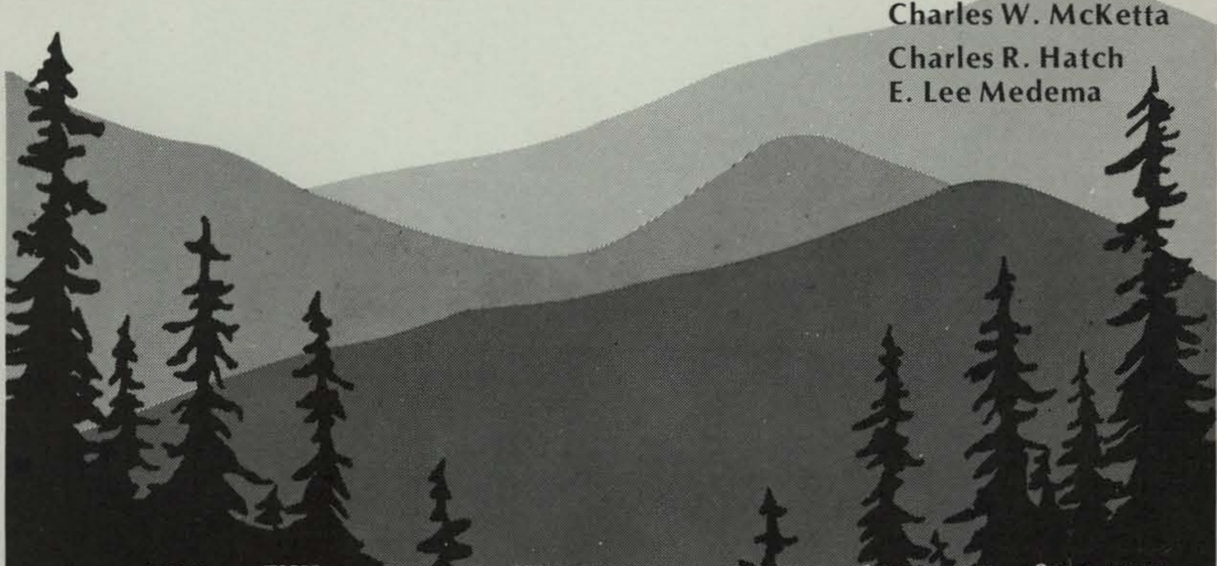
June 1978 Bulletin Number 26

College of Forestry, Wildlife and Range Sciences

Idaho Forest Productivity Study - Phase II Economic Analysis

Kjell A. Christophersen
Charles W. McKetta
Charles R. Hatch
E. Lee Medema



YEAR	STD AGE	INV AGE	MAI	NET PRES VALUE	SOIL RENT	1ST ROT NPV	2ND ROT + NPV
1977	3	2	0.	-774.45	-38.72	-72.00	-702.45
1994	20	19	0.	-119.15	-5.96	-72.00	-47.15
2014	40	39	128.	30.75	1.54	26.16	4.59
2034	60	59	487.	251.07	12.55	234.97	16.09
2044	70	69	505.	249.76	12.49	238.40	11.36
2054	80	79	513.	246.23	12.31	238.00	8.24
2064	90	89	505.	231.66	11.58	225.79	5.87
2074	100	99	494.	215.19	10.76	210.97	4.22
		OPP COSTS:		4.83			

FOREST, WILDLIFE AND RANGE EXPERIMENT STATION

John H. Ehrenreich
Director

Ali A. Moslemi
Associate Director

University of Idaho

IDAHO FOREST PRODUCTIVITY STUDY
PHASE II - ECONOMIC ANALYSIS

Kjell A. Christophersen
Charles W. McKetta
Charles R. Hatch
E. Lee Medema

Final Report
Prepared for
Idaho Department of Lands
Boise, Idaho

College of Forestry, Wildlife and Range Sciences
University of Idaho
Moscow, Idaho
June 1978

This study was accomplished by the College of Forestry, Wildlife and Range Sciences, University of Idaho, under a contract issued to the Idaho Department of Lands by the Pacific Northwest Regional Commission. The statements, findings, conclusions, and recommendations in this report are solely those of the College of Forestry, Wildlife and Range Sciences and do not necessarily reflect the view of the Idaho Department of Lands or the Pacific Northwest Regional Commission.

ISSN:0073-4586

Idaho Forest Productivity Technical Advisory Committee

State

Jack Gillette
Idaho Department of Lands
Boise, Idaho

Don Jones
Idaho Department of Lands
Coeur d'Alene, Idaho

Federal

Albert Stage
USDA Forest Service
Forestry Sciences Laboratory
Moscow, Idaho

Richard Deden
USDA Forest Service
Timber Management, Region 1
Missoula, Montana

Ed Harvey
USDA Forest Service
Timber Management, Region 4
Ogden, Utah

Alan Green
USDA Forest Service
Forestry Survey, Intermountain Region
Ogden, Utah

Educational

Charles Hatch, Professor
College of Forestry, Wildlife
and Range Sciences
University of Idaho
Moscow, Idaho

Kjell Christophersen, Assistant Professor
College of Forestry, Wildlife
and Range Sciences
University of Idaho
Moscow, Idaho

Kenneth Sowles, Assistant Dean
College of Forestry, Wildlife
and Range Sciences
University of Idaho
Moscow, Idaho

Charles McKetta, Assistant Professor
College of Forestry, Wildlife
and Range Sciences
University of Idaho
Moscow, Idaho

Lee Medema, Assistant Professor
College of Forestry, Wildlife
and Range Sciences
University of Idaho
Moscow, Idaho

Forest Industry

E. C. Scheider
Group Timberlands Manager
Boise Cascade Corporation
Boise, Idaho

William Marr
Potlatch Corporation
Lewiston, Idaho

Jay Gruenfeld
Vice-President, Forest and Lands
Potlatch Corporation
Lewiston, Idaho

ACKNOWLEDGMENTS

The Idaho Forest Productivity Technical Advisory Committee is acknowledged for the advice and suggestions given the researchers throughout this study. Data analysis and computer programming assistance provided by G.L. Houck are gratefully acknowledged. Financial support was provided by the Idaho Department of Lands and the Pacific Northwest Regional Commission.

The organizations and agencies within the State of Idaho that supplied information are gratefully acknowledged: USDA Forest Service, Region 1; USDA Forest Service, Region 4; USDA Forest Service, Intermountain Forest and Range Experiment Station; Bureau of Land Management; Idaho Department of Lands; Potlatch Corporation; Boise Cascade Corporation.

TABLE OF CONTENTS

EXECUTIVE SUMMARY

PROBLEM

Increasing demands for forest products from Idaho's 14 million acres of commercial forest land, coupled with a decreasing forest land base, have triggered concern about Idaho's future forest productivity. This concern is focused on the economic potential of Idaho's forest lands and the corresponding implications to the state's economy.

OBJECTIVES

1. To identify stand management practices and evaluate the frequency and intensities with which they might be employed over the rotation period.

2. To analyze and evaluate forest investment decisions under financial and biological maturity criteria.

PROCEDURES

Existing forest inventory data were used to classify the commercial forest stands in Idaho into 117 separate age-class and species composition groups. An additional 39 hypothetically regenerated stands were formulated. Separate yield tables were developed for five levels of management intensity for each stand.

Each of the stands was analyzed employing both economic and biological management criteria. The biological criteria were based on maximizing annual wood fiber production, while the economic criteria were based on maximizing long-run financial returns. Under assumptions reflecting reasonable future economic conditions, these two types of management criteria were evaluated. Sensitivity of the results to deviations in assumed future economic conditions was also assessed.

RESULTS AND CONCLUSIONS

1. Idaho has high timber production potential.
   The best quality sites produced 498 board feet/acre/year.

2. Idaho forest lands can be financially productive.
   The least productive land resulted in positive economic returns from investment in forestry under at least one of the evaluated management regimes.

3. Biologically determined rotation ages are costly.
   Implementing biological management instead of financial management could result in forgoing potential revenues of 21 million dollars annually.

4. Intensive forest management is not always an optimal investment.
   The optimal management regime in 89 percent of the case study stands was the no-treatment alternative. Planting was the financially optimal management regime in only one of the 195 artificially regenerated stand combinations. Management regimes including fertilization and commercial thinning comprised 85 percent of the optimal management regimes.

A number of crucial assumptions are made at each stage of this analysis which influence the results. The biological production functions consist of assumed yield responses by management regimes; economic variables are based on historical trends which may or may not continue in the future. The list of management regimes considered is by no means exhaustive. Of the economic assumptions utilized in the analysis, the results were found to be most sensitive to the discount rate, the rate of real stumpage price increase and the stumpage value change.

RECOMMENDATIONS FOR FURTHER STUDY

1. In view of the magnitude of the potential revenue losses indicated in this study, a complete and detailed comparison between financial and biological management criteria should be undertaken for specific ownerships within the state.

2. The case study approach in this analysis should be converted to a total timber system approach for commercial forest lands in the state. This would enable forest products industries to more adequately project timber flows within the state and enable them to adjust to and capitalize on new opportunities.

3. Recent studies suggest that timber flow constraints actually cause economic instability. Therefore, even-flow timber patterns should be assessed in terms of their impacts on the state's economy.

4. In view of potential reductions in commercial forest land acreage through wilderness withdrawals, impacts of these withdrawals on Idaho's economy and forest industry should be evaluated. Without knowing these implications, withdrawals may be made which are detrimental to both the State of Idaho and the nation.

5. Information regarding the economic impacts associated with silvicultural practices is incomplete and should be further assessed.

CHAPTER 1
INTRODUCTION

BACKGROUND

Increasing demands for forest products, coupled with a decreasing commercial forest land base, have triggered concern about forest productivity in Idaho. This concern focuses on the economic potential of Idaho's forest lands.

It is generally recognized that Idaho's 14 million acres in commercial forest land play an important role in the economic well-being of the state. Thus, Idaho is particularly sensitive to any changes in the forest industry. This study is timely for Idaho, where changes affecting the forest industry, such as wilderness classifications and commercial forest land encroachments, are indeed taking place.

In the first phase of the Idaho Forest Productivity Study (Hatch et al. 1977) timber supplies were projected for a given set of yield assumptions and utilization intensities. The results led to the conclusions that under 1976 forest management practices Idaho's commercial forest lands could continue to produce existing levels of timber volume through the year 2045, and would likely exceed the existing levels under more intensive management. These conclusions were reached assuming the commercial forest land base and the social, economic and environmental management objectives would remain unchanged throughout the entire projection period.

In this phase of the productivity study, the emphasis is shifted from physical supply projections to economic projections under alternative management regimes. The regimes represent various management intensities and investment levels measured in economic rates of return.

THE PROBLEM

The Idaho Forest Productivity Study Phase II, is concerned with the analysis of economic investment criteria associated with alternative forest stand management strategies. Rates of return under financial management will be compared with those obtainable under regimes strictly following biological criteria. The analytical framework examines stands to be harvested at financial as well as at biological maturity. The difference between the two measurements is defined as the opportunity cost of the biological harvest criteria.

It is important to note that the forest is examined on an individual stand basis, with separate and distinct site and stand characteristics, not as a total entity. This stand approach to the investment analyses ensures that the investments made to produce rapid growth in a young stand will have no revenue counterparts from harvesting old age timber elsewhere in the forest. That is, the analyses are not subject to an "allowable cut effect" (Dowdle 1976). Resulting cash flows are site and stand specific.

PURPOSE AND OBJECTIVES

The purpose of this phase of the productivity study was to estimate economic benefits and costs associated with various investment alternatives. Specific objectives were 1) to identify stand management practices and evaluate the frequency and intensity with which they might be employed over the rotation period and 2) to analyze and evaluate forest investment alternatives under financial and biological maturity criteria.

The delineation of a set of investment alternatives must necessarily be based on numerous variables, including the physical characteristics of the site and the composition of the stand being studied. Case study and regenerated stands portray a range of commercial forest stand conditions in Idaho. Chapter 2 identifies the physical and biological input factors considered in this study and presents the biological production functions, setting the stage for subsequent economic analyses. Chapter 3 outlines the structure of the economic analysis, lists the economic assumptions, and develops a base case to represent the future status of commercial forestry in Idaho. Chapter 4 singles out for further detailed analysis stands representing two species growing abundantly in Idaho. In Chapter 5 the base case is subjected to sensitivity analyses to cover alternative assumptions concerning the outlook for commercial forestry in Idaho. Chapter 6 presents conclusions and recommendations and also includes a discussion of researchable areas.

CHAPTER 2

DEVELOPMENT OF THE BIOLOGICAL PRODUCTION FUNCTIONS

INTRODUCTION

A biological production function describes the amount of wood fiber produced with varying levels of different inputs. In this study, the inputs include site and stand characteristics as well as management regimes. This chapter defines each of the inputs and explains how they were used to develop the biological production functions.

STAND SELECTION AND DESCRIPTION

This section outlines the methods and procedures used to select the case study and regenerated stands that are used throughout the analysis. It also describes the general composition and structure of both types of stands.

Case Study Stand Selection

In Phase I of the Idaho Forest Productivity Study, the most recent forest inventory data collected on the State of Idaho's commercial forest lands were obtained from federal and state land management agencies and from forest industry (Hatch et al. 1977). These data were used in this study to separate forest stands into similar age-class and species composition groups.

The growing stock on each inventory plot was classified by age and species composition using 20-year age-class categories. The 20-year-old category was defined as predominately containing growing stock between 0 and 20 years of age. The last age-class category, 160 years old, contained all inventory plots 160 years of age or older.

Within each age-class category, species composition was designated for two levels of stocking. The first level, denoted 75 percent, consisted of inventory plots where a single species comprised 75 percent or more of the basal area per acre. The second level, denoted 50 percent, consisted of inventory plots where a single species comprised at least 50 percent but less than 75 percent of the basal area per acre. A majority of the forest inventory plots were represented by one of these stocking levels. Separate age-species composition groups were developed for northern and southern Idaho, using the Salmon River as a general dividing line. The age-species composition groups for northern and southern Idaho totaled 117 case study situations. Each group represented a unique set of conditions and was analyzed separately.

Case Study Stand Composition and Structure

A tabular description of the 117 case study stands is given in Appendix 1a. Case study stands 1 through 70 were located in northern Idaho. Grand fir, subalpine fir, Douglas-fir, western larch, lodgepole pine, western white pine, ponderosa pine, western hemlock and western redcedar were represented by these stands. The case study stands were also well distributed throughout the age-class groups.

The primary species represented by the remaining 47 case study stands, located in southern Idaho, were grand fir, subalpine fir, Douglas-fir, Engelmann spruce, lodgepole pine and ponderosa pine. Only age-class groups 60 years of age and older were represented by case study stands in southern Idaho since younger age-class groups are not included in the existing forest inventory data bases.

Table 2.1 provides an estimate of the acreage associated with each of the 117 case study stands. These stands reflect the growing stock condition on over 60 percent of the public commercial forest land acreage in Idaho.

Few if any of the 117 case study stands have been managed using intensive forest management practices. Younger age-class case study stands are a function of past cutting practices. Previous management may also have created stands containing two or more size classes.

Case study stands were summarized over a range of soil and topographic conditions. Site quality was determined on the basis of estimated yield capabilities at the culmination of mean annual net cubic foot volume increment. A stand was defined as being on high site quality land (H) if it could produce at least 85 cubic feet per acre per year, on medium site quality land (M) if it could produce 50 to 85 cubic feet per acre per year, and on low site quality land (L) if it could produce less than 50 cubic feet per acre per year. Table 2.2 lists estimates of the site quality associated with each of the 117 case study stands. These estimates were derived from yield capacities associated with habitat type classifications.

Regeneration Stand Selection

The forest inventory data associated with Phase I of the Idaho Forest Productivity Study did not include information on recently regenerated commercial forest land acreages. Federal and state land management agency personnel and private commercial forest land owners were queried concerning current forest stand regeneration

Table 2.1. Estimated acreages associated with case study stands.

Case Study Stand No.	Acreage (1000 acres)	Case Study Stand No.	Acreage (1000 acres)	Case Study Stand No.	Acreage (1000 acres)
1	37.3	40	37.2	79	172.0
2	25.6	41	9.9	80	203.1
3	6.0	42	19.3	81	22.4
4	36.4	43	8.4	82	16.0
5	20.5	44	5.1	83	97.4
6	16.0	45	14.4	84	59.7
7	5.2	46	59.1	85	132.9
8	41.6	47	18.3	86	13.7
9	2.4	48	23.5	87	42.1
10	37.8	49	9.5	88	14.1
11	1.4	50	36.5	89	104.5
12	57.4	51	43.6	90	34.6
13	10.9	52	13.0	91	197.1
14	9.7	53	24.8	92	34.9
15	106.0	54	12.3	93	211.1
16	16.8	55	22.0	94	106.9
17	18.1	56	25.3	95	240.0
18	56.2	57	9.1	96	322.8
19	42.7	58	7.6	97	917.2
20	16.8	59	21.7	98	12.4
21	92.5	60	13.7	99	11.5
22	18.8	61	13.2	100	19.2
23	13.7	62	10.3	101	13.5
24	44.2	63	25.8	102	20.8
25	20.2	64	14.3	103	16.5
26	16.3	65	11.8	104	44.8
27	55.0	66	123.0	105	11.8
28	17.4	67	33.0	106	19.2
29	36.5	68	69.8	107	32.3
30	20.7	69	75.6	108	9.0
31	28.2	70	27.4	109	21.0
32	11.1	71	34.3	110	312.8
33	32.7	72	10.6	111	29.4
34	14.9	73	31.7	112	45.8
35	16.8	74	40.9	113	114.3
36	141.1	75	52.3	114	62.8
37	56.6	76	105.1	115	85.8
38	124.2	77	25.5	116	67.9
39	66.1	78	127.2	117	242.4

practices. Based on their responses, 39 hypothetical regenerated stands were formulated to represent growing stock conditions on artificially and naturally regenerated acreages in northern and southern Idaho. Each stand was designed to represent a unique set of conditions and was analyzed separately.

Regeneration Stand Composition and Structure

Hypothetical regenerated stands were assumed to be even-aged and to contain not more than two species. Seedlings were assumed to be 3 years old in 1977 and to average 1.5 feet in height. Each stand was formulated at three stocking levels: 300, 450 and 600 trees per acre. Numbers 1 through 21 were formulated for northern Idaho species mixes. The remaining 18 stands reflected southern Idaho species mixes. A tabular description of the 39 stands is given in Appendix 2.

The range of stocking levels in the regenerated stands was intended to reflect management strategies of different intensities and philosophies. It may also reflect environmental and ecological factors which differ widely from site to site.

These stands could be established by natural or artificial means, or by a combination of both. For example, during the period following planting a stand may incur natural regeneration which supplements the initial planting density. To represent this phenomenon in the analytical framework, the 450 trees per acre density may be interpreted as a stand initially planted with 300 trees, followed by the addition of 150 trees per acre through natural regeneration. Regenerated stands containing 450 trees per acre could also represent either natural or artificial stands of that density.

The site quality was based on estimated yield capabilities at the culmination of mean annual net cubic foot volume increment under the optimal biological management regime. Table 2.3 lists estimates of site quality associated with each of the 39 regenerated stands.

Table 2.2. Site quality classes associated with each of the case study stands.

Case Study Stand No.	Site Class *	Case Study Stand No.	Site Class	Case Study Stand No.	Site Class
1	H	40	H	79	M
2	M-L	41	H	80	M
3	H	42	H	81	M
4	M	43	M	82	L
5	H	44	H	83	M-L
6	M-L	45	M	84	M
7	M	46	H	85	M
8	M-L	47	M	86	M
9	H	48	M-L	87	L
10	M	49	H	88	M
11	H	50	M	89	M-L
12	H	51	H	90	M
13	M-L	52	M	91	M
14	M	53	M-L	92	M
15	M-L	54	H	93	L
16	H	55	M	94	M
17	M	56	H	95	M-L
18	M	57	M	96	M
19	H	58	H	97	M
20	M-L	59	M	98	L
21	M-L	60	H	99	M-L
22	H	61	M	100	M
23	M	62	H	101	L
24	M	63	H	102	M-L
25	H	64	M	103	M
26	M-L	65	H	104	M
27	M-L	66	H	105	L
28	M	67	H	106	M-L
29	M	68	M	107	M
30	H	69	H	108	M
31	M	70	H	109	L
32	H	71	M-L	110	M
33	H	72	M	111	M-L
34	M	73	L	112	M
35	H	74	M-L	113	L
36	H	75	M	114	M
37	M-L	76	M	115	M-L
38	M	77	L	116	M
39	H	78	M-L	117	M

* H – capable of producing more than 85 cubic feet/acre/year
M – capable of producing between 50 and 85 cubic feet/acre/year
L – capable of producing less than 50 cubic feet/acre/year

MANAGEMENT REGIMES

The preceding section addresses the stand and site characteristics which were used as inputs to the biological production functions. This section addresses the management regime inputs. Management regimes are represented by combinations and variations of individual forest management practices.

Case Study Stands

The case study stands were subjected to each of the following management regimes: 1) no management, 2) commercial thinning, 3) commercial thinning and fertilization, 4) overstory removal and commercial thinning, and 5) overstory removal, commercial thinning and fertilization.

When the commercial thinning management regime was employed in this study, stands were commercially thinned whenever 1) minimum removal volume was 1500 board feet per acre on trees with diameters at least 5 inches and 2) the removal volume and tree size constraints could be met without reducing the residual stand below 100 square feet basal area per acre.

When fertilization was employed, it was applied at the same time as the intermediate harvest operation. An annual cubic foot volume growth rate response of 12 percent was assumed for a 5-year period following application (Scanlin et al. 1976). Only stands 60 years or less in age were subjected to management regimes containing fertilization.

Table 2.3. Site quality classes associated with each of the hypothetical regenerated stands.

Regenerated Stand No.	Site Quality Class*
1–3	M
4–6	H
7–9	M
10–12	M
13–15	L
16–18	M
19–21	M
22–24	M
25–27	H
28–30	L
31–33	M
34–36	L
37–39	M

*H – capable of producing more than 85 cubic feet/acre/year
M – capable of producing between 50 and 85 cubic feet/acre/year
L – capable of producing less than 50 cubic feet/acre/year

Because of past management practices, the younger case study stands frequently contained trees from the previous stand. The overstory removal management regime converted these to stands containing a more uniform size and age-class structure by immediately removing all trees 12 inches and larger in diameter. This management regime was only applied to case study stands 40 years or less in age. A tabular description of the case study stands following the overstory removal management regime is given in Appendix 1b.

Regenerated Stands

The regenerated stands were treated both as naturally established and as artificially established. A 10-year regeneration lag was assumed for naturally established stands. In the artificially established stands 2-year-old seedlings were planted 1 year following the harvest cut. Regenerated stands were subjected to each of the following management regimes: 1) no management, 2) commercial thinning, 3) commercial thinning and fertilization, 4) precommercial and commercial thinning, and 5) precommercial and commercial thinning and fertilization.

Management regimes containing commercial thinning and fertilization were applied to these stands according to the constraints and conditions defined for case study stands.

When the precommercial thinning management regime was employed, regenerated stands 20 years old and containing more than 300 trees per acre were precommercially thinned to a residual stand density of 300 trees per acre.

YIELD TABLE DEVELOPMENT

Biological production functions, or yield tables, are a tabulation of the volume of wood fiber in a stand by species at the beginning of each decade. A separate yield table was derived for each management regime.

Stand Prognosis Model

A mathematical stand projection system was used to construct the yield tables (Stage 1973). The system is designed to project the development of a specific stand through time. A stand is described by its site characteristics as well as by information on the number of trees per acre and the size and species of trees in the stand. This information serves as projection system input. The stand develops through time subject to a specified management regime. The output of the projection system includes both the volume of the residual stand and the volumes removed at the beginning of each decade.

Yield Tables

The projection system was used to construct a separate yield table for each management regime for the 117 case study stands and the 39 regenerated stands. These tables are available on request.

CHAPTER 3
STRUCTURE OF ECONOMIC ANALYSIS

INTRODUCTION

This chapter introduces the analytical framework for economic analysis, including methodology, economic assumptions employed, and a description of the economic base case criteria. These criteria can be used to estimate the future forest investment environment in Idaho.

METHODOLOGY

Economic analysis of forest management alternatives is a process of assembling relevant economic information and transforming it into a meaningful economic picture for the planning horizon. In this study net present values (NPV) and soil expectation values (SEV) were used as investment decision indicators. These analytical criteria are similar in methodology, utilize the same data base, but yield different interpretive results. The NPV and SEV criteria are used to rank the economic attractiveness of the management regimes considered for case study stands and regenerated stands, respectively.

Both financial criteria are particularly sensitive to the timing of events. Early events will have a greater impact than later ones of the same magnitude, which explains, in part, the economic difference between financial and biological maturity.

In a biological sense the ideal rotation of a stand is determined at the point where the mean annual increment (MAI) reaches a maximum – i.e., where annual wood production is maximized. This point, of course, varies with species, density and site characteristics, but not with economic criteria. In this study the magnitudes and timing of costs and revenues associated with the biological production function are used to determine the ideal financial rotation age of a stand. This age is defined as the point in time when NPV or SEV reaches a maximum.

Net Present Value

The NPV (dollars/acre) criterion, as employed in this study, analyzes the economics of further investment in the case study stands. The issue is what should be done with stands in the future. Existing value, composition and structure are functions of past management. Previous expenditures are sunk costs in a present-day context.

In NPV analysis, projected net cash flows (benefits minus costs) are discounted to the present by an appropriate rate of discount. (The choice of an appropriate discount rate is an important one and is discussed in detail later in this chapter.) The result indicates the present value of a stream of net incomes anticipated over the planning horizon. The mathematical formulation is given in Appendix 3. A positive NPV suggests economic feasibility, particularly if the discount rate chosen equals or exceeds the opportunity cost of capital. The opportunity cost of capital is defined as the highest rate of return obtainable from alternative investments.

The maximum NPVs reported for the case study stands were adjusted for land rent. Land rent is defined as the capitalized value of soil rent, which is the annual opportunity cost of occupying the land for the purpose of growing trees. The maximum SEV for a regenerated stand best corresponding to the case study stand being analyzed is converted to land rent. The land rent is applied only when maximum SEV is positive; otherwise it equals zero. The mathematical formulation for land rent is described in Appendix 3.

Soil Expectation Value

The SEV (dollars/acre) investment criterion used in this study was applied only to regenerated stands. Economic criteria are brought into the analytical framework by means of a generalized Faustmann formulation, a mathematical method of compounding and discounting cash flow in analyzing forest investments (Faustmann 1849). In this analysis the Faustmann approach has been modified to provide for price and cost increases over time (Goforth and Mills 1975). It is mathematically formulated in Appendix 3. This form of NPV analysis takes the frequency and magnitudes of benefits and costs into account in determining the optimal rotation age of a stand over an infinite number of rotations, assuming that the highest and best potential use of the land is reflected in its present usage. Since the land in this study has been classified as commercial forest land, the maximum SEV was assumed to reflect the species composition and growing stock level which provides the greatest potential use of the land. Thus, the best potential use is for wood fiber production.

The optimal rotation age occurs when the SEV reaches a maximum. Figure 3.1 illustrates the probable behavior of a financial yield curve over rotation length for an even-aged stand subjected to a specific management regime. Between points A and C the bare land is valued positively, and the curve reflects the present value of potential income streams. At point B the SEV reaches a maximum that identifies the age of financial maturity. Consequently, B would reflect the stand rotation age that would maximize financial returns. The lower curve illustrates a financial yield curve for a lesser valued species or a more costly management regime. Here the present value of costs exceeds the present value of the growing stock and resulting SEVs are negative. Actual SEV horizons for Douglas-fir/grand fir and lodgepole pine are presented in Fig. 5.3.

Financial yield curves such as those shown in Fig. 3.1 were not derived for case study stands because the information needed to determine the shape of the SEV curve prior to the present age of the stand was not available. As illustrated in Fig. 3.2, the present age and mixture of species and tree sizes within a stand can provide a situation where the point of financial maturity has already occurred (curve a), coincides with the present age of the stand (curve b), or occurs soon after present age (curve c).

Opportunity Costs

The management regimes considered for all stands cover the period from stand initiation (or, alternatively, from the present age of the stand) through the culmination of mean annual board foot increment (MAI). Opportunity costs, in the context of this study, represent the values forgone by not harvesting at financial maturity.

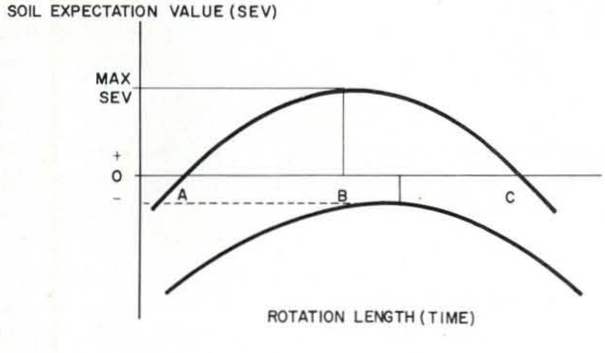


Fig. 3.1. Soil Expectation Value over time, even-aged stand. The lower curve illustrates a lesser valued species or more costly management regime.

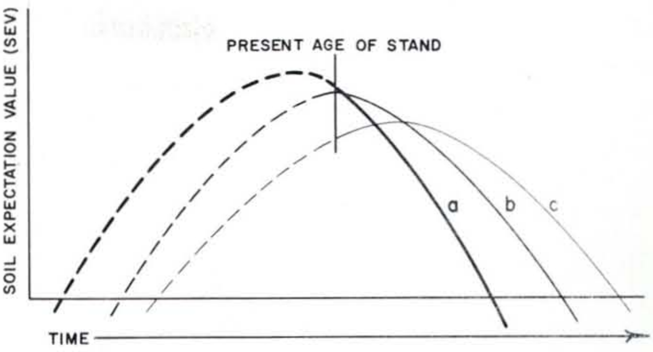


Fig. 3.2. Soil Expectation Value over time, case study stands. Curve a = stand already matured; curve b = financial maturity at present age of stand; curve c = financial maturity soon after present age of stand.

ECONOMIC ASSUMPTIONS

This section describes the justifications and assumptions that were made concerning the discount rate, values, costs and market conditions. The selection of numerical values for each of these variables directly influences the magnitude of the analytical result. It is important that the reader understand the rationale behind their selection.

Rate of Discount

The magnitudes of NPVs and SEVs depend primarily on the selected real discount rate. The rate chosen is likely to vary among decision-makers, depending on individual financial conditions.

In this study, a 3 percent real rate of interest is used in combination with a risk premium of 2 percent, which provides a discount rate of 5 percent. Yohe and Karnosky (1969) found that between 1962 and 1969 the real rate of interest fluctuated around 3 percent plus or minus 0.45 percent, based on the yields of the AAA corporate bonds adjusted by the gross national product price deflator. An extension of their work to 1977 done for this report determined that, except for a significant 1-year drop during 1975, the real rate has remained at 3 percent.

There is no well-documented estimate of the risk premium applicable to forestry. The 2 percent estimate may seem conservative in view of the biological or physical risks associated with forestry, such as change of climate, fire, disease and insect infestation. Financial risks may also seem high in view of the widely fluctuating nature of stumpage prices. Between 1968 and 1976 the average price for public sawtimber stumpage in real terms deviated up to 250 percent from its trend. Corporate bond ratings for major wood products companies, however, indicate low risk. Their asset portfolios tend to be well diversified and to compensate for the financial and biological risks associated with forest investment.

Real before-tax corporate capital yields have dropped from a previous 15 percent to 10 percent in the early 1970s (Nordhaus 1974). Presuming forestry is close to the norm, a 5 percent discount rate as a measure of the opportunity cost of capital then becomes plausible. Public agencies under direction of the Office of Management and Budget have used the 5 percent rate. The USDA Forest Service used 5 percent in its recent *Timber Harvest Scheduling Issues Study* (1976) and in its RPA assessment for 1975 (1977). Marion Clawson, in his *Economics of National Forest Management* (1976), also used a 5 percent rate. Modifications of the discount rate assumption are covered in Chapter 5 on sensitivity.

Stumpage Values

Real prices of sawtimber stumpage have increased over time. The *Outlook for Timber* (USDA Forest Service 1973) measured the real increase in stumpage since 1910 at 3.5 percent per year for Douglas-fir and 3.2 percent per year for southern pine. Goforth and Mills (1975) note 3.1 percent in ponderosa pine, and this study measured average public land stumpage in Idaho between 1968 and 1976 at 3.2 percent real annual increase. Real lumber prices have increased at a rate between 1.7 and 2 percent since 1850 (USDA 1973).

To extrapolate trends from these two real price increases would be meaningless, since by 2008 stumpage prices would exceed lumber prices. Instead, the real price increase used in this paper is 2 percent extrapolated for the first rotation, after which price increases cease. That is, stumpage prices during the second and subsequent rotation are equal to stumpage prices at the end of the first rotation. This assumption corroborates the one made in the *Phase II Washington State Forest Productivity Study* (Larsen 1977).

The stumpage prices used as the base data points from which future cash flows are computed are taken from State of Idaho weighted average prices paid for the time period 1972 to 1976 (Table 3.1). These prices are based on actual bids rather than appraised values and are inflated to 1976 prices by means of the wholesale lumber price index. The prices are also adjusted for development costs to neutralize the accessibility factor. All case study stands and regenerated stands are assumed accessible. Yearly state harvest volumes and corresponding 1976 prices for northern and southern Idaho are given in Appendix 4. Sensitivity analysis of alternative price assumptions will be explored in Chapter 5.

Costs

Three management practices include costs: planting, precommercial thinning and fertilization. Each practice represents an investment in the stand at the beginning of or during the rotation for which returns are realized only at intermediate cuttings or final harvest. The cost of each

Table 3.1. Weighted Idaho state average stumpage values, 1972-1976.

Species	Weighted average stumpage values ($ per MBF*)
Western white pine	89.86
Western larch	46.11
Douglas-fir	46.11
Grand fir	42.14
Western hemlock	42.14
Western redcedar	90.50
Lodgepole pine	30.13
Engelmann spruce	45.88
Subalpine fir	42.14
Ponderosa pine	54.58
Pulp	4.20
Other	42.14

Source: Idaho Department of Lands, 1977.

*MBF = thousand board feet.

management practice is employed in accordance with the constraints outlined in Chapter 2. Costs represent inputs with alternative employment possibilities and therefore real costs are not expected to increase.

Planting Costs. Planting costs used as base data points are taken from State of Idaho weighted average costs incurred between 1972 and 1976 (Table 3.2). The costs are inflated to 1976 levels by means of the wholesale lumber price index, to be consistent with the stumpage price base figures.

The $61.59 figure was divided into a fixed cost component of $45 per acre plus 6¢ per seedling. The regenerated stand for which this total cost estimate applies has approximately 300 stems per acre. Variants of this density with corresponding cost adjustments will be discussed in Chapter 5.

Precommercial Thinning. Precommercial thinning costs are also taken from state data covering the period 1972 to 1976 (Table 3.2) and are weighted by the acreages involved and inflated to 1976 levels by the wholesale lumber price index. The $83.18 estimate is generally higher than precommercial thinning costs incurred by private industry, but lower than those incurred on USDA Forest Service lands. Chapter 5 will address the situations more applicable to individual ownerships.

Fertilization. Fertilization cost estimates are also based on state data, inflated to 1976 levels and weighted by the acreages fertilized (Table 3.2). The $56.19 estimate represents the total cost of fertilizing one acre based on aerial application costs. Variants of this cost will be discussed in Chapter 5.

