these activities (and others) are needed for a sustained yield operation. However, it is logical to evaluate alternative means of regeneration to determine which would be most efficient, or to evaluate various thinning opportunities to determine which stands should be thinned with the money available. Some specific goal must be chosen before alternatives can be determined and evaluated as means of reaching that goal.

The efficient use of public funds is a basic requirement in public land management. Order and consistency in decision making are highly desirable so that decisions may be both biologically and economically sound.

This paper is concerned with the establishment of timber stands in lands capable of growing western white pine. Included are a discussion of the biological aspects of species selection for regenerating cutover land for the primary purpose of timber production, and a description of a method of evaluating alternative species and alternative means of stand establishment for efficient use of money for timber production.

The task of evaluation of species for stand establishment involves a series of evaluations that may overlap, depending on the conditions of an individual project. In general, the following steps are taken:

1. Determining the objective of the stand establishment project.
2. Determining the species alternatives by means of an ecological evaluation of the site.
3. Eliminating those species that are clearly impractical for reasons of high risk, low timber value, or other known disadvantages.
4. Evaluating remaining alternative species under alternative methods of treatment for
    a. probable cost of stand establishment,
    b. probable yield of stand,
    c. probable value of stand, and
    d. probable rate of return (or other criterion) under alternative investment plans.
5. Choosing the species or species mixture that offers greatest probability of achieving the objective.

The first three steps require judgments based on knowledge and experience. Step 4 requires computations based on all available data on costs, yields, and values for the various species to be evaluated. With the help of electronic data processing (EDP) equipment, such computations can be made with relative ease. All of these operations are described in some detail in this paper.

DETERMINING PRACTICAL SPECIES ALTERNATIVES

For the accomplishment of any given objective, the theoretical alternatives always outnumber the real or practical ones. Theoretically almost any species could be grown in the white pine lands under discussion. Most species can be eliminated, however, for obvious economic or biological reasons. The purpose of regenerating stands for timber production is to produce a high yield of merchantable wood. Therefore, the first task in evaluation is to make a realistic selection of species that seem likely to meet this timber growing goal.

The primary factors to be considered in choosing a species or species mixture to regenerate for timber production are the suitability of the site for different species, and the risk of loss associated with each species during the timber growing rotation. Other factors, such as timber quality of the species and special treatment requirements, also enter into the management decision.

Site Suitability

Habitat Type

The suitability of a particular site for certain species may be judged on the basis of the habitat type. This classification describes an area according to the climax association of species that is expected to occupy the area generally in the course of natural plant succession. Thus it provides a useful basis for (1) classifying the ecological character of a forest site and (2) describing (to a certain degree) the relative biotic productive potential of a given site for each species. This is especially true in the absence of more definitive data with which fo estimate the comparative productivity of various species for different sites.

Essentially, foresters are either accelerating or delaying natural succession of vegetation with silvicultural practices designed to improve the forest crop. Because the habitat type classification identifies the probable plant succession, it is a useful indication of the species that should be seriously considered for regeneration on a specific site. Determining the habitat type is not simple, but it is an essential part of the timber manager's job. With training, he can identify the ecological indicator plants growing in association with major tree species, and can relate topographic and physiographic site conditions to the habitat so as to reach a reliable conclusion.

Species Associated With Western White Pine

Western white pine occurs in several habitat types. It grows in association with a large number of species and in a variety of plant associations. It occurs only as a seral (successional) species, however, and is eventually replaced by more tolerant climax species.

The range of environmental conditions over which tree species occur is determined primarily by moisture and temperature. The range of one species may overlap the range of another; to the extent of this overlap, the two species may be grown together. Figure 1 shows the relative range of conditions under which white pine and its associate species will grow. The two dashed lines mark the limits of the habitat condition range of white pine. Other species whose ranges fall at least partially within these lines could be associate species on a given area. The habitat condition range of any other species could be marked on the diagram to show associate species.

The diagram indicates that at lower elevations, where the habitat is dry, ponderosa pine occupies most of the forested area. Farther up the slope, the habitat becomes cooler and generally more moist, and Douglas-fir begins to mix with the ponderosa pine. Still farther

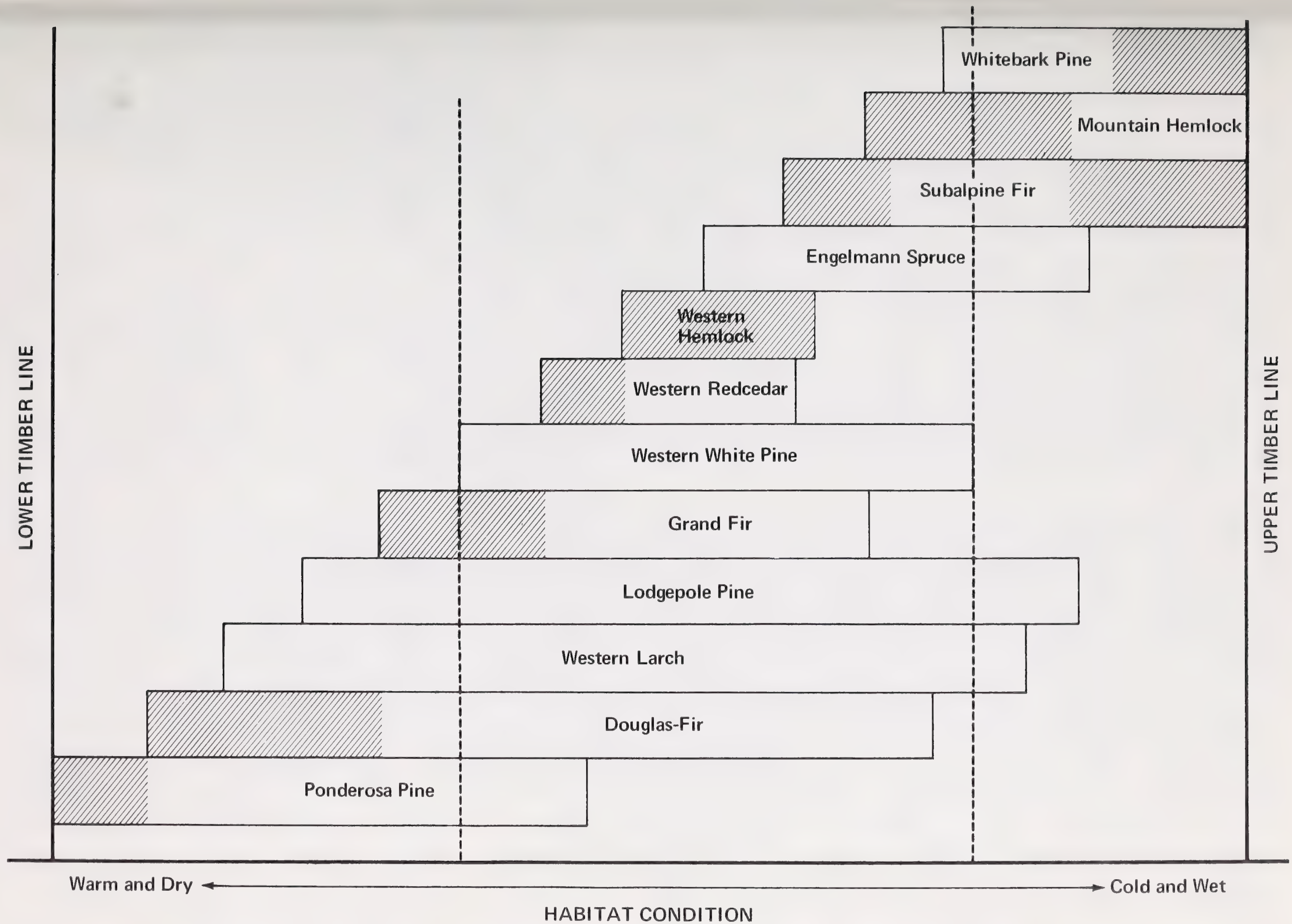


Figure 1.—Relative ecological position and extent of occurrence of major species in the Northern Rocky Mountains. Crosshatching in species bar indicates relative range of occurrence in which species is climax. Dashed lines indicate the range of white pine occurrence. (Adapted from R. Daubenmire, see footnote 1.)

up the slope, under more cool and more moist conditions, other species begin to appear. As elevation increases, ponderosa pine is no longer present; then other species disappear while new ones appear. This process continues up to the timberline.

The diagram is a simplification, and shows only the effects of changes in elevation on the moisture-temperature regimes of the habitat situation. Other site features, such as topography, aspect, vegetative cover, and soil characteristics, also affect the habitat condition, and thus the range of individual species. For example, the difference between south and north slopes can have an effect equivalent to a difference in elevation. The combined features of the environment provide some habitat condition to which each species is adapted to some degree.

Also shown relatively in figure 1 is the range of conditions under which a species occurs as a climax species; that is, the range in which it can perpetuate itself in competition with other species native to the site. The crosshatching on each species bar shows the extent to which that species is climax. White pine, larch, lodgepole pine, and Engelmann spruce are strictly successional species.[1] The other species can become climax in certain situations and over sufficient length of time. However, the important timber species are seral over most of their natural range (table 1).

Factors of Risk

The species that can be grown on white pine lands may be determined from the chart (fig. 1) and table 1. For some of these species, however, the element of risk may be great enough to eliminate the species from consideration. A degree of risk in growing any species is a biological fact of life in forestry, but risk varies widely. Volume losses from

[1]*Engelmann spruce may become climax, but only in the Engelmann spruce-subalpine fir-grouse whortleberry (huckleberry) habitat type, which Daubenmire feels is uncommon and peripheral in the Northern Region, since he found only four isolated occurrences in northeast Washington and north Idaho. (R. Daubenmire. Vegetation: Identification of typal communities. Science 151 (3708): 291-298. 1966.)*

Table 1.—**The distribution and ecological role of the major species by important tree union**[1]

(Key: s, minor seral role; S, major seral role; c, minor climax role; C, major climax role.)

Major Species	Climax tree union					
	Ponderosa pine	Douglas-fir	Grand fir	Spruce-fir	Cedar	Hemlock
White pine	—	—	s	S	S	S
Subalpine fir	—	—	—	C	—	s
Engelmann spruce	—	—	—	S,c	—	s
Western hemlock	—	—	—	—	—	C
Mountain hemlock	—	—	—	—	—	C
Western redcedar	—	—	—	—	C	S
Whitebark pine	—	—	—	S	—	—
Lodgepole pine	—	S	S	S	S	S
Grand fir	—	—	C	S	S	S
Western larch	—	S,s	S	S,s	S	S
Douglas-fir	—	C	S	S,s	S	S
Ponderosa pine	C	S	S	—	s	s

[1]*Adapted from Daubenmire, R. F., Classification of conifer forests in eastern Washington and northern Idaho. Northwest Sci. 27:17-24, 1953.*

insects, diseases, fires, and storms range from small percentages of potential production to total wipeout of individual stands. Certain species are more susceptible to fire and storm damage, and to attack by insects or disease. Some respond more dramatically than others to such injuries. The threat of the unknown, especially in view of past insect and disease problems, injects into the problem of species selection more speculation than is comfortable for the land manager. However, some estimate of risk is a necessary part of the species evaluation, even if it must be based on judgment rather than measurement.

For individual stands, catastrophic losses from fires and storms cannot be predicted. Insect and disease attacks cannot ordinarily be predicted with the surety desired. For large areas, however, risk is usually assigned a value in terms of a discount applied to the gross volume yield normally expected from stands of certain species. The greater the discount applied to gross yield, the less attractive the species or species mixture may be for a timber production program. However, the comparative importance of the risk factor is apparent only in the net volume yield estimate. A stand of one species discounted 15 percent may produce more net volume than another species discounted only 10 percent.

It is obvious that the present risk in growing white pine is too high. The volume yields expected from stands established during the past 25 years will probably have to be discounted 75 percent or more because of mortality and growth losses from blister rust and bark beetles. Other species could be similarly devastated. Blister rust and bark beetles are the current sources of extreme risk, but other serious pest problems are evident.

Dwarfmistletoe probably ranks next to blister rust as a source of growth loss, chiefly affecting lodgepole and ponderosa pine, Douglas-fir, and western larch. Casebearer damage on western larch has become serious during the past few years. Larch stands are expected to suffer annual defoliation for at least the next decade and perhaps for two decades before the casebearer can be effectively controlled by natural means. The real effects of such defoliation are unknown, of course, but a substantial reduction in growth and perhaps some mortality are expected.

Currently insects and disease are causing loss of timber value in other species — in varying degrees depending on locality and stand conditions. Any one of these nuisances could flare into a serious setback for the species. Also, the threat of another imported disease reminiscent of blister rust or chestnut blight always exists.

Risks are important considerations in timber growing decisions, but there is no reason to assume timber growing will cease because of the risks involved. Land managers must increase the biological and economic soundness of their timber growing projects by carefully considering predictable volume losses and by using the best means available for reducing the amount of unknown risk that confronts them in their evaluations. Risk and expected losses must be reevaluated as a matter of course through the life of the stand, because the sources and degree of risk associated with an individual stand change with time and advances in technology.

Good insurance against the risks associated with a single species is to forgo monoculture forestry and concentrate on stands of mixed compatible species. When choosing the species mixture, the manager must consider the degree of risk (expected loss) associated with each alternative species and make some judgment as to which combination will give the best results relative to the expected costs. Also he should recognize that mixed stands are more difficult to manage than single-species stands.

ESTIMATING COST OF STAND ESTABLISHMENT

When the possible species alternatives have been reduced by eliminating those that do not seem likely to achieve the desired objectives, economic evaluations should be made to determine which of the remaining species are most promising. First, an estimate of costs of stand establishment must be made for each species and for each management alternative that applies.

Variable Costs

Various individual costs will enter into the estimate. This report is concerned only with variable costs. Fixed costs, primarily those associated with land administration and fire protection, can be assumed to be fairly constant regardless of species.