Table 3.2. Weighted Idaho state silvicultural costs, 1972-1976, nominal and inflated 1976 levels.

	Planting			Pre-Commercial Thinning			Fertilization		
Year	Acres	Nominal $/Acre	1976 $/Acre	Acres	Nominal $/Acre	1976 $/Acre	Acres	Nominal $/Acre	1976 $/Acre
1972	1969	49.03	71.67	374	76.06	111.18	469	40.46	59.14
1973	1657	44.72	50.78	515	55.10	62.56	635	30.63	34.78
1974	383	90.28	101.57	1056	58.12	65.39	–	–	–
1975	1190	54.99	66.56	879	83.63	101.22	1598	57.29	69.34
1976	6384	57.97	57.97	165	101.75	101.75	1316	49.48	49.48
Totals	11583		61.59	2989		83.18	4018		56.19

Source: Idaho Department of Land, 1977.

Market Conditions

The behavior of the market for forest products is directly dependent upon prices, costs, population, income and a number of other interacting variables. Yet, with the long time horizon applicable in forestry and the difficulty in forecasting market fluctuations with any degree of confidence, the assumption is made that buyers are readily available when harvested quantities are put up for sale.

Base Case Summary

It should be emphasized that the results given in this report are strictly a function of the assumptions. These reflect existing commercial forest stand conditions in Idaho and also provide analytical flexibility in an "if-then" context (i.e., if a stand has certain characteristics and a particular management regime is applied, then what would be the outcome?). The assumptions describe the "base case" for which the economic analyses were conducted. Variants of the base case will be discussed in Chapter 5, where alternative assumptions are made.

For case study and regenerated stands, the base case real discount rate was 5 percent, coupled with a 2 percent real rate of stumpage increase for the first or present rotation. Costs (planting, precommercial thinning, fertilization) were held constant over the rotation period.

Each regenerated stand was subjected to all five management regimes and to planting or no-planting alternatives. A 10-year regeneration lag was assumed for the latter. Younger case study stands were subjected to all five management regimes, whereas older ones were subjected to only regimes 1, 2 and 3.

CHAPTER 4
RESULTS, REPRESENTATIVE STANDS – BASE CASE

INTRODUCTION

This chapter selects 4 representative stands from among the 117 case study and 39 regenerated stands and follows those examples through a complete analysis. Stands were picked to conform to the area and value of species in Idaho.

Predominant species, Douglas-fir and lodgepole pine, comprise 38.9 percent and 18.2 percent of the sampled public land base, respectively. These represent medium- and low-valued species in the analysis. Regenerated and case study stands both were selected under these criteria.

Base case results for all case study and regenerated stands are given in Appendices 5a and b. The tables presented in these appendices show the economic behavior of the stands only for the points in time when they reach biological and financial maturity. In this chapter, however, results for these four representative stands are presented in more detail.

CASE STUDY STANDS

The representative case study stands chosen were stands 100 and 8. These were subjected to the following management regimes: 1 (no treatment) and 2 (commercial thinning) for stand 100, and 1, 4 (overstory removal and commercial thinning) and 5 (overstory removal, commercial thinning and fertilization) for stand 8. Other management regimes were not considered for these stands because of assumptions cited earlier.

Step 1: Stand Composition and Structure

The physical makeup of case study stands 100 and 8 is given in Table 4.1. Stand 100, 50 percent Douglas-fir,

Table 4.1. Composition and structure of representative case study stands, Idaho, 1977.

	Species†											
	GF	AF	WL	ES	LP	WP	PP	DF	WC	WH	OTH	TOT
Case Study Stand No. 100: Southern Idaho, 80 years old – 50% Douglas-fir												
Basal Area/Acre (sq. ft.)	7.3	6.2	0.5	0.0	5.8	0.0	26.7	79.0	0.0	0.0	8.5	134.
Trees/Acre	31.6	35.7	1.3	0.0	32.6	0.0	68.0	206.8	0.0	0.0	59.7	435.
Average DBH* (inches)	6.5	5.6	8.5	0.0	5.7	0.0	8.5	8.4	0.0	0.0	5.1	7.
Case Study Stand No. 8: Northern Idaho, 40 years old – 75% Lodgepole pine												
Basal Area/Acre (sq. ft.)	0.5	0.1	1.0	0.0	87.5	0.8	0.0	1.1	0.0	0.6	0.1	91.
Trees/Acre	6.1	4.4	0.7	0.0	378.5	5.2	0.0	15.4	0.0	2.0	2.2	414.
Average DBH (inches)	4.1	2.1	16.6	0.0	6.5	5.4	0.0	3.6	0.0	7.3	2.1	6.

*DBH = diameter at breast height.

†GF = grand fir, AF = alpine fir, WL = western larch, ES = Engelmann spruce, LP = lodgepole pine, WP = western white pine, PP = ponderosa pine, DF = Douglas-fir, WC = western redcedar, WH = western hemlock, OTH = other, and TOT = total.

Source: Appendix 1a.

Table 4.2. Economic response to management alternatives, Idaho, 1977.

Case Study Stand No. 100: Southern Idaho, 80 years old – 50% Douglas-fir

			Management Alternative 1				Management Alternative 2			
Year	Stand Age (yrs)	Investment Age (yrs)	MAI† (bd ft/ac/yr)	NPV* ($/ac)	Land Rent ($/ac)	NPV ($/ac)	MAI (bd ft/ac/yr)	NPV* ($/ac)	Land Rent ($/ac)	NPV ($/ac)
1977	80	0	114	477.93	0.0	477.93	114	477.93	0.0	477.93
1987	90	10	109	379.53	45.09	334.44	109	379.53	45.09	334.44
1997	100	20	104	291.13	72.78	218.35	104	291.13	72.78	218.35
2007	110	30	103	235.07	89.78	145.29	107	258.29	89.78	168.51
2017	120	40	102	189.09	100.21	88.88	109	230.80	100.21	130.59
2027	130	50	100	150.36	106.61	43.75	109	202.32	106.61	95.71
2037	140	60	98	118.13	110.55	7.58	108	176.50	110.55	65.95
			Opportunity Costs: 0.0				Opportunity Costs: 0.0			

*NPV unadjusted for land rent.
†MAI = mean annual increment; NPV = net present value.

contained 436 trees per acre, with an average diameter at breast height (dbh) of 7.5 inches. Average dbh for individual species also exceeded the minimum merchantable size requirement of 5 inches. The second most dominant single species was ponderosa pine. Case study stand 8, 75 percent lodgepole pine, had 415 stems per acre and an average dbh of 6.4 inches.

Step 2: The Biological Production Function

The biological yield and timing of treatments for each management regime in each case study stand is available on request. Case study stand 100 was subjected to only the first two management regimes. Stand 8 was subjected to management regimes 1, 4 and 5. An overstory removal of 2054 board feet per acre took place at the present age of the stand.

Step 3: Economic Results

The economic response of the representative stands to different management regimes is given in Tables 4.2 and 4.3. Table 4.2 shows that case study stand 100 has reached a maximum MAI at its present age (80 years). Maximum refers to the point in time closest to culmination of MAI, because the present age of the stand may already have passed the point where the growth culminated. Figure 3.2 illustrates the investment horizon which gives rise to this problem.

Under both management regimes 1 and 2 the NPVs maximize at the present age. This means that the economic response to the commercial thinning operation was not sufficient to surpass the NPV of the no-treatment alternative. Therefore, the optimal economic management regime

Table 4.3. Economic response to management alternatives, Idaho, 1977.

Case Study Stand No. 8: Northern Idaho, 40 years old – 75% Lodgepole pine

			Management Alternative 1				Management Alternative 4				Management Alternative 5			
ear	Stand Age (yrs)	Investment Age (yrs)	MAI† (bd ft /ac /yr)	NPV* ($/ac)	Land Rent ($/ac)	NPV ($/ac)	MAI (bd ft /ac /yr)	NPV* ($/ac)	Land Rent ($/ac)	NPV ($/ac)	MAI (bd ft /ac /yr)	NPV* ($/ac)	Land Rent ($/ac)	NPV ($/ac)
977	40	0	158	353.11	0.0	353.11	158	353.11	0.0	353.11	158	353.11	0.0	353.11
987	50	10	156	233.96	30.81	203.15	157	258.81	30.81	228.00	163	210.57	30.81	179.76
997	60	20	164	188.28	49.72	138.56	174	261.60	49.72	211.88	183	213.36	49.72	163.64
007	70	30	170	164.53	61.34	103.19	173	244.01	61.34	182.67	184	194.99	61.34	133.65
017	80	40	160	132.30	68.46	63.84	179	226.39	68.46	157.93	182	172.08	68.46	103.62
027	90	50	151	105.66	72.82	32.84	168	200.18	72.82	127.36	168	143.91	72.82	71.09
037	100	60	136	80.85	75.53	5.32	162	180.27	75.53	104.74	161	123.56	75.53	48.03
047	110	70	126	60.97	77.12	-16.15	147	161.35	77.12	84.23	146	104.40	77.12	27.28
057	120	80	113	45.00	78.19	-33.19	137	147.19	78.19	69.00	136	90.52	78.19	12.33
067	130	90	103	33.87	78.81	-44.94	125	135.58	78.81	56.77	124	78.99	78.81	0.18
077	140	100	93	24.99	79.19	-54.20	115	126.64	79.19	47.45	114	70.24	79.19	-8.95
			Opportunity Costs: $249.92				Opportunity Costs: $195.18				Opportunity Costs: $219.46			

NPV unadjusted for land rent.
MAI = mean annual increment; NPV = net present value.

for this stand would be to curtail any further investments in the stand and to liquidate it immediately. Opportunity costs under this regime would be zero, since maximum MAI and financial maturity coincide.

Case study stand 8, subjected to management regimes 1, 4 and 5, also shows financial maturity at present age of the stand in all cases (Table 4.3). Biological maturity, however, is reached at different points in time. Under management alternative 1, MAI culminates at age 70 (investment age 30), where NPV equals $103.19 per acre. Maximum NPV for that alternative is $353.11 per acre at the present age of the stand. The difference in NPV between the two maturity criteria is the opportunity cost of deferring harvest until biological maturity, or $249.92 per acre.

Culmination of MAI for management alternative 4 occurs at age 80 (investment age 40), where the corresponding NPV is $157.93 per acre, significantly higher than the NPV associated with biological maturity in the previous regime, as reflected in the lower opportunity cost ($195.18 per acre). However, even when the stand is released by removing the overstory, the economic response is not sufficient to surpass the NPV of immediate liquidation.

The benefits gained from fertilization (management regime 5) are biological. This treatment slightly increases the growth rate, when compared with both management alternatives 1 and 4. Biological growth culminates at age 70, with a corresponding NPV of $133.65 per acre. The opportunity cost is $219.46 per acre. In this case the application of fertilizer would be costly in relation to its economic returns.

In summary, the optimal management prescription for stand 8 is no treatment coupled with liquidation at present age. Although this stand is only 40 years old, further investment is not economically feasible because of existing stand composition and structure.

Case Study Stands, Summary

The tables given in Appendix 5a show the NPVs associated with biological and financial maturity criteria for each management alternative considered. Table 4.4 shows which management regime is optimal for each case study stand under the base case assumptions.

The optimal financial management regime for 94 percent of the case study stands is the no-treatment alternative. Several of these stands, however, were not subjected to any treatment because of their existing composition and structure. The fourth management regime, overstory removal and commercial thinning, was the optimal financial management regime for six stands 40 years old or younger. In these cases the biological response of the residual stands, coupled with the revenues from the overstory harvests, economically justifies the additional investments associated with that management treatment. Management alternative 2, commercial thinning, was the optimal financial management regime for only one stand (19). The alternatives involving fertilization (3 and 5) were not economically optimal.

The relationships between management treatments representing stand investments and the economic response as shown in Table 4.4 were expected. Few stands respond economically to treatments except the younger ones, where biological growth is still increasing at an increasing rate. This identifies the problem of economic productivity directly as one of rotation age. This important variable is reflected in the opportunity cost column of Table 4.4, showing values forgone by deferring harvest until biological maturity.

The optimal biological management regime is no-treatment, coupled with longer rotation ages in most cases, in 83 percent of the 117 case stands. Only 20 case study stands would benefit biologically from applying any management regime more intensive than the no-treatment alternative.

All case study stands considered to be mature or overmature by the financial criterion were aggregated and are shown in Appendix 6. In these stands, the maximum NPVs occur at present age and indicate economic advisability of immediate liquidation.

The estimated value of financially mature or overmature stands represented by this sample amounts to 5.11 billion dollars. Deferring the harvest of the portion of these stands not yet biologically mature to biological maturity would result in estimated additional holding cost of 416.7 million dollars in present terms.

REGENERATED STANDS

The representative regenerated stands selected for this study were 10, 11, 12, 22, 23 and 24. These were subjected to all five management regimes. Furthermore, each stocking density (300, 450 and 600 trees per acre) was represented, whether planted or naturally regenerated.

Step 1: Stand Composition and Structure

The physical make-up of the regenerated stands was less complicated than that given for the case study stands. The even-aged regenerated stands contained a maximum of two species. The composition and structure are given in Table 4.5.

Step 2: The Biological Production Function

The only difference between the yield functions fo

Table 4.4. Summary of case study investment analyses, base case assumptions, Idaho, 1977.

		Financial			Biological				
Case Study Stand No.	Present Age (yrs)	Optimal Management Alternative	Investment Age (yrs)	Adjusted Maximum NPV ($/ac)	Optimal Management Alternative	Investment Age (yrs)	Maximum MAI (bd ft/ac/yr)	Adjusted NPV ($/ac)	Opportunity Costs ($/ac)
1	20	1	0	508.51	5	90	532	415.99	92.53
2	20	1	0	137.34	4	50	199	26.49	110.84
3	20	4	30	1354.31	1	0	731	908.44	445.87
4	20	4	10	782.25	1	0	499	566.17	216.08
5	40	4	50	613.82	5	90	437	539.50	74.32
6	40	1	0	139.94	5	70	186	45.08	94.86
7	40	1	0	187.40	5	80	111	87.66	99.74
8	40	1	0	353.11	5	30	184	133.65	219.46
9	40	4	50	878.92	4	100	262	777.76	101.16
10	40	1	0	644.57	5	60	200	454.61	189.96
11	40	1	0	695.41	1	0	399	695.41	0.0
12	60	1	0	888.15	3	70	352	392.13	496.02
13	60	1	0	393.62	1	30	155	197.23	196.39
14	60	1	0	147.93	1	80	84	5.91	142.02
15	60	1	0	222.69	1	40	123	71.60	151.09
16	60	1	20	445.63	1	80	248	148.19	297.44
17	60	1	0	303.96	1	50	125	55.41	248.55
18	60	1	0	585.57	1	0	157	585.57	0.0
19	80	2	10	1443.92	2	60	334	723.57	720.35
20	80	1	0	426.49	2	40	143	182.17	244.32
21	80	1	0	374.99	1	10	108	287.19	87.80
22	80	1	0	1125.38	1	50	220	437.86	687.52
23	80	1	0	594.65	1	0	137	594.65	0.0
24	80	1	0	1540.41	1	0	247	1540.41	0.0
25	100	1	0	969.72	1	60	201	202.97	766.75
26	100	1	0	713.51	1	10	139	467.23	246.28
27	100	1	0	527.18	1	10	119	352.21	174.97
28	100	1	0	888.41	1	0	164	888.41	0.0
29	100	1	0	1245.49	1	0	183	1245.49	0.0
30	120	1	0	1041.92	1	40	188	348.52	693.40
31	120	1	0	851.74	1	0	148	851.74	0.0
32	120	1	0	1000.92	1	60	133	256.74	744.18
33	140	1	0	1403.53	1	0	195	1403.53	0.0
34	140	1	0	488.99	1	0	79	488.99	0.0
35	140	1	0	2629.21	1	0	248	2629.21	0.0
36	160	1	0	1623.37	1	0	183	1623.37	0.0
37	160	1	0	532.24	1	40	81	146.02	386.22
38	160	1	0	934.54	1	0	109	934.54	0.0
39	160	1	0	2434.23	1	0	176	2434.23	0.0
40	160	1	0	1407.73	1	0	203	1407.73	0.0
41	20	4	20	1382.40	1	0	1380	1379.13	3.27
42	40	1	0	825.57	5	60	461	773.40	32.17
43	40	1	0	475.90	1	0	219	475.90	0.0
44	40	4	30	1088.06	5	70	432	1000.40	87.66
45	40	1	0	818.97	1	0	343	818.97	0.0
46	60	1	0	931.87	3	60	393	604.73	327.14
47	60	1	0	451.30	1	0	162	451.30	0.0
48	60	1	0	627.57	1	0	191	627.57	0.0
49	60	1	20	605.72	3	60	285	376.69	229.03
50	60	1	0	820.03	1	0	203	820.03	0.0

Table 4.4. Continued.

Case Study Stand No.	Present Age (yrs)	Financial: Optimal Management Alternative	Financial: Investment Age (yrs)	Financial: Adjusted Maximum NPV ($/ac)	Biological: Optimal Management Alternative	Biological: Investment Age (yrs)	Biological: Maximum MAI (bd ft/ac/yr)	Biological: Adjusted NPV ($/ac)	Opportunity Costs ($/ac)
51	80	1	0	1145.44	2	60	319	739.53	405.91
52	80	1	0	425.93	1	0	114	425.93	0.0
53	80	1	0	694.06	1	0	199	694.06	0.0
54	80	1	0	1738.43	2	50	296	960.52	777.91
55	80	1	0	803.87	1	0	196	803.87	0.0
56	100	1	0	1316.73	2	40	256	766.03	550.70
57	100	1	0	727.89	1	0	149	727.89	0.0
58	100	1	0	1060.63	1	50	211	400.21	660.42
59	100	1	0	1029.01	1	0	225	1029.01	0.0
60	120	1	0	1322.39	1	0	211	1322.39	0.0
61	120	1	0	1172.30	1	0	185	1172.30	0.0
62	120	1	0	1371.90	1	40	173	523.02	848.88
63	140	1	0	1354.59	1	0	209	1354.59	0.0
64	140	1	0	1597.79	1	0	185	1597.79	0.0
65	140	1	0	2015.71	1	0	193	2015.71	0.0
66	160	1	0	1850.97	1	0	229	1850.97	0.0
67	160	1	0	3092.68	1	0	246	3092.68	0.0
68	160	1	0	1520.89	1	0	166	1520.89	0.0
69	160	1	0	3408.05	1	0	282	3408.05	0.0
70	160	1	0	1769.50	1	0	216	1769.50	0.0
71	60	1	0	46.54	1	60	88	7.76	38.78
72	60	1	0	145.68	1	80	90	15.91	129.77
73	80	1	0	319.62	1	40	114	148.57	171.05
74	80	1	0	192.59	1	50	84	34.90	157.69
75	80	1	0	495.51	1	0	120	495.51	0.0
76	80	1	0	472.17	1	0	113	472.17	0.0
77	100	1	0	514.55	1	0	118	514.55	0.0
78	100	1	0	365.57	1	0	83	365.57	0.0
79	100	1	0	632.23	1	0	121	632.23	0.0
80	100	1	0	640.49	1	0	147	640.49	0.0
81	120	1	0	767.02	1	0	146	767.02	0.0
82	120	1	0	374.20	1	40	90	157.16	217.04
83	120	1	0	424.37	1	0	72	424.37	0.0
84	120	1	0	692.35	1	0	106	692.35	0.0
85	120	1	0	951.90	1	0	165	951.90	0.0
86	140	1	0	917.54	1	0	153	917.54	0.0
87	140	1	0	482.28	1	40	91	188.70	293.58
88	140	1	0	1191.48	1	0	190	1191.48	0.0
89	140	1	0	603.63	1	0	94	603.63	0.0
90	140	1	0	736.87	1	0	97	736.87	0.0
91	140	1	0	735.69	1	0	123	735.69	0.0
92	160	1	0	735.53	1	60	107	137.19	598.34
93	160	1	0	558.80	1	40	83	210.04	348.76
94	160	1	0	1283.54	1	0	175	1283.54	0.0
95	160	1	0	371.96	1	60	54	21.31	350.65
96	160	1	0	1130.15	1	0	136	1130.15	0.0
97	160	1	0	1071.17	1	0	149	1071.17	0.0
98	80	1	0	377.45	2	50	140	187.73	189.72
99	80	1	0	266.53	1	60	80	45.66	220.87
100	80	1	0	477.93	1	0	114	477.93	0.0

Table 4.4. Continued.

Case Study Stand No.	Present Age (yrs)	Financial: Optimal Management Alternative	Investment Age (yrs)	Adjusted Maximum NPV ($/ac)	Biological: Optimal Management Alternative	Investment Age (yrs)	Maximum MAI (bd ft/ac/yr)	Adjusted NPV ($/ac)	Opportunity Costs ($/ac)
101	100	1	0	677.04	2	10	156	593.05	83.99
102	100	1	0	418.63	1	0	91	418.63	0.0
103	100	1	0	973.52	1	0	179	973.52	0.0
104	100	1	0	658.05	1	0	132	658.05	0.0
105	120	1	0	497.55	1	40	102	181.53	316.02
106	120	1	0	442.12	1	0	86	442.12	0.0
107	120	1	0	746.10	1	0	129	746.10	0.0
108	140	1	0	899.89	1	0	143	899.89	0.0
109	140	1	0	788.97	1	0	128	788.97	0.0
110	140	1	0	1155.06	1	0	180	1155.06	0.0
111	140	1	0	606.71	1	10	79	434.45	172.26
112	140	1	0	853.32	1	0	126	853.32	0.0
113	160	1	0	738.15	1	0	91	738.15	0.0
114	160	1	0	1217.98	1	0	170	1217.98	0.0
115	160	1	0	454.51	1	0	69	454.51	0.0
116	160	1	0	1339.95	1	0	156	1339.95	0.0
117	160	1	0	1118.09	1	0	152	1118.09	0.0

planted and naturally regenerated stands is a 10-year displacement of the volume data in the tables for the unplanted option. The biological yield and timing of treatment for each of the regenerated stands is available on request.

Under the no-treatment management regime, biological yield for stands 10, 11 and 12 tends to favor lower stocking densities. Stands 22, 23 and 24 do not exhibit the same pattern. Here, denser stocking is consistent with larger total volumes.

Under the second management regime, intermediate removals take place at the same points in time for each stocking density (stands 10, 11 and 12). The volumes removed increase with increasing stocking density, as do the residual stocking volumes after the removal. The same pattern is evident in stands 22, 23 and 24.

Under the third management regime, fertilization in conjunction with commercial thinning increases volume growth considerably, and hence, volumes available for intermediate harvests. The frequency of intermediate removals for stands 10, 11, 12 and 22 does not change from the previous regime, nor does the timing of removals. For stands 23 and 24, however, the yields from the combined thinning and fertilization treatments are large enough to produce merchantable timber for additional commercial thinning operations.

Regime 5 is the most intensive management regime considered. It consists of precommercial thinning, commercial thinning and fertilization. Only the two denser stocking levels were candidates for precommercial thinning. This combination of practices does not produce any significant increase in volume relative to the other management regimes.

Step 3: Economic Results

The economic response of the regenerated stands to different management regimes is shown in detail for the "best" and "worst" cases only. Refer to the tables in Appendix 5b for the economic responses for all management regimes. Changes in the base case assumptions may alter the results, as indicated in Chapter 5.

Best Case: Douglas-Fir/Grand Fir. Of the three representative Douglas-fir/grand fir regenerated stands, the third management regime (commercial thinning and fertilization)

Table 4.5. Composition and structure of regenerated stands, Idaho, 1977.

Regenerated Stand No.	Stocking Density (trees/acre)	% Species*: LP	DF	GF
10	300		50	50
11	450		50	50
12	600		50	50
22	300	100		
23	450	100		
24	600	100		

*LP = lodgepole pine, DF = Douglas-fir, GF = grand fir.

Table 4.6. Economic stand results, Idaho, 1977.

Regenerated Stand No. 12: Northern Idaho, Stocking 600, 50% Douglas-fir – 50% Grand fir

Management Alternative 3, Planting

Year	Stand Age (yrs)	Investment Age (yrs)	MAI (bd ft/ ac/yr)	SEV ($/ac)	Soil Rent ($/ac)	1st Rot SEV ($/ac)	2nd Rot SEV ($/ac)
1977	3	2	0	-871.26	0.0	-81.00	-790.26
1984	10	9	0	-227.92	0.0	-81.00	-146.92
1994	20	19	0	-134.05	0.0	-81.00	-53.05
2004	30	29	0	-106.99	0.0	-81.00	-25.99
2014	40	39	0	-95.20	0.0	-81.00	-14.20
2024	50	49	0	-88.76	0.0	-80.63	-8.13
2034	60	59	6	-78.12	0.0	-73.73	-4.39
2044	70	69	72	-46.82	0.0	-45.20	-1.62
2054	80	79	193	-9.81	0.0	-9.60	-0.21
2064	90	89	267	6.69	0.33	6.54	0.15
2074	100	99	320	15.69	0.78	15.43	0.25
2084	110	109	403	30.28	1.51	29.95	0.33
2094	120	119	461	36.67	1.83	36.38	0.30
2104	130	129	489	34.84	1.74	34.61	0.24
2114	140	139	493	29.34	1.47	29.15	0.18

Opportunity Costs: $7.33

MAI = Mean annual increment; SEV = Soil equivalent value.

produced the highest SEVs for both the planting and natural regeneration alternatives with 600 stems per acre stocking density (Tables 4.6 and 4.7).

The stand age and investment age are offset by 1 year for the planting alternative, since seedlings are 2 years old when planted and the regeneration lag is 1 year. Thus the stand is 3 years old, while the investment age is only 2 years.

Table 4.6 shows the behavior of the SEV function over the entire rotation for management alternative 3. Because of planting costs incurred at the beginning of the rotation, SEVs are negative for several decades, until the stand reaches merchantable size. The optimal financial rotation occurs at investment age 119.

The biological rotation, identified at maximum MAI, occurs at investment age 139. The corresponding SEV at that point is $29.34 per acre, compared with the SEV of $36.67 for the financial rotation. The $7.33 difference is the opportunity cost of deferring the final harvest.

The SEVs are based on all costs and revenues taking place within the rotation. The timing of revenues is particularly important, since the base case assumes a 2 percent real rate of increase in stumpage prices during the first rotation. This topic will be covered in detail in Chapter 5.

The natural regeneration alternative is economically superior to the planting alternative (Table 4.7). The SEV for unplanted regime 3 is $49.53 higher than the SEV for planted regime 3. In this case planting is not economically preferable.

Unplanted stand 12 matures biologically at investment age 150 with an SEV of $80.53 and financially at investment age 130 with a maximum SEV of $85.90. The opportunity cost between the two maturity criteria within this single management alternative is $5.37 per acre.

Best Case: Lodgepole Pine. The best possible outcome for the representative lodgepole pine stand in the planting category (regenerated stand 23) is management regime 3 in conjunction with 450 stems per acre stocking density. The SEV in this case, however, remains negative for the entire rotation, again a function of planting cost dominance. The least negative SEV occurs at investment age 79 (-$9.36 per acre), which identifies the financial maturity of the stand. Biological maturity is reached at investment age 99, with a corresponding SEV of -$15.05 per acre. The opportunity cost between the two maturity criteria is $5.69 per acre (Table 4.8).

In the no-planting category, regime 3 SEVs are all positive (Table 4.9). Moreover, a denser stocking (600 stems per acre) is economically preferable. The difference in value between the planting and no-planting regimes at financial maturity is $61.64 per acre.

Worst Case: Douglas-Fir/Grand Fir. The worst of all possible outcomes for the representative Douglas-fir/grand

Table 4.7. Economic stand results, Idaho, 1977.

Regenerated Stand No. 12: Northern Idaho, Stocking 600, 50% Douglas-fir – 50% Grand fir

Management Alternative 3, Natural Regeneration

Year	Stand Age (yrs)	Investment Age (yrs)	MAI (bd ft/ ac/yr)	SEV ($/ac)	Soil Rent ($/ac)	1st Rot SEV ($/ac)	2nd Rot SEV ($/ac)
1977	3	13	0	0.0	0.0	0.0	0.0
1984	10	20	0	0.0	0.0	0.0	0.0
1994	20	30	0	0.0	0.0	0.0	0.0
2004	30	40	0	0.0	0.0	0.0	0.0
2014	40	50	0	0.0	0.0	0.0	0.0
2024	50	60	0	0.28	0.01	0.27	0.02
2034	60	70	5	5.46	0.27	5.28	0.18
2044	70	80	62	26.56	1.33	26.03	0.54
2054	80	90	169	52.55	2.63	51.90	0.65
2064	90	100	237	64.33	3.22	63.81	0.52
2074	100	110	288	70.76	3.54	70.38	0.38
2084	110	120	366	81.31	4.07	81.00	0.31
2094	120	130	422	85.90	4.30	85.67	0.23
2104	130	140	451	84.55	4.23	84.38	0.16
2114	140	150	457	80.53	4.03	80.42	0.12

Opportunity Costs: $5.37

fir regenerated stand is associated with management alternative 4 (precommercial thinning) and the highest stocking density for the planted regime (Table 4.10). All SEVs are negative, indicating that investment in precommercial thinning is not economically desirable. When stands are naturally regenerated the financial rotation SEV is a positive $42.92 per acre at investment age 120 (Table 4.11). The negative SEVs appearing earlier in the rotation stem from the precommercial thinning operation, for which there is no revenue counterpart.

The value difference between the "best" and "worst" outcomes at financial maturity is $55.80 per acre when stands are planted. Similarly, under natural regeneration the difference is $42.71 per acre.

Worst Case: Lodgepole Pine. As in the previous case, management regime 4 produces the least economically attractive results in both planted and naturally regenerated stands. Stocking densities were 600 and 300 stems per acre, respectively. As expected, planting costs and precommercial thinning costs dominate the SEV estimates, as shown in Tables 4.12 and 4.13. Opportunity costs between financial and biological maturity were $2.46 per acre for planted stands and $6.01 per acre for unplanted stands. Between regeneration regimes the difference in value at financial maturity is $82.30 per acre, and between the "worst" and "best" cases, it is $116.84 in terms of revenues forgone.

Table 4.8. Economic stand results, Idaho, 1977.

Regenerated Stand No. 23: Southern Idaho, Stocking 450, 100% Lodgepole pine

Management Alternative 3, Planting

Year	Stand Age (yrs)	Investment Age (yrs)	MAI (bd ft/ac/yr)	SEV ($/ac)	Soil Rent ($/ac)	1st Rot SEV ($/ac)	2nd Rot SEV ($/ac)
1977	3	2	0	-774.45	0.0	-72.00	-702.45
1984	10	9	0	-202.60	0.0	-72.00	-130.60
1994	20	19	0	-119.15	0.0	-72.00	-47.15
2004	30	29	0	-95.11	0.0	-72.00	-23.11
2014	40	39	0	-81.71	0.0	-69.53	-12.19
2024	50	49	0	-63.83	0.0	-57.98	-5.84
2034	60	59	66	-39.40	0.0	-37.19	-2.21
2044	70	69	166	-19.98	0.0	-19.29	-0.69
2054	80	79	244	-9.36	0.0	-9.26	-0.11
2064	90	89	262	-11.16	0.0	-11.17	0.00
2074	100	99	265	-15.05	0.0	-15.10	0.04
2084	110	109	251	-20.95	0.0	-21.00	0.05
2094	120	119	232	-26.49	0.0	-26.55	0.06
2104	130	129	211	-31.23	0.0	-31.69	0.06
2114	140	139	190	-34.97	0.0	-35.02	0.06

Opportunity Costs: $5.69

Table 4.9. Economic stand results, Idaho, 1977.

Regenerated Stand No. 24: Southern Idaho, Stocking 600, 100% Lodgepole pine

Management Alternative 3, Natural Regeneration

Year	Stand Age (yrs)	Investment Age (yrs)	MAI (bd ft/ac/yr)	SEV ($/ac)	Soil Rent ($/ac)	1st Rot SEV ($/ac)	2nd Rot SEV ($/ac)
1977	3	13	0	0.0	0.0	0.0	0.0
1984	10	20	0	0.0	0.0	0.0	0.0
1994	20	30	0	0.0	0.0	0.0	0.0
2004	30	40	0	0.0	0.0	0.0	0.0
2014	40	50	0	1.70	0.08	1.55	0.15
2024	50	60	0	7.24	0.36	6.85	0.39
2034	60	70	70	30.22	1.51	29.23	0.99
2044	70	80	125	37.38	1.87	36.63	0.75
2054	80	90	223	51.00	2.55	50.31	0.69
2064	90	100	253	52.28	2.61	51.80	0.49
2074	100	110	268	51.28	2.56	50.94	0.34
2084	110	120	267	48.67	2.43	48.43	0.24
2094	120	130	251	44.95	2.25	44.79	0.16
2104	130	140	230	41.53	2.08	41.41	0.12
2114	140	150	209	38.82	1.94	38.74	0.09

Opportunity Costs: $1.00

Regenerated Stands, Summary

Tables in Appendix 5b give a detailed picture of the economic response of all regenerated stands to different management regimes. Table 4.14 summarizes this information, showing only the optimal management treatment and corresponding values under base case assumptions. The results are the best possible outcomes under both financial and biological criteria, given stand conditions. Thus, if the objective is to maximize economic returns, then the financial results in Table 4.14 are applicable. If the objective is to maximize biological output, then the best biological management regime is applicable. The difference between the SEVs associated with these two objectives is the opportunity cost.

Planting costs incurred at the beginning of the rotation, representing the initial investment in the stand, are dominant, since they are offset by subsequent revenues in only 1 of the 39 regenerated stands (stand 6). (This stand contained the relatively more highly valued ponderosa pine species growing on a high productivity site.) Therefore, natural regeneration is generally preferable to planting.

Increasing the stocking density of the stands to 600 stems per acre increases SEVs in almost all cases. Only stands 14, 17, 32 and 38 deviated from this pattern. None of the optimal stands had a stocking density of less than 450 stems per acre.

Except for stand 9, which responded to the second management alternative, the third management alternative

Table 4.10. Economic stand results, Idaho, 1977.

Regenerated Stand No. 12: Northern Idaho, Stocking 600, 50% Douglas-fir – 50% Grand fir

Management Alternative 4, Planting

Year	Stand Age (yrs)	Investment Age (yrs)	MAI (bd ft/ ac/yr)	SEV ($/ac)	Soil Rent ($/ac)	1st Rot SEV ($/ac)	2nd Rot SEV ($/ac)
1977	3	2	0	-871.26	0.0	-81.00	-790.26
1984	10	9	0	-227.92	0.0	-81.00	-146.92
1994	20	19	0	-134.05	0.0	-81.00	-53.05
2004	30	29	0	-150.48	0.0	-113.92	-36.56
2014	40	39	0	-133.89	0.0	-113.92	-19.97
2024	50	49	0	-123.74	0.0	-112.41	-11.33
2034	60	59	26	-101.75	0.0	-96.03	-5.72
2044	70	69	133	-58.28	0.0	-56.27	-2.01
2054	80	79	208	-35.06	0.0	-34.36	-0.70
2064	90	89	257	-24.24	0.0	-24.05	-0.19
2074	100	99	309	-19.58	0.0	-19.57	-0.01
2084	110	109	320	-20.45	0.0	-20.52	0.07
2094	120	119	325	-24.55	0.0	-24.64	0.09
2104	130	129	332	-28.57	0.0	-28.66	0.09
2114	140	139	335	-33.17	0.0	-33.25	0.08

Opportunity Costs: $13.59

Table 4.11. Economic stand results, Idaho, 1977.

Regenerated Stand No. 10: Northern Idaho, Stocking 300, 50% Douglas-fir – 50% Grand fir

Management Alternative 4, Natural Regeneration

Year	Stand Age (yrs)	Investment Age (yrs)	MAI (bd ft/ ac/yr)	SEV ($/ac)	Soil Rent ($/ac)	1st Rot SEV ($/ac)	2nd Rot SEV ($/ac)
1977	3	13	0	0.0	0.0	0.0	0.0
1984	10	20	0	0.0	0.0	0.0	0.0
1994	20	30	0	0.0	0.0	0.0	0.0
2004	30	40	0	-22.43	0.0	-19.25	-3.19
2014	40	50	0	-21.09	0.0	-19.25	-1.84
2024	50	60	0	-18.01	0.0	-17.05	-0.96
2034	60	70	29	-5.27	0.0	-5.10	-0.17
2044	70	80	96	15.97	0.80	15.65	0.32
2054	80	90	160	30.33	1.52	29.95	0.38
2064	90	100	215	39.09	1.95	38.77	0.32
2074	100	110	251	42.85	2.14	42.60	0.25
2084	110	120	271	42.92	2.15	42.74	0.18
2094	120	130	293	41.69	2.08	41.56	0.13
2104	130	140	311	39.30	1.97	39.21	0.09
2114	140	150	323	36.11	1.81	36.04	0.07

Opportunity Costs: $6.81

Table 4.12. Economic stand results, Idaho, 1977.

Regenerated Stand No. 24: Southern Idaho, Stocking 600, 100% Lodgepole pine

Management Alternative 4, Planting

Year	Stand Age (yrs)	Investment Age (yrs)	MAI (bd ft/ ac/yr)	SEV ($/ac)	Soil Rent ($/ac)	1st Rot SEV ($/ac)	2nd Rot SEV ($/ac)
1977	3	2	0	-871.26	0.0	-81.00	-790.26
1984	10	9	0	-227.92	0.0	-81.00	-146.92
1994	20	19	0	-134.05	0.0	-81.00	-53.05
2004	30	29	0	-150.48	0.0	-113.92	-36.56
2014	40	39	0	-129.77	0.0	-110.41	-19.36
2024	50	49	0	-110.99	0.0	-100.83	-10.16
2034	60	59	92	-81.51	0.0	-76.93	-4.58
2044	70	69	159	-68.45	0.0	-66.09	-2.36
2054	80	79	208	-64.56	0.0	-63.20	-1.37
2064	90	89	219	-67.02	0.0	-66.18	-0.84
2074	100	99	217	-72.58	0.0	-72.04	-0.53
2084	110	109	209	-78.35	0.0	-78.01	-0.34
2094	120	119	195	-83.93	0.0	-83.72	-0.21
2104	130	129	175	-88.97	0.0	-88.84	-0.13
2114	140	139	156	-92.83	0.0	-92.75	-0.08

Opportunity Costs: $2.46

Table 4.13. Economic stand results, Idaho, 1977.

Regenerated Stand No. 22: Southern Idaho, Stocking 300, 100% Lodgepole pine

Management Alternative 4, Natural Regeneration

Year	Stand Age (yrs)	Investment Age (yrs)	MAI (bd ft/ ac/yr)	SEV ($/ac)	Soil Rent ($/ac)	1st Rot SEV ($/ac)	2nd Rot SEV ($/ac)
1977	3	13	0	0.0	0.0	0.0	0.0
1984	10	20	0	0.0	0.0	0.0	0.0
1994	20	30	0	0.0	0.0	0.0	0.0
2004	30	40	0	-22.43	0.0	-19.25	-3.19
2014	40	50	0	-18.35	0.0	-16.75	-1.60
2024	50	60	0	-10.00	0.0	-9.46	-0.54
2034	60	70	41	1.07	0.05	1.03	0.04
2044	70	80	148	17.74	0.89	17.39	0.36
2054	80	90	178	17.03	0.85	16.81	0.21
2064	90	100	197	15.60	0.78	15.47	0.13
2074	100	110	201	11.73	0.59	11.66	0.07
2084	110	120	198	8.43	0.42	8.39	0.04
2094	120	130	189	4.94	0.25	4.91	0.03
2104	130	140	177	1.92	0.10	1.90	0.02
2114	140	150	163	-0.61	0.0	-0.63	0.01

Opportunity Costs: $6.01

Table 4.14. Optimal regenerated stand management by stand type, Idaho, 1977.

	Financial Criterion					Biological Criterion					Comparison
Plantation No.	Stocking Level (Stems/ac)	Management Alternative	Investment Age (yrs)	Maximum SEV † ($/ac)	Soil Rent ($/yr)	Stocking Level (Stems/ac)	Management Alternative	Investment Age (yrs)	Maximum MAI † (bd ft /ac /yr)	Maximum MAI SEV (4)($/ac)	Opportunity Costs ($/ac)
Northern Idaho, 100% Lodgepole pine, Site M, Yield 69 cu ft/ac/yr											
1-3	600	3N*	90	79.86	3.99	600	3P	89	376	26.54	53.32
Northern Idaho, 100% Ponderosa pine, Site H, Yield 130 cu ft/ac/yr											
4-6	600	3P*	69	323.67	16.48	600	3P	69	600	323.67	0.0
Northern Idaho, 50% Grand fir – 50% White pine, Site M, Yield 70 cu ft/ac/yr											
7-9	600	2N	130	98.30	4.91	600	3P	129	431	42.71	55.59
Northern Idaho, 50% Douglas-fir – 50% Grand fir, Site M, Yield 75 cu ft/ac/yr											
10-12	600	3N	130	85.90	4.30	600	3P	139	494	29.34	56.56
Northern Idaho, 50% Douglas-fir – 50% Western larch, Site L, Yield 45 cu ft/ac/yr											
13-15	450	3N	100	48.36	2.42	600	3P	129	233	-22.61	70.97
Northern Idaho, 50% Douglas-fir – 50% White pine, Site M, Yield 71 cu ft/ac/yr											
16-18	450	3N	120	93.80	4.69	600	4P	139	347	-27.94	121.74
Northern Idaho, 50% Douglas-fir – 50% Ponderosa pine, Site M, Yield 74 cu ft/ac/yr											
19-21	600	3N	110	125.56	6.28	600	3P	99	410	90.51	35.05
Southern Idaho, 100% Lodgepole pine, Site M, Yield 54 cu ft/ac/yr											
22-24	600	3N	100	52.28	2.61	600	3P	99	299	-11.54	63.82
Southern Idaho, 100% Ponderosa pine, Site H, Yield 88 cu ft/ac/yr											
25-27	600	3N	90	157.35	7.87	600	3P	79	393	134.18	23.17
Southern Idaho, 50% Spruce – 50% Lodgepole pine, Site L, Yield 42 cu ft/ac/yr											
28-30	600	3N	100	37.72	1.89	600	3P	109	218	-33.61	71.33
Southern Idaho, 50% Douglas-fir – 50% Grand fir, Site M, Yield 50 cu ft/ac/yr											
31-33	450	3N	130	42.13	2.11	450	3P	139	287	-20.42	62.55
Southern Idaho, 50% Douglas-fir – 50% Lodgepole pine, Site L, Yield 42 cu ft/ac/yr											
34-36	600	3N	120	33.44	1.67	600	3P	129	203	-39.73	73.17
Southern Idaho, 50% Douglas-fir – 50% Ponderosa pine, Site M, Yield 80 cu ft/ac/yr											
37-39	450	3N	100	116.70	5.84	600	5P	109	379	27.76	88.94

*N = Natural regeneration; P = Planting
†SEV = Soil equivalent value; MAI = Maximum annual increment

(commercial thinning and fertilization) was the most desirable economically. This indicates that fertilization in conjunction with commercial thinning generally pays off under conditions of real increases in stumpage prices. A change in the price assumption, however, is likely to alter the results, as will be shown in the following chapter.

Under the biological criteria (maximum MAI), the third management regime remained preferable in 11 of the 13 optimal cases. When compared with the optimal financial management regime, stand 9 changed from regime 2 to 3, stand 17 changed from 3 to 4, and stand 38 from 3 to 5. All biologically optimal regimes were artificially regenerated. It is interesting to note that the fifth and most intensive management alternative was biologically optimal in only one case and in only a single stand, stand 6, did financial and biological maturity coincide.

The opportunity cost of following biological criteria in forest management is substantial. Maximum SEVs under financial criteria are all positive. On the biological side, however, six SEVs are negative, even under the most favorable of possible outcomes. Moreover, those stands that are positive under the biological criteria are still substantially lower in terms of SEVs than those under financial criteria, as measured by the opportunity cost column in Table 4.14.

CHAPTER 5
SENSITIVITY ANALYSIS

INTRODUCTION

Sensitivity analysis, the response of an estimate to input changes, is commonly used in evaluating model output. In the Goforth-Mills (1975) model used in this analysis, as in any formula approach, a change in assumptions and inputs will obviously change the derived estimates. The question becomes, "To what extent?" For example, sensitivities of forest investment analyses are summarized in Mills, Goforth and Hart (1976) and in Schweitzer (1970) for differences in investment input assumptions.

Schweitzer utilized a partial derivative technique which is difficult to apply to this formulation but which points out the relative importance of changes in various inputs. For example, in jack pine he measured the relative error in input necessary to cause a $1.00 change in the NPV estimate as shown in Table 5.1. These magnitudes would change for other species, but forest investment theory indicates that the order of importance should remain unchanged.

Table 5.1. Critical valuation inputs (in order of importance) to cause a $1.00 change in NPV.

Rank	Input	% Input Change Required
1	Rotation length	2.5
2	Discount rate	3.0
3	Harvest returns	5.0
4	Establishment costs	10.0
5	Annual costs	17.5

Additionally, Goforth and Mills (1975) indicate that "given the long term of forestry investments, relatively small inflation rates (in stumpage prices) produce large changes in assumed future prices." In their study, treatment costs varied between -190 percent and +52 percent and returns ranged from -269 percent to +106 percent before the internal rate of return changed by 1 percent. Although criteria differ in the two examples, ranking of input sensitivity is similar.

While a partial derivative approach is awkward to formulate, the basic philosophy remains useful. Holding all other variables constant, what is the change in the estimate with respect to a change in one of the variables? In most cases the direction of response is apparent but the magnitude is not. For example, the magnitude depends on the original value of all variables and on the amount of change in the altered variable. The sensitivity analysis follows the order of importance indicated in Table 5.1.

Modification of all stands by each individual variable over even a small range of sensitivity levels was estimated to have required over 600,000 separate computations. The mass of output would be unintelligible in its profusion. Consequently, two groups of stands were selected as representative of Idaho forest conditions in both their incidence in local forests and their timber production potential (regenerated stands 10, 11, 12 and 22, 23, 24). The use of these particular stands does not suggest any inference to general forest conditions in Idaho. They are used as an illustration, to put estimation changes in perspective.

Sensitivity analysis is performed only on regenerated stands. Case study stands differ in that mature timber is usually present as a harvestable stand or overstory. Crucial changes in discount rate, real rate of stumpage increase, fertilization cost and planting costs are clearly time dependent. These make little difference in the optimal value of a mature stand although they might have changed the point of maturity for some of the case study stands. For younger case study stands a close approximation of sensitivity is available from comparable regenerated stands.

THE RATIONAL OPTIMIST, RATIONAL PESSIMIST AND BASE CASE SCENARIOS

As shown in Chapter 3, a wide range of investment assumptions could easily be employed, depending on one's posture toward forestry as an investment. To portray reasonable extremes, these input assumptions are grouped to reflect the expectation of rational pessimists and rational optimists (Table 5.2). The procedure establishes a range of likely outcomes and optimal practices, as indicated in Table 5.3. The unplanted, commercially thinned and fertilized stands appear to dominate. The financial SEV

Table 5.2. Assumption scenarios (stocking constant at 450 stems/ acre, medium quality site).

Parameter	Rational Pessimist	Base Case	Rational Optimist
Discount rate	7%	5%	3%
Stumpage values	State - 20%	State values	State + 20%
Stumpage real increases	0%	2%/year for 1 rotation	3%/year ad infinitum
Costs	State + 10%	State values	State - 10%
Cost real increase	2%/year ad infinitum	0%	0%

column indicates the range which can be expected. For example, the range in the Douglas-fir/grand fir stand was $1.18 to $6346.30. An investor's perception of market conditions as reflected in his selection of assumptions becomes a critical determinant of the valuation exercise. In the remaining sections only the base case assumptions are altered.

THE DISCOUNT RATE

The 5-percent discount rate applied to forestry in this study is not a consensus, as exemplified in the following quotations:

> "Under sustained-yield forestry, there is no compound interest." (Shepard 1925)

> "If, for example, it were certain that there would be a steady market for fat lambs or knotty pine timber in the future and that there were no risks involved in producing these products, there would be, in national or social terms, no reason to discount the capital investment at all." (Helliwell 1974)

> "What interest rate is appropriate for forestry? I hesitate to pronounce on such a complex matter. A dozen years ago I might incautiously have said 12 percent or more." (Samuelson 1974).

This study took the representative stand through 1 percent intervals, from the real rate of 1 percent to a risk-averse investor's real rate of 10 percent. The latter is currently equivalent to a nominal average cost of capital of 18 to 20 percent.

As discount rates increase, both financial optimum rotation age and soil expectation value decrease. For the Idaho Douglas-fir/grand fir (10, 11, 12) and lodgepole pine (22, 23, 24) representative stands, the relationships are presented in Fig. 5.1 and Fig. 5.2, respectively. Note that as the discount rate approaches zero the soil expectation value approaches infinity. A non-discounted sum of the value of an infinite series of rotations must necessarily equal infinity.

The lowest discount rate measured (1%) is not portrayed here because of its disproportionate magnitude (e.g., $4175 for the lodgepole pine stand and $14,428 for the Douglas-fir/grand fir stand). These large values are the result of a compounded real rate of stumpage increase greater than the discount rate, causing the effective discount rate to approach zero and negative values. (Effective discount rate is measured by the equation

$$\frac{1.0 + \text{discount rate}}{1.0 + \text{real rate of increase}} - 1$$

[Goforth and Mills 1975].)

Table 5.3. Scenario results.

	Financial Rotation (yrs)	Financial SEV ($/ac)	Optimal Financial Regime	Maximum MAI (bd ft/ac/yr)	Maximum MAI Rotation (yrs)	Table MAI SEV ($/ac)	Optimal Biological Regime	Opportunity Cost of MAI ($/ac)
Lodgepole pine (Regenerated Stands 22, 23, 24)								
Rational pessimist	80	1.42	NR†, 1 or 3	265.2	99	-78.32	Plant, 3	79.74
Best guess	100	52.28	NR, 3	298.0	99	-11.54	Plant, 3	63.82
Rational optimist	130	881.00	NR, 3	265.2	99	789.99	Plant, 3	91.01
Douglas-fir/grand fir (Regenerated Stands 10, 11, 12)								
Rational pessimist	90	1.18	NR, 1 or 3	426.9*	139	-87.55	Plant, 3	88.73
Best guess	130	85.90	NR, 3	493.5	139	29.34	Plant, 3	56.56
Rational optimist	150	6346.30	NR, 3	426.9*	139	6299.70	Plant, 3	46.60

*These solutions are maximized at the analysis age limit and may not be the highest value.
†Naturally regenerated.

Higher discount rates discriminate against longer rotations and against many intensive silvicultural practices, particularly those associated with early stages of stand development. The Douglas-fir/grand fir stand example (Fig. 5.1) demonstrates this effect. At a 3 percent discount rate, the most intensive practices (3 and 5) tend to dominate, with significantly higher SEVs. At a 4 percent real rate, the regime ranking has begun to shift. By 5 percent there is a clear re-ordering of preferred alternatives caused by the compounded costs of regeneration practices. The remainder of the silvicultural practices have little effect on value. Patterns in the lodgepole pine stand are similarly grouped. In the lower-valued species, the planting effects become obvious at 4 percent (see Fig. 5.2).

The SEV is more sensitive to discount rate selection below 7 percent than to higher rates (Table 5.4). Using the 5 percent base case as a norm, the percent response associated with the other discount rates commonly used in forestry is significant even in a naturally managed stand.

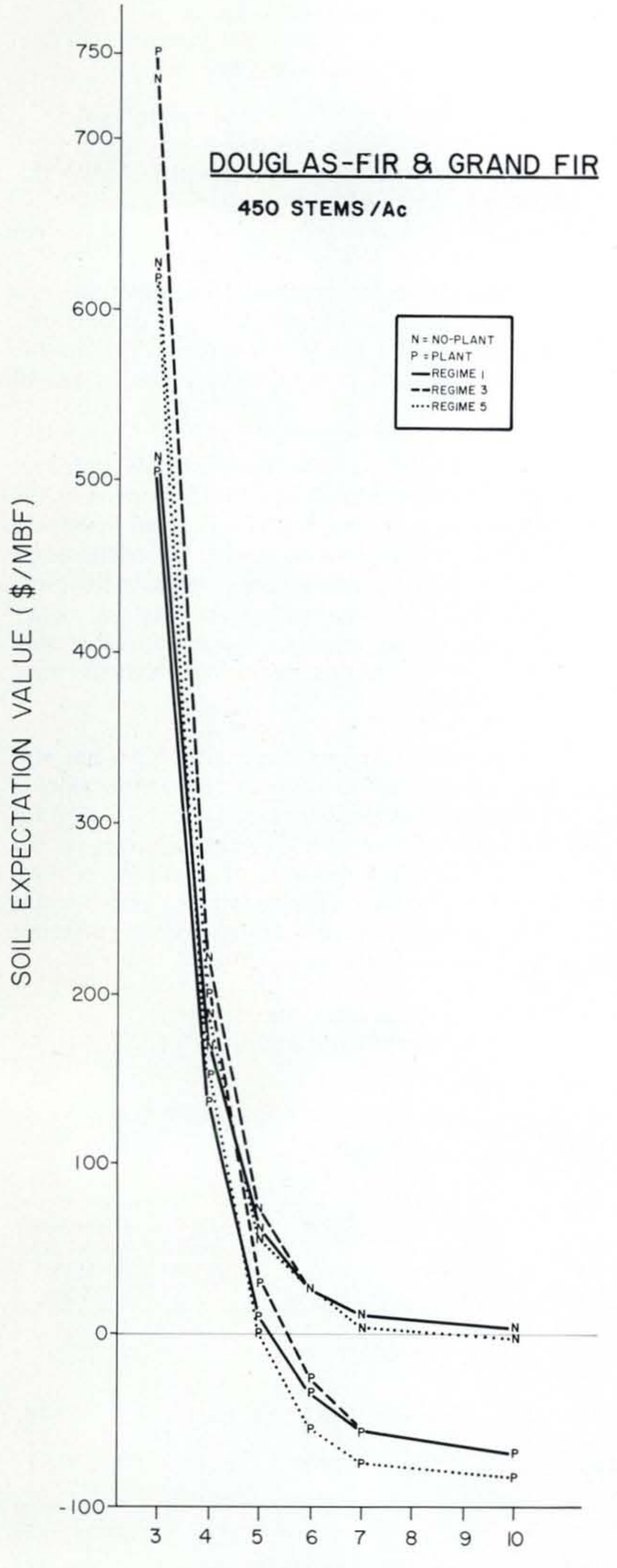


Fig. 5.1. Effect of discount rate on SEV – Douglas-fir/grand fir.

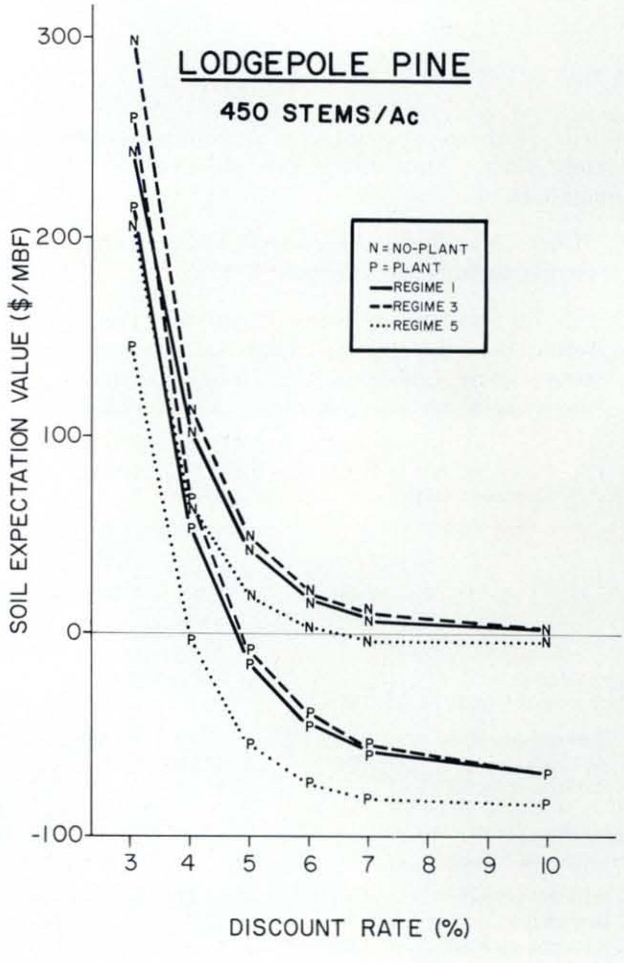


Fig. 5.2. Effect of discount rate on SEV – lodgepole pine.

Table 5.4. Response of SEV to discount rate changes.

Discount Rate (%)	Douglas-fir/grand fir % Change	Lodgepole pine % Change
3	+ 762	+ 476
5	Norm	Norm
7*	- 97	- 95

*Rates higher than 7% cause little additional change.

Great care must be taken in the application of this analysis. Almost any desired position on forest investment can be justified by selecting the appropriate discount rate. It is as misleading to artificially favor an investment as to discriminate against it.

ROTATION AGE

The rotation age is not an assumption variable in this study as it was in the Schweitzer reference (see Table 5.1). For the Idaho Productivity Study it is a decision variable. The optimal rotation ages have been reported in Chapter 4. It may be of interest, however, to compare time horizons in our representative stands to assess the influence of a misplaced rotation decision.

Figure 5.3 indicates the present value horizons of Douglas-fir/grand fir and lodgepole pine stands, respectively. All cases exhibit convexity. Cost items dominate in earlier decades and are later displaced by stand value growth until the point where compounding of cost items again causes a downward shift in SEV. The financial manager will choose the regime and rotation which maximize the SEV – non-planted regime 3 at 130 years in this particular Douglas-fir/grand fir example and non-planted regime 3 at 90 years in the lodgepole pine stand.

Just as discount rate selection affects the value of forestry alternatives, it also shifts the rotation age at which that value is maximized. Although rotation determination is evaluated in decades, a significant shift is apparent.

Figure 5.4 is an estimation of the rotations in non-planted, naturally managed stands of Douglas-fir/grand fir and lodgepole pine compared with those in planted, intensively managed stands of the same species. As in SEVs, the rotations associated with intensive management practices are the more sensitive to changes in discount rates, evidenced by the steeper slopes. Although these rotations are the optimal ones for the regime, positive SEVs are not guaranteed. An optimal SEV may also be the smallest value of a series of negative solutions.

STUMPAGE VALUES

As noted in Chapter 3, there are a number of factors which affect stumpage value. As stumpage is a residual value, changes in costs of retrieval, as well as in the value of the timber as a raw material, affect its market price. In weighing the effects of such changes, the stumpage price is shifted by incremental percentages. It is again important to note that the same unit stumpage price is used for all ages of material, so that distinctions in grade or logging costs by age or size of material have been otherwise ignored.

A comparison of the stumpage values used in this study with other estimates (Table 5.5) indicates a possible discrepancy among sources. Whether this is due to

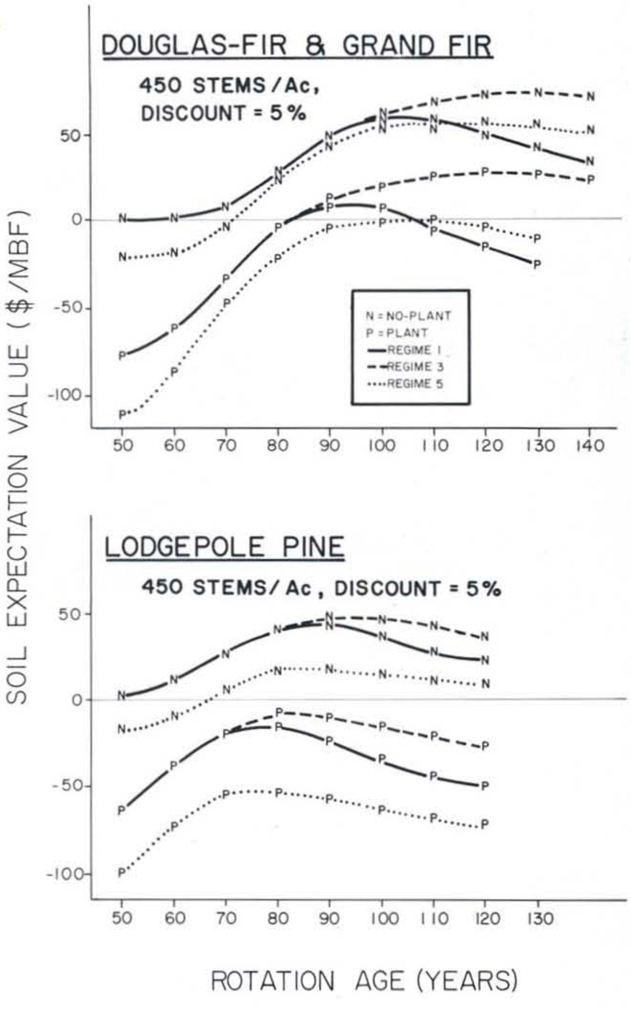


Fig. 5.3. Effect of rotation age on SEV – Douglas-fir/grand fir and lodgepole pine.

Table 5.5. 1976 Idaho weighted average stumpage prices ($/MBF).

Species	State	USFS*	% diff†	Industry**	% diff†
Douglas-fir	46.11	37.26	-19	50	+8
Ponderosa pine	54.58	52.27	-4	40	-27
Western white pine	89.86	70.31	-22	150	+67
Lodgepole pine	30.13	18.96	-37	NA††	NA
Englemann spruce	45.88	33.46	-27	45	-2
Western hemlock	42.14	20.77	-51	50	+19
Western redcedar	90.50	39.99	-56	200	+121
Western larch	46.11	39.86	-14	50	+8
True firs	42.14	25.77	-39	50	+19

* USFS from 2400-17 Regions 1 & 4; Region 1 1972-76; Region 4 1974-76, inflated to 1976.

** Averaged corporate estimates.

† % diff uses state data as a norm.

†† NA = not applicable.

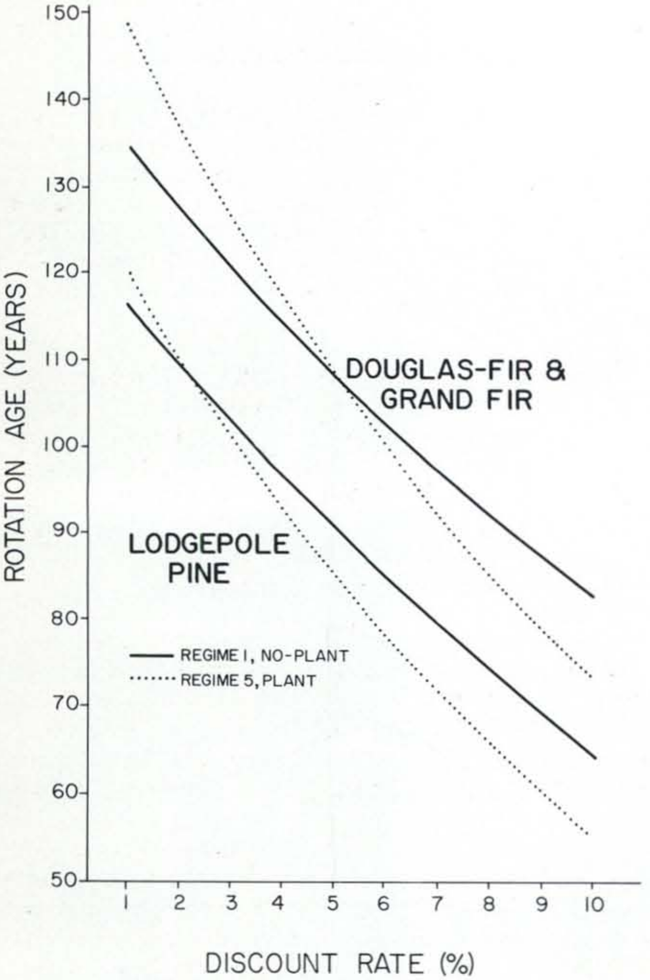


Fig. 5.4. Effect of discount rate on optimal rotation – Douglas-fir/grand fir and lodgepole pine.

differences in management, contracting, physical characteristics or estimation procedures is not clear. It does emphasize the need for any user of the results presented in Chapter 4 to adjust prices according to their application.

A range of alternative stumpage values was tested by using a series of deviations from the base case norm in 10 percent increments. The user may then select what he feels is the appropriate adjustment (Table 5.6).

Six applications of altered stumpage input were made in each representative species to determine the magnitude of value change. Although stumpage value was thought to be a dominant variable, Fig. 5.5 indicates that the SEV response is small and linear. (Although the ratio of percent response to percent perturbation, or elasticity, is commonly used, it is dependent on the magnitude of the norm. In a linear relationship that ratio is not a constant.)

The most extreme response is found in planted, intensively managed Douglas-fir/grand fir stands, as indicated by the steepness of the slope. For each 10 percent change in stumpage values, SEV changes $11.00. The minimum response is in the naturally regenerated, intensively managed lodgepole pine stand, which shifts $3.00 for each 10 percent stumpage change. Although statistically significant, this level of response is smaller than expected.

The most useful factors would be those for the optimal regimes (non-planted option 3) for both species. In the Douglas-fir/grand fir stand, the linear relationship is calculated as follows: Adjusted SEV = Previous optimal SEV + $0.75 (percent stumpage change). This gives a $7.50 shift for each 10 percent change. In the same option for the lodgepole pine stands, the slope of the line is 0.47, a $4.70 shift for each 10 percent change.

The change by percent is useful, but it is abstract. To put this in perspective, a sample calculation is presented in Appendix 7.

Table 5.6. Stumpage value inputs ($/MBF).

	Percent Change						
Species	-30	-20	-10	Norm	+10	+20	+30
Douglas-fir	32.28	36.89	41.50	46.11	50.72	55.33	59.94
Grand fir	29.50	33.71	37.93	42.14	46.35	50.57	54.78
Lodgepole pine	21.09	24.10	27.12	30.13	33.14	36.16	39.17

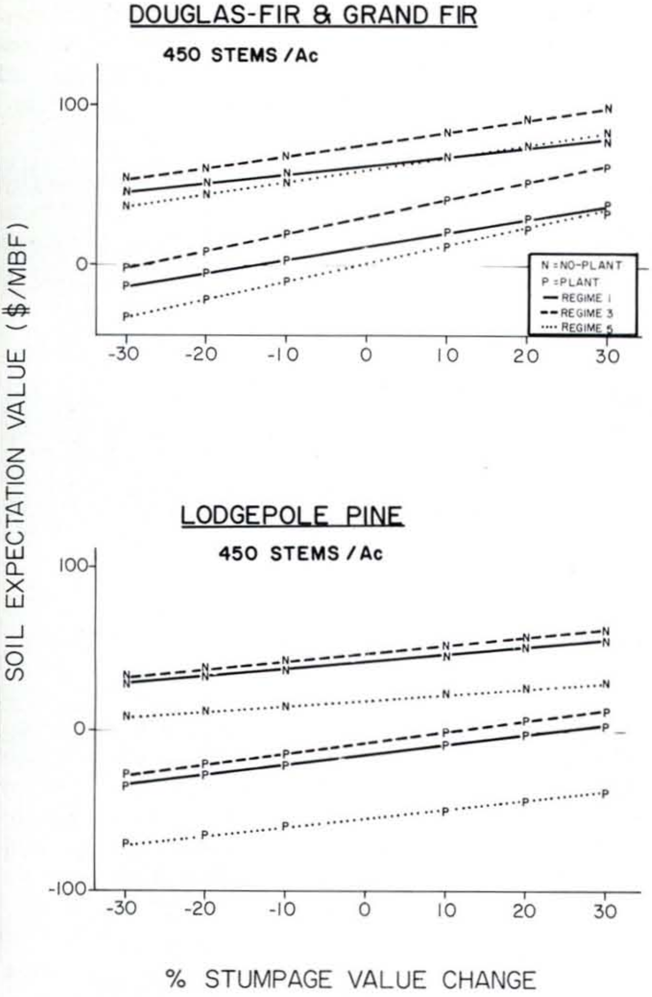


Fig. 5.5. Response of SEV to changes in stumpage value – Douglas-fir/grand fir and lodgepole pine.

REAL STUMPAGE APPRECIATION RATES

The modification of the real price increase assumption takes two forms. Both the rate of increase and the duration of that increase are variable. The base case presumed a 2 percent rise only over the initial rotation. Annual rate appreciations from -1 percent to 3 percent, representing the range of historical trends, were also tested. Historically rates decline slightly in fiber-oriented stumpage, but show regular increases in sawtimber stumpage. McKetta and Medema (1977) point out that while rotation age can be lengthened slightly by real stumpage increases, the significant impact is in magnification of the SEV. This analysis measures that response in SEV. Figures 5.6 and 5.7 indicate single rotation real rate response in the representative species.

Since this response is a function of the effective discount rate applied to revenues, one would expect the inverse of relationships that appeared in earlier calculations due to discount rate changes. As the discount rate increases, the revenue effective discount rate increases. As the real rate of stumpage change increases, however, the effective discount rate decreases. Therefore, the negative response of SEV to discount rate is consistent with a positive response of SEV to real stumpage appreciation rate.

At low or negative real stumpage rate changes, the management regimes are grouped according to planting options. The critical effect of early rotation costs indicates the dominance of the base case 5 percent discount rate. A stumpage rate increase in excess of 2 percent shifts optimal management to the intensive practices which increase volume response. As stumpage value is magnified, harvest revenues become the dominant variable. This is especially true in the Douglas-fir/grand fir stand, due to its higher initial value. It is clear that a real stumpage value increase assumption is a critical determinant of valuation results and must be made with care.

Extension of the real rate of increase to an infinite series of rotations has minimal effect at low rates of increase. Table 5.7 shows only the planted alternative 3 results for both species and makes a comparison between single and multiple rotation assumptions. At higher rates, the effect is predictably larger. Only planted, commercially thinned and fertilized stands at 450 stems per acre are used in this example.

Stumpage prices escalate significantly, however, due to this adjustment. In 130 years Douglas-fir's 1976 rate of \$46.11/MBF becomes a real price of \$2150.97/MBF at only 3 percent per year. At 260 years, the end of a second rotation, the real price becomes \$100,339.87/MBF.

COST CHANGES

Variation in costs of silvicultural practices was observed among ownerships (Table 5.8). This reflects differences in standards as well as in operating conditions. In addition, a variety of practices are optionally applied. This cost adjustment analysis determines the response of value estimations to changes of input cost.