The variable costs for timber growing in the Northern Region are broadly classified under the following activities:[2]

Regeneration: Site preparation, planting, seeding
Stocking control: Precommercial thinning
Quality control: Pruning
Protection: Insect, disease, and animal control

The management alternatives for a particular species in any given situation may range from no treatment to any combination of treatments. Volume yields can be manipulated to some degree by cultural treatments. The kind, extent, and timing of such treatments greatly affect the costs of growing timber.

In estimating costs, we may be concerned with (1) the general or average level of cost associated with the type of work required by the treatment; (2) the range of costs applicable to a particular job; and (3) the variation in cost due to variation in the conditions under which work is done. Average level costs and range of costs, such as those shown in table 2, are useful only as guides in project planning. Variations must be estimated as far as possible.

Timber growing costs on specific projects vary widely depending on size of area, topography, and amount of work required (as determined, for example, by type of site preparation needed or number of trees planted). Even the cost of site preparation by itself varies. If fuels are adequate, site preparation may be accomplished by the fire that is designed primarily to reduce hazard. If fuels are light, it may be necessary to use some form of mechanical treatment, which is more costly.

At the present time, the Northern Region estimates the average costs for regeneration establishment to range from a low of $2 to $3 per acre to well over $100 per acre, depending on the species established, site preparation needs, and regeneration methods.

Costs and Management Alternatives

When there are several species alternatives, the cost of the regeneration project is influenced by the choice of the silvicultural system used to harvest the existing stand and to regenerate a new stand. Species vary in their silvicultural requirements and the land manager must choose a system compatible with

[2] *The allocation of costs for these activities may vary. For example, site preparation does not include slash disposal for hazard reduction, which customarily is charged against the crop just harvested. Only the cost incurred as a result of the decision to utilize the land to grow more trees should be charged against the future crop. In some instances site preparation can be fully accomplished in the course of hazard reduction; in such cases the cost of site preparation is zero. When slashing of the residual stand is necessary to provide enough fuel to achieve adequate site preparation, felling costs are charged against the future crop. Any increase in burning costs caused by slashing the residual stand must also be charged to the future crop. Note also that some degree of stocking control is achieved through control of planting density.*

the species to be grown and the condition of the stand to be harvested. Careful consideration of all feasible systems is important in a cost evaluation.

For example, it is known that small clearcuts involve comparatively higher regeneration expenses than larger clearcuts do. The cost of site preparation for regeneration establishments varies inversely with size of area treated, up to a point. Site preparation for large blocks (40 acres and larger) is less expensive per unit area than for smaller blocks. However, portions of larger areas may need to be planted to achieve adequate stocking.

Seed tree cuts, on the other hand, can be expensive even on large areas. Scattered seed trees cost money because they represent capital tied up for a period of time. During this time they are in the high risk category because of increased likelihood of loss. The need to protect the selected seed trees also raises the costs of logging and site preparation. Finally, seed trees may be worth less money because many logging operators are reluctant to go back and pick up small volumes per acre, particularly when this must be done without damage to the newly established stand.

Regardless of what methods or techniques of stand establishment and management are used, from an investment standpoint there is a real economic advantage in delaying major management costs. This is due to the effect of time on compounding interest rates.

Consider as an illustration a choice between planting and natural regeneration with thinning. Each plan has advantages. Artificial regeneration largely eliminates the guesswork in establishing a stand. It also has the advantage of establishing a predetermined number of trees per acre. However, planting is a costly operation that is capitalized over the entire rotation. Natural regeneration, if it is prompt and adequate to establish the desired stand, is the least expensive method of growing timber over the long haul, even if the stand requires a substantial thinning in 10 to 15 years.

Consider that one stand is planted at a cost of $50 per acre and receives no additional treatment, whereas another stand is regenerated naturally for $20 per acre. On the second stand, the $30 not needed for regeneration is otherwise invested for 15 years; then it is spent for thinning. Both stands represent a total investment of $50 per acre. After 80 years, however, the $50 invested in the planted stand represents $1,152 if compounded at a nominal 4 percent per year. The $50 spent on the natural stand, however, represents only $845 after 80 years. This means that to earn

Table 2.—**Average costs and range in costs[1] for important timber growing activities, Northern Region, fiscal year 1966**

Activity	Average cost	Range in cost
	- - - - *Dollars per acre* - - - -	
Site preparation and hazard reduction:		
Prescribed burning	18	3-95
Dozer piling and scarification	43	10-165
Slashing of residual stand	20	4-57
Burning dozer piles	6	2-43
Terracing	47	16-171
Regeneration:		
Seeding	18 (est.)	
Planting	34	11-80
Stocking control[2]	30	11-139

[1]*Project level.*
[2]*Thinning only — does not include marking.*

4 percent on the $50 invested, the planted stand must be sold for $1,152 per acre; to earn 4 percent, the natural stand need be sold for only $845 per acre (fig. 2).

However, natural regeneration loses some of its economic advantage (1) if the chance for successful establishment of the desired species is uncertain, (2) if to attain it requires cutting in small blocks or leaving seed trees and waiting a considerable time for stand establishment, or (3) if species growth differentials are significant. If natural reproduction is not established in 5 years, necessity for another site preparation job is almost a certainty.

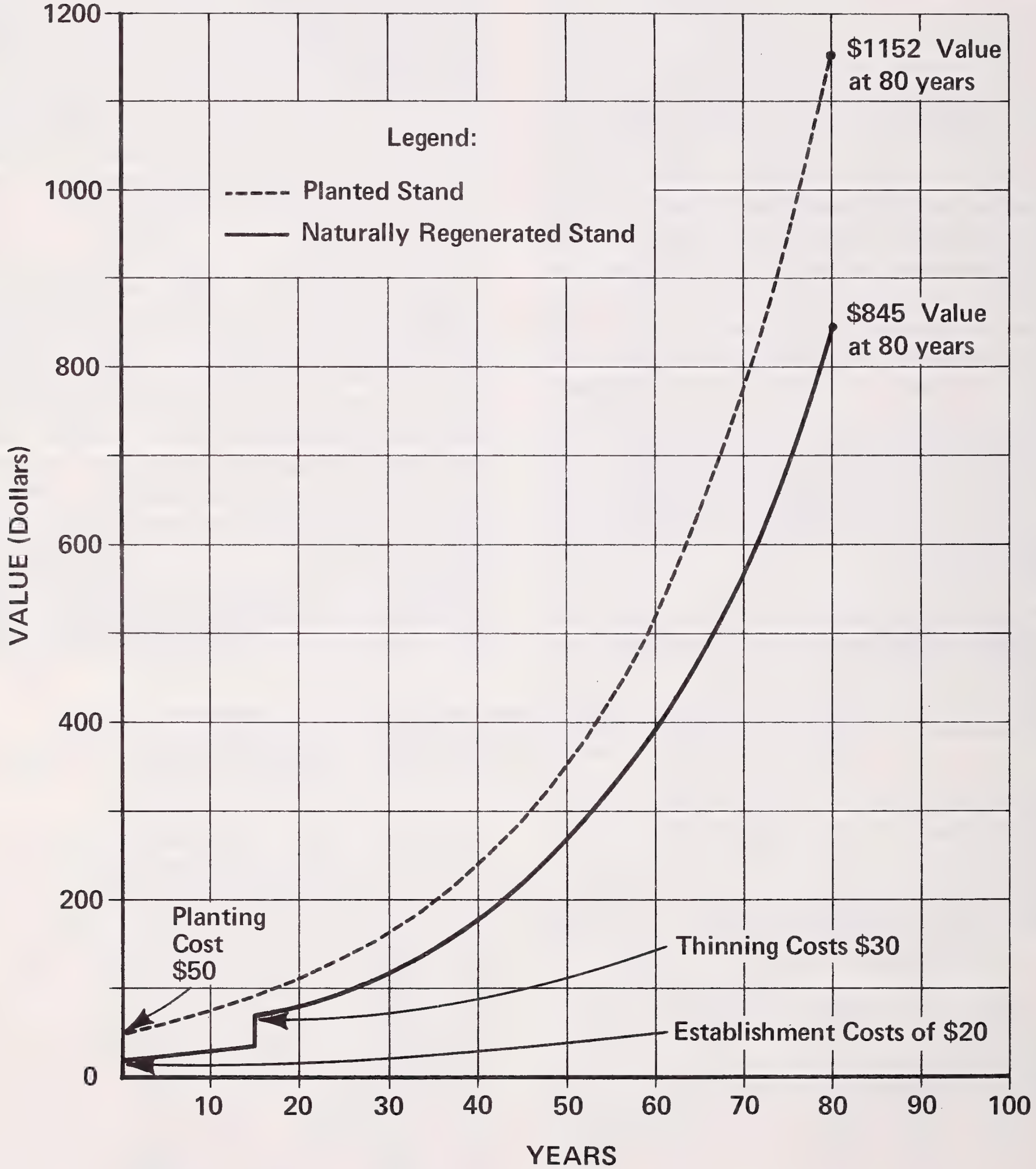


Figure 2.—The effect of time on the future value of investments.

ESTIMATING COMPARATIVE YIELDS AND VALUES

Yields

To evaluate species alternatives in terms of wood production for a given period of time, some means are needed for estimating comparative volume yields of different species for a particular site. This involves an estimate of growth potential of individual species in different site and habitat situations. At the present time, not enough reliable data are available to permit making an ideally accurate estimate. However, some approaches to yield estimates do exist and can provide a working approximation.

Site index is commonly used to indicate relative land quality for any given species. Generally, site 80 land will grow more of a given species than will site 60 land. But site index primarily reflects the capacity of the trees to attain a specified height at a given age, usually 50 years. It does not tell how much timber the site will produce in a specified time. In spite of its limitations, however, site index does afford a means of separating broad classes of land quality with which the land manager must work.

In existing yield tables for major species growing on white pine land, gross cubic-foot volumes are based on the assumption that every tree is 100 percent sound. Projecting stand growth over long periods of time requires downward adjustments for cull, mortality, and growth loss from natural causes.

Despite the uncertainty of growth and losses, a realistic look at the potential yield of any given stand will reveal that the yield can be expected to fall within some defined range. Using species yield tables, the manager can determine some probable minimum and maximum volumes, barring a catastrophic wipeout. Then, by ranking the stand for risk, the land manager may make an estimate of future yields within the probable range and define the confidence he has in the estimate.

Values

Estimates of future value yield must be based on some assumption about future stumpage prices. Presently there are differences in average net stumpage prices among major species. However, a recent study by Benson and Kirkwold[3] indicates that price differences among species have been shrinking over the past several years; the prices of formerly low-value species have been rising, while the prices of formerly high-value species have been dropping.

If this trend continues, species price differences for stands now being regenerated could become insignificant. On the other hand, these price differentials may not narrow below their present spread, or they could widen again in the future.

Although estimation of future stumpage prices is highly speculative, the land manager will have to make some price assumptions in the course of species evaluations. In doing so, he should recognize that uniformity of tree size and amount of merchantable wood per acre do influence the net stumpage values. It is generally recognized that logging and tree conversion costs vary inversely with tree size and volume per acre.

[3] *Benson, Robert E., and Larry L. Kirkwold.* Market trends for western white pine. *U.S. Forest Serv. Res. Note INT-65, 8 pp., illus., 1967.*

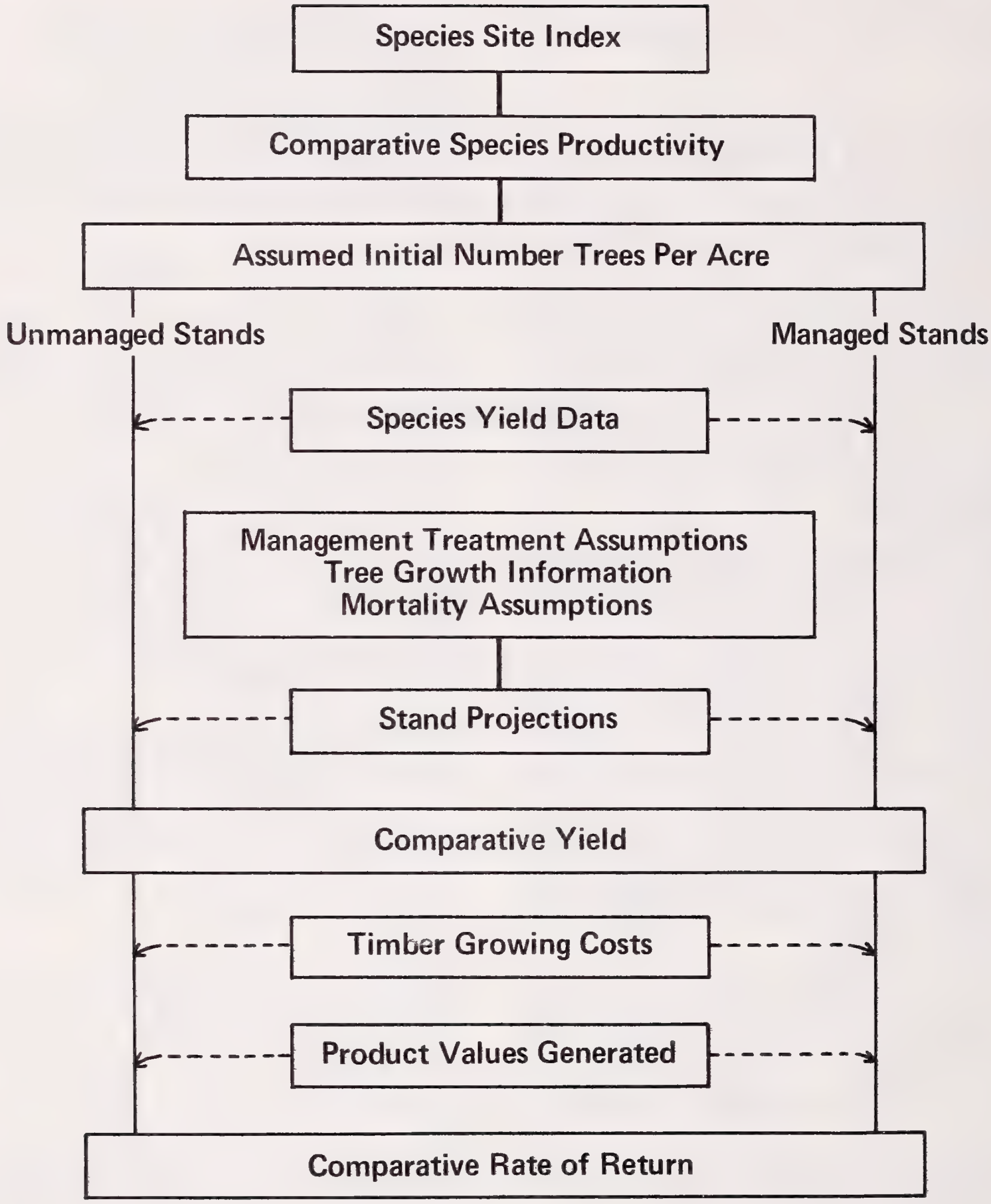


Figure 3.—A method of evaluating species alternatives for stand establishment.

MAKING ECONOMIC EVALUATIONS

Economic evaluations can be made in a variety of ways.[4] The rate of return on investment is the method most commonly used to evaluate alternative opportunities to spend money to achieve specified goals, and this is the method discussed in this paper. Rate of return considers costs, value yield, and time to indicate the rate at which value grows. This in turn indicates some rate of efficiency of money use.

Other methods of evaluation could be used. For certain projects, the least-cost approach would be appropriate. If the goal were merely to cut over a stand and regenerate a new stand of trees to meet the requirements of multiple land use objectives, the species or species combination that could be established at least cost would be a natural choice. Such a decision disregards differences in yields of values that would be generated for the money spent and the length of time required for yields or values to accrue. If these considerations are unimportant, the least-cost decision is valid.

In some situations, estimated future yields and values could be compared. If cost were no object, the species estimated to provide the greatest yield or value would be rightly chosen. But again, this kind of evaluation ignores time; only if it made no difference whether the yield would be available at 50 or 100 years could the decision stand.

In another method, the benefit-cost comparison, future values are not discounted. The species or combination that promises the greatest volume or value yield for the money is the obvious choice. This method also ignores the time required to attain the yield or value.

An evaluation procedure is outlined in figure 3. The diagram shows the sequence of calculations that produces estimates of yield and rate of return for each species to be evaluated, under managed or unmanaged conditions. With site index and productivity data, the comparative productivity of the species to be evaluated may be estimated. A decision is then made as to initial number of trees per acre to be assumed in the evaluation. Following the decision to manage the stand or to leave it unmanaged, yield data or stand projections (based on assumptions of management, tree growth, and mortality) are taken together with the number of trees per acre to calculate expected yield for the stand. On the basis of this anticipated yield, timber growing costs and product values generated are taken together to calculate a rate of return for the species. This procedure, carried out for each species to be considered, gives the timber manager a comparative measure of the efficiency of a stand establishment operation in terms of rate of return. The outline in figure 3 is an idealization of the method; it assumes a foundation of consistent biological data and value assumptions on which to base expected value returns.

[4] *Marty, Robert, Charles Rindt, and John Fedkiw. A guide for evaluating reforestation and stand improvement projects in timber management planning on the National Forests. U.S. Dep. Agr., Agr. Handbook 304, 24 pp. 1966.*

MECHANICS OF AN EVALUATION - AN EXAMPLE

The steps in the proposed method of evaluation have been outlined in the introduction. The tedious mathematical calculations normally associated with rate-of-return computations that are complicated can be largely eliminated by using one of the several EDP investment analysis programs now available. Two such programs — one by Hall[5] and the second by Row[6] — have been adapted for use in problems of the kind discussed in this paper. The modified programs are described in detail in appendix B. Illustrations in the example are taken from computer output of these programs.

The example that follows will clarify the procedures required, particularly those making use of EDP equipment for rate-of-return calculations.

This illustration of the evaluation and decision process is designed to show how silvicultural decisions (or necessities) can influence the economic efficiency of timber growing operations. The example is somewhat simplified and does not take into account all the possible alternatives. However, it does show the flow of thinking necessary to sound decisions in stand regeneration.

> *Problem:* From a timber type of several hundred acres, a mature stand of white pine and Douglas-fir with minor volumes of grand fir and Engelmann spruce is to be harvested and regenerated for the primary purpose of timber production. The timber manager is free to decide on cutting unit size and layout. The habitat type is a spruce-fir climax tree union.
>
> The goal is to grow a merchantable stand of sawtimber of mixed species in the most efficient manner. The criterion of efficiency will be the rate of return on investment earned by alternative plans that will achieve the goal.

Preliminary Selection of Species

The species to be evaluated are those normally associated with the habitat (see table 1) and particularly those that apparently did well in the stand to be harvested. As the first step in evaluation, the land manager considers each of these potential species and makes the following decisions:

1. **White pine.**—Poor risk because of blister rust. Drop from consideration.

2. **Subalpine fir.** — Risk is moderate, but trees would have to be planted because seed trees are few in existing stand and in stands outside harvest area. This species is not usually grown in the nursery and probably should not be considered.

3. **Engelmann spruce.**—Some risk because of spruce budworm but worth considering.

4. **Whitebark pine.** — Not good timber species; high risk because of blister rust. Drop from consideration.

5. **Lodgepole pine.** — Good species but would have to be planted; sufficient seed from an acceptable seed zone for producing planting stock would be difficult to obtain. Drop from consideration.

6. **Grand fir.** — Some loss expected from heart rot but definitely worth consideration.

7. **Western larch.**—Good species, but expected loss in growth and unknown mortality from casebearer makes it risky at this time. Drop.

8. **Douglas-fir.**—Moderate risk because of spruce budworm but good species to grow.

The elimination process leaves three species that are judged likely to produce acceptable

[5] *Hall, Otis. Evaluating complex investments in forestry and other long-term enterprises using a digital computer. Purdue Univ. Res. Bull. 752, 11 pp., 1962. Also, Supplemental appendix, 2 pp., 1963.*

[6] *In Marty, et al. See footnote 4.*

volumes of merchantable wood. The timber manager ranks them in order of preference as follows: Douglas-fir, Engelmann spruce, and grand fir. He decides to grow a mixed stand, so at least two and probably all three species should be grown.

Notice that in this example the timber manager does not need to make further choice between species alternatives. Under different site conditions, he might find that he had a choice among four or five species. In that event, he would follow the evaluation process described below for several species mixtures — as many as he judged likely to achieve the project goal — and would choose the most efficient.

Preliminary Estimates

The timber manager now sees two alternative plans for regenerating and managing the new stand:

A. **Clearcut in small blocks** (20 acres), **regenerating** all three species **naturally** with seed from the residual stand.

B. **Clearcut in large block (100 acres)** and **regenerate by planting** mostly grand fir and spruce. Some Douglas-fir will seed in.

In either case, natural seeding of most species will probably occur within the first 5 years, requiring subsequent thinning to bring about the species composition and proportions desired.

At this point in the economic evaluation, the manager must decide what alternative plans are compatible with the project goal, so that he may compare the costs likely to be incurred. Of basic concern are the investment periods and the cultural treatments to be evaluated. For this illustration, two treatment plans — A and B — are evaluated. Costs are estimated for each plan according to two time periods and two stocking control treatments adapted to these time periods.

General Assumptions

The following assumptions are made in the calculations of comparative costs of stand establishment:

1. **Site preparation:** The same standard for site preparation applies to both planting and natural regeneration.

2. **Costs of site preparation:** Not including slash disposal, costs range from $15 per acre on 20-acre units to $11 per acre on 100-acre units.

3. **Seed source:** Under natural regeneration, there is a charge to seed source to cover the additional costs of sale layout and administration entailed by cutting in small blocks. This is estimated at $3 per acre.

4. **Time to stand establishment:** Under natural regeneration, there is a 3-year lag between site preparation and stand establishment. Planting can be completed within 1 year of site preparation.

5. **Number of trees planted:** On a 100-acre unit, planted trees per acre average 290. This assumes full planting (450 trees per acre) on 30 acres and an average of 225 trees per acre on the remaining 70 acres that are likely to receive some natural regeneration.

6. **Thinning:** A precommercial thinning is required 15 years after stand establishment. Thinning costs average $35 per acre in natural stands and only $20 per acre in planted stands because fewer trees need to be removed.

Volume Yields Assumed

The estimate of gross volume yield is based on increments of 100 cubic feet per acre per year for spruce, 80 cubic feet for grand fir and 60 cubic feet for Douglas-fir. On planted areas species distribution is expected to be about 50 percent spruce and 50 percent grand fir. In the natural stand a relatively high proportion (60 percent) of Douglas-fir is expected, with 20 percent each of spruce and grand fir.

Investment period assumed. — The two investment periods used in this illustration are (1) the time required to grow a merchantable stand in which nearly all the volume is in trees 8 inches d.b.h. and larger, and (2) a full sawtimber rotation of a length required to grow trees to the size class objectives currently in effect for National Forests in the Northern Rocky Mountain area.

The planted stand — predominantly spruce and grand fir — is expected to be merchantable, as defined in (1) above, in about 55 years from time of planting. Depending on the proportion of Douglas-fir, the natural stand could reach merchantable size in 60 to 65 years from regeneration date.

The sawtimber rotations required to meet the current size class objectives would be 100 years for species in the planted stand and 110 years from regeneration for species in natural stands.

Anticipated volume.—Making the above assumptions, and discounting potential yields for risk by some reasonable percentage, the land manager finds that the anticipated volumes of standing timber when the stand reaches merchantable size are as follows:

	Cu. ft.
1. **Planted stands at 55 years**	
Spruce	2,750
Grand fir	2,200
2. **Natural stands at 66 years**	
Spruce	1,260
Grand fir	1,008
Douglas-fir	2,268

Growing stands to a full sawtimber rotation would require an intermediate cut at about 55 to 65 years. The estimated yields from intermediate and harvest cuts are as follows:

	Cu. ft.
1. **Planted stands**	
Intermediate cut at 55 years	
Spruce	1,215
Grand fir	1,215
Harvest cut at 100 years	
Spruce	3,800
Grand fir	3,200
2. **Natural stands**	
Intermediate cut at 60 years	
Douglas-fir	972
Spruce	324
Grand fir	324
Harvest cut at 110 years	
Douglas-fir	5,160
Spruce	1,220
Grand fir	1,220

Values Assumed

The perils of predicting future wood values have already been pointed out. However, whenever money is allocated for timber-growing projects some assumption about the future is implied if not stated. It is important that, regardless of what price estimates are used for these future values, all analysts within an operational unit should use the same estimate. In this illustration the following stumpage value relationships are used:

	Per cubic foot
Douglas-fir	$0.06
Spruce	.05
Grand fir	.07

Having estimated costs, yield, values, and time schedule, the timber manager can now conclude the evaluation by summarizing the details of each alternative plan preliminary to recording them on the input data coding forms that are the basic information source for the EDP program.

Evaluation Summary and Computer Analysis

Short Investment Period

Plan A

Clearcut in small blocks of 20 acres and regenerate naturally to Douglas-fir, grand fir, and spruce.

Costs:

Seed source	$3 per acre at year 0
Site preparation	$15 per acre at year 0
Thinning at age 15	$35 per acre at year 18

Returns: Value of merchantable stand at age 66	
Spruce	
1,260 cu. ft. at $0.05	$ 63.00
Douglas-fir	
2,268 cu. ft. at $0.06	136.08
Grand fir	
1,008 cu. ft. at $0.07	70.56
Total	$269.64

Plan B

Clearcut in large block of 100 acres and regenerate by planting mostly grand fir and spruce with some Douglas-fir seeding in.

Costs:
- Site preparation — $11 per acre at year 0
- Planting — $25 per acre at year 1
- Thinning at age 15 — $20 per acre at year 18

Returns: Value of stand at age 56

Spruce	
2,750 cu. ft. at $0.05	$137.50
Grand fir	
2,200 cu. ft. at $0.07	154.00
Total	$291.50

This information when recorded for machine use would appear as in figure 4 if Hall's program is used. The information on each line represents one card to be used in the program. (Detailed instructions for recording information to be used in this program are given in appendix B.) The output (figure 5) from the investment analysis prints out the details of the alternative plans, the name of the Forest submitting the problem, the person to whom the output is to be sent, the name of the project, and the rate of return on the investment relative to the estimates of value yields provided. The rate of return for the plan analyzed is the last rate printed in the list of trials produced by the computer.

Long Investment Period

Plan A

Clearcut in small blocks of 20 acres and regenerate naturally to Douglas-fir, grand fir, and spruce.

Costs:
- Seed source — $3 per acre at year 0
- Site preparation — $15 per acre at year 1
- Thinning at age 15 — $35 per acre at year 18

Returns: Intermediate cut at year 60

Douglas-fir	
972 cu. ft. at $0.06	$58.32
Spruce	
324 cu. ft. at $0.05	16.20
Grand fir	
324 cu. ft. at $0.07	22.68
Total	$97.20

Harvest cut at year 113

Douglas-fir	
5,160 cu. ft. at $0.06	$309.60
Spruce	
1,220 cu. ft. at $0.05	61.00
Grand fir	
1,220 cu. ft. at $0.07	85.40
Total	$456.00

Plan B

Clearcut in large block of 100 acres and regenerate by planting mostly grand fir and spruce with some Douglas-fir seeding in.

Costs:
- Site preparation — $11 per acre at year 0
- Planting — $25 per acre at year 1
- Thinning at age 15 — $20 per acre at year 16

Returns: Intermediate cut at year 60

Spruce	
1,215 cu. ft. at $0.05	$ 60.75
Grand fir	
1,215 cu. ft. at $0.07	85.05
Total	$145.80

Harvest cut at year 100

Spruce	
3,800 cu. ft. at $0.05	$190.00
Grand fir	
3,200 cu. ft. at $0.07	224.00
Total	$414.00

This information on the input data form would appear as in figure 6, and the output as in figure 7.