Modified State of Idaho data were used in the base case. This analysis looks at 10 percent incremental changes in cost assumptions as indicated in Table 5.9. The planting cost has been augmented to reflect additional labor and seedling costs at the example stocking level of 450 stems per acre. Results presume all costs are uniformly adjusted by the same percentage.

The effect of a cost change on SEV is linear, similar to the harvest value response. The more costly regimes

Table 5.7. Effect on SEV of extending real rate of stumpage increases to subsequent rotations.

Real rate of increase (%)	Douglas-fir/grand fir: Increase over 1st rotation only ($)	Douglas-fir/grand fir: Over all rotations ($)	Douglas-fir/grand fir: Difference ($)	Lodgepole pine: Increase over 1st rotation only ($)	Lodgepole pine: Over all rotations ($)	Lodgepole pine: Difference ($)
-1	-67.21	-67.29	-.08	-67.61	-67.73	-.12
0	-58.81	-58.81	.00	-60.63	-60.63	0.0
+1	-34.96	-34.60	+.35	-44.21	-43.38	.83
+2 (base case)	29.42	32.34	+2.92	-9.36	-3.41	5.95
+3	210.24	234.96	+24.72	68.67	99.21	30.54

Table 5.8. Costs per acre of silvicultural practices.

Item	State of Idaho	USFS	Firm 1	Firm 2	Woodlot owners
Planting	61.59	135.00	61.25	NA*	65.00
Precommercial thinning	83.18	161.43	32.42	23.00	40.00
Fertilizer	56.16	NA	43.85	9.00	NA

*NA = not applicable.

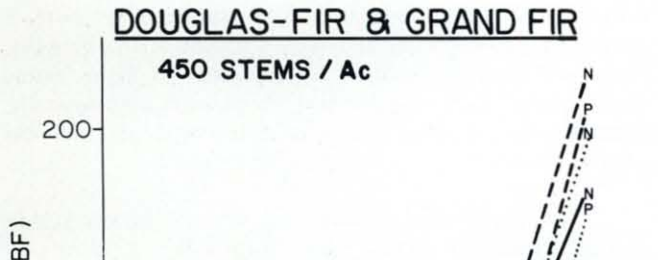


Fig. 5.6. Effect of single rotation real rate stumpage increase on SEV – Douglas-fir/grand fir.

are more sensitive. The dominant cost is planting. The four naturally regenerated stands have slightly negative relationships compared with the planted set (Fig. 5.8). The addition of the precommercial thinning cost of regime 5 to regime 3's fertilization charges shows only slight influence.

REAL RATE IN COST CHANGES

Unlike stumpage real values, which indicate historically increasing economic scarcity, base case real costs have been presumed constant. That is, nominal costs are expected to fluctuate with the general economy. Significant technological change and extraordinary specialized forest labor costs may occur, but they have not been predicted in this model.

There is speculation on rising energy costs which may have an effect on forest productivity; however, most of the costs measured are not energy intensive. Harvesting and collection costs could rise, but would only affect the stumpage residual, lowering harvest values.

The one cost that would be directly affected is fertilization. Urea is an energy-intensive product and its price is keyed to the prices of its natural gas origins. Only recently have real (1967) urea prices increased from $70.24/ton in 1971 to $91.80/ton in 1976 (USDA Agr Price Rep. Svc. 1976).

Using a real rate of increase of all costs as a general indicator, the model was run with real cost increases over all rotations. The levels tested were -1, 0, 1, 2 and 3 per cent annually. The negative is included should energy intensive materials return to their previous real price decline. Figure 5.9 indicates the change in the value of Idaho forest productivity which could be expected as a result.

Regime 3 analyses were used to isolate the fertilization cost effect from precommercial thinning escalation. As the real rate of cost increase rises, the SEV declines

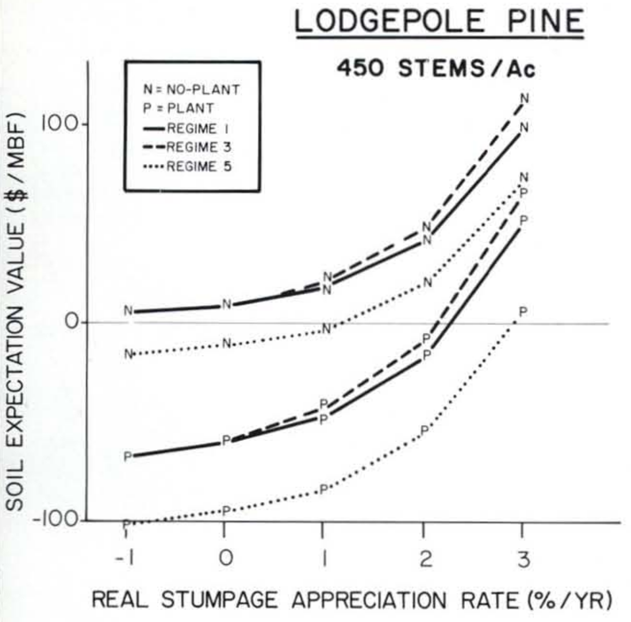


Fig. 5.7. Effect of single rotation real rate stumpage increase on SEV – lodgepole pine.

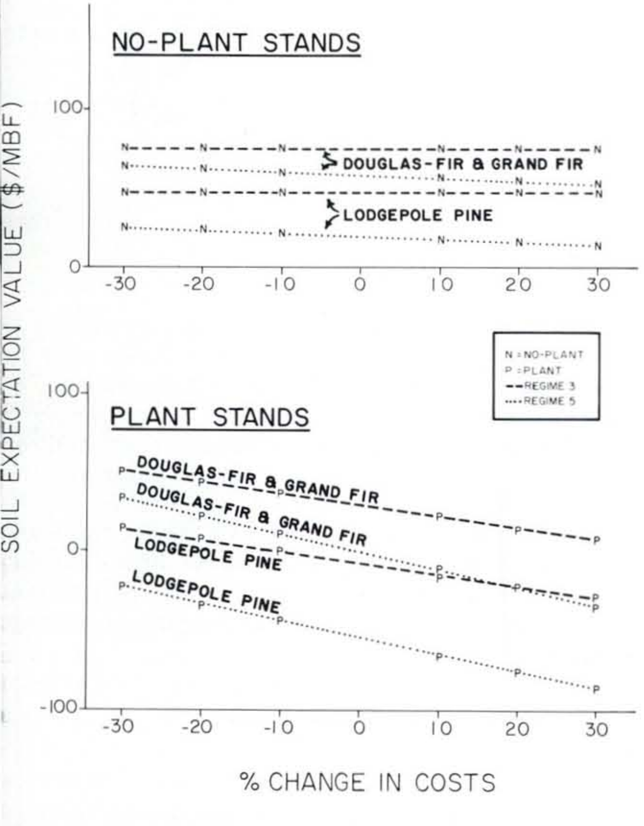


Fig. 5.8. Effect of cost changes on optimal SEV – planted and unplanted options.

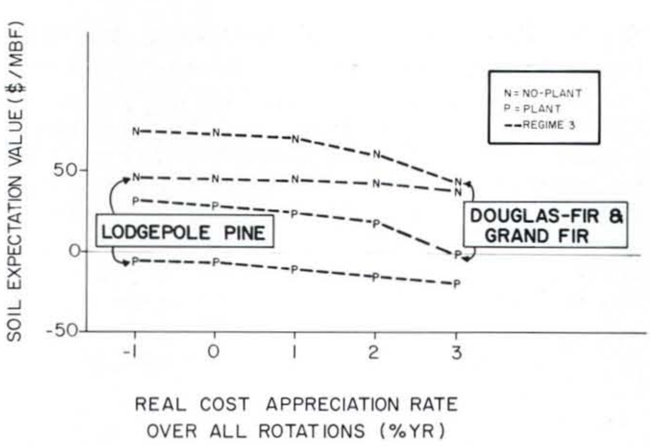


Fig. 5.9. Effect of real cost rate changes on optimal SEV – Douglas-fir/grand fir and lodgepole pine.

Douglas-fir/grand fir stands exhibit a greater impact due to longer financial rotations which include additional fertilization cycles.

At real rates of 1 percent and less, the effect is less than $3.00 per percentage point change. Beyond that level the change becomes $11.00 to $13.00 per percentage point. It is doubtful that fertilization cost increases will drive naturally regenerated stand SEVs into negative values. Where the carrying cost of planting investment is present, SEVs will become negative at higher real cost rate increases. Planted Douglas-fir/grand fir, regime 3, is a good example of planting cost dominance.

STOCKING LEVELS

In the base case analyses, initial stand density had little effect on SEV. The stocking options explored (300, 450 and 600 stems/acre) did not reflect situations where precommercial thinning would be an economically feasible management practice.

This sensitivity analysis, using the naturally regenerated Douglas-fir/grand fir stand, tested initial stand densities of 1200, 1800 and 2400 stems per acre. From a biological perspective, stands not precommercially thinned begin to have significantly lower maximum MAIs at densities greater than 900 stems per acre, due to stagnation.

Table 5.9. Cost inputs ($/acre).

	Percent Change						
Procedure	-30	-20	-10	Base	+10	+20	+30
Planting	50.40	57.60	64.80	72.00	79.20	86.40	93.60
Precommercial thinning	58.22	66.54	74.86	83.18	91.50	99.82	108.14
Fertilization	39.30	44.92	50.54	56.16	61.78	67.40	73.02

Yields from naturally regenerated regime 3 declined rapidly from 457 board feet per acre per year at 600 stems per acre to 217 board feet per acre per year at 1200 stems per acre. This regime's precommercially thinned counterpart, regime 5, dropped only from 336 board feet per acre per year to 328 board feet per acre per year over the same stocking change. Thinning was from below, so the residual stand contained a greater percentage of more highly valued Douglas-fir as initial stocking increased – thus the increase in SEV with increasing initial stocking. From an initial stand containing 2400 stems per acre thinned at stand age 20, regime 5 eventually yields 421 board feet per acre per year.

Financial and biological performance are similar with respect to initial stand density. A density of 600 stems per acre remains optimal, returning the financial maximum SEV of $85.90 which was found in regime 3 (no precommercial thinning). If high initial stem density is a given condition, Fig. 5.10 indicates that the regimes with precommercial thinning are preferable at greater than 1000 stems per acre. The biological response due to thinning compensates for the carrying cost of an expenditure early in the rotation.

ANNUAL CHARGES

In this type of analysis constant annual cash flows have a direct effect on SEVs but not on financial rotation age. The base cases considered no annual costs or revenues, since each valuation would vary by ownership, taxation techniques and levys, overhead charges, regular maintenance or protection costs, and annual revenues.

Any of the resultant SEVs may be modified to include annual cash flow by adding the capitalized value of the payment stream. The net present value of a perpetuity is simply the annual value divided by the appropriate real discount rate, which was assumed to be 5 percent in the base case.

For example, 1976 Latah County forest land taxes averaged $.43 per acre. If the forest also faced annual overhead and protection costs of $1.00 per acre, the net annual cash flow would be -$1.43. Then -$1.43/.05 equals a wealth deduction from SEV of $28.60. In the Douglas-fir/grand fir representative stand with natural regeneration and management regime 3 at 600 stems per acre, the maximum SEV was $85.90 without annual charges. This reduces to $57.30 when these annual costs are applied. Likewise, the lodgepole pine stand example would drop from $42.29 to $13.69 under the same management and cost assumptions. If the net annual cash flow is negative, as in the preceding examples, SEVs of low-valued stands may become negative.

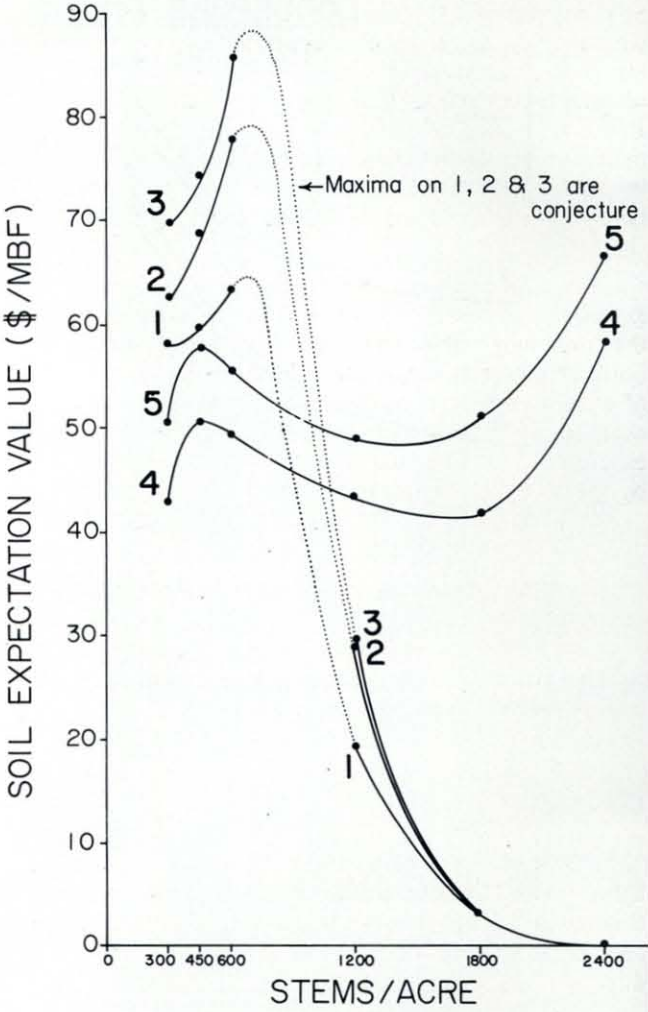


Fig. 5.10. Effect of stocking level on optimal SEV.

ADDITIONAL ADJUSTMENTS

Irregular charges such as animal control, pruning or other single stand entries can be easily discounted at the appropriate discount rate from their projected time of occurrence. If these procedures have an impact on output values, a stumpage adjustment procedure as outlined previously must be applied. Volume adjustments are integral to the computer program and not directly incorporated into this analysis. A proxy using a compensatory stumpage value change is preferable. End-of-rotation costs such as slash or yield taxes or additional development costs may also be accounted for by the stumpage change technique.

SUMMARY OF INPUT CHANGE EFFECTS

Most sensitivity responses are non-linear. An estimation of sensitivity is made in the immediate vicinity of the base case. The percent input change in the base case (Table 5.10) required to cause a $1.00 change in optima

SEV for Douglas-fir/grand fir regime 3 can be compared with the Schweitzer results. Rankings from the Idaho Productivity Study are comparable, with the single exception of rotation age. Changes in magnitude and ranking may be attributed to the differences between jack pine in the original example and Douglas-fir/grand fir in this case. A change in the longer rotation or the higher value is divided by a larger norm in the Douglas-fir/grand fir example.

Again, it should be emphasized that results are extremely responsive to input levels. This is apparent in the preceding table and from the forest management optimist/pessimist comparison. In the latter, combinations of sensitive assumptions caused SEV deviations of -99 percent to +3373 percent from the Douglas-fir/grand fir base case. Since the adherence to these assumptions varies by investor and owner, it is tenuous to apply this set of estimates wholesale to the State of Idaho without additional indicators of Idaho forest management incentive and behavior.

Table 5.10. Critical valuation inputs (in order of importance).

Rank	Input	% input change from base case value
1	Discount rate	0.4
2	Real rate of stumpage increase	0.6
3	Stumpage value change	1.3
4	Cost changes	1.4
5	Rotation age	2.6
6	Stocking	17.0
7	Real rate of cost increase	undefined*
8	Annual costs	undefined

* Undefined results from division by zero.

CHAPTER 6
CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

This section is composed of three parts. First, it highlights important conclusions stemming from the analysis. Second, it briefly discusses limitations associated with the use and application of the analysis, and third, it suggests direction for further research.

Conclusion 1: *Idaho has high timber production potential.*

The Rocky Mountain states are generally characterized as having low forest productivity potential. Within this region, however, Idaho has the highest potential, as indicated by the distributions in Table 6.1. Idaho has a large area of commercial forest and is the nation's fourth largest lumber producer from an annual cut which is regularly exceeded by growth.

Table 6.1. Rocky Mountain commercial forest land sites by percent.*

State	Quality		
	High	Medium	Low
Idaho	38.4	25.9	29.1
Montana	35.6	30.0	33.6
Wyoming	1.8	11.2	64.8
Arizona	4.7	53.2	60.6
Colorado	4.1	11.8	62.2
New Mexico	3.2	29.0	65.6
Utah	2.2	9.5	82.9

*Percentages may not total 100.0% due to operability constraints.

Source: USDA 1973.

The stand simulator used yield tables derived from actual stand conditions to generate physical productivity. The 39 regenerated stands subject to 10 management combinations resulted in 13 biologically optimal treatment combinations. None of these resulted in annual growth less than 200 board feet per acre per year. High sites averaged 496 BF per acre per year, medium sites 377 BF per acre per year, and even low sites averaged maximum MAIs of 214 BF per acre per year.

Conclusion 2: *Idaho forest lands can be financially productive.*

Although financial returns from forestry investment in Idaho may be low relative to Pacific coastal states, no stands are sub-marginal under the base case assumptions applying optimal management regimes. Several management alternatives may result in negative returns, but for each case study and regenerated stand at least one alternative is positive.

The best index of financial forest productivity in Idaho is the regenerated stand financial return synopsis in Table 4.4. Even on the lowest quality site the optimal SEV is \$32.75 per acre, while 4 of the 13 optimal regimes exceed \$100.00 per acre. High quality site ponderosa pine has the highest SEV (\$323.67), which compares favorably with Pacific Northwest coastal values.

Conclusion 3: *Biologically determined rotations are costly.*

In only one instance does the rotation which optimizes biological productivity coincide with a financially optimal rotation. This occurs in a high quality site, high value ponderosa pine regenerated stand. Within the 390 separate regenerated stand combinations of management and stand conditions, only 23 (5.9%) have the same economic performance for biologically and financially determined rotations.

This result is significant, particularly as increases in real stumpage prices assumed for all combinations favor the longer rotation associated with biologically oriented management. In no case do biological values exceed financial values. Applied to actual Idaho conditions as reflected in the case study stands (which represent approximately 60% of Idaho's public commercial forest land base), waiting for biological maturity instead of financial maturity could result in forgoing potential revenues of $417 million in present terms, the equivalent of $20.8 million annually.

Conclusion 4: *Intensive forest management is not always an optimal investment.*

Intensive forest management, often called "good forestry," can detract from financial productivity. For example, planting results in positive economic returns in only 95 (49%) of 195 planted management combinations considered in the regenerated stand analysis. Due to the early planting cost outlay and displacement of returns to the end of the rotation, non-planted stands generally result in higher returns, even though stand establishment is deferred 10 years. Only one planting option in this study was regarded as optimal and that was in a high quality site, high species value regenerated stand. Although precommercial thinning was not isolated as a unique practice, none of the management regimes which use it show up as optimal. However, as shown in the sensitivity analysis, it becomes economically desirable in densely stocked stands. Similarly, commercial thinning (not accompanied by fertilization) is optimal in only two stands. This may be attributable in part to the growth response to thinning assumed in the yield simulator.

Economically, fertilization is a surprisingly feasible investment. Even though the cost data include record high urea prices, fertilization and its assumed response pay off regularly. Fertilization (accompanied by commercial thinning) comprises 11 of the 13 optimum management regimes.

LIMITATIONS OF THE ANALYSIS AND RESULTS

This report examines the wide range of forest productivity conditions present in Idaho. The examination does provide valuable insight into the economic potential of timber production in the state in general. Other forest values are not addressed here, but must not be ignored in impact analyses.

A number of crucial assumptions are made at each stage of the analysis. The biological production function consists of assumed yield responses by management regimes, while prices and costs are based on historical trends which may or may not continue in the future, and the list of management regimes considered is by no means exhaustive. Chapter 5 of this report addresses these uncertainties by measuring the extent to which economic assumptions can alter results.

The possible link between this report and the spectrum of possible forest policies should be in terms of techniques used rather than results obtained. The results presented are a function of the assumptions and do not address any specific policy issues. Finer resolutions could be obtained by tailoring the assumptions to particular investment and policy questions.

RECOMMENDATIONS FOR FURTHER RESEARCH

The set of analytical techniques and results used in the Idaho Forest Productivity Study Phase II could be used to examine forest management and policy questions which have important economic ramifications for the State of Idaho. Several major researchable areas became evident during this study.

Management Goals and Criteria

Two basic management objectives were used to outline the potential of northern Rocky Mountain forest types under several levels of management intensity. As noted in the conclusions, a significant gap exists between the financial returns of the two sets of criteria. The income potential of forests managed to optimize financial return is higher than that of forests managed to optimize biological returns. To allow the sample's 30 percent of stands not yet biologically mature to reach that maturity would cost $417 million in present-term income potential. That translates to a $20.8 million annual loss on the sample of 60 percent of the public commercial forest land in Idaho. This loss is based solely on a rotation age difference. A more detailed reliable accounting could be developed on specific ownerships by refinement of the model inputs.

Economic Timber Flow Projections

Timber flow is not solely a function of biological forest productivity. Wood fiber markets are described by economic indicators. The major signals of prices, costs and interest rates have been proven in this study to significantly affect the value of timber investment and hence the production of timber.

By converting case studies into a total timber system, the conditions of wood production and utilization in Idaho could be more accurately projected to enable the Idaho forest economy to adjust to and capitalize on new opportunities.

Analysis of Timber Flow Constraints

As shown by the sensitivity analysis, the model is highly responsive to input level changes. The United States economy is a dynamic one, in which all economic variables undergo constant fluctuation. The long horizon of timber production is thought to mitigate against this oscillation. However, long-term investments are also uncertain, as they are subject to the variability of economic conditions.

Some timber management systems attempt to eliminate changes by regulation and flow constraint. One technique, sustained yield non-declining even flow, purports to increase forest industry and dependent forest community stability. Recent analyses, however, suggest that flow constraints actually cause instability (Waggener 1977).

An extension of the Idaho Forest Productivity Study could simulate economic timber flow patterns from strict even flow to price responsive flow. These results could be used in conjunction with an impact analysis model to assess the effects of arbitrary timber flow control on the Idaho economy.

Reserved and Roadless Area Designation

In the State of Idaho more than 2.7 million acres of national forest lands are in existing wilderness or primitive areas and over 7 million acres are currently tied up in the RARE II process. These statistics do not address the issues and implications involved in allocating land to non-timber use.

To date, the potential impacts on Idaho's economy and forest industries which would result from a reduction in commercial forest land acreage are not known. The Idaho Forest Productivity Study has the potential to address this issue. Rational decisions involving forest resource allocation require a full evaluation of the trade-offs involved, as well as redistribution of associated benefits. Without knowing the implications to Idaho's economy of alternative levels of non-timber use, land allocation decisions which are detrimental to both the State of Idaho and the nation are likely.

Deferred Harvest Decisions

The indecision surrounding the RARE II process has caused the deferral of silvicultural investments and harvests on public lands. The forest is not an object which remains inert. There is a cost associated with holding an unused asset and there are losses associated with neglecting investment opportunities. The structure of the Idaho Forest Productivity economic model is well suited to that analysis.

Economic Analysis of Silvicultural Practices

Research on the biological effects of forest silvicultural and management practices has always been heavily emphasized. It is important to measure not only the response of the biota but also the benefits and returns to man of investments in forestry. The economic analysis of "good forestry" in Idaho is spotty and incomplete. Traditional stand manipulations must be evaluated economically.

A number of counterintuitive results were evident in the general application of the Idaho Forest Productivity Study Phase II model, where optimal management practice combinations were identified. Applications to specific stand conditions could be accomplished such that any set of investments could be evaluated without waiting a rotation for results, as is commonly done in post-mortem approaches. Continued use and modification of the model should improve both its accuracy and its applicability.

LITERATURE CITED

Clawson, M. 1976. The economics of national forest management. Resources for the Future Working Paper EN-6. Resources for the Future, Inc., Washington, DC. 117 pp.

Dowdle, B. 1976. Some further comments on the allowable cut effect. Forest Industries 103(12):52.

Faustmann, M. 1849. Calculation of the value which forest land and immature stands possess for forestry. Translated by M. Gane, 1968, *in* Martin Faustmann and the Evolution of Discounted Cash Flow. Oxford Univ. Press, England. 53 pp.

Goforth, M.H., and T.J. Mills. 1975. Discounting perpetually recurring payments under conditions of compounded relative value increases. USDA Forest Serv. Res. Note WO-10, Washington, DC. 3 pp.

Hatch, C.R., G.M. Allen, G.L. Houck and K.M. Sowles. 1976. Timber supply projections for the State of Idaho. Forest, Wildlife and Range Exp. Sta. Bull. No. 15., Univ. of Idaho, Moscow. 19 pp.

Helliwell, D.R. 1974. Discount rates in land-use planning. Forestry 47(2):147-152.

Larson, D.N. 1977. Washington Forest Productivity Study Phase II Economic Analysis. Washington State Dept. of Natural Res., Olympia. 116 pp.

McKetta, C.W., and E.L. Medema. 1977. Always jam tomorrow. Work in progress on the effects of real stumpage rate increases on forest investment analysis. Univ. of Idaho, Moscow. Unpublished.

Mills, T.J., M.H. Goforth and T.P. Hart. 1976. Sensitivity of estimated financial returns on timber investments to data errors. USDA Forest Serv. Res. Pap. WO-31, Washington, DC. 23 pp.

Nordhaus, W.D. 1974. The falling share of profits. Pages 169-217 *in* Okun, A.M., ed. Brookings Papers on Economic Activity. Brookings Inst., Washington, DC.

Samuelson, P. 1974. Economics of forestry in an evolving society. Draft of a paper presented at a symposium titled The Economics of Sustained Yield Forestry, at Univ. of Washington, Seattle, 1974.

Scanlin, D.C., H. Loewenstein and F.H. Pitkin. 1976. Two-year response of north Idaho stands of Douglas-fir and grand fir to urea fertilizer and thinning. Forest, Wildlife and Range Exp. Sta. Bull. No. 18, Univ. of Idaho, Moscow. 17 pp.

Schweitzer, D.L. 1970. The impact of estimation errors on evaluation of timber production opportunities. USDA Forest Serv. Res. Pap. NC-43, North Central Forest Exp. Sta., St. Paul, MN. 18 pp.

Shepard, W. 1925. The bogey of compound interest. J. Forest. 23(3):251-259.

Stage, A.R. 1973. Prognosis model for stand development. USDA Forest Serv. Res. Pap. INT-137, Intermountain Forest and Range Exp. Sta., Ogden, UT. 32 pp.

U.S. Department of Agriculture, Agricultural Price Reporting Service. 1976. Agricultural Price Summary, Annual Report. U.S. Govt. Printing Office, Washington, DC.

U.S. Department of Agriculture. 1973. The outlook for timber in the United States. Forest Resource Rep. 20. U.S. Govt. Printing Office, Washington, DC. 374 pp.

U.S. Department of Agriculture Forest Service. 1976. Timber harvest scheduling issues study. U.S. Govt. Printing Office, Washington, DC. 292 pp.

U.S. Department of Agriculture Forest Service. 1977. The nation's renewable resources–an assessment 1975. Forest Resource Rep. No. 21. U.S. Govt. Printing Office, Washington, DC. 243 pp.

Waggener, T.R. 1977. Community stability as a forest management objective. J. Forest. 75(11):710-714.

Yohe, W.P., and D.S. Karnosky. 1969. Interest rates and price level changes, 1952-69. Federal Reserve Bank of St. Louis Review 5(12):18-38.

Appendix 1a

Description of Case Study Stands

GF = grand fir, AF = subalpine fir, WL = western larch, ES = Engelmann spruce, LP = lodgepole pine, WP = western white pine, PP = ponderosa pine, DF = Douglas-fir, WC = western redcedar, WH = western hemlock, OTH = other species

	GF	AF	WL	ES	LP	WP	PP	DF	WC	WH	OTH	Total
Case Study Stand No. 1: Northern Idaho, 20 year old – 75% grand fir												
Basal Area (sq. ft./acre)	58.2	0.0	0.0	0.0	0.0	1.4	0.0	0.8	0.3	1.2	0.0	62.0
Trees/Acre	150.9	2.3	0.0	0.0	0.0	0.7	0.0	7.3	2.7	4.8	0.0	168.7
Average DBH (inches)	8.4	1.9	0.0	0.0	0.0	19.3	0.0	4.5	4.7	6.7	0.0	8.2
Case Study Stand No. 2: Northern Idaho, 20 year old – 75% lodgepole pine												
Basal Area/Acre	0.0	0.0	0.0	0.0	44.4	0.0	0.0	0.0	0.7	0.8	0.0	45.9
Trees/Acre	0.0	0.0	0.0	0.0	261.5	0.0	0.0	0.0	6.3	0.9	0.0	268.7
Average DBH	0.0	0.0	0.0	0.0	5.6	0.0	0.0	0.0	4.4	13.0	0.0	5.6
Case Study Stand No. 3: Northern Idaho, 20 year old – 75% western white pine												
Basal Area/Acre	5.5	0.0	0.0	0.0	0.0	74.4	0.0	2.5	1.0	2.5	0.0	85.9
Trees/Acre	25.8	0.0	0.0	0.0	0.0	124.7	0.0	1.3	18.8	7.7	0.0	178.3
Average DBH	6.2	0.0	0.0	0.0	0.0	10.5	0.0	18.8	3.2	7.7	0.0	9.4
Cast Study Stand No. 4: Northern Idaho, 20 year old – 75% Douglas-fir												
Basal Area/Acre	1.6	0.6	1.1	0.1	0.0	0.5	0.6	81.4	0.1	0.0	0.0	86.2
Trees/Acre	16.7	4.4	1.0	4.0	0.0	0.3	0.2	140.0	4.0	0.0	0.0	170.6
Average DBH	4.2	5.2	13.9	2.5	0.0	18.2	24.3	10.3	2.5	0.0	0.0	9.6
Case Study Stand No. 5: Northern Idaho, 40 year old – 75% grand fir												
Basal Area/Acre	69.4	0.2	0.4	0.3	0.0	0.2	0.0	3.0	1.1	1.1	0.1	75.7
Trees/Acre	247.0	1.4	0.5	1.8	0.0	0.2	0.0	11.1	2.1	4.2	1.5	269.8
Average DBH	7.2	5.1	12.3	5.5	0.0	13.0	0.0	7.1	9.7	6.8	3.3	7.2
Case Study Stand No. 6: Northern Idaho, 40 year old – 75% subalpine fir												
Basal Area/Acre	0.1	49.7	0.0	2.2	0.9	0.1	0.0	1.5	0.9	0.0	0.1	55.5
Trees/Acre	5.6	312.5	0.0	6.2	6.1	5.6	0.0	5.9	0.3	0.0	5.6	347.8
Average DBH	1.5	5.4	0.0	8.1	5.2	1.8	0.0	6.7	23.3	0.0	2.1	5.4
Case Study Stand No. 7: Northern Idaho, 40 year old – 75% western larch												
Basal Area/Acre	0.1	0.2	59.3	0.1	0.0	0.0	0.0	2.0	0.4	0.0	0.0	62.0
Trees/Acre	5.4	5.4	203.4	5.4	0.0	0.0	0.0	23.9	14.3	0.0	0.0	257.8
Average DBH	1.9	2.7	7.3	1.8	0.0	0.0	0.0	3.9	2.1	0.0	0.0	6.6
Case Study Stand No. 8: Northern Idaho, 40 year old – 75% lodgepole pine												
Basal Area/Acre	0.5	0.1	1.0	0.0	87.5	0.8	0.0	1.1	0.0	0.6	0.1	91.8
Trees/Acre	6.1	4.4	0.7	0.0	378.5	5.2	0.0	15.4	0.0	2.0	2.2	414.5
Average DBH	4.1	2.1	16.6	0.0	6.5	5.4	0.0	3.6	0.0	7.3	2.1	6.4
Case Study Stand No. 9: Northern Idaho, 40 year old – 75% western white pine												
Basal Area/Acre	0.7	0.0	0.0	0.0	0.0	50.0	0.0	1.8	0.4	0.0	0.0	52.9
Trees/Acre	26.0	0.0	0.0	0.0	0.0	98.9	0.0	1.9	26.1	0.0	0.0	152.9
Average DBH	2.2	0.0	0.0	0.0	0.0	9.6	0.0	13.0	1.7	0.0	0.0	8.0
Case Study Stand No. 10: Northern Idaho, 40 year old – 75% Douglas-fir												
Basal Area/Acre	2.6	0.7	0.3	0.1	0.3	0.4	0.8	79.2	0.4	0.0	0.3	85.1
Trees/Acre	27.4	9.0	2.5	3.5	2.0	2.2	3.1	316.0	11.9	0.0	0.3	377.9
Average DBH	4.2	3.7	4.7	2.7	5.4	5.5	6.9	6.8	2.6	0.0	13.6	6.4

	GF	AF	WL	ES	LP	WP	PP	DF	WC	WH	OTH	Total
Case Study Stand No. 11: Northern Idaho, 40 year old – 75% western hemlock												
Basal Area/Acre	3.3	0.0	0.2	0.0	0.5	0.6	0.0	0.0	0.0	88.0	0.0	92.6
Trees/Acre	23.5	0.0	3.7	0.0	0.7	0.3	0.0	0.0	0.0	189.1	0.0	217.3
Average DBH	5.0	0.0	3.5	0.0	11.3	19.0	0.0	0.0	0.0	9.2	0.0	8.8
Case Study Stand No. 12: Northern Idaho, 60 year old – 75% grand fir												
Basal Area/Acre	93.2	1.5	1.2	1.3	0.4	0.0	0.0	5.1	1.0	0.5	0.0	104.3
Trees/Acre	267.3	5.3	0.6	2.2	0.4	0.0	0.0	15.9	11.3	0.7	0.0	303.7
Average DBH	8.0	7.3	19.5	10.4	14.0	0.0	0.0	7.7	4.1	11.1	0.0	7.9
Case Study Stand No. 13: Northern Idaho, 60 year old – 75% subalpine fir												
Basal Area/Acre	0.0	103.4	0.0	3.8	1.9	1.0	0.0	0.0	0.0	0.0	2.9	113.0
Trees/Acre	0.0	350.9	0.0	14.5	2.5	1.6	0.0	0.0	0.0	0.0	14.4	383.9
Average DBH	0.0	7.3	0.0	6.9	11.9	10.5	0.0	0.0	0.0	0.0	6.1	7.3
Case Study Stand No. 14: Northern Idaho, 60 year old – 75% western larch												
Basal Area/Acre	2.5	0.0	81.5	0.0	0.4	0.0	0.8	3.0	3.1	0.4	0.0	91.6
Trees/Acre	29.2	0.0	413.5	0.0	4.3	0.0	4.8	34.9	58.7	19.6	0.0	565.0
Average DBH	3.9	0.0	6.0	0.0	4.2	0.0	5.5	3.9	3.1	1.9	0.0	5.5
Case Study Stand No. 15: Northern Idaho, 60 year old – 75% lodgepole pine												
Basal Area/Acre	0.4	0.3	0.3	0.3	100.7	0.1	0.2	1.0	0.1	0.1	0.1	103.6
Trees/Acre	8.5	8.7	3.3	8.6	488.1	2.9	1.2	12.0	2.0	2.0	4.8	542.1
Average DBH	2.9	2.6	4.2	2.7	6.1	3.0	5.2	3.9	2.9	2.6	2.0	5.9
Case Study Stand No. 16: Northern Idaho, 60 year old – 75% western white pine												
Basal Area/Acre	1.3	0.0	2.8	1.1	3.1	50.7	0.0	5.3	0.0	0.0	0.0	64.3
Trees/Acre	15.6	0.0	10.1	1.7	2.6	163.2	0.0	21.6	0.0	0.0	0.0	214.8
Average DBH	3.9	0.0	7.1	10.7	14.8	7.6	0.0	6.7	0.0	0.0	0.0	7.4
Case Study Stand No. 17: Northern Idaho, 60 year old – 75% ponderosa pine												
Basal Area/Acre	0.0	0.0	0.0	0.0	1.8	0.0	73.4	1.6	0.0	0.0	0.0	76.7
Trees/Acre	0.0	0.0	0.0	0.0	5.5	0.0	177.1	3.4	0.0	0.0	0.0	186.0
Average DBH	0.0	0.0	0.0	0.0	7.7	0.0	8.7	9.3	0.0	0.0	0.0	8.7
Case Study Stand No. 18: Northern Idaho, 60 year old – 75% Douglas-fir												
Basal Area/Acre	2.6	0.5	0.4	0.1	0.4	0.4	0.1	91.9	0.4	0.3	0.1	97.3
Trees/Acre	40.2	2.2	2.2	2.4	0.9	4.1	0.1	291.9	9.8	5.8	1.2	360.8
Average DBH	3.4	6.6	5.6	2.3	9.6	4.5	15.0	7.6	2.8	2.9	4.6	7.0
Case Study Stand No. 19: Northern Idaho, 80 year old – 75% grand fir												
Basal Area/Acre	118.7	0.0	2.3	1.1	0.5	0.6	0.2	4.2	1.7	0.4	0.0	129.7
Trees/Acre	269.4	0.0	3.2	0.8	1.1	0.3	0.1	4.8	6.5	3.4	0.0	289.6
Average DBH	9.0	0.0	11.6	16.0	8.9	18.6	20.6	12.6	6.8	4.7	0.0	9.1
Case Study Stand No. 20: Northern Idaho, 80 year old – 75% subalpine fir												
Basal Area/Acre	1.2	115.9	1.1	3.0	0.6	0.0	0.0	1.2	0.0	0.0	2.9	125.8
Trees/Acre	2.7	345.0	0.4	6.7	0.4	0.0	0.0	2.9	0.0	0.0	29.3	387.4
Average DBH	9.1	7.8	22.3	9.0	16.4	0.0	0.0	8.6	0.0	0.0	4.2	7.7