The rates of return (percent interest) calculated by the computer for the four alternatives are as follows:

Short investment period: plan A, 2.95; plan B, 3.30

Long investment period: plan A, 2.79; plan B, 2.95

Under the assumptions used, planting large clearcut blocks costs less and yields more than regenerating naturally in small units, and consequently plan B shows a higher rate of return than plan A, for both investment periods. Different plans with different assumptions would give different results. Unless there were some good reasons why grand fir and spruce would not completely satisfy all the goals of the timber production program,

INPUT DATA CODING FORM	UNIT	JOB DESCRIPTION	SYSTEM	PROGRAM	JOB NUMBER	DATE

FIELD DESCRIPTIONS

SEND TO: FOREST SERVICE, MISSOULA
ATTENTION: TIMBER MANAGEMENT

INSTRUCTIONS FOR E.D.P.:
1. PUNCH CARDS AND VERIFY
2. RUN WITH INVESTMENT ANALYSIS NO. 1
3. RETURN OUTPUT TO USER

LINE NO.	Entry	Cols 51–54	Col 60	Cols 63–65	Cols 74–80
1	CØEUR D' ALENE				
2	SUPERVISØRS ØFFICE				
3	RØBERT CØØK				
4	BEAR CREEK PRØPØSED SALE - SHØRT PERIØD				
5	PLAN A, SMALL BLØCK CLEARCUT, NATURAL REGEN.	004			
6	1 SEED SØURCE, NATURAL REGEN., SMALL BLØCK		2	0	-31.00
7	2 SITE PREP.		2	1	-115.00
8	3 THINNING		2	18	-35.00
9	4 TIMBER VALUES (1260 CUFT. SP, 1008 GF, 2268 DF)		2	67	269.64
10	REPEAT CARD 4				
11	PLAN B, LARGE BLØCK CLEARCUT, PLANT	004			
12	1 SITE PREP.		2	0	-111.00
13	2 PLANTING (AVE. 290 TREES/ACRE)		2	1	-25.00
14	3 THINNING		2	16	-20.00
15	4 TIMBER VALUES (2750 CUFT. SP, 2200 GF)		2	56	291.50
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					

R4-6600-12b (8/66)

Figure 4.—Details of alternative plans as listed for use in EDP investment analysis.

```
NATIONAL FOREST - COEUR D≠ ALENE
UNIT - SUPERVISOR≠S OFFICE
ATTENTION - ROBERT COOK


                                        INVESTMENT ANALYSIS PROGRAM  NO. 1

PROBLEM - BEAR CREEK PROPOSED SALE--SHORT PERIOD

PLAN A, SMALL BLOCK CLEARCUT, NATURAL REGEN.          4

  1 SEED SOURCE, NATURAL REGEN.,SMALL BLOCK                 2    0          -3.00
  2 SITE PREPARATION                                        2    1         -15.00
  3 THINNING                                                2   18         -35.00
  4 TIMBER VLAUES (1260 CU. FT. SP., 1008 G.F., 2268 D.F.) 2   67         269.00

NT. RATE      0        SUM =             216.00
NT. RATE  .0200        SUM =              29.16
NT. RATE  .0400        SUM =             -15.27
NT. RATE  .0390        SUM =             -14.29
NT. RATE  .0380        SUM =             -13.23
NT. RATE  .0370        SUM =             -12.08
NT. RATE  .0360        SUM =             -10.84
NT. RATE  .0350        SUM =              -9.50
NT. RATE  .0340        SUM =              -8.05
NT. RATE  .0330        SUM =              -6.48
NT. RATE  .0320        SUM =              -4.79
NT. RATE  .0310        SUM =              -2.96
NT. RATE  .0300        SUM =              -1.00
NT. RATE  .0290        SUM =               1.12
NT. RATE  .0299        SUM =              -0.79
NT. RATE  .0298        SUM =              -0.59
NT. RATE  .0297        SUM =              -0.38
NT. RATE  .0296        SUM =              -0.17
NT. RATE  .0295        SUM =                .04

PROBLEM - BEAR CREEK PROPOSED SALE--SHORT PERIOD

PLAN B, LARGE BLOCK CLEARCUT, PLANT                   4

  1 SITE PREPARATION                                        2    0         -11.00
  2 PLANTING (AVE. 290 TREES PER ACRE)                      2    1         -25.00
  3 THINNING                                                2   16         -20.00
  4 TIMBER VALUES (2750 CU.FT. SP., 2200 G.F.)              2   56         291.50

NT. RATE      0        SUM =             235.50
NT. RATE  .0200        SUM =              46.09
NT. RATE  .0400        SUM =             -13.30
NT. RATE  .0390        SUM =             -11.69
NT. RATE  .0380        SUM =              -9.99
NT. RATE  .0370        SUM =              -8.18
NT. RATE  .0360        SUM =              -6.26
NT. RATE  .0350        SUM =              -4.23
NT. RATE  .0340        SUM =              -2.07
NT. RATE  .0330        SUM =                .22
NT. RATE  .0339        SUM =              -1.85
NT. RATE  .0338        SUM =              -1.62
NT. RATE  .0337        SUM =              -1.40
NT. RATE  .0336        SUM =              -1.17
NT. RATE  .0335        SUM =              -0.94
NT. RATE  .0334        SUM =              -0.71
NT. RATE  .0333        SUM =              -0.48
NT. RATE  .0332        SUM =              -0.25
NT. RATE  .0331        SUM =              -0.02
NT. RATE  .0330        SUM =                .22
```

Figure 5.—Machine output from investment analysis of illustration problem. A, Plan A, short investment period; B, Plan B, short investment period.

INPUT DATA CODING FORM

UNIT	JOB DESCRIPTION	SYSTEM	PROGRAM	JOB NUMBER	DATE

FIELD DESCRIPTIONS

SEND TO: FOREST SERVICE, MISSOULA

ATTENTION: TIMBER MANAGEMENT

INSTRUCTIONS FOR E.D.P.
1. PUNCH CARDS AND VERIFY
2. RUN WITH INVESTMENT ANALYSIS NO. 1
3. RETURN OUTPUT TO USER

LINE NO.	1–50	51–60	61–70	71–80
1	CØEUR D' ALENE			
2	SUPERVISORS ØFFICE			
3	RØBERT CØØK			
4	BEAR CREEK PRØPØSED SALE - LØNG PERIØD			
5	PLAN A, SMALL BLØCK CLEARCUT, NATURAL REGEN.	005		
6	1 SEED SOURCE, NATURAL REGEN. SMALL BLØCK	2	0	-31.00
7	2 SITE PREP.	2	1	-115.00
8	3 THINNING	2	18	-135.00
9	4 INTERMEDIATE CUT (1972 CUFT. DF, 324 SP, 324 GF)	2	60	97.00
10	5 HARVEST CUT (5160 CUFT. DF, 1220 SP, 1220 GF)	2	113	456.00
11	REPEAT CARD 4			
12	PLAN B, LARGE BLØCK CLEARCUT, PLANT	005		
13	1 SITE PREP.	2	0	-111.00
14	2 PLANTING (AVE. 290 TREES/ACRE)	2	1	-125.00
15	3 THINNING	2	16	-120.00
16	4 INTERMEDIATE CUT (1215 CUFT SP, 1215 GF)	2	60	145.80
17	5 HARVEST CUT (3800 CUFT SP, 3200 GF)	2	100	414.00
18				
19				
20				
21				
22				
23				
24				
25				

R4-6600-12b (8/66)

Figure 6.—Details of alternative plans as listed for use by EDP investment analysis.

```
NATIONAL FOREST - COEUR D ALENE
UNIT - SUPERVISORS OFFICE
ATTENTION - ROBERT COOK



                                            INVESTMENT ANALYSIS PROGRAM  NO. 1

PROBLEM - BEAR CREEK PROPOSED SALE - LONG PERIOD

PLAN A, SMALL BLOCK CLEARCUT, NATURAL REGEN.          5


  1 SEED SOURCE, NATURAL REGEN. SMALL BLOCK                  2    0           -3.00
  2 SITE PREP.                                               2    1          -15.00
  3 THINNING                                                 2   18          -35.00
  4 INTERMEDIATE CUT (972 CUFT.DF,324 SP,324 GF)             2   60           97.20
  5 HARVEST CUT (5160 CUFT.DF,1220 SP,1220 GF)               2  113          456.00

NT. RATE       0          SUM =              500.20
NT. RATE   .0200          SUM =               36.07
NT. RATE   .0400          SUM =              -20.04
NT. RATE   .0390          SUM =              -19.18
NT. RATE   .0380          SUM =              -18.23
NT. RATE   .0370          SUM =              -17.16
NT. RATE   .0360          SUM =              -15.97
NT. RATE   .0350          SUM =              -14.65
NT. RATE   .0340          SUM =              -13.18
NT. RATE   .0330          SUM =              -11.54
NT. RATE   .0320          SUM =               -9.73
NT. RATE   .0310          SUM =               -7.71
NT. RATE   .0300          SUM =               -5.47
NT. RATE   .0290          SUM =               -2.98
NT. RATE   .0280          SUM =               -0.22
NT. RATE   .0270          SUM =                2.85
NT. RATE   .0279          SUM =                 .07

PROBLEM - BEAR CREEK PROPOSED SALE - LONG PERIOD

PLAN B, LARGE BLOCK CLEARCUT, PLANT                    5


  1 SITE PREP.                                               2    0          -11.00
  2 PLANTING (AVE. 290 TREES/ACRE)                           2    1          -25.00
  3 THINNING                                                 2   16          -20.00
  4 INTERMEDIATE CUT (1215 CUFT.SP, 1215 GF)                 2   60          145.80
  5 HARVEST CUT (3800 CUFT.SP, 3200 GF)                      2  100          414.00

NT. RATE       0          SUM =              503.80
NT. RATE   .0200          SUM =               51.50
NT. RATE   .0400          SUM =              -23.66
NT. RATE   .0390          SUM =              -22.20
NT. RATE   .0380          SUM =              -20.60
NT. RATE   .0370          SUM =              -18.87
NT. RATE   .0360          SUM =              -16.97
NT. RATE   .0350          SUM =              -14.91
NT. RATE   .0340          SUM =              -12.66
NT. RATE   .0330          SUM =              -10.21
NT. RATE   .0320          SUM =               -7.54
NT. RATE   .0310          SUM =               -4.62
NT. RATE   .0300          SUM =               -1.45
NT. RATE   .0290          SUM =                2.02
NT. RATE   .0299          SUM =               -1.11
NT. RATE   .0298          SUM =               -0.78
NT. RATE   .0297          SUM =               -0.44
NT. RATE   .0296          SUM =               -0.10
NT. RATE   .0295          SUM =                 .25
```

Figure 7.—Machine output from investment analysis of illustration problem. A, Plan A, long investment period; B, Plan B, long investment period.

the manager in this case would no doubt choose plan B regardless of the time period involved.

With thoughtful screening of species, realistic cost and value yield estimates based on the best data available, and full use of the speed and convenience of modern EDP equipment, economic evaluation of alternatives can be made more easily and with more consistency than ever before. Once he has these evaluations, the timber manager is in a good position to make sound decisions about particular timber growing projects because he is able to judge the effectiveness with which money and land are combined to reach timber production goals.

SUMMARY

The 3.5 million acres of National Forest land in the Northern Rocky Mountain area that are capable of growing western white pine are also highly productive for growing a number of other species.

Lack of a means to suppress blister rust makes it imperative that other species be substituted for white pine at the present time. Also, if public agencies are to use their money efficiently, economic evaluations of species alternatives are necessary. The species choice for timber production is determined by the capacity of the site to grow various species and the degree of efficiency with which each species may be used to attain the timber production goal or objective. Rate of return on the tree-growing investments is the most useful measure of efficiency.

The real species alternatives to evaluate are those judged to have the best chance of producing a merchantable stand. As a hedge against unknown future losses of any given species from insects and disease, mixed species stands should be the rule.

Choice of species mixtures to regenerate for timber production can be based on the following evaluation:

1. Determine the species biologically best suited to the area to be regenerated. This calls for a determination of habitat type and a close examination of the species present and thriving in the stand to be harvested.

2. Eliminate from consideration those species thought to be the poorest risks because of current disease or insect problems, or other obvious disadvantages.

3. Estimate the costs necessary to establish a satisfactory stand of the alternative species and to manage it at a specified level until harvest.

4. Estimate the intermediate and harvest yields likely from the level of management prescribed.

5. Estimate the values of these yields.

6. Compute the alternative rate of return (interest rate) from estimated value yield and costs of the timber growing operation.

For effective use of such evaluations, (1) only practical alternatives should be evaluated, (2) the most reliable information available should be used, and (3) each area to be regenerated should be considered within the framework of its own peculiarities and conditions.

APPENDIX A

WHITE PINE LAND AREA SUMMARIES
FOR NATIONAL FOREST LAND
IN THE NORTHERN REGION

Appendix table 1.--LAND AREA BY WHITE PINE SITE CLASS AND ASPECT

(In acres)

Aspect	White pine site index <40	40	50	60	70	80	90+	Total
				SAWTIMBER STANDS				
N	52,562	38,035	54,448	64,084	55,275	14,597	8,551	287,552
NE	7,216	29,745	42,839	14,840	40,615	6,665	5,813	147,733
E	58,311	37,882	37,886	67,284	52,127	12,275	13,350	279,115
Subtotal	118,089	105,662	135,173	146,208	148,017	33,537	27,714	714,400
SE	15,880	25,619	27,260	100,839	21,120	20,366		211,084
NW	8,110	8,920	46,061	44,469	20,795	486	1,971	130,812
Subtotal	23,990	34,539	73,321	145,308	41,915	20,852	1,971	341,896
S	24,168	36,126	65,969	63,255	33,069	17,277	9,360	249,224
SW	22,249	30,141	27,938	46,882	29,222	7,063		163,495
W	57,709	56,617	82,302	38,439	37,171	19,012	1,442	292,692
Subtotal	104,126	122,884	176,209	148,576	99,462	43,352	10,802	705,411
Flat	16,138	1,611	12,510	15,753	2,786	15,857		64,655
Undesignated		6,100	10,461	1,133	6,462			24,156
TOTAL	262,343	270,796	407,674	456,978	298,642	113,598	40,487	1,850,518
				POLE STANDS				
N	5,483		3,898	35,200	20,409	14,714	21,137	100,841
NE	2,766	4,043	14,951		9,029	11,652	9,754	52,195
E		7,577	12,813	27,064	16,071	4,142	12,446	80,113
Subtotal	8,249	11,620	31,662	62,264	45,509	30,508	43,337	233,149
SE	5,480			2,002	16,175	4,043	2,558	30,258
NW	14,221	14,867	16,037	3,983	18,780	11,153	840	79,881
Subtotal	19,701	14,867	16,037	5,985	34,955	15,196	3,398	110,139
S	7,577	7,258	25,688	25,938	15,769	6,789	11,625	100,644
SW	3,410	1,073	2,768	19,915	6,464			33,630
W	15,280	7,656	31,428	18,808	4,172	6,387	14,968	98,699
Subtotal	26,267	15,987	59,884	64,661	26,405	13,176	26,593	232,973
Flat		6,079	13,872	6,709	2,865	9,578	4,212	43,315
Undesignated								
TOTAL	54,217	48,553	121,455	139,619	109,734	68,458	77,540	619,576

Aspect	White pine site index <40	40	50	60	70	80	90+	Total	Nonstock
				SEEDLING AND SAPLING STANDS					
N	17,789	10,470	68,611	28,824	15,055		22,453	163,202	22,156
NE	12,536	12,320	20,676	7,851	12,916	2,518	9,717	78,534	
E	20,034	22,279	16,624	28,312	11,735		8,148	107,132	45,442
Subtotal	50,359	45,069	105,911	64,987	39,706	2,518	40,318	348,868	67,598
SE	6,872	4,668	8,552				2,246	22,338	37,609
NW	9,522		8,616	18,493	8,023	9,757	17,497	71,908	12,536
Subtotal	16,394	4,668	17,168	18,493	8,023	9,757	19,743	94,246	50,145
S	5,163	28,490	18,358	26,133	6,939		5,534	90,617	70,378
SW	3,721		16,904	36,484		14,823		71,932	50,066
W	17,960	14,344	13,843	35,499	16,181	4,128	2,427	104,382	37,375
Subtotal	26,844	42,834	49,105	98,116	23,120	18,951	7,961	266,931	157,819
Flat		3,405	16,670	2,825	7,637		8,110	38,647	
Undesignated									2,524
TOTAL	93,597	95,976	188,854	184,421	78,486	31,226	76,132	748,692	278,086
				ALL STANDS-ALL FORESTS					
N	75,834	48,505	126,957	128,108	90,739	29,311	52,141	551,595	
NE	22,518	46,108	78,466	22,691	62,560	20,835	25,284	278,462	
E	78,345	67,738	67,323	122,660	79,933	16,417	33,944	466,360	
Subtotal	176,697	162,351	272,746	273,459	233,232	66,563	111,369	1,296,417	
SE	28,232	30,287	35,812	102,841	37,295	24,409	4,804	263,680	
NW	31,853	23,787	70,714	66,945	47,598	21,396	20,308	282,601	
Subtotal	60,085	54,074	106,526	169,786	84,893	45,805	25,112	546,281	
S	36,908	71,874	110,015	115,326	55,777	24,066	26,519	440,485	
SW	29,380	31,214	47,610	103,281	35,686	21,886		269,057	
W	90,949	78,617	127,573	92,746	57,524	29,527	18,837	495,773	
Subtotal	157,237	181,705	285,198	311,353	148,987	75,479	45,356	1,205,315	
Flat	16,138	11,095	43,052	25,287	13,288	25,435	12,322	146,617	
Undesignated		6,100	10,461	1,133	6,462			24,156	
TOTAL	410,157	415,325	717,983	781,018	486,862	213,282	194,159	3,218,786	

Appendix table 2.--LAND AREA BY WHITE PINE SITE CLASS, SLOPE PERCENT, AND STAND SIZE

(In acres)

WPSI	Slope percent				Total
	0-30	31-50	51-70	71+	
			SAWTIMBER STANDS		
< 40	97,558	112,285	40,768	11,732	262,343
40	119,401	106,318	38,014	7,063	270,796
50	184,803	143,745	67,447	11,679	407,674
60	202,423	151,322	70,898	32,335	456,978
70	144,122	84,692	69,828		298,642
80	56,326	29,245	28,027		113,598
90+	19,671	8,293	12,523		40,487
Total	824,304	635,900	327,505	62,809	1,850,518
			POLE STANDS		
< 40	20,735	26,989	6,493		54,217
40	25,370	9,387	13,796		48,553
50	28,335	52,917	36,126	4,077	121,455
60	53,434	53,441	27,179	5,565	139,619
70	61,124	28,934	18,235	1,441	109,734
80	33,842	27,751	6,865		68,458
90+	37,704	30,301	9,535		77,540
Total	260,544	229,720	118,229	11,083	619,576
			SEEDLING AND SAPLING STANDS		
< 40	21,518	11,517	46,184	14,378	93,597
40	35,805	51,119	9,052		95,976
50	67,828	85,255	29,061	6,710	188,854
60	104,599	39,190	35,580	5,052	184,421
70	39,802	22,849	15,835		78,486
80	4,360	4,572	22,294		31,226
90+	34,591	39,255	2,286		76,132
Total	308,503	253,757	160,292	26,140	748,692
			ALL STANDS		
< 40	139,811	150,791	93,445	26,110	410,157
40	180,576	166,824	60,862	7,063	415,325
50	280,966	281,917	132,634	22,466	717,983
60	360,456	243,953	133,657	42,952	781,018
70	245,048	136,475	103,898	1,441	486,862
80	94,528	61,568	57,186		213,282
90+	91,966	77,849	24,344		194,159
Total	1,393,351	1,119,377	606,026	100,032	3,218,786

Appendix table 3.--LAND AREA BY WHITE PINE SITE CLASS AND SITE INDEX OF PRINCIPAL SPECIES: SAWTIMBER STANDS

(In acres)

WPSI	Site index <40	40	50	60	70	80	90+	Total
				DOUGLAS-FIR				
<40	13,114							13,114
40		9,203	4,668					13,871
50	1,341		19,978	46,464		4,668	2,766	75,217
60			6,565	53,128	58,356	27,409	5,967	151,425
70				15,157	19,639	24,121	22,397	81,314
80						9,314	3,310	12,624
90+						839	1,841	2,680
Total	14,455	9,203	31,211	114,749	77,995	66,351	36,281	350,245
				PONDEROSA PINE				
<40	38,289		7,347	3,045	3,405			52,086
40					5,217			5,217
50								
60		4,667	728			3,853		9,248
70				365				365
80								
90+								
Total	38,289	4,667	8,075	3,410	8,622	3,853		66,916
				WHITE PINE				
<40	12,018							12,018
40		43,199						43,199
50			69,444					69,444
60				87,460				87,460
70					56,627			56,627
80						21,257		21,257
90+							13,267	13,267
Total	12,018	43,199	69,444	87,460	56,627	21,257	13,267	303,272
				LODGEPOLE PINE				
<40			1,441	15,149	20,484	4,608	13,537	55,219
40				4,042	4,967	3,897	14,105	27,011
50	3,405			6,739			19,319	29,463
60							5,541	5,541
70							10,871	10,871
80					4,043		11,105	15,148
90+								
Total	3,405		1,441	25,930	29,494	8,505	74,478	143,253
				GRAND FIR				
<40	14,782	3,405						18,187
40	25,814	3,749	554					30,117
50	82,624	442	16,033	1,003				100,102
60	7,063	23,950	23,716	3,267	6,215			64,211
70		10,231	23,126	28,113				61,470
80			12,040	10,883	7,063			29,986
90+					5,480		7,827	13,307
Total	130,283	41,777	75,469	43,266	18,758		7,827	317,380
				ALPINE FIR				
<40	12,464							12,464
40	26,021							26,021
50	11,047							11,047
60		18,207		2,517				20,724
70			1,339					1,339
80								
90+								
Total	49,532	18,207	1,339	2,517				71,595

WPSI	Site index <40	40	50	60	70	80	90+	Total
				SPRUCE				
<40				3,826	3,826			7,652
40		14,547	6,462					21,009
50			1,742	5,481	11,141	3,826		22,190
60					7,091	35,063		42,154
70							8,631	8,631
80								
90+								
Total		14,547	8,204	9,307	22,058	38,889	8,631	101,636
				MOUNTAIN HEMLOCK				
<40	2,899	8,447	7,039					18,385
40								
50								
60								
70								
80								
90+								
Total	2,899	8,447	7,039					18,385
				WESTERN HEMLOCK				
<40	4,428	1,063	31,272	1,507				38,270
40		6,100		21,001	7,614			34,715
50			3,151	7,331	8,881			19,363
60				5,597	4,041	2,091		11,729
70					3,749	6,670	1,559	11,978
80						2,894	9,427	12,321
90+								
Total	4,428	7,163	34,423	35,436	24,285	11,655	10,986	128,376
				WESTERN REDCEDAR				
<40	3,629	7,354	2,851	8,933				22,767
40			22,226	15,189	8,858			46,273
50		3,427		10,328	486	12,783		27,024
60			6,709	5,721				12,430
70				14,314	19,371		441	34,126
80					486	13,608	554	14,648
90+						1,442	6,215	7,657
Total	3,629	10,781	31,786	54,485	29,201	27,833	7,210	164,925
				WESTERN LARCH				
<40								
40		5,774	6,128	11,461				23,363
50			14,554	28,632	2,766		7,872	53,824
60				24,210	17,600	8,110	2,136	52,056
70				4,408	10,185	17,328		31,921
80							7,614	7,614
90+					3,576			3,576
Total		5,774	20,682	68,711	34,127	25,438	17,622	172,354

Appendix table 4.--LAND AREA BY WHITE PINE SITE CLASS AND SITE INDEX OF PRINCIPAL SPECIES; POLE STANDS, SEEDLING AND SAPLING STANDS

(In acres)

WPSI	Site index <40	40	50	60	70	80	90+	Total
				DOUGLAS-FIR				
<40	27,929	3,410						31,339
40	6,254	8,245	8,467					22,966
50	1,742		19,400	13,126				34,268
60		24,491	20,533	21,222	19,357	1,320		86,923
70			13,775	4,155	6,158	865		24,953
80				2,822	10,041			12,863
90+				6,603	7,637	5,565	18,724	38,529
Total	35,925	36,146	62,175	47,928	43,193	7,750	18,724	251,841
				PONDEROSA PINE				
<40		5,217		2,394		2,286		9,897
40			12,536					12,536
50								
60			5,217					5,217
70								
80								
90+		3,112						3,112
Total		8,329	17,753	2,394		2,286		30,762
				WHITE PINE				
<40	18,310							18,310
40		9,317						9,317
50			16,579					16,579
60				11,828				11,828
70					11,407			11,407
80						19,932		19,932
90+							37,419	37,419
Total	18,310	9,317	16,579	11,828	11,407	19,932	37,419	124,792
				LODGEPOLE PINE				
<40	12,536	11,105		5,480	9,383	4,042		42,546
40			2,286	12,537	21,412	12,008	12,178	60,421
50		2,190	2,768	2,766	2,453	22,692	34,250	67,119
60						4,724	43,589	48,313
70				2,071			39,173	41,244
80							23,384	23,384
90+							12,095	12,095
Total	12,536	13,295	5,054	22,854	33,248	43,466	164,669	295,122
				GRAND FIR				
<40	2,524							2,524
40								
50	16,044	4,042						20,086
60	15,833	19,893	2,894					38,620
70		6,416	39,732					46,148
80			1,442	19,447				20,889
90+		3,919	10,267	19,604	4,707	5,480		43,977
Total	34,401	34,270	54,335	39,051	4,707	5,480		172,244
				ALPINE FIR				
<40	16,861							16,861
40	3,426	4,668						8,094
50	57,316							57,316
60	4,969	12,948			2,450			20,367
70			13,160					13,160
80			1,468					1,468
90+	890							890
Total	83,462	17,616	14,628		2,450			118,156

WPSI	Site index <40	40	50	60	70	80	90+	Total
				SPRUCE				
<40	5,480							5,480
40	8,715							8,715
50		3,637	1,655					5,292
60			1,424			5,480		6,904
70				2,286	6,617			8,903
80					2,518			2,518
90+			7,290			3,225		10,515
Total	14,195	3,637	10,369	2,286	9,135	8,705		48,327
				MOUNTAIN HEMLOCK				
<40	8,447							8,447
40								
50		6,865						6,865
60								
70								
80								
90+								
Total	8,447	6,865						15,312
				WESTERN HEMLOCK				
<40								
40								
50			7,102	4,724				11,826
60			839					839
70								
80					4,043			4,043
90+								
Total			7,941	4,724	4,043			16,708
				WESTERN REDCEDAR				
<40	1,655		6,816					8,471
40		1,874		11,729				13,603
50	4,966	16,215	8,959	18,680	2,385			51,205
60		8,110	14,654	6,709				29,473
70					11,780			11,780
80								
90+			1,887	2,422		2,826		7,135
Total	6,621	26,199	32,316	39,540	14,165	2,826		121,667
				WESTERN LARCH				
<40	2,769	1,170						3,939
40		4,970	3,907					8,877
50			21,893	17,860				39,753
60				39,861	35,695			75,556
70			1,063	839	9,523	19,200		30,625
80							14,587	14,587
90+								
Total	2,769	6,140	26,863	58,560	45,218	19,200	14,587	173,337

Appendix table 5.--LAND AREA BY WHITE PINE SITE CLASS AND SITE INDEX OF PRINCIPAL SPECIES; ALL STANDS

(In acres)