	GF	AF	WL	ES	LP	WP	PP	DF	WC	WH	OTH	Total
Case Study Stand No. 21: Northern Idaho, 80 year old – 75% lodgepole pine												
Basal Area/Acre	1.2	0.7	1.2	0.4	116.8	0.3	0.0	1.3	0.2	0.0	0.6	122.7
Trees/Acre	16.5	14.6	5.4	3.2	511.5	1.6	0.0	11.3	4.4	2.2	2.4	573.1
Average DBH	3.7	3.0	6.3	4.5	6.5	5.5	0.0	4.6	3.1	2.0	7.0	6.3
Case Study Stand No. 22: Northern Idaho, 80 year old – 75% western white pine												
Basal Area/Acre	2.1	1.5	0.0	1.0	0.0	79.3	0.0	1.3	0.0	0.0	0.5	85.8
Trees/Acre	8.2	2.1	0.0	8.3	0.0	104.2	0.0	6.1	0.0	0.0	0.4	129.3
Average DBH	6.9	11.6	0.0	4.6	0.0	11.8	0.0	6.4	0.0	0.0	15.2	11.0
Case Study Stand No. 23: Northern Idaho, 80 year old – 75% ponderosa pine												
Basal Area/Acre	0.0	0.0	0.6	0.0	0.0	0.0	83.8	6.2	0.0	0.0	0.0	90.7
Trees/Acre	0.0	0.0	0.2	0.0	0.0	0.0	161.7	17.2	0.0	0.0	0.0	179.1
Average DBH	0.0	0.0	23.0	0.0	0.0	0.0	9.8	8.2	0.0	0.0	0.0	9.6
Case Study Stand No. 24: Northern Idaho, 80 year old – 75% Douglas-fir												
Basal Area/Acre	3.1	0.1	0.8	0.5	1.1	0.4	1.9	108.8	0.6	0.2	0.0	117.4
Trees/Acre	24.7	0.2	4.8	2.3	2.0	1.8	2.1	252.7	6.4	5.0	1.0	303.0
Average DBH	4.8	10.9	5.5	6.1	10.0	6.2	12.8	8.9	4.1	2.4	2.7	8.4
Case Study Stand No. 25: Northern Idaho, 100 year old – 75% grand fir												
Basal Area/Acre	97.7	0.0	0.4	1.0	0.0	0.7	0.0	5.1	0.7	0.3	0.0	106.0
Trees/Acre	231.2	0.0	0.4	0.9	0.0	1.2	0.0	4.7	2.9	0.5	0.0	241.8
Average DBH	8.8	0.0	14.3	14.3	0.0	10.6	0.0	14.1	6.7	10.8	0.0	9.0
Case Study Stand No. 26: Northern Idaho, 100 year old – 75% subalpine fir												
Basal Area/Acre	0.0	135.9	0.0	6.0	0.0	0.7	0.0	1.6	0.2	3.3	3.3	151.0
Trees/Acre	0.0	390.3	0.0	18.2	0.0	0.2	0.0	5.2	5.9	2.3	4.3	426.4
Average DBH	0.0	8.0	0.0	7.8	0.0	25.6	0.0	7.5	2.4	16.2	11.9	8.1
Case Study Stand No. 27: Northern Idaho, 100 year old – 75% lodgepole pine												
Basal Area/Acre	1.1	2.6	1.8	1.1	131.0	0.5	0.4	2.7	0.6	0.0	0.0	141.9
Trees/Acre	6.2	21.0	3.5	1.8	453.8	0.8	2.7	16.2	2.3	0.0	0.0	508.3
Average DBH	5.7	4.7	9.7	10.8	7.3	10.8	5.3	5.6	7.2	0.0	0.0	7.2
Case Study Stand No. 28: Northern Idaho, 100 year old – 75% ponderosa pine												
Basal Area/Acre	0.0	0.0	0.0	0.0	0.4	0.0	115.1	5.2	0.0	0.0	0.0	120.7
Trees/Acre	0.0	0.0	0.0	0.0	0.8	0.0	145.9	17.5	0.0	0.0	0.0	164.2
Average DBH	0.0	0.0	0.0	0.0	9.4	0.0	12.0	7.4	0.0	0.0	0.0	11.6
Case Study Stand No. 29: Northern Idaho, 100 year old – 75% Douglas-fir												
Basal Area/Acre	2.0	0.3	1.3	0.0	0.2	0.4	1.1	110.7	1.4	0.0	0.2	117.7
Trees/Acre	12.2	2.2	2.8	0.0	1.6	1.1	0.3	213.7	7.0	2.8	1.4	245.1
Average DBH	5.5	5.1	9.2	0.0	5.3	7.9	25.6	9.7	6.2	1.5	4.6	9.4
Case Study Stand No. 30: Northern Idaho, 120 year old – 75% grand fir												
Basal Area/Acre	108.9	0.0	1.1	0.2	0.4	2.3	0.0	6.8	1.9	0.3	0.0	121.8
Trees/Acre	220.5	0.0	1.8	0.2	0.3	4.7	0.0	9.1	2.7	0.4	0.0	239.7
Average DBH	9.5	0.0	10.8	14.1	15.8	9.4	0.0	11.7	11.3	11.0	0.0	9.7

	GF	AF	WL	ES	LP	WP	PP	DF	WC	WH	OTH	Total
Case Study Stand No. 31: Northern Idaho, 120 year old – 75% Douglas-fir												
Basal Area/Acre	3.8	0.0	1.1	0.0	0.4	0.2	3.0	106.2	0.6	0.0	0.0	115.3
Trees/Acre	24.2	0.0	2.1	0.0	0.9	0.2	1.4	170.6	4.8	0.0	0.0	204.2
Average DBH	5.3	0.0	9.7	0.0	9.3	12.0	19.9	10.7	4.8	0.0	0.0	10.2
Case Study Stand No. 32: Northern Idaho, 120 year old – 75% western redcedar												
Basal Area/Acre	6.0	0.0	0.4	1.8	0.0	0.5	0.0	0.5	96.4	0.0	0.6	106.1
Trees/Acre	15.9	0.0	0.5	1.1	0.0	0.4	0.0	9.6	161.2	0.0	0.6	189.3
Average DBH	8.3	0.0	12.7	17.2	0.0	14.4	0.0	3.0	10.5	0.0	13.4	10.1
Case Study Stand No. 33: Northern Idaho, 140 year old – 75% grand fir												
Basal Area/Acre	112.5	0.0	1.2	0.2	0.2	2.8	0.0	4.3	1.8	0.9	0.1	124.1
Trees/Acre	148.6	0.0	0.7	0.2	1.4	2.6	0.0	5.7	2.7	1.1	2.4	165.4
Average DBH	11.8	0.0	18.1	13.6	5.1	14.0	0.0	11.8	11.1	12.4	2.0	11.7
Case Study Stand No. 34: Northern Idaho, 140 year old – 75% Douglas-fir												
Basal Area/Acre	0.8	0.0	1.5	0.0	0.5	0.3	1.2	89.4	0.5	0.0	0.6	94.8
Trees/Acre	7.1	0.0	5.7	0.0	0.9	1.0	4.4	128.0	1.4	0.0	6.3	154.8
Average DBH	4.5	0.0	6.9	0.0	10.3	7.9	7.0	11.3	8.2	0.0	4.3	10.6
Case Study Stand No. 35: Northern Idaho, 140 year old – 75% western redcedar												
Basal Area/Acre	8.7	0.6	1.2	1.4	1.0	0.3	0.0	2.5	148.9	0.0	0.0	164.5
Trees/Acre	32.6	0.4	0.6	0.9	1.0	6.5	0.0	1.0	142.8	3.9	0.0	189.7
Average DBH	7.0	15.9	18.9	17.0	13.6	2.9	0.0	21.4	13.8	1.4	0.0	12.6
Case Study Stand No. 36: Northern Idaho, 160 year old – 75% grand fir												
Basal Area/Acre	113.8	0.3	1.2	0.8	0.3	2.2	0.0	4.1	3.4	0.9	0.0	127.0
Trees/Acre	215.2	1.9	1.2	1.1	0.7	2.0	0.0	6.6	10.2	3.1	0.0	242.1
Average DBH	9.8	5.3	13.4	11.5	8.6	14.3	0.0	10.7	7.9	7.2	0.0	9.8
Case Study Stand No. 37: Northern Idaho, 160 year old – 75% subalpine fir												
Basal Area/Acre	0.0	104.4	0.2	5.3	1.0	0.2	0.0	0.4	0.0	0.0	5.6	117.2
Trees/Acre	0.0	281.0	0.0	12.7	1.0	0.0	0.0	0.1	0.0	0.0	8.9	303.8
Average DBH	0.0	8.3	37.0	8.8	13.2	33.6	0.0	27.0	0.0	0.0	10.7	8.4
Case Study Stand No. 38: Northern Idaho, 160 year old – 75% Douglas-fir												
Basal Area/Acre	3.2	0.5	0.7	0.1	0.1	0.6	1.6	107.3	0.5	0.3	0.1	114.9
Trees/Acre	17.9	0.7	0.7	2.0	0.3	0.6	0.4	197.7	3.1	1.4	0.1	225.0
Average DBH	5.7	10.6	13.8	3.4	6.8	12.9	27.0	10.0	5.5	6.3	9.8	9.7
Case Study Stand No. 39: Northern Idaho, 160 year old – 75% western redcedar												
Basal Area/Acre	11.7	0.1	1.8	1.4	0.1	2.7	0.0	1.8	141.0	0.4	0.2	161.0
Trees/Acre	30.4	0.5	0.7	1.1	0.1	0.8	0.0	2.7	120.9	0.4	0.1	157.6
Average DBH	8.4	6.8	22.0	15.4	10.3	24.7	0.0	10.9	14.6	14.2	24.5	13.7
Case Study Stand No. 40: Northern Idaho, 160 year old – 75% western hemlock												
Basal Area/Acre	3.4	0.9	1.3	2.5	0.0	2.2	0.0	0.0	3.1	136.6	0.0	150.0
Trees/Acre	12.3	0.4	5.9	1.6	0.0	3.0	0.0	0.0	2.2	236.5	0.9	262.8
Average DBH	7.1	20.0	6.5	17.2	0.0	11.6	0.0	0.0	15.9	10.3	1.6	10.2

	GF	AF	WL	ES	LP	WP	PP	DF	WC	WH	OTH	Total
Case Study Stand No. 41: Northern Idaho, 20 year old – 50% western white pine												
Basal Area/Acre	15.5	0.0	8.1	0.0	2.6	85.9	1.3	17.5	3.9	11.9	0.0	146.6
Trees/Acre	15.1	0.0	3.9	0.0	6.7	86.9	0.6	45.5	27.2	12.1	0.0	198.0
Average DBH	13.7	0.0	19.5	0.0	8.5	13.5	19.6	8.4	5.1	13.4	0.0	11.7
Case Study Stand No. 42: Northern Idaho, 40 year old – 50% grand fir												
Basal Area/Acre	77.1	2.7	3.6	0.4	4.8	2.5	0.9	16.1	10.1	13.4	0.0	131.6
Trees/Acre	215.9	7.6	4.3	0.5	10.2	8.2	1.0	47.6	24.3	41.9	0.0	361.5
Average DBH	8.1	8.1	12.4	12.4	9.3	7.5	12.7	7.9	8.7	7.6	0.0	8.2
Case Study Stand No. 43: Northern Idaho, 40 year old – 50% western larch												
Basal Area/Acre	10.2	2.6	69.1	3.3	4.6	2.4	0.1	24.1	2.6	1.4	0.6	121.0
Trees/Acre	45.7	5.0	199.5	23.4	11.8	7.2	4.9	79.9	42.9	26.6	2.1	449.0
Average DBH	6.4	9.8	8.0	5.1	8.4	7.9	1.4	7.4	3.3	3.1	7.5	7.0
Case Study Stand No. 44: Northern Idaho, 40 year old – 50% western white pine												
Basal Area/Acre	17.4	2.6	5.0	0.0	1.3	59.1	0.0	13.3	5.3	6.8	0.2	111.1
Trees/Acre	108.0	4.1	4.2	0.0	1.9	120.9	0.0	28.2	15.4	28.1	19.4	330.2
Average DBH	5.4	10.7	14.8	0.0	11.1	9.5	0.0	9.3	8.0	6.6	1.5	7.9
Case Study Stand No. 45: Northern Idaho, 40 year old – 50% Douglas-fir												
Basal Area/Acre	23.9	1.3	7.7	1.7	2.7	2.9	7.3	72.0	3.8	1.2	0.6	125.2
Trees/Acre	116.1	3.8	23.9	3.8	10.6	9.9	7.5	216.1	47.7	8.1	3.9	451.4
Average DBH	6.1	8.0	7.7	8.9	6.8	7.4	13.3	7.8	3.8	5.3	5.5	7.1
Case Study Stand No. 46: Northern Idaho, 60 year old – 50% grand fir												
Basal Area/Acre	94.3	2.3	4.1	9.3	5.8	2.7	0.0	27.2	10.0	0.6	0.0	156.4
Trees/Acre	429.0	3.4	5.8	11.0	8.9	5.3	0.0	84.5	24.4	8.3	0.0	580.6
Average DBH	6.3	11.1	11.4	12.4	10.9	9.7	0.0	7.7	8.7	3.6	0.0	7.0
Case Study Stand No. 47: Northern Idaho, 60 year old – 50% western larch												
Basal Area/Acre	10.3	1.6	75.2	6.3	6.6	3.6	0.5	16.2	2.8	1.3	1.3	125.6
Trees/Acre	110.0	6.5	181.3	44.5	38.8	21.1	1.9	89.1	24.4	35.3	10.5	563.4
Average DBH	4.2	6.6	8.7	5.1	5.6	5.6	6.8	5.8	4.6	2.6	4.8	6.4
Case Study Stand No. 48: Northern Idaho, 60 year old – 50% lodgepole pine												
Basal Area/Acre	6.6	11.7	4.1	6.0	91.5	3.4	0.7	14.5	1.4	0.0	2.9	147.9
Trees/Acre	38.3	39.6	24.5	37.9	271.0	22.2	1.1	65.5	43.7	0.0	19.8	563.6
Average DBH	5.6	7.4	5.6	5.4	7.9	8.3	11.0	6.4	2.4	0.0	5.2	6.9
Case Study Stand No. 49: Northern Idaho, 60 year old – 50% western white pine												
Basal Area/Acre	4.1	0.0	12.5	1.5	11.4	52.3	1.3	10.4	4.1	2.5	0.0	100.0
Trees/Acre	7.3	0.0	32.0	10.2	25.6	116.7	1.6	10.8	6.9	9.9	0.0	221.0
Average DBH	10.2	0.0	8.5	5.2	9.0	9.1	12.0	13.3	10.4	6.8	0.0	9.1
Case Study Stand No. 50: Northern Idaho, 60 year old – 50% Douglas-fir												
Basal Area/Acre	17.9	1.5	6.4	2.6	6.5	0.7	9.3	73.7	3.5	0.8	1.9	124.7
Trees/Acre	121.5	6.7	21.5	20.9	13.7	1.0	9.3	225.1	30.0	5.1	7.4	462.2
Average DBH	5.2	6.3	7.4	4.8	9.3	11.3	13.5	7.7	4.6	5.3	6.9	7.0

	GF	AF	WL	ES	LP	WP	PP	DF	WC	WH	OTH	Total
Case Study Stand No. 51: Northern Idaho, 80 year old – 50% grand fir												
Basal Area/Acre	111.2	2.1	10.2	7.3	5.6	7.3	1.8	21.9	13.4	1.6	0.0	182.3
Trees/Acre	305.9	6.6	17.8	15.8	12.5	8.7	0.5	41.1	42.5	5.6	0.0	457.1
Average DBH	8.2	7.7	10.3	9.2	9.0	12.4	25.4	9.9	7.6	7.2	0.0	8.6
Case Study Stand No. 52: Northern Idaho, 80 year old – 50% western larch												
Basal Area/Acre	16.0	2.0	77.1	1.9	10.3	1.5	0.7	14.7	4.3	2.7	0.0	131.1
Trees/Acre	115.1	7.4	212.0	9.6	19.0	6.4	1.3	40.6	48.3	32.5	0.0	492.2
Average DBH	5.0	7.0	8.2	6.0	10.0	6.6	9.8	8.2	4.0	3.9	0.0	7.0
Case Study Stand No. 53: Northern Idaho, 80 year old – 50% lodgepole pine												
Basal Area/Acre	15.1	10.7	8.7	5.6	104.8	3.5	2.6	18.3	0.9	0.2	1.0	171.7
Trees/Acre	105.2	72.3	19.6	26.3	313.5	10.5	3.5	76.1	17.6	4.0	2.0	650.6
Average DBH	5.1	5.2	9.0	6.3	7.8	7.9	11.8	6.6	3.1	2.8	9.6	7.0
Case Study Stand No. 54: Northern Idaho, 80 year old – 50% western white pine												
Basal Area/Acre	19.3	1.5	3.3	4.5	1.5	76.5	0.0	12.5	3.6	1.1	0.0	123.7
Trees/Acre	35.4	1.6	4.9	17.7	1.1	86.9	0.0	25.6	2.0	12.9	0.0	188.1
Average DBH	10.0	13.3	11.0	6.8	15.6	12.7	0.0	9.5	18.0	4.0	0.0	11.0
Case Study Stand No. 55: Northern Idaho, 80 year old – 50% Douglas-fir												
Basal Area/Acre	20.7	1.5	5.7	0.9	14.4	2.0	11.1	88.8	5.3	0.7	0.4	151.4
Trees/Acre	84.3	3.3	11.7	1.1	37.9	5.0	8.9	191.6	31.0	11.6	1.3	387.7
Average DBH	6.7	9.1	9.4	12.2	8.4	8.5	15.1	9.2	5.6	3.4	7.1	8.5
Case Study Stand No. 56: Northern Idaho, 100 year old – 50% grand fir												
Basal Area/Acre	101.6	1.6	9.8	5.5	7.2	6.0	1.4	14.1	23.8	4.3	0.0	175.3
Trees/Acre	264.0	5.1	14.3	9.9	15.4	9.3	0.8	21.3	70.0	18.2	0.0	428.3
Average DBH	8.4	7.6	11.2	10.1	9.2	10.8	18.0	11.0	7.9	6.6	0.0	8.7
Case Study Stand No. 57: Northern Idaho, 100 year old – 50% western larch												
Basal Area/Acre	17.1	2.1	86.2	2.2	6.6	3.5	1.6	23.0	7.2	2.4	0.0	151.9
Trees/Acre	112.5	8.7	164.8	3.8	14.9	5.7	0.8	86.7	51.7	43.1	0.0	492.7
Average DBH	5.3	6.6	9.8	10.4	9.0	10.7	19.1	7.0	5.1	3.2	0.0	7.5
Case Study Stand No. 58: Northern Idaho, 100 year old – 50% western white pine												
Basal Area/Acre	11.5	1.8	10.3	11.8	2.9	73.1	0.0	9.6	4.7	3.5	2.1	131.2
Trees/Acre	50.3	14.9	15.1	43.3	4.8	107.8	0.0	26.4	29.1	29.6	2.5	323.8
Average DBH	6.5	4.7	11.2	7.1	10.5	11.1	0.0	8.2	5.4	4.7	12.3	8.6
Case Study Stand No. 59: Northern Idaho, 100 year old – 50% Douglas-fir												
Basal Area/Acre	26.7	3.1	9.8	3.8	4.9	4.9	10.5	99.0	7.8	0.2	0.0	170.8
Trees/Acre	70.5	8.1	20.1	8.7	12.6	8.5	7.5	173.4	32.0	0.6	0.0	342.0
Average DBH	8.3	8.3	9.5	9.0	8.4	10.3	16.0	10.2	6.7	8.6	0.0	9.6
Case Study Stand No. 60: Northern Idaho, 120 year old – 50% grand fir												
Basal Area/Acre	97.3	2.0	3.8	1.4	2.5	7.4	1.1	22.5	19.4	0.6	0.0	158.1
Trees/Acre	195.5	1.6	2.5	0.7	3.9	9.3	0.7	24.7	29.2	1.0	0.0	269.1
Average DBH	9.6	15.3	16.7	19.1	10.9	12.1	16.8	12.9	11.1	10.7	0.0	10.4

Case Study Stand No. 61: Northern Idaho, 120 year old – 50% Douglas-fir

	GF	AF	WL	ES	LP	WP	PP	DF	WC	WH	OTH	Total
Basal Area/Acre	26.7	1.0	5.2	1.3	1.4	4.1	20.4	90.9	3.3	0.5	0.0	154.7
Trees/Acre	62.3	6.9	7.8	0.3	2.7	5.3	17.8	123.6	18.4	6.6	0.0	251.7
Average DBH	8.9	5.1	11.1	28.3	9.6	11.9	14.5	11.6	5.8	3.6	0.0	10.6

Case Study Stand No. 62: Northern Idaho, 120 year old – 50% western redcedar

	GF	AF	WL	ES	LP	WP	PP	DF	WC	WH	OTH	Total
Basal Area/Acre	24.3	0.0	12.6	2.7	0.7	7.7	0.0	12.8	91.0	4.0	1.0	156.7
Trees/Acre	45.8	0.0	11.3	4.2	0.6	6.5	0.0	31.2	213.2	21.7	0.2	334.7
Average DBH	9.9	0.0	14.3	10.8	14.1	14.7	0.0	8.7	8.8	5.8	30.3	9.3

Case Study Stand No. 63: Northern Idaho, 140 year old – 50% grand fir

	GF	AF	WL	ES	LP	WP	PP	DF	WC	WH	OTH	Total
Basal Area/Acre	100.6	1.4	7.7	4.1	1.4	9.9	2.5	16.7	23.1	1.1	0.4	169.1
Trees/Acre	178.9	1.1	4.3	4.8	2.5	7.0	0.8	17.3	24.1	1.6	0.3	242.7
Average DBH	10.2	15.4	18.2	12.6	10.0	16.1	24.0	13.3	13.3	11.3	15.9	11.3

Case Study Stand No. 64: Northern Idaho, 140 year old – 50% Douglas-fir

	GF	AF	WL	ES	LP	WP	PP	DF	WC	WH	OTH	Total
Basal Area/Acre	27.3	4.6	6.1	3.6	0.0	6.5	6.9	92.7	8.4	0.0	2.8	158.9
Trees/Acre	107.7	17.1	5.5	3.4	0.0	2.9	8.7	131.2	29.6	0.0	4.6	310.7
Average DBH	6.8	7.0	14.3	13.9	0.0	20.2	12.1	11.4	7.2	0.0	10.5	9.7

Case Study Stand No. 65: Northern Idaho, 140 year old – 50% western redcedar

	GF	AF	WL	ES	LP	WP	PP	DF	WC	WH	OTH	Total
Basal Area/Acre	41.0	0.9	4.5	2.6	0.9	5.7	0.0	10.9	117.0	4.6	1.3	189.5
Trees/Acre	101.7	1.0	5.7	11.1	0.5	2.4	0.0	25.5	149.4	18.6	0.4	316.3
Average DBH	8.6	13.1	12.0	6.6	17.7	20.9	0.0	8.9	12.0	6.8	24.4	10.5

Case Study Stand No. 66: Northern Idaho, 160 year old – 50% grand fir

	GF	AF	WL	ES	LP	WP	PP	DF	WC	WH	OTH	Total
Basal Area/Acre	105.6	1.8	6.0	4.4	1.3	11.2	0.7	18.3	19.4	7.0	0.3	176.1
Trees/Acre	210.5	4.8	7.0	4.0	1.4	6.2	0.2	26.3	27.1	17.6	3.1	308.1
Average DBH	9.6	8.2	12.6	14.2	13.3	18.2	25.3	11.3	11.5	8.6	4.5	10.2

Case Study Stand No. 67: Northern Idaho, 160 year old – 50% western white pine

	GF	AF	WL	ES	LP	WP	PP	DF	WC	WH	OTH	Total
Basal Area/Acre	27.5	3.6	7.0	0.9	1.8	103.2	0.0	13.1	7.6	16.4	1.6	182.7
Trees/Acre	55.9	7.0	5.0	1.0	2.4	65.5	0.0	15.4	10.5	27.0	0.7	190.4
Average DBH	9.5	9.7	16.0	12.8	11.8	17.0	0.0	12.5	11.5	10.6	20.5	13.3

Case Study Stand No. 68: Northern Idaho, 160 year old – 50% Douglas-fir

	GF	AF	WL	ES	LP	WP	PP	DF	WC	WH	OTH	Total
Basal Area/Acre	26.4	2.9	6.0	2.2	1.8	6.8	10.0	96.2	8.5	0.5	1.0	162.3
Trees/Acre	78.4	3.7	7.3	3.4	3.4	6.1	5.2	132.6	20.3	2.4	3.8	266.6
Average DBH	7.9	12.0	12.3	11.0	9.9	14.3	18.7	11.5	8.7	6.0	7.0	10.6

Case Study Stand No. 69: Northern Idaho, 160 year old – 50% western redcedar

	GF	AF	WL	ES	LP	WP	PP	DF	WC	WH	OTH	Total
Basal Area/Acre	39.2	0.3	9.4	5.7	1.2	16.7	0.7	15.6	145.8	6.3	0.6	241.3
Trees/Acre	59.1	0.2	6.0	4.2	1.2	6.9	0.1	22.4	181.1	5.4	0.3	287.0
Average DBH	11.0	16.0	16.9	15.7	13.2	21.1	35.3	11.3	12.2	14.5	19.0	12.4

Case Study Stand No. 70: Northern Idaho, 160 year old – 50% western hemlock

	GF	AF	WL	ES	LP	WP	PP	DF	WC	WH	OTH	Total
Basal Area/Acre	18.2	1.4	13.5	0.9	0.6	20.1	0.6	4.4	15.3	115.4	2.2	192.6
Trees/Acre	23.6	2.6	9.1	0.3	1.0	12.2	0.6	2.6	25.1	232.2	0.6	309.9
Average DBH	11.9	10.1	16.5	23.2	10.4	17.4	14.0	17.8	10.6	9.5	25.0	10.7

	GF	AF	WL	ES	LP	WP	PP	DF	WC	WH	OTH	Total
Case Study Stand No. 71: Southern Idaho, 60 year old – 75% lodgepole pine												
Basal Area/Acre	0.0	0.2	0.0	0.1	64.1	0.0	0.0	0.1	0.0	0.0	0.3	64.7
Trees/Acre	0.0	9.5	0.0	2.4	805.8	0.0	0.0	7.1	0.0	0.0	4.8	829.6
Average DBH	0.0	1.8	0.0	2.0	3.8	0.0	0.0	1.9	0.0	0.0	3.2	3.8
Case Study Stand No. 72: Southern Idaho, 60 year old – 75% Douglas-fir												
Basal Area/Acre	1.0	0.0	0.5	0.0	0.0	0.0	1.4	67.7	0.0	0.0	0.1	70.8
Trees/Acre	19.5	0.0	6.5	0.0	0.0	0.0	7.7	438.1	0.0	0.0	6.5	478.3
Average DBH	3.1	0.0	3.8	0.0	0.0	0.0	5.8	5.3	0.0	0.0	2.0	5.2
Case Study Stand No. 73: Southern Idaho, 80 year old – 75% subalpine fir												
Basal Area/Acre	0.0	105.9	0.0	2.4	0.9	0.0	0.0	1.7	0.0	0.0	1.3	112.1
Trees/Acre	0.0	450.5	0.0	4.1	10.8	0.0	0.0	5.9	0.0	0.0	21.7	493.0
Average DBH	0.0	6.6	0.0	10.3	3.9	0.0	0.0	7.2	0.0	0.0	3.3	6.5
Case Study Stand No. 74: Southern Idaho, 80 year old – 75% lodgepole pine												
Basal Area/Acre	0.0	1.5	0.0	0.4	104.3	0.0	0.0	0.7	0.0	0.0	0.3	107.3
Trees/Acre	0.0	36.4	0.0	6.4	754.7	0.0	0.0	9.8	0.0	0.0	7.0	814.3
Average DBH	0.0	2.8	0.0	3.6	5.0	0.0	0.0	3.6	0.0	0.0	2.9	4.9
Case Study Stand No. 75: Southern Idaho, 80 year old – 75% ponderosa pine												
Basal Area/Acre	0.2	0.0	0.0	0.0	0.0	0.0	92.5	1.6	0.0	0.0	0.3	94.7
Trees/Acre	1.9	1.4	0.0	0.0	1.4	0.0	212.6	12.1	0.0	0.0	0.1	229.5
Average DBH	4.6	2.0	0.0	0.0	1.1	0.0	8.9	5.0	0.0	0.0	21.6	8.7
Case Study Stand No. 76: Southern Idaho, 80 year old – 75% Douglas-fir												
Basal Area/Acre	0.4	0.3	0.0	0.1	0.2	0.0	1.7	96.4	0.0	0.0	0.2	99.3
Trees/Acre	10.5	4.1	0.0	0.7	1.2	0.0	10.5	321.3	0.0	0.0	4.0	352.3
Average DBH	2.6	3.4	0.0	4.7	5.8	0.0	5.4	7.4	0.0	0.0	3.2	7.2
Case Study Stand No. 77: Southern Idaho, 100 year old – 75% subalpine fir												
Basal Area/Acre	0.0	148.7	0.9	6.4	5.7	0.0	0.0	1.6	0.0	0.0	1.4	164.7
Trees/Acre	0.0	538.6	2.3	21.0	47.4	0.0	0.0	0.5	0.0	0.0	15.5	625.3
Average DBH	0.0	7.1	8.4	7.5	4.7	0.0	0.0	23.9	0.0	0.0	4.1	6.9
Case Study Stand No. 78: Southern Idaho, 100 year old – 75% lodgepole pine												
Basal Area/Acre	0.1	1.0	0.0	0.6	118.3	0.0	0.0	1.4	0.0	0.0	0.5	121.9
Trees/Acre	1.9	7.7	0.0	4.7	580.0	0.0	0.0	16.3	0.0	0.0	7.3	617.9
Average DBH	3.8	4.8	0.0	4.8	6.1	0.0	0.0	4.0	0.0	0.0	3.6	6.0
Case Study Stand No. 79: Southern Idaho, 100 year old – 75% ponderosa pine												
Basal Area/Acre	0.1	0.0	0.0	0.0	0.1	0.0	105.0	2.6	0.0	0.0	0.1	107.9
Trees/Acre	1.5	0.0	0.0	0.0	0.6	0.0	226.7	20.2	0.0	0.0	3.0	252.0
Average DBH	3.9	0.0	0.0	0.0	5.3	0.0	9.2	4.8	0.0	0.0	3.0	8.9
Case Study Stand No. 80: Southern Idaho, 100 year old – 75% Douglas-fir												
Basal Area/Acre	0.0	0.2	0.0	0.0	0.5	0.0	1.4	117.9	0.0	0.0	0.2	120.3
Trees/Acre	0.8	1.6	0.0	0.0	3.7	0.0	3.8	269.1	0.0	0.0	2.5	281.5
Average DBH	3.1	4.9	0.0	0.0	5.2	0.0	8.2	9.0	0.0	0.0	3.6	8.9