WPSI	Site index <40	40	50	60	70	80	90+	Total
				DOUGLAS-FIR				
<40	41,043	3,410						44,453
40	6,254	17,448	13,135					36,837
50	3,083		39,378	59,590		4,668	2,766	109,485
60		24,491	27,098	74,350	77,713	28,729	5,967	238,348
70			13,775	19,312	25,797	24,986	22,397	106,267
80				2,822	10,041	9,314	3,310	25,487
90+				6,603	7,637	6,404	20,565	41,209
Total	50,380	45,349	93,386	162,677	121,188	74,101	55,005	602,086
				PONDEROSA PINE				
<40	38,289	5,217	7,347	5,439	3,405	2,286		61,983
40			12,536		5,217			17,753
50								
60		4,667	5,945			3,853		14,465
70				365				365
80								
90+		3,112						3,112
Total	38,289	12,996	25,828	5,804	8,622	6,139		97,678
				WHITE PINE				
<40	30,328							30,328
40		52,516						52,516
50			86,023					86,023
60				99,288				99,288
70					68,034			68,034
80						41,189		41,189
90+							50,686	50,686
Total	30,328	52,516	86,023	99,288	68,034	41,189	50,686	428,064
				LODGEPOLE PINE				
<40	12,536	11,105	1,441	20,629	29,867	8,650	13,537	97,765
40			2,286	16,579	26,379	15,905	26,283	87,432
50	3,405	2,190	2,768	9,505	2,453	22,692	53,569	96,582
60						4,724	49,130	53,854
70				2,071			50,044	52,115
80					4,043		34,489	38,532
90+							12,095	12,095
Total	15,941	13,295	6,495	48,784	62,742	51,971	239,147	438,375
				GRAND FIR				
<40	17,306	3,405						20,711
40	25,814	3,749	554					30,117
50	98,668	4,484	16,033	1,003				120,188
60	22,896	43,843	26,610	3,267	6,215			102,831
70		16,647	62,858	28,113				107,618
80			13,482	30,330	7,063			50,875
90+		3,919	10,267	19,604	10,187	5,480	7,827	57,284
Total	164,684	76,047	129,804	82,317	23,465	5,480	7,827	489,624
				ALPINE FIR				
<40	29,325							29,325
40	29,447	4,668						34,115
50	68,363							68,363
60	4,969	31,155		2,517	2,450			41,091
70			14,499					14,499
80			1,468					1,468
90+	890							890
Total	132,994	35,823	15,967	2,517	2,450			189,751

WPSI	Site index <40	40	50	60	70	80	90+	Total
				SPRUCE				
<40	5,480			3,826	3,826			13,132
40	8,715	14,547	6,462					29,724
50		3,637	3,397	5,481	11,141	3,826		27,482
60			1,424		7,091	40,543		49,058
70				2,286	6,617		8,631	17,534
80					2,518			2,518
90+			7,290			3,225		10,515
Total	14,195	18,184	18,573	11,593	31,193	47,594	8,631	149,963
				MOUNTAIN HEMLOCK				
<40	11,346	8,447	7,039					26,832
40								
50		6,865						6,865
60								
70								
80								
90+								
Total	11,346	15,312	7,039					33,697
				WESTERN HEMLOCK				
<40	4,428	1,063	31,272	1,507				38,270
40		6,100		21,001	7,614			34,715
50			10,253	12,055	8,881			31,189
60			839	5,597	4,041	2,091		12,568
70					3,749	6,670	1,559	11,978
80					4,043	2,894	9,427	16,364
90+								
Total	4,428	7,163	42,364	40,160	28,328	11,655	10,986	145,084
				WESTERN REDCEDAR				
<40	5,284	7,354	9,667	8,933				31,238
40		1,874	22,226	26,918	8,858			59,876
50	4,966	19,642	8,959	29,008	2,871	12,783		78,229
60		8,110	21,363	12,430				41,903
70				14,314	31,151		441	45,906
80					486	13,608	554	14,648
90+			1,887	2,422		4,268	6,215	14,792
Total	10,250	36,980	64,102	94,025	43,366	30,659	7,210	286,592
				WESTERN LARCH				
<40	2,769	1,170						3,939
40		10,744	10,035	11,461				32,240
50			36,447	46,492	2,766		7,872	93,577
60				64,071	53,295	8,110	2,136	127,612
70			1,063	5,247	19,708	36,528		62,546
80							22,201	22,201
90+					3,576			3,576
Total	2,769	11,914	47,545	127,271	79,345	44,638	32,209	345,691

APPENDIX B

INVESTMENT ANALYSIS PROGRAMS

INVESTMENT PROGRAM NO. 1[7]

CDC-3100 VERSION OF OTIS HALL'S PROGRAM[8]

Complex Investments in Forestry

Limitations.—This program will handle up to 150 separate items of cost or income, will cover periods of up to 200 years, and will give an interest rate earned up to 50 percent, carried to the hundredth of a percent. The highest cash value that can be entered is $999,999,999.99.

Data input.—Data are prepared on 80-column punch cards. Three cards are used to provide data needed for returning output to user: two title cards identify the problem; one card each is used for each cash flow item of cost or income in any one year. The exception to this is an annual item that continues at a constant rate over the time period. Any annual item would be read in on a single card but would be coded as shown below.

Card 1—Identifies Forest
 Cols. 1-32—Name of Forest

Card 2—Identifies unit
 Cols. 1-32—Name of unit

Card 3—Identifies user
 Cols. 1-32—Name of user

Card 4—Title card
 Cols. 1-55—Name of problem

Card 5—Problem description
 Cols. 1-52—Description
 Cols. 53-55—Number of items (cards) or cost and income

Card 6 . . . n—(Item cards)
 Cols. 1-3—Number of item
 Cols. 4-59—Information identifying item
 Col. 60—If the item occurs in single year, code "2"; if the item recurs annually from the beginning of the investment, code "1."
 Cols. 63-65—Years since beginning of investment up to year of item. The number of years entered is the number that have elapsed since the investment program was initiated.
 Cols. 68-80—Cash value of the item to the nearest cent. The decimal point is punched in column 78. If the item is a cost, a minus sign is placed in the column before the first digit. (Therefore column 68 never contains a digit; it is reserved for the minus sign.) Cost items of less than $1.00 are punched with a decimal point in column 78 and the minus sign in column 77.

Card n+1—End-of-file card if last problem. Any number of problems can be run for a particular Forest by repeating cards 4 to n. Also, problems from any number of Forests can be run by placing a card with **NEW FOREST** in **columns 1-10** between each set of Forest problems. Repeat cards 1 to n for each Forest. End-of-file card follows last problem.

Output. — The output includes the data identifying the user, the problem identification, and the problem data cards. Following this, the interest rates tested and the corresponding sums (capital values) are printed. The last rate printed is the problem answer **unless**

1. the costs exceed the income, in which case the word LOSS is printed,
2. the rate earned is greater than 50 percent, in which case the statement INTEREST RATE GREATER THAN 50 PERCENT is printed.

---

[7] *Programs in this appendix were adapted by J. H. Wikstrom of Intermountain Station from Hall's and Row's works.*

[8] *See footnote 5.*

Test problem.—Following is a listing of the data (cards 6-16) used by Hall.

Cols 1-3	Cols 4-56	Col 60	Cols 63-65	Cols 68-80
001	COST OF LAND	2	000	-25.00
002	COST OF CLEARING AND PLANTING	2	000	-20.00
003	COST OF RELEASE FROM COMPETING VEGETATION	2	004	-6.00
004	COST OF SPRAYING FOR INSECTS	2	008	-3.00
005	INCOME FROM THINNING FOR PULPWOOD	2	015	20.00
006	INCOME FROM THINNING FOR PULPWOOD	2	025	36.00
007	INCOME FROM THINNING FOR PULPWOOD	2	033	40.00
008	INCOME FROM HARVEST OF SAWLOGS AND PULPWOOD	2	040	450.00
009	VALUE OF BARE LAND	2	040	25.00
010	ANNUAL COSTS IN PROPERTY TAXES, ETC.	1	040	-1.12

Problem answer. — Interest rate = 0.0601. Sum = 0.07 or 0.08, depending on the number of significant digits carried by the computer (fig. 8).

```
C     OTIS HALL PROGRAM--RATE EARNED, LONG TERM INVESTMENT
C     HALL--1962, RESEARCH BULLETIN NO. 752, PURDUE UNIV.
C     HALL--1963, SUPPLEMENT TO APPENDIX, RESEARCH BULLETIN NO. 752
C     REVISED 1967, INT. STA.(WIKSTROM) CDC 3100
      PROGRAM LTINV1
      INTEGER PR
      DIMENSION M(150),N(150),A(150)
      DIMENSION NAME(8)
      DIMENSION PR(20),PRB1(13),LBL(14)
    1 READ (60,10)(NAME(I),I=1,8'
   10 FORMAT (8A4)
      WRITE (61,9)(NAME(I),I=1,8)
    9 FORMAT(19H1NATIONAL FOREST - ,8A4)
      READ (60,10)(NAME(I),I=1,8)
      WRITE (61,8)(NAME(I),I=1,8)
    8 FORMAT( 8HOUNIT - ,8A4)
      READ (60,10)(NAME(I),I=1,8)
      WRITE(61,7)(NAME(I),I=1,8)
    7 FORMAT(13HOATTENTION - ,8A4/1H-)
      WRITE (61,20)
   20 FORMAT(1H0,41X34HINVESTMENT ANALYSIS PROGRAM  NO. 1)
   15 READ (60,4)(PR(I),I=1,20)
      GO TO(999,401)EOFCKF(60)
  401 IF(PR(1).EQ.4HNEW )1,402
    4 FORMAT(20A4)
  402 WRITE(61,3)(PR(I),I=1,20)
    3 FORMAT(11H0PROBLEM - ,20A4)
      READ(60,2)(PRB1(J),J=1,13),I
    2 FORMAT(13A4,I3)
      WRITE(61,5)(PRB1(J),J=1,13),I
    5 FORMAT(1H0,13A4,I4//)
      DO 21 ID=1,I
      READ(60,22)L,LBL,M(ID),N(ID),A(ID)
   22 FORMAT(I3,14A4,I1,2X,I3,2X,F13.2)
   21 WRITE(61,23)L,LBL,M(ID),N(ID),A(ID)
   23 FORMAT(1H I3,14A4,I1,2X,I3,2X,F13.2)
  120 FORMAT(1H0)
      WRITE(61,120)
      J=0
      SUM=0.0
      P=0.0
   40 DO 50 ID=1,I
      K=M(ID)
      GO TO(46,42)K
   42 D=A(ID)/(1.+P)**N(ID)
      GO TO 50
   46 IF(P)49,49,47
   47 D=A(ID)*((1. + P)**N(ID) - 1. )/(P*(1. +P)**N(ID))
      GO TO 50
   49 YR= N(ID)
      D= A(ID)*YR
   50 SUM=SUM + D
      IF (SUM)90,62,64
   62 PRINT 73,P,SUM
   73 FORMAT(10HINT. RATE F6.4,8X,7H SUM = F20.2)
      GO TO 15
   64 IF( P-0.5)70,70,65
   65 PRINT 66
   66 FORMAT (39H INTEREST RATE GREATER THAN 50 PERCENT )
      GO TO 15
   70 IF(J)80,71,80
   71 PRINT 73,P,SUM
      P=P+.0200
   76 SUM=0.0
      GO TO 40
   80 IF(J-1)81,82,81
   81 GO TO 62
   82 PRINT 73,P,SUM
      P=P+.0010
   85 P=P-.0001
      J=2
      GO TO 76
   90 IF(J)100,91,100
   91 IF(P)100,92,100
   92 PRINT 93
   93 FORMAT ( 6H LOSS )
      GO TO 15
  100 IF(J-2)101,110,101
  101 J=1
      PRINT 73, P,SUM
      P=P-.0010
      GO TO 76
  110 PRINT 73,P,SUM
      GO TO 85
  999 STOP
      END

        3200 FORTRAN DIAGNOSTIC RESULTS - FOR   LTINV1

NO ERRORS
LOAD,56
RUN, 15
```

Figure 8.—EDP program for investment analysis, No. 1, adapted from Otis Hall program.

INVESTMENT ANALYSIS PROGRAM NO. 2

CDC-3100 VERSION OF CLARK ROW'S INVESTMENT ANALYSIS PROGRAM[9]

This program is essentially the one published in Agriculture Handbook 304, "A guide for evaluating reforestation and timber stand improvement projects by Marty, et al. It has been modified for use on the CDC-3100 computer. The dimension of the program was cut to fit 60K storage. Also some statements were made consistent with CDC-3100 language.

Two features were added to the program in the process of revision:

1. The input was modified to include the name and address of the user. The first three input cards are used for this purpose. This was done simply to facilitate handling of both input and output.

2. Control cards 5, 6, and 7 are now printed out with labels to facilitate the checking of input should problems arise. **Note that the only optional card in the input is card 13. It is required whenever NX on card 6 is coded 02.** Note also that JX, MX, and NX on **control card 6 must always be "01" or larger.**

Output options.—The program computes

1. internal rate of return
2. present worth.

Either or both can be obtained — note "program options" columns 13-14 on control card 5.

---

[9]*In Marty, et al. See footnote 4.*

INSTRUCTIONS FOR PREPARING CONTROL CARDS

Card	Columns	ITEM	Field	Label
1	1-20	Name of Forest		Name
2	1-20	Name of unit		Name
3	1-20	Name of user		Name
4	1-80	Number and/or name of problem		Name
5	1-4	Minimum rate of interest	.XXX	RINT
	5-8	Interest rate increment	.XXX	
	9-12	Maximum rate of interest	.XXX	
	13-14	Program options 00 = Interest rate only 01 = Present worth and interest rate 02 = Present worth only	XX	IOUT
6	1-2	Type of alternatives 01 = Rotation 02 = Site index 03 = Production system	XX	LZ

Card	Columns	ITEM	Field	Label
	3-4	Number of alternatives	XX	LX
	5-7	Number identifying alternative 1	XXX	LI(1)
	8-10	Number identifying alternative 2	XXX	LI(2)
	11-13	Number identifying alternative 3	XXX	LI(3)
	23-25	Time period, alternative 1 (1-999)	XXX	LY(1)
	26-28	Time period, alternative 2	XXX	LY(2)
	29-31	Time period, alternative 3	XXX	LY(3)
	41-42	Maximum number of products (0-3)	XX	KX
	43-45	Maximum number of periodic costs	XXX	KCXX
	46-48	Number periodic costs, alternative 1	XXX	KCX(1)
	49-51	Number periodic costs, alternative 2	XXX	KCX(2)
	52-54	Number periodic costs, alternative 3	XXX	KCX(3)
	64-65	Number sets of annual costs (1-8)	XX	JX
	66-67	Number sets of product prices (1-8)	XX	MX
	68-69	Type of terminal calculation (01 = perpetual series; 02 = final value)	XX	NX
	70-71	Number of final value (0-10)	XX	NX
7	1-3	Maximum number of returns of product 1 (0-50) in any one plan	XXX	K1XX
	4-6	Number of product 1 returns, alternative 1	XXX	K1X(1)
	7-9	Number of product 1 returns, alternative 2	XXX	K1X(2)
	10-12	Number of product 1 returns, alternative 3	XXX	K1X(3)
	22-24	Maximum number returns of product 2 (0-50)	XX	K2XX
	25-27	Number of product 2 returns, alternative 1	XX	K2X(1)
	28-30	Number of product 2 returns, alternative 2	XX	K2X(2)
	31-33	Number of product 2 returns, alternative 3	XX	K2X(3)
	43-45	Maximum number returns of product 3 (0-50)	XX	K3XX
	46-48	Number of product 3 returns, alternative 1	XX	K3X(1)
	49-51	Number of product 3 returns, alternative 2	XX	K3X(2)
	52-54	Number of product 3 returns, alternative 3	XX	K3X(3)
8	1-20	Name and unit of measure, product 1		
	21-40	Name and unit of measure, product 2		
	41-60	Name and unit of measure, product 3		
9	1-3	Year of i^{th} cost, alternative 1	XXX	NC(L,KC)
	4-12	i^{th} cost for alternative 1	XXXXXX.XX	PECO(L,KC)
	13-15	Year of i^{th} cost, alternative 2	XXX	
	16-24	i^{th} cost, alternative 2	XXXXXX.XX	
	25-27	Year of i^{th} cost, alternative 3	XXX	
	28-36	i^{th} cost, alternative 3	XXXXXX.XX	

(Card 9 may be repeated 19 times if necessary to include all costs)

Card	Columns	ITEM	Field	Label
10	1-3	Year of j^{th} return, K^{th} product, plan 1	XXX	N1(L,KC)
	4-8	Volume of j^{th} yield, K^{th} product, plan 1	XXXXX[10]	JLD1(L,K1)
	9-12	Quality index, j^{th} yield, K^{th} product, plan 1	XXXX[11]	JUAL1(L,K1)
	13-15	Year of j^{th} return, K^{th} product, plan 2	XXX	
	16-20	Volume of j^{th} yield, K^{th} product, plan 2	XXXXX[10]	
	21-24	Quality index, j^{th} yield, K^{th} product, plan 2	XXXX[11]	
	25-27	Year of j^{th} return, K^{th} product, plan 3	XXX	
	28-32	Volume of j^{th} yield, K^{th} product, plan 3	XXXXX[10]	
	33-36	Quality index, j^{th} yield, K^{th} product, plan 3	XXXX[11]	
	(Card 10 may be repeated 49 times if necessary to include all product returns)			
11 (at least one card required)	1-9	1st annual cost assumption	XXXXX.XXX	ANC(J)
	10-18	1st change in annual cost	XXXXX.XXX	CANC(J)
	19-27	2nd annual cost assumption	XXXXX.XXX	
	28-36	2nd change in annual cost	XXXXX.XXX	
	37-45	3rd annual cost assumption	XXXXX.XXX	
	46-54	3rd change in annual cost	XXXXX.XXX	
	55-63	4th annual cost assumption	XXXXX.XXX	
	64-72	4th change in annual cost	XXXXX.XXX	
	(Card 11 may be repeated. Up to 8 annual cost assumptions can be used)			
12 (at least one card required)	1-9	i^{th} unit price assumption, product 1	XXXXX.XXX	PR(1,M)
	10-18	i^{th} change in unit price, product 1	XXXXX.XXX	CPR(1,M)
	19-27	i^{th} unit price assumption, product 2	XXXXX.XXX	PR(2,M)
	28-36	i^{th} change in unit price, product 2	XXXXX.XXX	CPR(2,M)
	37-45	i^{th} unit price assumption, product 3	XXXXX.XXX	PR(3,M)
	46-54	i^{th} change in unit price, product 3		CPR(3,M)
	(Card 12 may be repeated 9 times if additional price assumptions are needed)			
13	(Do not use if terminal calculation is infinite series)			
(at least one card required if NX=02)	1-9	1st final value assumption	XXXXX.XXX	FVAL(N)
	10-18	1st change in final value	XXXXX.XXX	
	19-27	2nd final value assumption	XXXXX.XXX	
	28-36	2nd change in final value	XXXXX.XXX	
	37-45	3rd final value assumption	XXXXX.XXX	
	46-54	3rd change in final value	XXXXX.XXX	
	(Card 13 may be repeated up to three times if additional final values are needed)			
14	1-2	Terminal card (punch 98 or 99) Punch 98 if another problem follows Punch 99 if last problem		
15	1-10	NEW FOREST — used only if problem that follows is from a new forest.		

[10]*Decimal implied before last digit (127.3 punched 01273).*
[11]*Decimal implied before third digit (1.15 punched 0115).*

Figure 9.—EDP program for investment analysis, No. 2, adapted from Clark Row program.

```
                                   3200  FORTRAN    (2.0)          09/12/67
      PROGRAM INVEST2
C     INVESTMENT ANALYSIS PROGRAM
C     CLARK ROW, SOUTHERN FOREST EXP. STA. 1963
C     ROW--USFS RESEARCH PAPER  SO-6
C     REVISED MARTY 1966--
C     MARTY--USDA HANDBOOK 304
C     REVISED INTERMOUNTAIN STA. (WIKSTROM)--1967
      DIMENSION ANC(10),CANC(10),NC(3,100),PECO(3,100),N1(3,100),JLD1(3,
     1 50),JUAL1(3, 50),N2(3,100),JUAL2(3, 50),N3(3,100),JLD3(3, 50),JUA
     2L3(3, 50),PR(3,10),CPR(3,10),FVAL(25),RATE(100),RTLOG(100),VALIN(
     33,100),LY(3),KCX(3),K1X(3),K2X(3),K3X(3),A(12),LI(3),JLD2(3, 50)
      DIMENSION RINT(3),NAME(20)
C
    1 READ (60,10)(NAME(I),I=1,8)
   10 FORMAT (8A4)
      WRITE (61,9)(NAME(I),I=1,8)
    9 FORMAT(19H1NATIONAL FOREST - ,8A4)
      READ (60,10)(NAME(I),I=1,8)
      WRITE (61,8)(NAME(I),I=1,8)
    8 FORMAT( 8HOUNIT - ,8A4)
      READ (60,10)(NAME(I),I=1,8)
      WRITE (61,7)(NAME(I),I=1,8)
    7 FORMAT(13HOATTENTION - ,8A4/1H-)
      WRITE(61,20)
   20 FORMAT(1H0,41X34HINVESTMENT ANALYSIS PROGRAM  NO. 2)
C  READ CARD 5, PROBLEM TITLE
  142 READ(60,15)(NAME(I),I=1,20)
   15 FORMAT(20A4)
      GO TO (410,143)EOFCKF(60)
  143 IF(NAME(1).EQ.4HNEW )1,144
  144 WRITE(61,21)(NAME(I),I=1,20)
   21 FORMAT (14H0  PROBLEM NO ,20A4)
C  READ CARD 1, RATE AND OUTPUT OPTIONS
      READ(60,17000)(RINT(I),I=1,3),IOUT
17000 FORMAT (3F4.3,I2)
      WRITE(61,1800)(RINT(I),I=1,3),IOUT
 1800 FORMAT(17H0CONTROL CARD 5   , 3F5.3,I4)
      RATE(1)=RINT(1)
      DO 17001 I=2,200
      IF(RATE(I-1)-RINT(3)) 17002,17003,17003
17002  RATE(I)=RATE(I-1)+RINT(2)
      GO TO 17001
17003 LENGTH=I-1
      IF(LENGTH-(LENGTH/2)*2)17004,17005,17004
17004  LLNGTH=(LENGTH+1)/2
      GO TO 137
17005  LLNGTH=LENGTH/2
      GO TO 137
17001  CONTINUE
137   DO 138  I=1,LENGTH
  138 RTLOG(I)=1.+RATE(I)
C
C  READ CARDS 6-7, PROBLEM DESCRIPTION AND SCHEDULE LABELS
      READ(60,11)LZ,LX,(LI(L),L=1,3),(LY(L),L=1,3),KX,KCXX,(KCX(L),L=1,3
     1),JX,MX,NZ,NX
   11 FORMAT(2I2,3I3,9X,3I3,9X,I2,4I3,9X,4I2)
      WRITE(61,99)
   99 FORMAT(1H016X,2HLZ,2X,2HLX,3(3X,2HLI),3(3X,2HLY),2X,2HKX,1X,4HKCXX
     1,3(2X,3HKCX),2X,2HJX,2X,2HMX,2X,2HNZ,2X,2HNX)
      WRITE(61,55)LZ,LX,(LI(L),L=1,3),(LY(L),L=1,3),KX,KCXX,(KCX(L),L=1,
     13),JX,MX,NZ,NX
   55 FORMAT(17HMCONTROL CARD 6   , I2,2X,I2,8(2X,I3),2X,I2,4(2X,I3),4(2X
     1,I2))
      READ(60,88)K1XX,(K1X(L),L=1,3),K2XX,(K2X(L),L=1,3),K3XX,(K3X(L),
```

```
     1L=1,3)
   88 FORMAT(4I3,9X,4I3,9X,4I3)
      WRITE(61,999)
  999 FORMAT(1H017X,4HK1XX,3(2X,3HK1X),1X,4HK2XX,3(2X,3HK2X),1X,4HK3XX,
     13(2X,3HK3X))
      WRITE(61,5)K1XX,(K1X(L),L=1,3),K2XX,(K2X(L),L=1,3),K3XX,(K3X(L),
     1L=1,3)
    5 FORMAT(17HMCONTROL CARD 7  ,12(2X,I3))
C
C
C  READ CARD 6, PRODUCT NAMES
      READ(60, 4)(A(I),I=1,12)
    4 FORMAT(14A5)
      IF(LZ-2)145,146,147
  145 WRITE(61,23)
   23 FORMAT (73H0                                                  ROTATI
     1ON LENGTH IN YEARS)
      GO TO 149
  146 WRITE(61,24)
   24 FORMAT (70H0                                                     SIT
     1E INDEX IN FEET)
      GO TO 149
  147 WRITE(61,25)
   25 FORMAT (69H0                                                     PRO
     1DUCTION SYSTEM)
  149 WRITE(61, 26) (LI(L), L=1,LX)
   26 FORMAT (7X,A4,2(16X,A4))
      IF (KCXX) 160,160,152
  152 WRITE(61,27)
   27 FORMAT (17H0  PERIODIC COSTS,/115H   YEAR    COST          YEAR    C
     1OST         YEAR    COST          YEAR    COST          YEAR    COST
     2      YEAR    COST)
C
C  READ CARDS 7, PERIODIC COSTS
      DO 155 KC=1,KCXX
      READ(60,13)(NC(L,KC),PECO(L,KC),L=1,3)
   13  FORMAT(3(I3,F9.2)  )
  155 WRITE(61,29)(NC(L,KC), PECO(L,KC),L=1,LX)
   29 FORMAT (I6,F9.2,2(I11,F9.2))
  160 IF (K1XX) 170,170,162
  162 WRITE(61,30)(A(I),I= 1,4)
   30 FORMAT (25H0  PERIODIC RETURNS FROM , 4A5)
      WRITE(61,31)
   31 FORMAT (118H   YEAR YIELD QUAL      YEAR YIELD QUAL      YEAR YIELD
     1QUAL      YEAR YIELD QUAL      YEAR YIELD QUAL      YEAR YIELD QUAL)
C
C  READ CARDS 8, PRODUCT 1 RETURNS
      DO 165 K1= 1,K1XX
      READ(60,14)(N1(L,K1),JLD1(L,K1),JUAL1(L,K1),L=1,3)
   14 FORMAT (3(I3,I5,I4))
  165 WRITE(61,32) (N1(L,K1),JLD1(L,K1),JUAL1(L,K1),
     1L=1,LX)
   32 FORMAT (3I6,2(I8,2I6))
  170 IF(K2XX) 180,180,172
  172 WRITE(61,30)(A(I),I=5,8)
      WRITE(61,31)
C
C  READ CARDS 8, PRODUCT 2 RETURNS
      DO 175 K2=1,K2XX
      READ(60,14)(N2(L,K2),JLD2(L,K2),JUAL2(L,K2),L=1,3)
  175 WRITE(61,32)(N2(L,K2),JLD2(L,K2),JUAL2(L,K2),L=1,LX)
  180 IF (K3XX) 190,190,182
  182 WRITE(61,30)(A(I), I=9,12)
      WRITE(61,31)
C
C  READ CARDS 8, PRODUCT 3 RETURNS
      DO 185 K3=1,K3XX
      READ(60,14)(N3(L,K3),JLD3(L,K3),JUAL3(L,K3),L=1,3)
  185 WRITE(61,32)(N3(L,K3),JLD3(L,K3),JUAL3(L,K3),L=1,LX)
12     FORMAT (8F9.3)
C
C  READ CARD 9, ANNUAL COSTS
  190 READ(60,12)(ANC(J), CANC(J),J=1,JX)
```

```
C
C  READ CARD 10, PRICES
      DO 191 M=1,MX
  191 READ(60,1200)(PR(K,M),CPR(K,M),K=1,KX)
 1200 FORMAT(6F9.3)
      IF(NZ-1)195,195,193
C
C  READ CARD 11, FINAL VALUE
  193 READ(60,12) (FVAL(N),N=1,NX)
  195 DO 390 J=1,JX
      DO 390 M=1,MX
      LLLX=NX
      IF (NX.EQ.0)196,198
  196 LLLX=1
  198 DO 390 N=1,LLLX
      WRITE(61,34)ANC(J),CANC(J)
   34 FORMAT (37H0  ANNUAL COST                            $, F7.2,  46H
     1 CHANGE IN ANNUAL COST                         , F13.4, 17H PERCENT PER
     2YEAR)
      DO 199  K=1,KX
      JJ1=(K*K+K-1+0)
      JJ2=JJ1+1
      JJ3=JJ1+2
      JJ4=JJ1+3
  199 WRITE(61,35)(A(JJ1),A(JJ2),A(JJ3),A(JJ4),PR(K,M),A(JJ1),A(JJ2),
     1A(JJ3),A(JJ4),CPR(K,M))
   35 FORMAT (12H0  PRICE OF , 4A5, 5H    $,  F7.2, 26H       CHANGE IN
     1PRICE OF , 4A5,  F13.4, 17H PERCENT PER YEAR)
      IF(NZ-1)204,204,205
  204 WRITE(61,36)
   36 FORMAT (30H0  PERPETUAL INVESTMENT SERIES)
      GO TO 210
  205 WRITE(61,37) FVAL(N)
   37 FORMAT (37H0  VALUE AT END OF ONE INVESTMENT   $, F7.2)
  210 DO 345 L=1,LX
      KCXA=KCX(L)
      K1XA=K1X(L)
      K2XA=K2X(L)
      K3XA=K3X(L)
      NZERO=1
       DO 340  I=1,LENGTH
      GO TO (220,330),NZERO
  220 DANC=0.0
      DCANC=0.0
      DKC=0.0
      DK1=0.0
      DK2=0.0
      DK3=0.0
      DFVAL=0.0
      RTLOI=RTLOG(I)
      DISCO=RTLOG(I) ** LY(L)
      IF(ANC(J)) 225,230,225
  225 DANC=(ANC(J)*(DISCO-1.))/(RATE(I)*DISCO)
  230 IF (CANC(J)) 235,240,235
  235 DCANC=(CANC(J)*ANC(J)*DISCO-LY(L)*(RATE(I)-1.)/(RATE(I)**2*DISCO))
  240 IF(KCXA) 250,250,241
  241 DO 245 KC=1,KCXA
      KXLY=NC(L,KC)
      DISC=RTLOI ** KXLY
  245 DKC=DKC+PECO(L,KC)/DISC
  250 IF (K1XA) 260,260,251
  251 DO 255 K1=1,K1XA
      KXLY=N1(L,K1)
      DISC=RTLOI ** KXLY
      QUAL1=JUAL1(L,K1) * .01
      YLD1=JLD1(L,K1) * .1
  255 DK1=DK1+(YLD1*PR(1,M)*QUAL1*(1.+CPR(1,M)*N1(L,K1))/DISC)
  260 IF (K2XA)270,270,261
  261 DO 265 K2=1,K2XA
      KXLY=N2(L,K2)
      DISC=RTLOI ** KXLY
      QUAL2=JUAL2(L,K2) * .01
      YLD2=JLD2(L,K2) * .1
  265 DK2=DK2+(YLD2*PR(2,M)*QUAL2*(1.+CPR(2,M)*N2(L,K2))/DISC)
  270 IF(K3XA)280,280,271
```

```
 271 DO 275 K3=1,K3XA
     KXLY=N3(L,K3)
     DISC=RTLOI ** KXLY
     QUAL3=JUAL3(L,K3) * .01
     YLD3=JLD3(L,K3) * .1
 275 DK3=DK3+(YLD3*PR(3,M)*QUAL3*(1.+CPR(3,M)*N3(L,K3))/DISC)
 280 TDVAL=DK1+DK2+DK3-DANC-DCANC-DKC
     IF(NZ-1)290,290,295
 290 VALIN(L,I)=TDVAL *(1.+1./(DISCO-1.))
     GO TO 340
 295 DFVAL=FVAL(N)/DISCO
     VALIN(L,I)=TDVAL+DFVAL
     IF(VALIN(L,I))330,340,340
 330 VALIN(L,I)=0.0
     NZERO=2
 340 CONTINUE
 345 CONTINUE
     DO 1308 I=1,LENGTH
     RATE(I)=RATE(I)*100.0
1308 CONTINUE
     IF (IOUT.GT.1)1320,1208
1208 WRITE(61,1309) (NAME(I),I=1,20)
1309 FORMAT (1H1,12HPROBLEM NO. ,20A4)
     DO 1311 L=1,LX
     DO 1312 I=1,LENGTH
     IF (VALIN(L,I).GT.0.0)1312,1207
1207 IF (VALIN(L,I).EQ.0.0)1314,1206
1206 IF (I.EQ.1)1316,1205
1205 WRITE(61,1313) LI(L),RATE(I-1),RATE(I),VALIN(L,I-1),VALIN(L,I)
1313 FORMAT (1H0,37HINTERNAL RATE OF RETURN FOR SCHEDULE ,A4,12H IS BET
    1WEEN ,F5.1,5H AND ,F5.1/1H ,23HWITH PRESENT WORTHS OF ,F6.2,5H AND
    2 ,F6.2,15H RESPECTIVELY.       )
     GO TO 1311
1314 WRITE(61,1315) LI(L),RATE(I)
1315 FORMAT (1H0,37HINTERNAL RATE OF RETURN FOR SCHEDULE ,A4,4H IS ,F7.
    11/)
     GO TO 1311
1312 CONTINUE
1316 WRITE(61,1317) LI(L),RATE(I),VALIN(L,I)
1317 FORMAT (1H0,37HINTERNAL RATE OF RETURN FOR SCHEDULE ,A4,32H IS NOT
    1 INCLUDED IN THE PROBLEM.)
1311 CONTINUE
1320 IF(IOUT.EQ.0)4665,1204
1204 WRITE(61,1309) (NAME(I),I=1,20)
     WRITE(61,38)
  38 FORMAT (70H   PRESENT DISCOUNTED NET WORTH AT GIVEN ALTERNATIVE RA
    1TES OF INTEREST)
     IF (LZ-2) 1300,1301,1301
1300 WRITE(61,40) (LY(L),L=1,3)
  40 FORMAT (7H0  RATE,15X,I3,2(17X,I3)/)
     GO TO 1302
1301 WRITE(61,1303) (LI(L),L=1,2)
1303 FORMAT (7H0  RATE,14X,A4,2(16X,A4)/)
1302 CONTINUE
     DO 365 I=1,LENGTH
     WRITE(61,41) RATE(I),(VALIN(L,I),L=1,LX)
  41 FORMAT (1H ,F7.1,3F20.2)
 365 CONTINUE
4665 DO 4667 I=1,LENGTH
4667 RATE(I)=RATE(I)/100.0
 390 CONTINUE
C
C  READ CARD 12, END OF PROBLEM
     READ(60,11) IEND
     IF(IEND-98)400,142,410
 400 WRITE(61,42)
  42 FORMAT(23H0  ERROR IN INPUT CARDS)
 410 STOP
     END

        3200 FORTRAN DIAGNOSTIC RESULTS - FOR   INVEST2


NO ERRORS
LOAD, 56
RUN,15
```