	GF	AF	WL	ES	LP	WP	PP	DF	WC	WH	OTH	Total
Case Study Stand No. 81: Southern Idaho, 120 year old – 75% grand fir												
Basal Area/Acre	106.6	0.3	0.8	1.2	0.4	0.0	1.0	4.7	0.0	0.0	0.0	114.9
Trees/Acre	188.6	4.1	0.5	0.8	6.6	0.0	0.4	3.5	0.0	0.0	0.0	204.5
Average DBH	10.2	3.4	16.8	16.8	3.2	0.0	20.9	15.7	0.0	0.0	0.0	10.1
Case Study Stand No. 82: Southern Idaho, 120 year old – 75% subalpine fir												
Basal Area/Acre	0.7	108.7	0.0	1.8	3.0	0.0	0.0	2.4	0.0	0.0	1.6	118.3
Trees/Acre	1.0	407.7	0.0	5.9	24.0	0.0	0.0	6.6	0.0	0.0	19.4	464.6
Average DBH	11.7	7.0	0.0	7.4	4.8	0.0	0.0	8.2	0.0	0.0	3.9	6.8
Case Study Stand No. 83: Southern Idaho, 120 year old – 75% lodgepole pine												
Basal Area/Acre	0.1	1.6	0.0	0.5	118.7	0.0	0.0	1.2	0.0	0.0	0.2	122.3
Trees/Acre	1.1	33.6	0.0	5.2	696.4	0.0	0.0	13.4	0.0	0.0	4.5	754.2
Average DBH	4.3	2.9	0.0	4.1	5.6	0.0	0.0	4.0	0.0	0.0	3.0	5.5
Case Study Stand No. 84: Southern Idaho, 120 year old – 75% ponderosa pine												
Basal Area/Acre	0.5	0.0	0.0	0.0	0.4	0.0	111.5	4.7	0.0	0.0	0.1	117.2
Trees/Acre	2.9	0.0	0.0	0.0	3.2	0.0	262.5	19.3	0.0	0.0	0.5	288.4
Average DBH	5.5	0.0	0.0	0.0	4.8	0.0	8.8	6.7	0.0	0.0	6.2	8.6
Case Study Stand No. 85: Southern Idaho, 120 year old – 75% Douglas-fir												
Basal Area/Acre	0.5	0.3	0.0	0.1	0.8	0.0	0.4	123.0	0.0	0.0	0.3	125.4
Trees/Acre	0.6	1.0	0.0	0.5	5.5	0.0	0.3	257.2	0.0	0.0	2.3	267.4
Average DBH	11.8	7.6	0.0	5.7	5.3	0.0	16.0	9.4	0.0	0.0	4.7	9.3
Case Study Stand No. 86: Southern Idaho, 140 year old – 75% grand fir												
Basal Area/Acre	128.8	1.2	0.0	1.9	0.3	0.0	0.5	5.1	0.0	0.0	0.0	137.8
Trees/Acre	256.1	7.0	0.0	14.1	0.5	0.0	0.1	10.4	0.0	0.0	0.0	288.2
Average DBH	9.6	5.6	0.0	5.0	11.1	0.0	30.5	9.4	0.0	0.0	0.0	9.4
Case Study Stand No. 87: Southern Idaho, 140 year old – 75% subalpine fir												
Basal Area/Acre	0.0	120.0	0.3	3.6	3.7	0.0	0.0	1.9	0.0	0.0	0.9	130.3
Trees/Acre	0.0	424.1	0.8	12.8	21.1	0.0	0.0	11.2	0.0	0.0	16.0	486.0
Average DBH	0.0	7.2	7.8	7.1	5.6	0.0	0.0	5.6	0.0	0.0	3.2	7.0
Case Study Stand No. 88: Southern Idaho, 140 year old – 75% Engelmann spruce												
Basal Area/Acre	1.8	10.0	1.6	150.8	3.4	0.0	0.0	2.6	0.0	0.0	0.0	170.3
Trees/Acre	8.1	39.2	0.2	211.5	21.7	0.0	0.0	2.1	0.0	0.0	0.0	282.8
Average DBH	6.4	6.8	38.7	11.4	5.4	0.0	0.0	15.1	0.0	0.0	0.0	10.5
Case Study Stand No. 89: Southern Idaho, 140 year old – 75% lodgepole pine												
Basal Area/Acre	0.0	1.7	0.0	0.5	133.0	0.0	0.0	1.8	0.0	0.0	0.1	137.3
Trees/Acre	0.8	19.1	0.0	3.9	637.9	0.0	0.0	18.8	0.0	0.0	3.9	684.4
Average DBH	1.3	4.1	0.0	5.0	6.2	0.0	0.0	4.2	0.0	0.0	2.4	6.1
Case Study Stand No. 90: Southern Idaho, 140 year old – 75% ponderosa pine												
Basal Area/Acre	0.0	0.0	0.0	0.0	0.0	0.0	92.0	5.8	0.0	0.0	0.0	97.7
Trees/Acre	0.0	0.0	0.0	0.0	0.0	0.0	111.8	13.8	0.0	0.0	0.0	125.6
Average DBH	0.0	0.0	0.0	0.0	0.0	0.0	12.3	8.8	0.0	0.0	0.0	11.9

	GF	AF	WL	ES	LP	WP	PP	DF	WC	WH	OTH	Total
Case Study Stand No. 91: Southern Idaho, 140 year old – 75% Douglas-fir												
Basal Area/Acre	0.8	0.5	0.1	0.1	1.1	0.0	1.1	124.1	0.0	0.0	0.1	127.9
Trees/Acre	6.5	3.0	0.1	1.1	5.2	0.0	1.4	261.2	0.0	0.0	0.9	279.4
Average DBH	4.7	5.4	14.4	3.0	6.2	0.0	11.9	9.3	0.0	0.0	5.4	9.2
Case Study Stand No. 92: Southern Idaho, 160 year old – 75% grand fir												
Basal Area/Acre	98.5	0.2	0.7	0.9	0.6	0.0	1.9	4.1	0.0	0.0	0.0	106.9
Trees/Acre	235.1	0.2	1.7	7.6	1.1	0.0	0.7	10.9	0.0	0.0	1.4	258.8
Average DBH	8.8	13.4	8.4	4.7	10.2	0.0	21.7	8.3	0.0	0.0	2.4	8.7
Case Study Stand No. 93: Southern Idaho, 160 year old – 75% subalpine fir												
Basal Area/Acre	0.0	108.1	0.0	2.1	2.3	0.0	0.0	2.6	0.0	0.0	1.7	116.8
Trees/Acre	0.4	466.7	0.0	8.8	13.2	0.0	0.0	6.3	0.0	0.0	4.8	500.2
Average DBH	1.3	6.5	0.0	6.7	5.6	0.0	0.0	8.7	0.0	0.0	8.0	6.5
Case Study Stand No. 94: Southern Idaho, 160 year old – 75% Engelmann spruce												
Basal Area/Acre	0.9	8.8	0.5	137.8	1.6	0.0	0.0	1.1	0.0	0.0	0.3	150.9
Trees/Acre	2.1	49.6	0.3	152.1	3.7	0.0	0.0	2.5	0.0	0.0	3.8	214.1
Average DBH	8.8	5.7	17.3	12.9	8.9	0.0	0.0	9.0	0.0	0.0	3.7	11.4
Case Study Stand No. 95: Southern Idaho, 160 year old – 75% lodgepole pine												
Basal Area/Acre	0.1	1.7	0.0	0.5	100.6	0.0	0.0	1.8	0.0	0.0	0.5	105.2
Trees/Acre	0.6	33.4	0.0	5.6	527.0	0.0	0.0	11.6	0.0	0.0	7.0	585.2
Average DBH	4.2	3.1	15.3	4.0	5.9	0.0	12.6	5.4	0.0	0.0	3.5	5.7
Case Study Stand No. 96: Southern Idaho, 160 year old – 75% ponderosa pine												
Basal Area/Acre	0.4	0.0	0.0	0.0	0.0	0.0	96.9	4.1	0.0	0.0	0.1	101.5
Trees/Acre	3.0	0.4	0.0	0.0	0.0	0.0	113.6	21.9	0.0	0.0	2.2	141.0
Average DBH	4.7	4.9	0.0	0.0	0.0	0.0	12.5	5.9	0.0	0.0	2.2	11.5
Case Study Stand No. 97: Southern Idaho, 160 year old – 75% Douglas-fir												
Basal Area/Acre	0.1	0.7	0.0	0.1	0.8	0.0	0.8	120.4	0.0	0.0	0.3	123.3
Trees/Acre	2.2	6.8	0.0	1.0	6.9	0.0	1.2	205.8	0.0	0.0	2.2	226.1
Average DBH	3.4	4.4	9.8	4.8	4.6	0.0	11.0	10.4	0.0	0.0	5.1	10.0
Case Study Stand No. 98: Southern Idaho, 80 year old – 50% subalpine fir												
Basal Area/Acre	0.0	96.6	2.4	23.5	22.5	0.0	0.0	4.4	0.0	0.0	9.3	158.7
Trees/Acre	0.0	651.6	2.8	95.4	110.6	0.0	0.0	11.7	0.0	0.0	212.3	1084.4
Average DBH	0.0	5.2	12.7	6.7	6.1	0.0	0.0	8.3	0.0	0.0	2.8	5.2
Case Study Stand No. 99: Southern Idaho, 80 year old – 50% lodgepole pine												
Basal Area/Acre	1.0	23.7	0.2	3.4	75.8	0.0	1.8	10.7	0.0	0.0	5.5	122.1
Trees/Acre	18.4	206.8	7.5	39.2	385.3	0.0	1.4	87.3	0.0	0.0	65.8	811.7
Average DBH	3.2	4.6	2.3	4.0	6.0	0.0	15.5	4.7	0.0	0.0	3.9	5.3
Case Study Stand No. 100: Southern Idaho, 80 year old – 50% Douglas-fir												
Basal Area/Acre	7.3	6.2	0.5	0.0	5.8	0.0	26.7	79.0	0.0	0.0	8.5	134.0
Trees/Acre	31.6	35.7	1.3	0.0	32.6	0.0	68.0	206.8	0.0	0.0	59.7	435.7
Average DBH	6.5	5.6	8.5	0.0	5.7	0.0	8.5	8.4	0.0	0.0	5.1	7.5

	GF	AF	WL	ES	LP	WP	PP	DF	WC	WH	OTH	Total
Case Study Stand No. 101: Southern Idaho, 100 year old – 50% subalpine fir												
Basal Area/Acre	0.0	141.3	10.6	38.3	14.9	0.0	0.0	15.4	0.0	0.0	7.6	228.
Trees/Acre	0.0	583.8	11.0	100.6	70.4	0.0	0.0	33.6	0.0	0.0	17.0	816.
Average DBH	0.0	6.7	13.3	8.4	6.2	0.0	0.0	9.2	0.0	0.0	9.1	7.
Case Study Stand No. 102: Southern Idaho, 100 year old – 50% lodgepole pine												
Basal Area/Acre	0.0	17.0	0.0	3.8	88.3	0.0	0.6	27.5	0.0	0.0	8.4	145.
Trees/Acre	0.0	113.1	0.0	25.0	378.7	0.0	0.4	118.1	0.0	0.0	48.5	683.
Average DBH	0.0	5.3	0.0	5.3	6.5	0.0	16.2	6.5	0.0	0.0	5.6	6.
Case Study Stand No. 103: Southern Idaho, 100 year old – 50% ponderosa pine												
Basal Area/Acre	1.8	0.0	0.0	0.0	0.4	0.0	96.8	49.6	0.0	0.0	6.6	155.
Trees/Acre	3.2	0.0	0.0	0.0	0.8	0.0	140.2	130.0	0.0	0.0	41.5	315.
Average DBH	10.1	0.0	0.0	0.0	9.9	0.0	11.3	8.4	0.0	0.0	5.4	9.
Case Study Stand No. 104: Southern Idaho, 100 year old – 50% Douglas-fir												
Basal Area/Acre	4.9	7.4	1.4	1.4	11.7	0.0	24.4	83.0	0.0	0.0	6.1	140.
Trees/Acre	17.0	23.8	2.3	5.5	58.1	0.0	36.4	206.6	0.0	0.0	26.5	376.
Average DBH	7.2	7.6	10.7	6.9	6.1	0.0	11.1	8.6	0.0	0.0	6.5	8.
Case Study Stand No. 105: Southern Idaho, 120 year old – 50% subalpine fir												
Basal Area/Acre	2.7	96.8	0.5	13.2	24.1	0.0	0.0	13.2	0.0	0.0	12.9	163.
Trees/Acre	3.3	442.7	1.6	58.5	128.7	0.0	0.0	16.1	0.0	0.0	51.2	702.
Average DBH	12.3	6.3	7.4	6.4	5.9	0.0	0.0	12.3	0.0	0.0	6.8	6.
Case Study Stand No. 106: Southern Idaho, 120 year old – 50% lodgepole pine												
Basal Area/Acre	1.6	21.1	0.5	9.9	101.4	0.0	0.0	22.5	0.0	0.0	6.3	163.
Trees/Acre	8.2	121.9	0.1	45.6	446.0	0.0	0.0	90.3	0.0	0.0	27.9	740.
Average DBH	5.9	5.6	29.9	6.3	6.5	0.0	0.0	6.8	0.0	0.0	6.4	6.
Case Study Stand No. 107: Southern Idaho, 120 year old – 50% Douglas-fir												
Basal Area/Acre	9.8	8.2	0.9	3.4	13.3	0.0	17.7	83.4	0.0	0.0	4.8	141.
Trees/Acre	26.9	43.8	0.9	6.2	47.3	0.0	51.5	162.3	0.0	0.0	16.7	355.
Average DBH	8.2	5.9	13.9	10.1	7.2	0.0	7.9	9.7	0.0	0.0	7.2	8.
Case Study Stand No. 108: Southern Idaho, 140 year old – 50% grand fir												
Basal Area/Acre	90.3	1.6	4.5	11.6	3.3	0.0	7.4	33.7	0.0	0.0	0.0	152.
Trees/Acre	235.1	3.5	3.0	15.4	16.9	0.0	30.9	63.5	0.0	0.0	0.0	368.
Average DBH	8.4	9.2	16.6	11.7	6.0	0.0	6.6	9.9	0.0	0.0	0.0	8.
Case Study Stand No. 109: Southern Idaho, 140 year old – 50% subalpine fir												
Basal Area/Acre	1.0	110.7	0.0	21.4	23.0	0.0	0.0	17.2	0.0	0.0	8.7	182.
Trees/Acre	0.8	596.7	0.0	69.4	100.5	0.0	0.0	39.6	0.0	0.0	47.2	854.
Average DBH	14.8	5.8	0.0	7.5	6.5	0.0	0.0	8.9	0.0	0.0	5.8	6.
Case Study Stand No. 110: Southern Idaho, 140 year old – 50% Engelmann spruce												
Basal Area/Acre	6.0	56.5	0.7	120.9	7.8	0.0	0.0	7.2	0.0	0.0	4.8	203.
Trees/Acre	13.2	182.9	0.1	216.2	21.4	0.0	0.0	6.5	0.0	0.0	12.0	452.
Average DBH	9.1	7.5	36.0	10.1	8.2	0.0	0.0	14.3	0.0	0.0	8.6	9.

	GF	AF	WL	ES	LP	WP	PP	DF	WC	WH	OTH	Total
Case Study Stand No. 111: Southern Idaho, 140 year old – 50% lodgepole pine												
Basal Area/Acre	1.5	21.0	0.2	8.4	92.2	0.0	0.0	22.5	0.0	0.0	5.4	151.2
Trees/Acre	4.8	135.8	0.1	27.3	387.3	0.0	0.0	82.2	0.0	0.0	34.6	672.1
Average DBH	7.6	5.3	17.0	7.5	6.6	0.0	0.0	7.1	0.0	0.0	5.4	6.4
Case Study Stand No. 112: Southern Idaho, 140 year old – 50% Douglas-fir												
Basal Area/Acre	9.2	8.5	1.0	1.8	17.3	0.0	14.6	76.9	0.0	0.0	2.0	131.4
Trees/Acre	14.7	29.2	0.3	5.1	75.6	0.0	14.6	139.7	0.0	0.0	12.0	291.2
Average DBH	10.7	7.3	24.5	8.1	6.5	0.0	13.5	10.0	0.0	0.0	5.6	9.1
Case Study Stand No. 113: Southern Idaho, 160 year old – 50% subalpine fir												
Basal Area/Acre	0.4	102.8	0.3	16.4	16.2	0.0	0.3	19.6	0.0	0.0	11.1	167.1
Trees/Acre	0.9	522.5	0.2	26.3	52.3	0.0	0.1	30.4	0.0	0.0	38.9	671.6
Average DBH	9.1	6.0	19.6	10.7	7.5	0.0	27.0	10.9	0.0	0.0	7.2	6.8
Case Study Stand No. 114: Southern Idaho, 160 year old – 50% Engelmann spruce												
Basal Area/Acre	2.5	45.3	1.7	116.7	9.6	0.0	0.0	9.4	0.0	0.0	3.7	188.9
Trees/Acre	12.5	210.9	0.7	170.1	15.0	0.0	0.0	18.4	0.0	0.0	4.5	432.0
Average DBH	6.1	6.3	21.9	11.2	10.8	0.0	0.0	9.7	0.0	0.0	12.3	9.0
Case Study Stand No. 115: Southern Idaho, 160 year old – 50% lodgepole pine												
Basal Area/Acre	0.2	23.9	0.0	6.6	82.8	0.0	0.3	16.8	0.0	0.0	7.4	138.0
Trees/Acre	0.8	155.8	0.0	13.7	351.7	0.0	0.2	78.2	0.0	0.0	42.3	642.7
Average DBH	6.0	5.3	0.0	9.4	6.6	0.0	19.1	6.3	0.0	0.0	5.7	6.3
Case Study Stand No. 116: Southern Idaho, 160 year old – 50% ponderosa pine												
Basal Area/Acre	3.1	0.0	0.4	0.0	0.7	0.0	94.9	48.1	0.0	0.0	2.6	149.8
Trees/Acre	12.7	0.8	0.3	0.8	3.6	0.0	113.9	246.6	0.0	0.0	16.3	394.9
Average DBH	6.7	1.1	16.4	1.4	5.8	0.0	12.4	6.0	0.0	0.0	5.4	8.3
Case Study Stand No. 117: Southern Idaho, 160 year old – 50% Douglas-fir												
Basal Area/Acre	4.0	13.0	0.3	3.8	10.6	0.0	18.8	81.9	0.0	0.0	4.1	136.5
Trees/Acre	29.2	56.1	0.7	7.9	53.5	0.0	13.0	157.2	0.0	0.0	12.1	329.8
Average DBH	5.0	6.5	8.8	9.4	6.0	0.0	16.3	9.8	0.0	0.0	7.8	8.7

Appendix 1b

Description of Case Study Stands Following Overstory Removal

Case Study Stand No. 1: Northern Idaho, 20 year old – 75% grand fir

	GF	AF	WL	ES	LP	WP	PP	DF	WC	WH	OTH	Total
Basal Area/Acre	23.4	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.7	0.0	24.8
Trees/Acre	130.3	0.0	0.0	0.0	0.0	0.0	0.0	7.0	0.4	4.3	0.0	142.0
Average DBH	5.7	0.0	0.0	0.0	0.0	0.0	0.0	3.0	11.6	5.5	0.0	5.7

Case Study Stand No. 2: Northern Idaho, 20 year old – 75% lodgepole pine

	GF	AF	WL	ES	LP	WP	PP	DF	WC	WH	OTH	Total
Basal Area/Acre	0.0	0.0	0.0	0.0	31.9	0.0	0.0	0.0	0.7	0.0	0.0	32.6
Trees/Acre	0.0	0.0	0.0	0.0	249.3	0.0	0.0	0.0	6.3	0.0	0.0	255.6
Average DBH	0.0	0.0	0.0	0.0	4.8	0.0	0.0	0.0	4.4	0.0	0.0	4.8

Case Study Stand No. 3: Northern Idaho, 20 year old – 75% western white pine

	GF	AF	WL	ES	LP	WP	PP	DF	WC	WH	OTH	Total
Basal Area/Acre	3.0	0.0	0.0	0.0	0.0	25.7	0.0	0.0	1.0	2.5	0.0	32.2
Trees/Acre	24.5	0.0	0.0	0.0	0.0	94.1	0.0	0.0	18.8	7.7	0.0	145.1
Average DBH	4.7	0.0	0.0	0.0	0.0	7.1	0.0	0.0	3.2	7.7	0.0	6.4

Case Study Stand No. 4: Northern Idaho, 20 year old – 75% Douglas-fir

	GF	AF	WL	ES	LP	WP	PP	DF	WC	WH	OTH	Total
Basal Area/Acre	0.4	0.2	0.5	0.1	0.0	0.0	0.0	29.2	0.1	0.0	0.0	30.6
Trees/Acre	8.0	4.0	0.7	4.0	0.0	0.0	0.0	107.2	4.0	0.0	0.0	127.9
Average DBH	3.2	2.7	11.8	2.5	0.0	0.0	0.0	7.1	2.5	0.0	0.0	6.6

Case Study Stand No. 5: Northern Idaho, 40 year old – 75% grand fir

	GF	AF	WL	ES	LP	WP	PP	DF	WC	WH	OTH	Total
Basal Area/Acre	33.8	0.2	0.2	0.3	0.0	0.0	0.0	1.4	0.2	0.6	0.1	36.9
Trees/Acre	224.5	1.4	0.3	1.8	0.0	0.0	0.0	6.8	1.9	3.8	1.5	242.0
Average DBH	5.3	5.1	11.7	5.5	0.0	0.0	0.0	6.2	4.9	5.4	3.3	5.3

Case Study Stand No. 6: Northern Idaho, 40 year old – 75% subalpine fir

	GF	AF	WL	ES	LP	WP	PP	DF	WC	WH	OTH	Total
Basal Area/Acre	0.0	36.9	0.0	2.2	0.1	0.0	0.0	0.7	0.0	0.0	0.1	40.1
Trees/Acre	0.0	304.2	0.0	6.2	5.6	0.0	0.0	5.2	0.0	0.0	5.6	326.8
Average DBH	0.0	4.7	0.0	8.1	2.0	0.0	0.0	5.1	0.0	0.0	2.1	4.7

Case Study Stand No. 7: Northern Idaho, 40 year old – 75% western larch

	GF	AF	WL	ES	LP	WP	PP	DF	WC	WH	OTH	Total
Basal Area/Acre	0.0	0.2	37.3	0.0	0.0	0.0	0.0	2.0	0.2	0.0	0.0	39.7
Trees/Acre	0.0	5.4	177.5	0.0	0.0	0.0	0.0	23.9	5.4	0.0	0.0	212.2
Average DBH	0.0	2.7	6.2	0.0	0.0	0.0	0.0	3.9	2.9	0.0	0.0	5.9

Case Study Stand No. 8: Northern Idaho, 40 year old – 75% lodgepole pine

	GF	AF	WL	ES	LP	WP	PP	DF	WC	WH	OTH	Total
Basal Area/Acre	0.5	0.1	0.0	0.0	73.1	0.6	0.0	0.7	0.0	0.6	0.1	75.6
Trees/Acre	3.9	4.4	0.0	0.0	304.1	4.9	0.0	6.3	0.0	2.0	2.2	327.8
Average DBH	4.9	2.1	0.0	0.0	6.6	4.6	0.0	4.5	0.0	7.3	2.1	6.5

Case Study Stand No. 9: Northern Idaho, 40 year old – 75% western white pine

	GF	AF	WL	ES	LP	WP	PP	DF	WC	WH	OTH	Total
Basal Area/Acre	0.4	0.0	0.0	0.0	0.0	9.0	0.0	0.0	0.0	0.0	0.0	9.4
Trees/Acre	13.0	0.0	0.0	0.0	0.0	68.5	0.0	0.0	0.0	0.0	0.0	81.5
Average DBH	2.5	0.0	0.0	0.0	0.0	4.9	0.0	0.0	0.0	0.0	0.0	4.6

Case Study Stand No. 10: Northern Idaho, 40 year old – 75% Douglas-fir

	GF	AF	WL	ES	LP	WP	PP	DF	WC	WH	OTH	Total
Basal Area/Acre	1.5	0.7	0.1	0.1	0.3	0.2	0.3	51.4	0.4	0.0	0.0	55.1
Trees/Acre	26.4	9.0	2.4	2.3	0.8	2.1	2.8	233.0	11.9	0.0	0.0	290.7
Average DBH	3.2	3.7	3.1	3.1	8.2	3.9	4.6	6.4	2.6	0.0	0.0	5.9

Case Study Stand No. 11: Northern Idaho, 40 year old – 75% western hemlock

	GF	AF	WL	ES	LP	WP	PP	DF	WC	WH	OTH	Total
Basal Area/Acre	0.7	0.0	0.2	0.0	0.5	0.0	0.0	0.0	0.0	21.3	0.0	22.7
Trees/Acre	14.8	0.0	3.7	0.0	0.7	0.0	0.0	0.0	0.0	121.8	0.0	141.0
Average DBH	3.0	0.0	3.5	0.0	11.3	0.0	0.0	0.0	0.0	5.7	0.0	5.4

	GF	AF	WL	ES	LP	WP	PP	DF	WC	WH	OTH	Total
Case Study Stand No. 41: Northern Idaho, 20 year old – 50% western white pine												
Basal Area/Acre	4.8	0.0	0.0	0.0	2.6	16.8	0.0	5.6	2.5	2.6	0.0	34.9
Trees/Acre	8.3	0.0	0.0	0.0	6.7	46.6	0.0	37.2	26.0	4.4	0.0	129.2
Average DBH	10.3	0.0	0.0	0.0	8.5	8.1	0.0	5.2	4.2	10.4	0.0	7.0
Case Study Stand No. 42: Northern Idaho, 40 year old – 50% grand fir												
Basal Area/Acre	37.1	1.6	1.0	0.0	2.6	1.0	0.4	9.0	2.5	6.2	0.0	61.5
Trees/Acre	161.1	6.6	2.3	0.0	8.4	5.2	0.9	43.2	21.4	28.3	0.0	277.4
Average DBH	6.5	6.6	8.9	0.0	7.5	5.9	9.2	6.2	4.7	6.3	0.0	6.4
Case Study Stand No. 43: Northern Idaho, 40 year old – 50% western larch												
Basal Area/Acre	7.6	2.6	43.6	2.7	4.6	1.1	0.0	15.4	2.6	1.3	0.6	82.2
Trees/Acre	43.8	5.0	181.4	22.6	11.8	6.2	0.0	72.9	42.9	16.8	2.1	405.5
Average DBH	5.6	9.8	6.6	4.7	8.4	5.7	0.0	6.2	3.3	3.7	7.5	6.1
Case Study Stand No. 44: Northern Idaho, 40 year old – 50% western white pine												
Basal Area/Acre	11.9	1.3	1.3	0.0	1.3	30.4	0.0	2.8	2.8	5.6	0.0	57.3
Trees/Acre	83.8	2.7	1.8	0.0	1.9	103.0	0.0	20.5	14.1	27.7	0.0	255.5
Average DBH	5.1	9.3	11.5	0.0	11.1	7.4	0.0	5.0	6.1	6.1	0.0	6.4
Case Study Stand No. 45: Northern Idaho, 40 year old – 50% Douglas-fir												
Basal Area/Acre	16.3	0.9	4.8	1.0	1.7	1.0	0.9	37.4	3.2	1.0	0.6	68.8
Trees/Acre	111.1	3.5	21.5	3.3	9.4	8.3	4.4	159.8	47.4	7.9	3.9	380.5
Average DBH	5.2	7.0	6.4	7.3	5.7	4.7	6.2	6.6	3.5	4.8	5.5	5.8

Appendix 2

Description of Regenerated Stands

REGENERATED STAND NUMBER	GENERAL DESCRIPTION
	Northern Idaho
1	300 T/A, 100% lodgepole pine
2	450 T/A, 100% lodgepole pine
3	600 T/A, 100% lodgepole pine
4	300 T/A, 100% ponderosa pine
5	450 T/A, 100% ponderosa pine
6	600 T/A, 100% ponderosa pine
7	300 T/A, 50% grand fir – 50% white pine
8	450 T/A, 50% grand fir – 50% white pine
9	600 T/A, 50% grand fir – 50% white pine
10	300 T/A, 50% Douglas-fir – 50% grand fir
11	450 T/A, 50% Douglas-fir – 50% grand fir
12	600 T/A, 50% Douglas-fir – 50% grand fir
13	300 T/A, 50% Douglas-fir – 50% western larch
14	450 T/A, 50% Douglas-fir – 50% western larch
15	600 T/A, 50% Douglas-fir – 50% western larch
16	300 T/A, 50% Douglas-fir – 50% white pine
17	450 T/A, 50% Douglas-fir – 50% white pine
18	600 T/A, 50% Douglas-fir – 50% white pine
19	300 T/A, 50% Douglas-fir – 50% ponderosa pine
20	450 T/A, 50% Douglas-fir – 50% ponderosa pine
21	600 T/A, 50% Douglas-fir – 50% ponderosa pine
	Southern Idaho
22	300 T/A, 100% lodgepole pine
23	450 T/A, 100% lodgepole pine
24	600 T/A, 100% lodgepole pine
25	300 T/A, 100% ponderosa pine
26	450 T/A, 100% ponderosa pine
27	600 T/A, 100% ponderosa pine
28	300 T/A, 50% Engelmann spruce – 50% lodgepole pine
29	450 T/A, 50% Engelmann spruce – 50% lodgepole pine
30	600 T/A, 50% Engelmann spruce – 50% lodgepole pine
31	300 T/A, 50% Douglas-fir – 50% grand fir
32	450 T/A, 50% Douglas-fir – 50% grand fir
33	600 T/A, 50% Douglas-fir – 50% grand fir
34	300 T/A, 50% Douglas-fir – 50% lodgepole pine
35	450 T/A, 50% Douglas-fir – 50% lodgepole pine
36	600 T/A, 50% Douglas-fir – 50% lodgepole pine
37	300 T/A, 50% Douglas-fir – 50% ponderosa pine
38	450 T/A, 50% Douglas-fir – 50% ponderosa pine
39	600 T/A, 50% Douglas-fir – 50% ponderosa pine

T/A = trees per acre

Appendix 3

Mathematical Formulation of Investment Criteria

This appendix mathematically defines the financial investment criteria used in this paper. Net present value (NPV) in dollars per acre is expressed as

$$NPV = \sum_{t=0}^{k} \frac{R_t - C_t}{(1+i)^t}$$

where

R_t = revenues received at time t in dollars per acre,

C_t = costs incurred at time t (exclusive of land rent) in dollars per acre,

t = time in years,

k = length of the site occupancy period in years,

i = discount rate.

The NPV of case study stands will be further adjusted for land rent as indicated in subsequent equations.

The soil expectation value (SEV) in dollars per acre was derived using a generalized Faustmann formula (Stoffle 1977):

SEV = (NPV of the first financial rotation) + (NPV of all subsequent financial rotations)

This expression is formulated mathematically as

$$SEV_{ab} = \sum_{t=0}^{r} \frac{P_{a0}(1+f)^t Q_{at}}{(1+i)^t} - \sum_{t=0}^{r} \frac{C_{b0}(1+h)^t}{(1+i)^t}$$

$$+ \frac{\displaystyle\sum_{t=0}^{r} \frac{P_{ar} Q_{at} \left(\frac{1+g}{1+i}\right)^t}{1 - \left(\frac{1+g}{1+i}\right)^r} - \sum_{t=0}^{r} \frac{C_{br} \left(\frac{1+j}{1+i}\right)^t}{1 - \left(\frac{1+j}{1+i}\right)^r}}{(1+i)^r}$$

where SEV_{ab} = soil expectation value for species a and management practice b in dollars per acre,

r = financial rotation (includes any regeneration lag) in years,

P_{ak} = stumpage value of species a at time k in dollars per unit,

Q_{at} = quantity of species a at time t in units per acre,

C_{bk} = cost of management practice b at time k in dollars per acre,

f = stumpage value appreciation rate during the first financial rotation,

h = cost appreciation rate during the first financial rotation,

g = stumpage value appreciation rate during second and subsequent financial rotations,

j = cost appreciation rate during second and subsequent financial rotations,

i = discount rate.

$$SEV = \sum_{m=1}^{t_s} \sum_{n=1}^{t_m} SEV_{mn}$$

where SEV_{mn} = soil expectation value for species m and management practice n in dollars per acre,

t_s = total number of species in the stand,

t_m = total number of management practices conducted in the stand during a financial rotation.

The mathematical formulation for land rent is

$$LR = \frac{SR\ [(1 + i)^t - 1]}{i \cdot (1 + i)^t}$$

where LR = land rent in present dollars per acre from time 0 to time t in the site occupancy period,

SR = maximum annual soil rent in dollars per acre,

i = discount rate,

t = site occupancy period in years.

Soil rent is defined as

$$SR = SEV \cdot i$$

where i = discount rate, and

SEV = SEV obtained from a regenerated stand analysis.

By combining the net present value and land rent equations, an adjusted net present value can be obtained which is used to analyze case study stands. Adjusted net present value is defined as

$$NPV^* = NPV - LR$$

where NPV* = adjusted net present value in dollars per acre,

LR = land rent in dollars per acre.

Appendix 4

**Yearly State Harvest
Volumes and Corresponding 1976 Prices
by Northern and Southern Idaho**

Aggregate of all State of Idaho timber sales, 1972-1976.

Species	1972 Volume (MBF)	1972 Price ($/MBF)	1973 Volume (MBF)	1973 Price ($/MBF)	1974 Volume (MBF)	1974 Price ($/MBF)	1975 Volume (MBF)	1975 Price ($/MBF)	1976 Volume (MBF)	1976 Price ($/MBF)	Total Volume (MBF)	Total Price ($/MBF)
NORTH IDAHO												
WP	40035	69.35	52330	69.33	23185	121.85	22585	117.60	7600	203.26	145735	92.15
PP	1710	48.66	1955	61.30	460	89.15	2690	78.69	1400	39.12	8215	62.15
DF & Larch	18730	46.00	23345	70.53	19255	58.51	20910	35.09	13585	30.71	95825	49.94
GF, SAF & Hem	25825	41.12	49375	36.19	32785	64.24	32240	30.15	24475	38.62	164700	41.73
Cedar	6960	65.78	17320	61.46	18770	95.81	22115	80.03	20260	131.17	85425	90.70
ES	1020	36.27	395	63.82	595	93.42	2470	55.88	2495	41.73	6975	47.30
LPP	915	29.78	935	65.71	770	53.10	735	20.69	55	73.32	3410	43.64
Pulp	–	–	6335	.87	20420	5.82	29085	4.45	8510	1.95	64350	4.21
SOUTH IDAHO												
WP	7960	47.95	–	–	–	–	–	–	–	–	7960	47.95
PP	7200	52.76	2020	96.54	2195	105.12	1150	10.00	6360	24.16	18925	51.29
DF & Larch	14760	31.00	7750	61.15	1545	91.42	1730	8.33	7800	12.15	33585	35.19
GF, SAF & Hem	1995	36.46	2170	101.75	1420	88.70	35	5.00	3420	8.22	9040	49.53
Cedar	450	53.07	–	–	–	–	–	–	–	–	450	53.07
ES	935	35.66	485	56.32	480	76.85	–	–	590	11.57	2490	41.90
LPP	610	40.23	230	42.88	80	57.05	1960	10.00	745	6.18	3625	17.43
GRAND TOTAL												
WP											153695	89.86
PP											27140	54.58
DF & Larch											129410	46.11
GF, SAF & Hem											173740	42.14
Cedar											85875	90.50
ES											9465	45.88
LPP											7035	30.13
Pulp											64350	4.21

WP = white pine, PP = ponderosa pine, DF = Douglas-fir, GF = grand fir, SAF = subalpine fir, Hem = hemlock, ES = Engelmann spruce, LPP = lodgepole pine.

Appendix 5a

Base Case Results, Case Study Stands

Case study stand no.	Stand age (years)	Mgt. alt.	Financial: Investment age (years)	Financial: Maximum NPV ($)	Financial: Land rent Value/source[1] ($)		Financial: Adjusted maximum NPV ($)	Financial: MAI (BF/acre/yr)	Biological: Investment age (years)	Biological: NPV ($)	Biological: Maximum MAI (BF/acre/yr)	Biological: Land rent Value/source ($)		Biological: Adjusted NPV ($)	Opportunity cost ($)
1	20	1	0	508.51	0.0	7–9	508.51	456.	0	508.51	456.	0.0	7–9	508.51	0.0
	20	2	0	508.51	0.0	7–9	508.51	456.	0	508.51	456.	0.0	7–9	508.51	0.0
	20	3	0	508.51	0.0	7–9	508.51	456.	0	508.51	456.	0.0	7–9	508.51	0.0
	20	4	0	508.51	0.0	7–9	508.51	456.	110	530.99	491.	97.74	7–9	433.25	75.26
	20	5	0	508.51	0.0	7–9	508.51	456.	90	512.97	532.	96.98	7–9	415.99	92.53
2	20	1	0	137.34	0.0	1–3	137.34	183.	0	137.34	183.	0.0	1–3	137.34	0.0
	20	4	0	137.34	0.0	1–3	137.34	183.	50	166.74	199.	72.84	1–3	93.90	43.44
	20	5	0	137.34	0.0	1–3	137.34	183.	60	102.02	196.	75.53	1–3	26.49	110.84
3	20	1	0	908.44	0.0	7–9	908.44	731.	0	908.44	731.	0.0	7–9	908.44	0.0
	20	2	0	908.44	0.0	7–9	908.44	731.	0	908.44	731.	0.0	7–9	908.44	0.0
	20	3	0	908.44	0.0	7–9	908.44	731.	0	908.44	731.	0.0	7–9	908.44	0.0
	20	4	30	1429.79	75.48	7–9	1354.31	479.	0	908.44	731.	0.0	7–9	908.44	445.87
	20	5	30	1390.39	75.48	7–9	1314.91	489.	0	908.44	731.	0.0	7–9	908.44	406.47
4	20	1	0	566.17	0.0	10–12	566.17	499.	0	566.17	499.	0.0	10–12	566.17	0.0
	20	4	10	815.45	33.20	10–12	782.25	351.	0	566.17	499.	0.0	10–12	566.17	216.23
	20	5	10	763.62	33.20	10–12	730.42	356.	0	566.17	499.	0.0	10–12	566.17	164.25
5	40	1	0	561.67	0.0	10–12	561.67	303.	50	307.32	333.	78.50	10–12	228.82	332.85
	40	2	0	561.67	0.0	10–12	561.67	303.	90	323.03	376.	84.93	10–12	238.10	323.57
	40	3	0	561.67	0.0	10–12	561.67	303.	70	364.29	407.	83.17	10–12	281.12	280.55
	40	4	50	692.32	78.50	10–12	613.82	365.	100	653.13	416.	85.35	10–12	567.78	46.04
	40	5	50	647.90	78.50	10–12	569.40	379.	90	624.43	437.	84.93	10–12	539.50	29.90
6	40	1	0	139.94	0.0	10–12	139.94	67.	60	110.92	138.	81.40	10–12	29.52	110.42
	40	2	0	139.94	0.0	10–12	139.94	67.	70	95.89	140.	83.17	10–12	12.72	127.22
	40	3	0	139.94	0.0	10–12	139.94	67.	60	109.06	145.	81.40	10–12	27.66	112.28
	40	4	0	139.94	0.0	10–12	139.94	67.	60	201.08	181.	81.40	10–12	119.68	20.26
	40	5	0	139.94	0.0	10–12	139.94	67.	70	128.25	186.	83.17	10–12	45.08	94.86
7	40	1	0	187.40	0.0	13–15	187.40	96.	0	187.40	96.	0.0	13–15	187.40	0.0
	40	4	0	187.40	0.0	13–15	187.40	96.	80	190.83	110.	47.42	13–15	143.41	44.00
	40	5	0	187.40	0.0	13–15	187.40	96.	80	135.09	111.	47.42	13–15	87.66	99.74
8	40	1	0	353.11	0.0	1–3	353.11	159.	30	164.53	170.	61.34	1–3	103.19	249.92
	40	4	0	353.11	0.0	1–3	353.11	159.	40	226.39	180.	68.46	1–3	157.92	195.19
	40	5	0	353.11	0.0	1–3	353.11	159.	30	194.99	184.	61.34	1–3	133.65	219.46
9	40	1	0	698.41	0.0	7–9	698.41	226.	60	337.43	227.	92.94	7–9	244.48	453.93
	40	4	50	968.56	89.64	7–9	878.92	213.	100	875.21	262.	97.45	7–9	777.76	101.17
	40	5	50	913.50	89.64	7–9	823.86	212.	100	820.32	262.	97.45	7–9	722.86	101.00
10	40	1	0	644.57	0.0	10–12	644.57	197.	0	644.57	197.	0.0	10–12	644.57	0.0
	40	4	0	644.57	0.0	10–12	644.57	197.	0	644.57	197.	0.0	10–12	644.57	0.0
	40	5	0	644.57	0.0	10–12	644.57	197.	60	536.01	200.	81.40	10–12	454.61	189.96

			Financial						Biological						
Case study stand no.	Stand age (years)	Mgt. alt.	Investment age (years)	Maximum NPV ($)	Land rent Value/source ($)		Adjusted maximum NPV ($)	MAI (BF/acre/yr)	Investment age (years)	NPV ($)	Maximum MAI (BF/acre/yr)	Land rent Value/source ($)		Adjusted NPV ($)	Opportunity cost ($)
11	40	1	0	695.41	0.0	10–12	695.41	399.	0	695.41	399.	0.0	10–12	695.41	0.0
	40	4	0	695.41	0.0	10–12	695.41	399.	0	695.41	399.	0.0	10–12	695.41	0.0
	40	5	0	695.41	0.0	10–12	695.41	399.	0	695.41	399.	0.0	10–12	695.41	0.0
12	60	1	0	888.15	0.0	10–12	888.15	215.	50	405.33	293.	78.50	10–12	326.83	561.32
	60	2	0	888.15	0.0	10–12	888.15	215.	80	455.95	332.	84.26	10–12	371.69	516.46
	60	3	0	888.15	0.0	10–12	888.15	215.	70	475.30	352.	83.17	10–12	392.13	496.02
13	60	1	0	393.62	0.0	10–12	393.62	135.	30	263.33	155.	66.10	10–12	197.23	196.39
	60	2	0	393.62	0.0	10–12	393.62	135.	30	263.26	155.	66.10	10–12	197.16	196.46
	60	3	0	393.62	0.0	10–12	393.62	135.	30	263.28	155.	66.10	10–12	197.18	196.44
14	60	1	0	147.93	0.0	13–15	147.93	47.	80	53.33	84.	47.42	13–15	5.91	142.02
15	60	1	0	222.69	0.0	1–3	222.69	80.	40	140.06	123.	68.46	1–3	71.60	151.09
16	60	1	20	506.82	61.19	7–9	445.63	144.	80	244.41	248.	96.22	7–9	148.19	297.44
	60	2	20	506.82	61.19	7–9	445.63	144.	80	279.34	238.	96.22	7–9	183.12	262.51
	60	3	20	506.82	61.19	7–9	445.63	144.	80	274.04	242.	96.22	7–9	177.82	267.81
17	60	1	0	303.96	0.0	19–21	303.96	100.	50	170.06	125.	114.65	19–21	55.41	248.55
18	60	1	0	585.57	0.0	10–12	585.57	157.	0	585.57	157.	0.0	10–12	585.57	0.0
19	80	1	0	1315.88	0.0	10–12	1315.88	309.	0	1315.88	309.	0.0	10–12	1315.88	0.0
	80	2	10	1477.12	33.20	10–12	1443.92	310.	60	804.97	334.	81.40	10–12	723.57	720.35
20	80	1	0	426.49	0.0	10–12	426.49	118.	40	221.90	138.	73.78	10–12	148.12	278.37
	80	2	0	426.49	0.0	10–12	426.49	118.	40	255.95	143.	73.78	10–12	182.17	244.32
21	80	1	0	374.99	0.0	1–3	374.99	106.	10	318.00	108.	30.81	1–3	287.19	87.79
22	80	1	0	1125.38	0.0	7–9	1125.38	202.	50	527.50	220.	89.64	7–9	437.86	687.52
23	80	1	0	594.65	0.0	19–21	594.65	137.	0	594.65	137.	0.0	19–21	594.65	0.0
24	80	1	0	1540.41	0.0	10–12	1540.41	247.	0	1540.41	247.	0.0	10–12	1540.41	0.0
	80	2	0	1540.41	0.0	10–12	1540.41	247.	0	1540.41	247.	0.0	10–12	1540.41	0.0
25	100	1	0	969.72	0.0	10–12	969.72	168.	60	284.37	201.	81.40	10–12	202.97	766.75
26	100	1	0	713.51	0.0	10–12	713.51	135.	10	500.43	139.	33.20	10–12	467.23	246.28
27	100	1	0	527.18	0.0	1–3	527.18	115.	10	383.02	119.	30.81	1–3	352.21	174.97
28	100	1	0	888.41	0.0	19–21	888.41	164.	0	888.41	164.	0.0	19–21	888.41	0.0
29	100	1	0	1245.49	0.0	10–12	1245.49	183.	0	1245.49	183.	0.0	10–12	1245.49	0.0
	100	2	0	1245.49	0.0	10–12	1245.49	183.	0	1245.49	183.	0.0	10–12	1245.49	0.0
30	120	1	0	1041.92	0.0	10–12	1041.92	187.	40	422.30	188.	73.78	10–12	348.52	693.40

Case study stand no.	Stand age (years)	Mgt. alt.	Financial: Investment age (years)	Financial: Maximum NPV ($)	Financial: Land rent Value/source ($)		Financial: Adjusted maximum NPV ($)	Financial: MAI (BF/acre/yr)	Biological: Investment age (years)	Biological: NPV ($)	Biological: Maximum MAI (BF/acre/yr)	Biological: Land rent Value/source ($)		Biological: Adjusted NPV ($)	Opportunity cost ($)
31	120	1	0	851.74	0.0	10–12	851.74	148.	0	851.74	148.	0.0	10–12	851.74	0.0
32	120	1	0	1000.92	0.0	7–9	1000.92	100.	60	349.68	133.	92.94	7–9	256.74	744.18
33	140	1	0	1403.53	0.0	10–12	1403.53	195.	0	1403.53	195.	0.0	10–12	1403.53	0.0
34	140	1	0	488.99	0.0	10–12	488.99	79.	0	488.99	79.	0.0	10–12	488.99	0.0
35	140	1	0	2629.21	0.0	7–9	2629.21	248.	0	2629.21	248.	0.0	7–9	2629.21	0.0
36	160	1	0	1623.37	0.0	10–12	1623.37	183.	0	1623.37	183.	0.0	10–12	1623.37	0.0
37	160	1	0	532.24	0.0	10–12	532.24	72.	40	219.80	81.	73.78	10–12	146.02	386.22
38	160	1	0	934.54	0.0	10–12	934.54	109.	0	934.54	109.	0.0	10–12	934.54	0.0
39	160	1	0	2434.23	0.0	7–9	2434.23	176.	0	2434.23	176.	0.0	7–9	2434.23	0.0
40	160	1	0	1407.73	0.0	10–12	1407.73	203.	0	1407.73	203.	0.0	10–12	1407.73	0.0
41	20	1	0	1379.13	0.0	16–18	1379.13	1380.	0	1379.13	1380.	0.0	16–18	1379.13	0.0
	20	2	0	1379.13	0.0	16–18	1379.13	1380.	0	1379.13	1380.	0.0	16–18	1379.13	0.0
	20	3	0	1379.13	0.0	16–18	1379.13	1380.	0	1379.13	1380.	0.0	16–18	1379.13	0.0
	20	4	20	1440.85	58.45	16–18	1382.40	802.	0	1379.13	1380.	0.0	16–18	1379.13	3.27
	20	5	0	1379.13	0.0	16–18	1379.13	1380.	0	1379.13	1380.	0.0	16–18	1379.13	0.0
42	40	1	0	825.57	0.0	10–12	825.57	404.	0	825.57	404.	0.0	10–12	825.57	0.0
	40	2	0	825.57	0.0	10–12	825.57	404.	0	825.57	404.	0.0	10–12	825.57	0.0
	40	3	0	825.57	0.0	10–12	825.57	404.	60	503.82	426.	81.40	10–12	422.42	403.15
	40	4	0	825.57	0.0	10–12	825.57	404.	60	889.91	422.	81.40	10–12	808.51	17.06
	40	5	0	825.57	0.0	10–12	825.57	404.	60	854.80	461.	81.40	10–12	733.40	52.17
43	40	1	0	475.90	0.0	13–15	475.90	219.	0	475.90	219.	0.0	13–15	475.90	0.0
	40	4	0	475.90	0.0	13–15	475.90	219.	0	475.90	219.	0.0	13–15	475.90	0.0
	40	5	0	475.90	0.0	13–15	475.90	219.	0	475.90	219.	0.0	13–15	475.90	0.0
44	40	1	0	824.67	0.0	7–9	824.67	346.	40	580.14	352.	84.25	7–9	495.89	328.78
	40	2	0	824.67	0.0	7–9	824.67	346.	60	622.76	358.	92.94	7–9	529.82	294.85
	40	3	0	824.67	0.0	7–9	824.67	346.	60	658.63	385.	92.94	7–9	565.69	258.98
	40	4	30	1163.54	75.48	7–9	1088.06	354.	90	1064.42	403.	96.98	7–9	967.43	120.63
	40	5	30	1124.20	75.48	7–9	1048.72	363.	70	1095.38	432.	94.97	7–9	1000.40	48.32
45	40	1	0	818.97	0.0	10–12	818.97	343.	0	818.97	343.	0.0	10–12	818.97	0.0
	40	2	0	818.97	0.0	10–12	818.97	343.	0	818.97	343.	0.0	10–12	818.97	0.0
	40	3	0	818.97	0.0	10–12	818.97	343.	0	818.97	343.	0.0	10–12	818.97	0.0
	40	4	0	818.97	0.0	10–12	818.97	343.	0	818.97	343.	0.0	10–12	818.97	0.0
	40	5	0	818.97	0.0	10–12	818.97	343.	0	818.97	343.	0.0	10–12	818.97	0.0

Case study stand no.	Stand age (years)	Mgt. alt.	Financial: Investment age (years)	Financial: Maximum NPV ($)	Financial: Land rent Value/source ($)		Financial: Adjusted maximum NPV ($)	Financial: MAI (BF/acre/yr)	Biological: Investment age (years)	Biological: NPV ($)	Biological: Maximum MAI (BF/acre/yr)	Biological: Land rent Value/source ($)		Biological: Adjusted NPV ($)	Opportunity cost ($)
46	60	1	0	931.87	0.0	10–12	931.87	306.	40	427.16	308.	73.78	10–12	353.38	578.49
	60	2	0	931.87	0.0	10–12	931.87	306.	70	675.24	364.	83.17	10–12	592.07	339.80
	60	3	0	931.87	0.0	10–12	931.87	306.	60	686.13	393.	81.40	10–12	604.73	327.14
47	60	1	0	451.30	0.0	13–15	451.30	162.	0	451.30	162.	0.0	13–15	451.30	0.0
48	60	1	0	627.57	0.0	28–30	627.57	191.	0	627.57	191.	0.0	28–30	627.57	0.0
	60	2	0	627.57	0.0	28–30	627.57	191.	0	627.57	191.	0.0	28–30	627.57	0.0
	60	3	0	627.57	0.0	28–30	627.57	191.	0	627.57	191.	0.0	28–30	627.57	0.0
49	60	1	20	664.17	58.45	16–18	605.72	229.	50	443.28	276.	85.62	16–18	357.66	248.06
	60	2	20	664.17	58.45	16–18	605.72	229.	80	379.21	269.	91.91	16–18	287.30	318.42
	60	3	20	664.17	58.45	16–18	605.72	229.	60	465.47	285.	88.78	16–18	376.69	229.03
50	60	1	0	820.03	0.0	10–12	820.03	203.	0	820.03	203.	0.0	10–12	820.03	0.0
	60	2	0	820.03	0.0	10–12	820.03	203.	0	820.03	203.	0.0	10–12	820.03	0.0
	60	3	0	820.03	0.0	10–12	820.03	203.	0	820.03	203.	0.0	10–12	820.03	0.0
51	80	1	0	1145.44	0.0	10–12	1145.44	292.	0	1145.44	292.	0.0	10–12	1145.44	0.0
	80	2	0	1145.44	0.0	10–12	1145.44	292.	60	820.93	319.	81.40	10–12	739.53	405.91
52	80	1	0	425.93	0.0	13–15	425.93	114.	0	425.93	114.	0.0	13–15	425.93	0.0
53	80	1	0	694.06	0.0	34–36	694.06	199.	0	694.06	199.	0.0	34–36	694.06	0.0
	80	2	0	694.06	0.0	34–36	694.06	199.	0	694.06	199.	0.0	34–36	694.06	0.0
54	80	1	0	1738.43	0.0	7–9	1738.43	287.	0	1738.43	287.	0.0	7–9	1738.43	0.0
	80	2	0	1738.43	0.0	7–9	1738.43	287.	50	1050.15	296.	89.64	7–9	960.52	777.91
55	80	1	0	803.87	0.0	10–12	803.87	196.	0	803.87	196.	0.0	10–12	803.87	0.0
	80	2	0	803.87	0.0	10–12	803.87	196.	0	803.87	196.	0.0	10–12	803.87	0.0
56	100	1	0	1316.73	0.0	10–12	1316.73	241.	0	1316.73	241.	0.0	10–12	1316.73	0.0
	100	2	0	1316.73	0.0	10–12	1316.73	241.	40	839.81	256.	73.78	10–12	766.03	550.70
57	100	1	0	727.89	0.0	13–15	727.89	149.	0	727.89	149.	0.0	13–15	727.89	0.0
	100	2	0	727.89	0.0	13–15	727.89	149.	0	727.89	149.	0.0	13–15	727.89	0.0
58	100	1	0	1060.63	0.0	7–9	1060.63	175.	50	489.84	211.	89.64	7–9	400.21	660.42
59	100	1	0	1029.01	0.0	10–12	1029.01	225.	0	1029.01	225.	0.0	10–12	1029.01	0.0
	100	2	0	1029.01	0.0	10–12	1029.01	225.	0	1029.01	225.	0.0	10–12	1029.01	0.0
60	120	1	0	1322.39	0.0	7–9	1322.39	211.	0	1322.39	211.	0.0	7–9	1322.39	0.0

Case study stand no.	Stand age (years)	Mgt. alt.	Financial: Investment age (years)	Financial: Maximum NPV ($)	Financial: Land rent Value ($)	Financial: Land rent source	Financial: Adjusted maximum NPV ($)	Financial: MAI (BF/acre/yr)	Biological: Investment age (years)	Biological: NPV ($)	Biological: Maximum MAI (BF/acre/yr)	Biological: Land rent Value ($)	Biological: Land rent source	Biological: Adjusted NPV ($)	Opportunity cost ($)
61	120	1	0	1172.30	0.0	10–12	1172.30	185.	0	1172.30	185.	0.0	10–12	1172.30	0.0
62	120	1	0	1371.90	0.0	16–18	1371.90	168.	40	603.50	173.	80.48	16–18	523.02	848.88
63	140	1	0	1354.59	0.0	7–9	1354.59	209.	0	1354.59	209.	0.0	7–9	1354.59	0.0
64	140	1	0	1597.79	0.0	10–12	1597.79	185.	0	1597.79	185.	0.0	10–12	1597.79	0.0
65	140	1	0	2015.71	0.0	16–18	2015.71	193.	0	2015.71	193.	0.0	16–18	2015.71	0.0
66	160	1	0	1850.97	0.0	7–9	1850.97	229.	0	1850.97	229.	0.0	7–9	1850.97	0.0
67	160	1	0	3092.68	0.0	7–9	3092.68	246.	0	3092.68	246.	0.0	7–9	3092.68	0.0
68	160	1	0	1520.89	0.0	10–12	1520.89	166.	0	1520.89	166.	0.0	10–12	1520.89	0.0
69	160	1	0	3408.05	0.0	7–9	3408.05	282.	0	3408.05	282.	0.0	7–9	3408.05	0.0
70	160	1	0	1769.50	0.0	10–12	1769.50	216.	0	1769.50	216.	0.0	10–12	1769.50	0.0
71	60	1	0	46.54	0.0	22–24	46.54	19.	60	57.17	88.	49.41	22–24	7.76	38.78
72	60	1	0	145.68	0.0	31–33	145.68	46.	80	57.26	90.	41.35	31–33	15.91	129.77
73	80	1	0	319.62	0.0	31–33	319.62	86.	40	184.78	114.	36.21	31–33	148.57	171.05
	80	2	0	319.62	0.0	31–33	319.62	86.	50	174.77	114.	38.52	31–33	136.25	183.37
74	80	1	0	192.59	0.0	22–24	192.59	54.	50	82.54	84.	47.65	22–24	34.90	157.69
75	80	1	0	495.51	0.0	37–39	495.51	120.	0	495.51	120.	0.0	37–39	495.51	0.0
76	80	1	0	472.17	0.0	31–33	472.17	113.	0	472.17	113.	0.0	31–33	472.17	0.0
77	100	1	0	514.55	0.0	31–33	514.55	118.	0	514.55	118.	0.0	31–33	514.55	0.0
78	100	1	0	365.57	0.0	22–24	365.57	83.	0	365.57	83.	0.0	22–24	365.57	0.0
79	100	1	0	632.23	0.0	37–39	632.23	121.	0	632.23	121.	0.0	37–39	632.23	0.0
80	100	1	0	40.49	0.0	31–33	640.49	147.	0	640.49	147.	0.0	31–33	640.49	0.0
	100	2	0	640.49	0.0	31–33	640.49	147.	0	640.49	147.	0.0	31–33	640.49	0.0

Case study stand no.	Stand age (years)	Mgt. alt.	Financial: Investment age (years)	Financial: Maximum NPV ($)	Financial: Land rent Value/source ($)		Financial: Adjusted maximum NPV ($)	Financial: MAI (BF/acre/yr)	Biological: Investment age (years)	Biological: NPV ($)	Biological: Maximum MAI (BF/acre/yr)	Biological: Land rent Value/source ($)		Biological: Adjusted NPV ($)	Opportunity cost ($)
81	120	1	0	767.02	0.0	31–33	767.02	146.	0	767.02	146.	0.0	31–33	767.02	0.0
82	120	1	0	374.20	0.0	31–33	374.20	74.	40	193.37	90.	36.21	31–33	157.16	217.04
83	120	1	0	424.37	0.0	22–24	424.37	72.	0	424.37	72.	0.0	22–24	424.37	0.0
84	120	1	0	692.35	0.0	37–39	692.35	106.	0	692.35	106.	0.0	37–39	692.35	0.0
85	120	1	0	951.90	0.0	31–33	951.90	165.	0	951.90	165.	0.0	31–33	951.90	0.0
86	140	1	0	917.54	0.0	31–33	917.54	153.	0	917.54	153.	0.0	31–33	917.54	0.0
87	140	1	0	482.28	0.0	31–33	482.28	75.	40	224.91	91.	36.21	31–33	188.70	293.58
88	140	1	0	1191.48	0.0	31–33	1191.48	190.	0	1191.48	190.	0.0	31–33	1191.48	0.0
89	140	1	0	603.63	0.0	22–24	603.63	94.	0	603.63	94.	0.0	22–24	603.63	0.0
90	140	1	0	736.87	0.0	37–39	736.87	97.	0	736.87	97.	0.0	37–39	736.87	0.0
91	140	1	0	735.69	0.0	31–33	735.69	123.	0	735.69	123.	0.0	31–33	735.69	0.0
92	160	1	0	735.53	0.0	31–33	735.53	106.	60	177.13	107.	39.94	31–33	137.19	598.34
93	160	1	0	558.80	0.0	31–33	558.80	69.	40	246.25	83.	36.21	31–33	210.04	348.76
94	160	1	0	1283.54	0.0	31–33	1283.54	175.	0	1283.54	175.	0.0	31–33	1283.54	0.0
95	160	1	0	371.96	0.0	22–24	371.96	47.	60	70.72	54.	49.41	22–24	21.31	350.65
96	160	1	0	1130.15	0.0	37–39	1130.15	136.	0	1130.15	136.	0.0	37–39	1130.15	0.0
97	160	1	0	1071.17	0.0	31–33	1071.17	149.	0	1071.17	149.	0.0	31–33	1071.17	0.0
98	80	1	0	377.45	0.0	31–33	377.45	109.	50	180.34	138.	38.52	31–33	141.82	235.63
	80	2	0	377.45	0.0	31–33	377.45	109.	50	226.25	140.	38.52	31–33	187.73	189.72
99	80	1	0	266.53	0.0	34–36	266.53	66.	60	77.27	80.	31.61	34–36	45.66	220.87
100	80	1	0	477.93	0.0	37–30	477.93	114.	0	477.93	114.	0.0	37–39	477.93	0.0
	80	2	0	477.93	0.0	37–39	477.93	114.	0	477.93	114.	0.0	37–39	477.93	0.0

Case study stand no.	Stand age (years)	Mgt. alt.	Financial: Investment age (years)	Financial: Maximum NPV ($)	Financial: Land rent Value/source ($)		Financial: Adjusted maximum NPV ($)	Financial: MAI (BF/acre/yr)	Biological: Investment age (years)	Biological: NPV ($)	Biological: Maximum MAI (BF/acre/yr)	Biological: Land rent Value/source ($)		Biological: Adjusted NPV ($)	Opportunity cost ($)
101	100	1	0	677.04	0.0	31–33	677.04	155.	0	677.04	155.	0.0	31–33	677.04	0.0
	100	2	0	677.04	0.0	31–33	677.04	155.	10	609.34	156.	16.29	31–33	593.05	83.99
102	100	1	0	418.63	0.0	34–36	418.63	91.	0	418.63	91.	0.0	34–36	418.63	0.0
103	100	1	0	973.52	0.0	37–39	973.52	179.	0	973.52	179.	0.0	37–39	973.52	0.0
104	100	1	0	658.05	0.0	34–36	658.05	132.	0	658.05	132.	0.0	34–36	658.05	0.0
	100	2	0	658.05	0.0	34–36	658.05	132.	0	658.05	132.	0.0	34–36	658.05	0.0
105	120	1	0	497.55	0.0	31–33	497.55	90.	40	217.74	102.	36.21	31–33	181.53	316.02
106	120	1	0	442.12	0.0	34–36	442.12	86.	0	442.12	86.	0.0	34–36	442.12	0.0
107	120	1	0	746.10	0.0	34–36	746.10	129.	0	746.10	129.	0.0	34–36	746.10	0.0
108	140	1	0	899.89	0.0	31–33	899.89	143.	0	899.89	143.	0.0	31–33	899.89	0.0
109	140	1	0	788.97	0.0	31–33	788.97	128.	0	788.97	128.	0.0	31–33	788.97	0.0
110	140	1	0	1155.06	0.0	31–33	1155.06	180.	0	1155.06	180.	0.0	31–33	1155.06	0.0
111	140	1	0	606.71	0.0	34–36	606.71	78.	10	447.35	79.	12.90	34–36	434.45	172.26
112	140	1	0	853.32	0.0	34–36	853.32	126.	0	853.32	126.	0.0	34–36	853.32	0.0
113	160	1	0	738.15	0.0	31–33	738.15	91.	0	738.15	91.	0.0	31–33	738.15	0.0
114	160	1	0	1217.98	0.0	31–33	1217.98	170.	0	1217.98	170.	0.0	31–33	1217.98	0.0
115	160	1	0	454.51	0.0	34–36	454.51	69.	0	454.51	69.	0.0	34–36	454.51	0.0
116	160	1	0	1339.95	0.0	37–39	1339.95	156.	0	1339.95	156.	0.0	37–39	1339.95	0.0
117	160	1	0	1118.09	0.0	31–33	1118.09	152.	0	1118.09	152.	0.0	31–33	1118.09	0.0

Appendix 5b

Base Case Results, Regenerated Stands

Regenerated stand no.	Composition[1]	Stocking level (trees/acre)	Mgt. alt. Regen. method	Financial: Investment age (yrs)	Financial: Maximum SEV ($)	Financial: Soil Rent ($)	Financial: Rotation 1 NPV ($)	Financial: Rotation 2 NPV ($)	Biological: Investment age (yrs)	Biological: Maximum MAI (BF/acre/yr)	Biological: SEV ($)	Biological: Opportunity cost ($)
1	100% LP	300	1 Natural	80	57.77	2.89	56.61	1.17	100	256.	42.76	15.01
	100% LP	300	2 N	80	58.23	2.91	57.02	1.21	110	254.	49.10	9.14
	100% LP	300	3 N	80	59.52	2.98	58.28	1.24	110	276.	50.21	9.30
	100% LP	300	1 Plant	69	15.40	0.77	14.87	0.53	79	287.	6.40	9.00
	100% LP	300	2 P	69	16.08	0.80	15.43	0.64	89	284.	9.01	7.07
	100% LP	300	3 P	69	17.23	0.86	16.54	0.68	89	308.	9.55	7.68
2	100% LP	450	1 N	80	62.29	3.11	61.04	1.26	90	276.	55.84	6.45
	100% LP	450	2 N	90	70.10	3.51	69.07	1.03	100	286.	67.44	2.67
	100% LP	450	3 N	90	72.14	3.61	71.08	1.06	100	308.	69.07	3.07
	100% LP	450	4 N	80	37.09	1.85	36.30	0.79	100	244.	31.59	5.50
	100% LP	450	5 N	80	37.96	1.90	37.15	0.81	100	263.	32.39	5.57
	100% LP	450	1 P	69	12.39	0.62	11.96	0.43	79	315.	3.95	8.44
	100% LP	450	2 P	79	23.90	1.20	23.01	0.89	79	323.	23.90	0.0
	100% LP	450	3 P	79	25.72	1.29	24.77	0.95	79	347.	25.72	0.0
	100% LP	450	4 P	69	-29.43	0.0	-28.51	-0.92	79	274.	-30.94	1.52
	100% LP	450	5 P	69	-28.86	0.0	-27.96	-0.90	89	296.	-35.82	6.96
3	100% LP	600	1 N	80	57.56	2.88	56.40	1.16	90	265.	54.22	3.34
	100% LP	600	2 N	90	77.27	3.86	76.10	1.17	110	312.	73.50	3.77
	100% LP	600	3 N	90	79.86	3.99	78.65	1.21	100	335.	79.24	0.62
	100% LP	600	4 N	80	37.11	1.86	36.32	0.79	100	255.	31.97	5.14
	100% LP	600	5 N	80	38.34	1.92	37.53	0.81	90	264.	37.85	0.49
	100% LP	600	1 P	69	-3.55	0.0	-3.42	-0.12	79	302.	-7.50	3.95
	100% LP	600	2 P	79	24.71	1.24	23.68	1.03	89	349.	22.49	2.21
	100% LP	600	3 P	79	27.30	1.36	26.19	1.10	89	376.	26.54	0.75
	100% LP	600	4 P	69	-38.72	0.0	-37.48	-1.24	89	286.	-44.30	5.58
	100% LP	600	5 P	69	-37.65	0.0	-36.44	-1.20	79	300.	-37.74	0.10
4	100% PP	300	1 N	70	215.38	10.77	208.30	7.08	70	415.	215.38	0.0
	100% PP	300	2 N	70	217.78	10.89	210.04	7.73	80	394.	216.98	0.80
	100% PP	300	3 N	80	240.30	12.02	234.49	5.81	80	451.	240.30	0.0
	100% PP	300	1 P	59	236.84	11.84	223.53	13.31	59	492.	236.84	0.0
	100% PP	300	2 P	59	240.82	12.04	225.93	14.89	69	457.	238.57	2.25
	100% PP	300	3 P	69	269.50	13.47	257.92	11.57	69	523.	269.50	0.0

[1] LP = lodgepole pine, PP = ponderosa pine, GF = grand fir, WP = white pine, DF = Douglas-fir, WL = western larch, SP = Engelmann spruce

Regenerated stand no.	Composition	Stocking level (trees/acre)	Mgt. alt. Regen. method	Financial: Investment age (yrs)	Financial: Maximum SEV ($)	Financial: Soil Rent ($)	Financial: Rotation 1 NPV ($)	Financial: Rotation 2 NPV ($)	Biological: Investment age (yrs)	Biological: Maximum MAI (BF/acre/yr)	Biological: SEV ($)	Opportunity cost ($)
5	100% PP	450	1 N	70	227.50	11.37	220.02	7.48	70	438.	227.50	0.0
	100% PP	450	2 N	70	203.14	10.16	195.82	7.32	110	390.	179.68	23.46
	100% PP	450	3 N	80	233.91	11.70	228.03	5.89	90	451.	232.17	1.74
	100% PP	450	4 N	70	158.19	7.91	152.69	5.50	120	369.	123.66	34.53
	100% PP	450	5 N	70	190.97	9.55	184.21	6.77	110	449.	174.62	16.36
	100% PP	450	1 P	49	244.50	12.22	222.11	22.39	59	519.	244.39	0.11
	100% PP	450	2 P	59	210.72	10.54	197.36	13.36	99	434.	176.19	34.53
	100% PP	450	3 P	59	251.07	12.55	234.97	16.09	79	514.	246.23	4.83
	100% PP	450	4 P	59	140.18	7.01	131.59	8.59	109	406.	92.04	48.13
	100% PP	450	5 P	59	183.78	9.19	172.30	11.48	99	498.	159.26	24.53
6	100% PP	600	1 N	70	196.88	9.84	190.41	6.47	80	403.	176.62	20.25
	100% PP	600	2 N	80	230.17	11.51	224.25	5.92	100	424.	211.92	18.25
	100% PP	600	3 N	80	293.13	14.66	285.48	7.64	80	518.	293.13	0.0
	100% PP	600	4 N	70	194.20	9.71	187.36	6.84	90	400.	160.50	33.70
	100% PP	600	5 N	70	227.37	11.37	219.17	8.20	90	464.	197.90	29.47
	100% PP	600	1 P	59	191.69	9.58	180.91	10.78	69	467.	162.67	29.02
	100% PP	600	2 P	69	238.71	11.94	227.48	11.24	89	476.	212.19	26.53
	100% PP	600	3 P	69	323.67	16.18	308.43	15.24	69	600.	323.67	0.0
	100% PP	600	4 P	59	181.57	9.08	170.28	11.29	79	455.	134.01	47.56
	100% PP	600	5 P	59	225.80	11.29	211.40	14.40	69	528.	208.07	17.72
7	50% GF WP	300	1 N	120	48.40	2.42	48.26	0.14	150	316.	31.11	17.29
	50% GF WP	300	2 N	130	48.15	2.41	48.05	0.10	150	334.	41.16	6.98
	50% GF WP	300	3 N	120	50.03	2.50	49.88	0.15	150	341.	41.23	8.76
	50% GF WP	300	1 P	109	3.40	0.17	3.39	0.02	139	341.	-20.25	23.66
	50% GF WP	300	2 P	119	3.14	0.16	3.10	0.04	139	360.	-6.41	9.55
	50% GF WP	300	3 P	109	5.57	0.28	5.52	0.05	139	368.	-6.37	11.92
8	50% GF WP	450	1 N	120	55.70	2.78	55.54	0.16	140	319.	41.35	14.34
	50% GF WP	450	2 N	130	58.99	2.95	58.86	0.13	150	361.	51.84	7.14
	50% GF WP	450	3 N	130	64.00	3.20	63.86	0.14	150	381.	54.68	9.32
	50% GF WP	450	4 N	120	31.96	1.60	31.85	0.11	150	298.	22.87	9.09
	50% GF WP	450	5 N	120	35.60	1.78	35.48	0.12	150	312.	24.13	11.48
	50% GF WP	450	1 P	109	4.42	0.22	4.40	0.02	129	346.	-15.20	19.62
	50% GF WP	450	2 P	119	9.05	0.45	8.96	0.09	139	390.	-0.71	9.76
	50% GF WP	450	3 P	119	15.73	0.79	15.61	0.12	139	411.	2.96	12.76
	50% GF WP	450	4 P	109	-34.76	0.0	-34.63	-0.13	139	321.	-47.04	12.29
	50% GF WP	450	5 P	109	-29.97	0.0	-29.86	-0.10	139	337.	-45.54	15.58