This modification of Row's program does essentially the same things as the Hall program used in the problem illustration. It is more complex, however, and accepts a more sophisticated input in that it requires fewer computed values.

For example, the estimated intermediate and final harvest values need not be computed. Instead, the analyst specifies the product(s), the expected volume of each product, the quality of each product, and a set of product prices. The assigned prices are automatically adjusted by the quality index specified and the yield values are computed as part of the program.

Another requirement of the program is that the analyst specifies the minimum and maximum interest rates to be considered and the interest rate increment to be used in searching for the internal rate of return to be earned by each alternative.

The program accepts three different types of alternatives (rotation length, site index, production system, etc.) and compares three alternatives (three stands, three thinning jobs, etc.) simultaneously. The program also computes the present net worth for the range of interest rates specified.

The input and output of the problem illustrated in the text are shown here (figs. 10, 11).

INPUT DATA CODING FORM	UNIT	JOB DESCRIPTION	SYSTEM	PROGRAM	JOB NUMBER	DATE

FIELD DESCRIPTIONS

TO: FOREST SERVICE, MISSOULA

ATTENTION: TIMBER MANAGEMENT

INSTRUCTIONS FOR E.D.P.:

1. PUNCH CARDS AND VERIFY
2. RUN WITH INVESTMENT ANALYSIS NO. 2
3. RETURN OUTPUT TO USER

LINE NO.	1–20	21–40	41–60	61–80
1	CØEUR D ALENE			
2	SUPERVISØRS ØFFICE			
3	RØBERT CØØK			
4	BEAR CREEK PRØPØSED	SALE -LØNG PERIØD		
5	.020.001.04001			
6	011020011002	11131100	011003003003	01010100
7	0060060004			
8	SAWTIMBER -CUBIC FE	ET		
9	0000000031.000000000	11.00		
10 / 9	0011000115.000011000	0251.00		
11 / 9	0118000351.000116000	0201.00		
12 / 10	06009720006006012150	0050		
13 / 10	06003240005006012150	0070		
14 / 10	06003240007011003800	0050		
15 / 10	11351600006011003200	0070		
16 / 10	111311220000050			
17 / 10	111311220000070			
18 / 11	000000.10000000001.000			
19 / 12	0000000.1100			
20 / 13				
21 / 14	99			
22				
23				
24				
25				

R4-6600-12b (8/66)

Figure 10.—Input for problem illustrated in the text, for use with EDP program No. 2.

```
NATIONAL FOREST - COEUR D ALENE
UNIT - SUPERVISORS OFFICE
ATTENTION - ROBERT COOK


                              INVESTMENT ANALYSIS PROGRAM  NO. 2

 PROBLEM NO BEAR CREEK PROPOSED SALE -LONG PERIOD

CONTROL CARD 5   .020 .001 .040   1
                 LZ  LX   LI   LI   LI   LY   LY   LY  KX KCXX  KCX  KCX  KCX  JX  MX  NZ  NX
CONTROL CARD 6    1   2    1    2    0  113  100    0   1    3    3    3    0   1   1   1   0

                 K1XX  K1X  K1X  K1X K2XX  K2X  K2X  K2X K3XX  K3X  K3X  K3X
CONTROL CARD 7      6    6    4    0    0    0    0    0    0    0    0    0

                                           ROTATION LENGTH IN YEARS
    0001               0002

 PERIODIC COSTS
 YEAR     COST        YEAR     COST        YEAR    COST        YEAR    COST        YEAR    COST        YEAR    COST
   0      3.00          0     11.00
   1     15.00          1     25.00
  18     35.00         16     20.00

 PERIODIC RETURNS FROM SAWTIMBER - CUBIC FE
 YEAR YIELD QUAL      YEAR YIELD QUAL      YEAR YIELD QUAL      YEAR YIELD QUAL      YEAR YIELD QUAL      YEAR YIELD QUAL
  60  9720   60         60 12150   50
  60  3240   50         60 12150   70
  60  3240   70        100 38000   50
 113 51600   60        100 32000   70
 113 12200   50          0     0    0
 113 12200   70          0     0    0

 ANNUAL COST                          $      0       CHANGE IN ANNUAL COST                              0 PERCENT PER YEAR

 PRICE OF SAWTIMBER - CUBIC FE        $    .10       CHANGE IN PRICE OF SAWTIMBER - CUBIC FE            0 PERCENT PER YEAR

 PERPETUAL INVESTMENT SERIES


 PROBLEM NO. BEAR CREEK PROPOSED SALE -LONG PERIOD

 INTERNAL RATE OF RETURN FOR SCHEDULE 0001 IS BETWEEN   2.7 AND   2.8
 WITH PRESENT WORTHS OF   2.99 AND  -0.23 RESPECTIVELY.

 INTERNAL RATE OF RETURN FOR SCHEDULE 0002 IS BETWEEN   2.9 AND   3.0
 WITH PRESENT WORTHS OF   2.14 AND  -1.53 RESPECTIVELY.
```

Figure 11.—Machine output for problem illustrated in the text, using EDP program No. 2.

PROBLEM NO. BEAR CREEK PROPOSED SALE -LONG PERIOD
PRESENT DISCOUNTED NET WORTH AT GIVEN ALTERNATIVE RATES OF INTEREST

RATE	113	100	0
2.0	40.38	59.75	
2.1	32.86	50.16	
2.2	26.25	41.63	
2.3	20.41	34.02	
2.4	15.25	27.22	
2.5	10.67	21.11	
2.6	6.61	15.61	
2.7	2.99	10.66	
2.8	-0.23	6.19	
2.9	-3.10	2.14	
3.0	-5.67	-1.53	
3.1	-7.96	-4.85	
3.2	-10.01	-7.87	
3.3	-11.85	-10.62	
3.4	-13.49	-13.12	
3.5	-14.96	-15.40	
3.6	-16.27	-17.48	
3.7	-17.45	-19.38	
3.8	-18.50	-21.11	
3.9	-19.44	-22.69	
4.0	-20.28	-24.14	

Headquarters for the Intermountain Forest and Range Experiment Station are in Ogden, Utah. Project headquarters are also at:

- Boise, Idaho
- Bozeman, Montana (in cooperation with Montana State University)
- Logan, Utah (in cooperation with Utah State University)
- Missoula, Montana (in cooperation with University of Montana)
- Moscow, Idaho (in cooperation with the University of Idaho)
- Provo, Utah (in cooperation with Brigham Young University)

AFPO / OGDEN, UTAH / 69

FOREST SERVICE CREED

The Forest Service of the U.S. Department of Agriculture is dedicated to the principle of multiple use management of the Nation's Forest Resources for sustained yields of wood, water, forage, wildlife, and recreation. Through forestry research, cooperation with the States and private owners, and management of the National Forests and National Grasslands, it strives — as directed by Congress — to provide increasingly greater service to a growing Nation.