				Financial					Biological			
Regenerated stand no.	Composition	Stocking level (trees/acre)	Mgt. alt. Regen. method	Investment age (yrs)	Maximum SEV ($)	Soil Rent ($)	Rotation 1 NPV ($)	Rotation 2 NPV ($)	Investment age (yrs)	Maximum MAI (BF/acre/yr)	SEV ($)	Opportunity cost ($)
9	50% GF WP	600	1 N	120	56.55	2.83	56.39	0.16	150	308.	32.38	24.18
	50% GF WP	600	2 N	130	98.30	4.91	98.05	0.25	150	389.	91.35	6.94
	50% GF WP	600	3 N	130	92.64	4.63	92.40	0.24	150	398.	84.73	7.92
	50% GF WP	600	4 N	110	30.05	1.50	29.90	0.15	150	273.	20.13	9.93
	50% GF WP	600	5 N	110	32.05	1.60	31.89	0.16	150	286.	21.17	10.88
	50% GF WP	600	1 P	109	-3.45	0.0	-3.43	-0.02	129	334.	-24.74	21.29
	50% GF WP	600	2 P	119	54.21	2.71	53.87	0.34	139	420.	44.69	9.52
	50% GF WP	600	3 P	119	46.20	2.31	45.88	0.32	129	431.	42.71	3.49
	50% GF WP	600	4 P	99	-46.66	0.0	-46.31	-0.35	139	295.	-59.83	13.17
	50% GF WP	600	5 P	99	-44.05	0.0	-43.72	-0.33	139	309.	-58.62	14.57
10	50% DF GF	300	1 N	100	57.99	2.90	57.55	0.44	130	319.	43.24	14.75
	50% DF GF	300	2 N	120	62.22	3.11	61.98	0.24	150	323.	55.37	6.85
	50% DF GF	300	3 N	120	69.73	3.49	69.47	0.26	150	340.	60.35	9.38
	50% DF GF	300	1 P	89	16.38	0.82	16.17	0.21	119	349.	-3.63	20.01
	50% DF GF	300	2 P	109	22.50	1.13	22.26	0.24	139	349.	13.17	9.33
	50% DF GF	300	3 P	109	32.40	1.62	32.09	0.31	139	367.	19.56	12.84
11	50% DF GF	450	1 N	100	59.46	2.97	59.01	0.45	140	308.	33.65	25.81
	50% DF GF	450	2 N	140	68.31	3.42	68.18	0.13	150	376.	65.87	2.44
	50% DF GF	450	3 N	130	74.08	3.70	73.88	0.20	150	396.	70.21	3.87
	50% DF GF	450	4 N	110	50.65	2.53	50.35	0.30	150	339.	39.57	11.09
	50% DF GF	450	5 N	120	57.63	2.88	57.38	0.25	150	338.	46.91	10.71
	50% DF GF	450	1 P	89	9.29	0.46	9.17	0.12	129	334.	-25.81	35.10
	50% DF GF	450	2 P	129	21.96	1.10	21.78	0.18	139	406.	18.62	3.34
	50% DF GF	450	3 P	119	29.42	1.47	29.16	0.26	139	427.	24.13	5.29
	50% DF GF	450	4 P	99	-9.10	0.0	-9.18	0.09	139	366.	-24.03	14.93
	50% DF GF	450	5 P	109	0.22	0.01	0.02	0.20	129	367.	-8.94	9.16
12	50% DF GF	600	1 N	100	63.19	3.16	62.71	0.48	150	296.	26.11	37.08
	50% DF GF	600	2 N	140	77.82	3.89	77.68	0.15	150	425.	74.41	3.42
	50% DF GF	600	3 N	130	85.90	4.30	85.67	0.23	150	457.	80.53	5.36
	50% DF GF	600	4 N	110	49.64	2.48	49.34	0.29	150	311.	39.48	10.16
	50% DF GF	600	5 N	120	55.50	2.78	55.26	0.24	150	336.	44.94	10.56
	50% DF GF	600	1 P	89	5.33	0.27	5.26	0.07	139	320.	-45.16	50.48
	50% DF GF	600	2 P	129	26.05	1.30	25.85	0.20	139	459.	21.36	4.69
	50% DF GF	600	3 P	119	36.67	1.83	36.38	0.30	139	494.	29.34	7.34
	50% DF GF	600	4 P	99	-19.58	0.0	-19.57	-0.01	139	335.	-33.17	13.59
	50% DF GF	600	5 P	109	-11.99	0.0	-12.13	0.14	129	362.	-21.45	9.46

Regenerated stand no.	Composition	Stocking level (trees/acre)	Mgt. alt. Regen. method	Financial					Biological			
				Investment age (yrs)	Maximum SEV ($)	Soil Rent ($)	Rotation 1 NPV ($)	Rotation 2 NPV ($)	Investment age (yrs)	Maximum MAI (BF/acre/yr)	SEV ($)	Opportunity cost ($)
13	50% DF WL	300	1 N	100	37.19	1.86	36.90	0.28	120	163.	28.24	8.95
	50% DF WL	300	2 N	100	37.19	1.86	36.90	0.28	130	176.	31.56	5.63
	50% DF WL	300	3 N	110	37.99	1.90	37.80	0.19	130	193.	34.75	3.24
	50% DF WL	300	1 P	89	-12.40	0.0	-12.23	-0.16	109	180.	-24.38	11.99
	50% DF WL	300	2 P	89	-12.40	0.0	-12.23	-0.16	119	193.	-19.71	7.32
	50% DF WL	300	3 P	99	-11.21	0.0	-11.15	-0.06	119	211.	-15.54	4.33
14	50% DF WL	450	1 N	90	44.73	2.24	44.17	0.55	110	172.	36.81	7.92
	50% DF WL	450	2 N	100	45.87	2.29	45.50	0.37	140	189.	37.55	8.32
	50% DF WL	450	3 N	100	48.36	2.42	47.98	0.39	140	210.	42.86	5.50
	50% DF WL	450	4 N	100	24.97	1.25	24.76	0.21	130	183.	16.32	8.64
	50% DF WL	450	5 N	100	27.05	1.35	26.83	0.22	130	194.	17.71	9.34
	50% DF WL	450	1 P	79	-11.48	0.0	-11.24	-0.24	99	191.	-21.78	10.29
	50% DF WL	450	2 P	89	-9.49	0.0	-9.41	-0.08	129	205.	-20.41	10.92
	50% DF WL	450	3 P	89	-6.28	0.0	-6.24	-0.04	119	229.	-9.81	3.54
	50% DF WL	450	4 P	89	-44.92	0.0	-44.38	-0.54	119	200.	-56.17	11.24
	50% DF WL	450	5 P	89	-42.28	0.0	-41.77	-0.51	119	212.	-54.64	12.36
15	50% DF WL	600	1 N	100	40.64	2.03	40.34	0.31	110	169.	35.96	4.69
	50% DF WL	600	2 N	100	41.19	2.06	40.87	0.32	150	194.	36.25	4.95
	50% DF WL	600	3 N	120	45.68	2.28	45.51	0.17	140	215.	42.84	2.84
	50% DF WL	600	4 N	100	19.78	0.99	19.63	0.15	150	184.	6.35	13.43
	50% DF WL	600	5 N	100	19.78	0.99	19.63	0.15	150	186.	6.14	13.64
	50% DF WL	600	1 P	89	-25.85	0.0	-25.52	-0.34	99	188.	-32.03	6.18
	50% DF WL	600	2 P	99	-25.07	0.0	-24.92	-0.15	129	210.	-28.05	2.98
	50% DF WL	600	3 P	109	-18.87	0.0	-18.86	0.0	129	233.	-22.61	3.74
	50% DF WL	600	4 P	89	-61.24	0.0	-60.44	-0.80	139	198.	-78.79	17.55
	50% DF WL	600	5 P	99	-61.11	0.0	-60.65	-0.46	119	203.	-69.78	8.68
16	50% DF WP	300	1 N	100	66.94	3.35	66.43	0.51	130	292.	45.00	21.93
	50% DF WP	300	2 N	110	67.48	3.37	67.08	0.39	140	271.	61.38	6.10
	50% DF WP	300	3 N	110	77.64	3.88	77.19	0.45	140	286.	66.37	11.27
	50% DF WP	300	1 P	89	28.75	1.44	28.38	0.37	119	319.	-1.21	29.96
	50% DF WP	300	2 P	99	29.70	1.48	29.28	0.42	129	294.	21.45	8.25
	50% DF WP	300	3 P	99	43.11	2.16	42.56	0.55	129	310.	27.62	15.49

				Financial					Biological			
Regenerated stand no.	Composition	Stocking level (trees/acre)	Mgt. alt. Regen. method	Investment age (yrs)	Maximum SEV ($)	Soil Rent ($)	Rotation 1 NPV ($)	Rotation 2 NPV ($)	Investment age (yrs)	Maximum MAI (BF/acre/yr)	SEV ($)	Opportunity cost ($)
17	50% DF WP	450	1 N	100	80.52	4.03	79.91	0.61	130	304.	46.51	34.01
	50% DF WP	450	2 N	110	85.64	4.28	85.11	0.53	150	296.	76.65	9.00
	50% DF WP	450	3 N	120	93.80	4.69	93.38	0.42	150	298.	82.60	11.20
	50% DF WP	450	4 N	100	50.17	2.51	49.72	0.45	150	280.	37.41	12.76
	50% DF WP	450	5 N	100	55.35	2.77	54.85	0.50	150	294.	40.84	14.50
	50% DF WP	450	1 P	89	38.42	1.92	37.92	0.50	119	332.	-8.15	46.57
	50% DF WP	450	2 P	99	45.76	2.29	45.08	0.68	139	320.	33.49	12.27
	50% DF WP	450	3 P	109	56.25	2.81	55.61	0.64	119	322.	52.64	3.61
	50% DF WP	450	4 P	99	-9.92	0.0	-10.03	0.11	139	302.	-27.00	17.08
	50% DF WP	450	5 P	89	-3.47	0.0	-3.61	0.14	129	318.	-17.84	14.37
18	50% DF WP	600	1 N	100	70.45	3.52	69.91	0.54	130	309.	47.15	23.29
	50% DF WP	600	2 N	120	78.91	3.95	78.57	0.34	150	302.	70.35	8.56
	50% DF WP	600	3 N	120	92.83	4.64	92.44	0.39	150	313.	80.83	12.00
	50% DF WP	600	4 N	120	54.92	2.75	54.70	0.22	150	322.	43.28	11.64
	50% DF WP	600	5 N	110	49.64	2.48	49.33	0.30	140	318.	38.20	11.44
	50% DF WP	600	1 P	89	15.37	0.77	15.17	0.20	119	338.	-16.30	31.67
	50% DF WP	600	2 P	109	27.48	1.37	27.08	0.41	139	326.	15.80	11.68
	50% DF WP	600	3 P	109	46.15	2.31	45.64	0.51	139	338.	29.70	16.45
	50% DF WP	600	4 P	109	-12.12	0.0	-12.20	0.09	139	347.	-27.94	15.82
	50% DF WP	600	5 P	99	-20.19	0.0	-20.19	0.0	129	345.	-35.59	15.40
19	50% DF PP	300	1 N	80	90.01	4.50	88.19	1.82	100	249.	73.25	16.76
	50% DF PP	300	2 N	90	90.98	4.55	89.72	1.26	120	254.	73.89	17.09
	50% DF PP	300	3 N	90	100.08	5.00	98.70	1.38	120	291.	82.51	17.57
	50% DF PP	300	1 P	69	60.40	3.02	58.32	2.08	89	280.	37.48	22.92
	50% DF PP	300	2 P	79	62.04	3.10	60.42	1.62	109	279.	38.66	23.38
	50% DF PP	300	3 P	79	73.65	3.68	71.77	1.89	109	320.	49.32	24.33
20	50% DF PP	450	1 N	80	101.33	5.07	99.28	2.04	100	266.	79.02	22.30
	50% DF PP	450	2 N	100	103.47	5.17	102.48	0.99	120	283.	91.85	11.62
	50% DF PP	450	3 N	100	121.11	6.06	119.95	1.16	110	339.	116.85	4.26
	50% DF PP	450	4 N	80	78.94	3.95	77.26	1.68	120	263.	58.40	20.55
	50% DF PP	450	5 N	90	86.48	4.32	85.25	1.23	110	298.	76.73	9.75
	50% DF PP	450	1 P	69	66.88	3.34	64.57	2.31	89	299.	36.35	30.53
	50% DF PP	450	2 P	89	70.35	3.52	68.96	1.39	99	312.	64.20	6.16
	50% DF PP	450	3 P	89	93.56	4.68	91.77	1.79	99	377.	87.55	6.01
	50% DF PP	450	4 P	69	29.05	1.45	27.84	1.21	99	290.	12.42	16.63
	50% DF PP	450	5 P	79	39.03	1.95	37.83	1.20	99	332.	25.63	13.40

Regenerated stand no.	Composition	Stocking level (trees/acre)	Mgt. alt. Regen. method	Financial					Biological			
				Investment age (yrs)	Maximum SEV ($)	Soil Rent ($)	Rotation 1 NPV ($)	Rotation 2 NPV ($)	Investment age (yrs)	Maximum MAI (BF/acre/yr)	SEV ($)	Opportunity cost ($)
21	50% DF PP	600	1 N	80	102.66	5.13	100.59	2.07	110	265.	64.50	38.16
	50% DF PP	600	2 N	110	111.47	5.57	110.73	0.74	130	322.	100.88	10.59
	50% DF PP	600	3 N	110	125.56	6.28	124.72	0.84	110	369.	125.56	0.0
	50% DF PP	600	4 N	80	92.48	4.62	90.51	1.97	120	288.	61.98	30.50
	50% DF PP	600	5 N	80	99.33	4.97	97.22	2.11	110	315.	78.79	20.54
	50% DF PP	600	1 P	69	59.41	2.97	57.36	2.05	89	297.	27.50	31.92
	50% DF PP	600	2 P	99	72.41	3.62	71.32	1.10	119	352.	57.87	14.55
	50% DF PP	600	3 P	99	90.51	4.53	89.19	1.33	99	410.	90.51	0.0
	50% DF PP	600	4 P	69	38.64	1.93	37.05	1.58	89	320.	23.47	15.16
	50% DF PP	600	5 P	69	47.56	2.38	45.67	1.89	99	350.	19.99	27.57
22	100% LP	300	1 N	80	37.39	1.87	36.63	0.75	100	198.	33.09	4.30
	100% LP	300	2 N	80	37.39	1.87	36.63	0.75	110	201.	31.07	6.32
	100% LP	300	3 N	80	37.39	1.87	36.63	0.75	120	207.	27.84	9.55
	100% LP	300	1 P	69	-13.06	0.0	-12.61	-0.45	89	222.	-18.07	5.01
	100% LP	300	2 P	69	-13.06	0.0	-12.61	-0.45	99	224.	-20.61	7.55
	100% LP	300	3 P	69	-13.06	0.0	-12.61	-0.45	89	230.	-14.89	1.83
23	100% LP	450	1 N	90	41.75	2.09	41.24	0.52	100	211.	35.50	6.25
	100% LP	450	2 N	90	44.97	2.25	44.37	0.60	110	226.	40.93	4.04
	100% LP	450	3 N	90	46.50	2.33	45.89	0.61	110	239.	42.18	4.32
	100% LP	450	4 N	90	17.93	0.90	17.71	0.22	110	194.	11.10	6.84
	100% LP	450	5 N	90	17.93	0.90	17.71	0.22	100	199.	15.42	2.51
	100% LP	450	1 P	79	-15.61	0.0	-15.28	-0.33	89	237.	-23.85	8.24
	100% LP	450	2 P	79	-11.11	0.0	-10.97	-0.14	99	251.	-16.04	4.92
	100% LP	450	3 P	79	-9.36	0.0	-9.26	-0.11	99	265.	-15.05	5.69
	100% LP	450	4 P	79	-55.25	0.0	-54.08	-1.17	89	216.	-58.63	3.38
	100% LP	450	5 P	79	-55.25	0.0	-54.08	-1.17	89	223.	-58.37	3.12
24	100% LP	600	1 N	90	42.29	2.11	41.76	0.52	100	213.	36.19	6.09
	100% LP	600	2 N	100	49.87	2.49	49.42	0.46	110	252.	48.83	1.04
	100% LP	600	3 N	100	52.28	2.61	51.80	0.49	110	269.	51.28	1.00
	100% LP	600	4 N	90	17.85	0.89	17.63	0.22	100	196.	15.59	2.26
	100% LP	600	5 N	90	17.85	0.89	17.63	0.22	100	203.	16.10	1.75
	100% LP	600	1 P	79	-24.06	0.0	-23.55	-0.51	89	239.	-32.01	7.95
	100% LP	600	2 P	89	-13.01	0.0	-13.02	0.01	99	280.	-14.17	1.16
	100% LP	600	3 P	89	-10.28	0.0	-10.36	0.08	99	299.	-11.54	1.25
	100% LP	600	4 P	79	-64.56	0.0	-63.20	-1.37	89	220.	-67.02	2.46
	100% LP	600	5 P	79	-64.56	0.0	-63.20	-1.37	89	228.	-66.55	1.98

				Financial					Biological			
Regenerated stand no.	Composition	Stocking level (trees/acre)	Mgt. alt. Regen. method	Investment age (yrs)	Maximum SEV ($)	Soil Rent ($)	Rotation 1 NPV ($)	Rotation 2 NPV ($)	Investment age (yrs)	Maximum MAI (BF/acre/yr)	SEV ($)	Opportunity cost ($)
25	100% PP	300	1 N	80	116.52	5.83	114.17	2.35	100	281.	85.32	31.20
	100% PP	300	2 N	80	115.79	5.79	113.34	2.45	100	276.	101.95	13.84
	100% PP	300	3 N	80	122.62	6.13	120.03	2.58	120	304.	93.94	28.68
	100% PP	300	1 P	69	97.41	4.87	94.05	3.36	79	320.	78.64	18.77
	100% PP	300	2 P	69	96.50	4.82	92.91	3.59	89	310.	77.35	19.14
	100% PP	300	3 P	69	105.39	5.27	101.50	3.90	89	342.	89.45	15.94
26	100% PP	450	1 N	80	125.06	6.25	122.54	2.52	90	293.	107.16	17.90
	100% PP	450	2 N	80	106.49	5.32	104.30	2.20	110	267.	80.91	25.59
	100% PP	450	3 N	80	120.18	6.01	117.68	2.50	100	316.	108.41	11.77
	100% PP	450	4 N	80	100.51	5.03	98.37	2.15	100	281.	85.54	14.97
	100% PP	450	5 N	80	107.56	5.38	105.27	2.29	100	309.	93.15	14.41
	100% PP	450	1 P	69	100.01	5.00	96.56	3.45	79	333.	75.17	24.84
	100% PP	450	2 P	69	74.14	3.71	71.47	2.67	99	297.	39.19	34.95
	100% PP	450	3 P	69	91.58	4.58	88.25	3.33	89	355.	74.90	16.68
	100% PP	450	4 P	69	59.19	2.96	56.87	2.32	89	316.	39.02	20.17
	100% PP	450	5 P	69	68.38	3.42	65.74	2.64	89	347.	48.33	20.06
27	100% PP	600	1 N	80	117.51	5.88	115.14	2.37	100	285.	86.37	31.14
	100% PP	600	2 N	90	149.85	7.49	147.42	2.43	110	329.	133.84	16.01
	100% PP	600	3 N	90	157.35	7.87	154.80	2.54	100	346.	144.87	12.48
	100% PP	600	4 N	80	98.45	4.92	96.35	2.09	100	282.	76.63	21.82
	100% PP	600	5 N	80	112.49	5.62	110.08	2.40	90	311.	100.25	12.24
	100% PP	600	1 P	69	80.14	4.01	77.38	2.77	79	321.	60.62	19.52
	100% PP	600	2 P	79	125.80	6.29	121.79	4.01	99	366.	103.55	22.25
	100% PP	600	3 P	79	134.18	6.71	129.94	4.24	79	393.	134.18	0.0
	100% PP	600	4 P	69	46.97	2.35	45.10	1.87	79	319.	38.09	8.88
	100% PP	600	5 P	69	64.91	3.25	62.36	2.55	79	354.	48.30	16.61
28	50% SP LP	300	1 N	90	30.95	1.55	30.57	0.38	110	156.	26.47	4.48
	50% SP LP	300	2 N	90	30.95	1.55	30.57	0.38	120	154.	23.63	7.32
	50% SP LP	300	3 N	90	30.95	1.55	30.57	0.38	120	163.	23.79	7.16
	50% SP LP	300	1 P	79	-21.41	0.0	-20.96	-0.45	99	174.	-26.97	5.56
	50% SP LP	300	2 P	79	-21.41	0.0	-20.96	-0.45	99	170.	-25.93	4.52
	50% SP LP	300	3 P	79	-21.41	0.0	-20.96	-0.45	109	179.	-30.83	9.42

				Financial					Biological			
Regenerated stand no.	Composition	Stocking level (trees/acre)	Mgt. alt. Regen. method	Investment age (yrs)	Maximum SEV ($)	Soil Rent ($)	Rotation 1 NPV ($)	Rotation 2 NPV ($)	Investment age (yrs)	Maximum MAI (BF/acre/yr)	SEV ($)	Opportunity cost ($)
29	50% SP LP	450	1 N	90	35.10	1.76	34.67	0.43	110	171.	29.46	5.64
	50% SP LP	450	2 N	100	36.67	1.83	36.35	0.32	120	179.	31.36	5.31
	50% SP LP	450	3 N	90	36.62	1.83	36.13	0.48	110	186.	33.47	3.15
	50% SP LP	450	4 N	90	14.35	0.72	14.17	0.18	110	169.	7.69	6.66
	50% SP LP	450	5 N	90	14.35	0.72	14.17	0.18	110	173.	7.59	6.76
	50% SP LP	450	1 P	79	-24.84	0.0	-24.31	-0.53	99	190.	-31.92	7.08
	50% SP LP	450	2 P	89	-22.19	0.0	-22.00	-0.19	109	197.	-29.09	6.90
	50% SP LP	450	3 P	79	-23.09	0.0	-22.67	-0.42	99	207.	-27.10	4.01
	50% SP LP	450	4 P	79	-60.22	0.0	-58.95	-1.28	99	187.	-68.45	8.23
	50% SP LP	450	5 P	79	-60.22	0.0	-58.95	-1.28	99	192.	-68.81	8.59
30	50% SP LP	600	1 N	90	36.03	1.80	35.58	0.45	110	168.	29.60	6.43
	50% SP LP	600	2 N	110	37.31	1.87	37.09	0.22	120	191.	35.01	2.30
	50% SP LP	600	3 N	100	37.72	1.89	37.40	0.32	120	198.	34.97	2.75
	50% SP LP	600	4 N	90	14.03	0.70	13.86	0.17	110	168.	7.45	6.58
	50% SP LP	600	5 N	90	14.03	0.70	13.86	0.17	110	178.	8.57	5.46
	50% SP LP	600	1 P	79	-32.75	0.0	-32.05	-0.69	99	187.	-40.80	8.06
	50% SP LP	600	2 P	99	-30.12	0.0	-29.98	-0.14	109	210.	-33.10	2.98
	50% SP LP	600	3 P	89	-30.10	0.0	-29.78	-0.32	109	218.	-33.61	3.51
	50% SP LP	600	4 P	79	-69.86	0.0	-68.38	-1.48	89	188.	-73.01	3.15
	50% SP LP	600	5 P	79	-69.86	0.0	-68.38	-1.48	99	197.	-76.68	6.82
31	50% DF GF	300	1 N	110	33.31	1.67	33.15	0.16	140	202.	21.82	11.49
	50% DF GF	300	2 N	110	34.23	1.71	34.06	0.17	150	209.	26.95	7.28
	50% DF GF	300	3 N	120	36.65	1.83	36.53	0.12	150	212.	27.24	9.42
	50% DF GF	300	1 P	99	-17.53	0.0	-17.39	-0.14	129	220.	-33.08	15.54
	50% DF GF	300	2 P	109	-16.22	0.0	-16.17	-0.05	139	225.	-25.98	9.75
	50% DF GF	300	3 P	109	-13.01	0.0	-12.98	-0.03	139	228.	-25.81	12.80
32	50% DF GF	450	1 N	110	33.49	1.67	33.33	0.16	140	190.	20.62	12.87
	50% DF GF	450	2 N	130	37.54	1.88	37.45	0.09	150	249.	34.37	3.16
	50% DF GF	450	3 N	130	42.13	2.11	42.03	0.10	150	266.	37.69	4.44
	50% DF GF	450	4 N	110	17.04	0.85	16.95	0.09	150	206.	8.98	8.06
	50% DF GF	450	5 N	110	19.07	0.95	18.97	0.10	150	207.	8.93	10.14
	50% DF GF	450	1 P	99	-26.36	0.0	-26.15	-0.21	129	206.	-43.75	17.38
	50% DF GF	450	2 P	119	-20.50	0.0	-20.48	-0.02	139	268.	-24.76	4.26
	50% DF GF	450	3 P	119	-14.40	0.0	-14.41	0.01	139	287.	-20.42	6.02
	50% DF GF	450	4 P	99	-55.55	0.0	-55.13	-0.42	139	222.	-66.16	10.61
	50% DF GF	450	5 P	99	-52.89	0.0	-52.49	-0.40	139	223.	-66.46	13.57

Regenerated stand no.	Composition	Stocking level (trees/acre)	Mgt. alt. Regen. method	Financial: Investment age (yrs)	Financial: Maximum SEV ($)	Financial: Soil Rent ($)	Financial: Rotation 1 NPV ($)	Financial: Rotation 2 NPV ($)	Biological: Investment age (yrs)	Biological: Maximum MAI (BF/acre/yr)	Biological: SEV ($)	Biological: Opportunity cost ($)
33	50% DF GF	600	1 N	110	31.46	1.57	31.32	0.15	150	180.	15.71	15.75
	50% DF GF	600	2 N	120	33.84	1.69	33.73	0.11	150	224.	29.26	4.58
	50% DF GF	600	3 N	120	36.91	1.85	36.79	0.12	150	234.	30.45	6.46
	50% DF GF	600	4 N	110	16.64	0.83	16.55	0.09	150	202.	6.44	10.20
	50% DF GF	600	5 N	110	18.28	0.91	18.18	0.10	150	205.	6.25	12.03
	50% DF GF	600	1 P	99	-38.23	0.0	-37.92	-0.31	139	194.	-59.47	21.24
	50% DF GF	600	2 P	119	-34.71	0.0	-34.65	-0.07	139	242.	-40.81	6.10
	50% DF GF	600	3 P	109	-30.74	0.0	-30.63	-0.12	139	252.	-39.40	8.66
	50% DF GF	600	4 P	99	-65.17	0.0	-64.67	-0.50	139	218.	-78.67	13.50
	50% DF GF	600	5 P	99	-63.05	0.0	-62.57	-0.48	129	222.	-74.09	11.04
34	50% DF LP	300	1 N	100	26.06	1.30	25.86	0.20	130	150.	18.02	8.04
	50% DF LP	300	2 N	100	26.06	1.30	25.86	0.20	140	152.	18.54	7.52
	50% DF LP	300	3 N	100	26.06	1.30	25.86	0.20	130	155.	21.61	4.45
	50% DF LP	300	1 P	89	-27.79	0.0	-27.43	-0.36	119	164.	-38.38	10.59
	50% DF LP	300	2 P	89	-27.79	0.0	-27.43	-0.36	119	165.	-33.84	6.05
	50% DF LP	300	3 P	89	-27.79	0.0	-27.43	-0.36	119	169.	-33.51	5.72
35	50% DF LP	450	1 N	100	27.92	1.40	27.71	0.21	130	160.	18.66	9.26
	50% DF LP	450	2 N	100	27.92	1.40	27.71	0.21	140	169.	21.73	6.19
	50% DF LP	450	3 N	110	28.07	1.40	27.93	0.14	140	171.	21.54	6.53
	50% DF LP	450	4 N	100	4.43	0.22	4.39	0.03	140	147.	-3.47	7.90
	50% DF LP	450	5 N	100	4.43	0.22	4.39	0.03	140	149.	-3.60	8.03
	50% DF LP	450	1 P	89	-34.33	0.0	-33.89	-0.45	119	174.	-46.52	12.19
	50% DF LP	450	2 P	89	-34.33	0.0	-33.89	-0.45	129	183.	-42.21	7.88
	50% DF LP	450	3 P	99	-33.98	0.0	-33.73	-0.25	119	186.	-39.12	5.15
	50% DF LP	450	4 P	89	-73.36	0.0	-72.40	-0.95	129	159.	-83.36	10.01
	50% DF LP	450	5 P	89	-73.36	0.0	-72.40	-0.95	129	162.	-83.69	10.33
36	50% DF LP	600	1 N	110	24.88	1.24	24.76	0.12	130	157.	18.58	6.30
	50% DF LP	600	2 N	120	31.22	1.56	31.11	0.11	140	180.	27.95	3.27
	50% DF LP	600	3 N	120	33.44	1.67	33.33	0.12	140	187.	30.24	3.20
	50% DF LP	600	4 N	100	3.20	0.16	3.17	0.02	140	150.	-2.46	5.66
	50% DF LP	600	5 N	100	3.20	0.16	3.17	0.02	140	152.	-2.46	5.66
	50% DF LP	600	1 P	99	-47.31	0.0	-46.93	-0.38	119	172.	-55.66	8.34
	50% DF LP	600	2 P	109	-38.34	0.0	-38.20	-0.14	129	196.	-42.65	4.31
	50% DF LP	600	3 P	109	-35.51	0.0	-35.39	-0.12	129	203.	-39.73	4.22
	50% DF LP	600	4 P	99	-83.85	0.0	-83.18	-0.67	129	162.	-90.98	7.13
	50% DF LP	600	5 P	99	-83.35	0.0	-83.18	-0.67	129	165.	-91.08	7.23

				Financial					Biological			
Regenerated stand no.	Composition	Stocking level (trees/acre)	Mgt. alt. Regen. method	Investment age (yrs)	Maximum SEV ($)	Soil Rent ($)	Rotation 1 NPV ($)	Rotation 2 NPV ($)	Investment age (yrs)	Maximum MAI (BF/acre/yr)	SEV ($)	Opportunity cost ($)
37	50% DF PP	300	1 N	80	95.69	4.78	93.76	1.93	100	270.	81.07	14.62
	50% DF PP	300	2 N	90	93.53	4.68	92.23	1.31	140	267.	68.63	24.90
	50% DF PP	300	3 N	90	105.29	5.26	103.82	1.47	130	289.	81.57	23.72
	50% DF PP	300	1 P	69	68.33	3.42	65.97	2.36	89	303.	48.29	20.04
	50% DF PP	300	2 P	79	65.60	3.28	63.86	1.74	129	290.	31.47	34.14
	50% DF PP	300	3 P	79	80.93	4.05	78.81	2.12	109	319.	57.78	23.14
38	50% DF PP	450	1 N	80	109.53	5.48	107.32	2.21	100	297.	89.60	19.94
	50% DF PP	450	2 N	90	104.23	5.21	102.78	1.45	150	294.	82.35	21.88
	50% DF PP	450	3 N	100	116.70	5.84	115.56	1.13	130	324.	99.80	16.89
	50% DF PP	450	4 N	90	83.55	4.18	82.35	1.19	120	276.	67.20	16.35
	50% DF PP	450	5 N	90	93.35	4.67	92.02	1.33	110	303.	81.24	12.11
	50% DF PP	450	1 P	69	78.33	3.92	75.63	2.70	89	333.	50.97	27.36
	50% DF PP	450	2 P	79	71.26	3.56	69.38	1.88	119	318.	54.97	16.29
	50% DF PP	450	3 P	89	87.45	4.37	85.73	1.72	99	358.	82.82	4.63
	50% DF PP	450	4 P	79	35.97	1.80	34.84	1.13	99	305.	23.15	12.82
	50% DF PP	450	5 P	79	48.57	2.43	47.14	1.44	99	336.	32.10	16.47
39	50% DF PP	600	1 N	80	103.96	5.20	101.87	2.10	100	280.	85.19	18.77
	50% DF PP	600	2 N	100	100.61	5.03	99.65	0.95	150	291.	86.89	13.71
	50% DF PP	600	3 N	110	114.44	5.72	113.65	0.78	130	332.	106.50	7.94
	50% DF PP	600	4 N	90	88.96	4.45	87.70	1.26	120	307.	73.34	15.62
	50% DF PP	600	5 N	90	98.93	4.95	97.53	1.39	120	345.	84.71	14.22
	50% DF PP	600	1 P	69	61.23	3.06	59.12	2.11	89	315.	35.76	25.47
	50% DF PP	600	2 P	89	57.27	2.86	56.08	1.19	129	316.	44.37	12.90
	50% DF PP	600	3 P	99	75.15	3.76	73.96	1.19	119	363.	64.26	10.90
	50% DF PP	600	4 P	79	34.29	1.71	33.20	1.09	109	338.	13.37	20.92
	50% DF PP	600	5 P	79	47.12	2.36	45.72	1.39	109	379.	27.76	19.36

Appendix 6

Opportunity Cost of Deferring Harvest of Financially Mature and Over-Mature Stands

Stand Number	Financial NPV ($/acre)	Opportunity Costs ($/acre)	Acreage (acre)	Total NPV ($1000)	Total Opportunity Costs ($1000)
1	508.51	92.53	33,869	17,222.7	3,133.9
2	137.34	110.84	30,823	4,233.2	3,416.4
6	139.94	94.86	18,360	2,569.3	1,741.6
7	187.40	99.74	11,100	2,080.1	1,107.1
8	353.11	219.46	47,233	16,678.4	10,365.8
10	644.57	189.96	54,083	34,860.3	10,273.6
11	695.41	0.0	447	310.8	0.0
12	888.15	496.02	34,215	30,388.1	16,971.3
13	393.62	196.39	10,948	4,309.4	2,150.1
14	147.93	142.02	8,455	1,250.7	1,200.8
15	222.69	151.09	106,178	23,644.8	16,042.4
17	303.96	248.55	14,318	4,352.1	3,558.7
18	585.57	0.0	62,582	36,646.1	0.0
20	426.49	244.32	20,297	8,656.5	4,959.0
21	374.99	87.80	70,802	26,550.0	6,216.4
22	1125.38	687.52	18,171	20,449.3	12,492.9
23	594.65	0.0	20,234	12,032.1	0.0
24	1540.41	0.0	69,371	106,859.8	0.0
25	969.72	766.75	28,145	27,292.8	21,580.2
26	713.51	246.28	12,716	9,073.0	3,131.7
27	527.18	174.97	30,693	16,180.7	5,370.4
28	888.41	0.0	10,993	9,766.3	0.0
29	1245.49	0.0	41,083	51,168.5	0.0
30	1041.92	693.40	15,101	15,734.0	10,471.0
31	851.74	0.0	27,486	23,410.9	0.0
32	1000.92	744.18	9,463	9,471.7	7,042.2
33	1403.53	0.0	24,414	34,265.8	0.0
34	488.99	0.0	18,455	9,024.3	0.0
35	2629.21	0.0	23,912	62,869.7	0.0
36	1623.37	0.0	114,220	185,421.3	0.0
37	532.24	386.22	46,718	24,865.2	18,043.4
38	934.54	0.0	105,411	98,510.8	0.0
39	2434.23	0.0	50,693	123,398.4	0.0
40	1407.73	0.0	43,844	61,720.5	0.0
42	825.57	32.17	16,144	13,328.0	519.4
43	475.90	0.0	12,918	6,147.7	0.0
45	818.97	0.0	16,866	13,812.7	0.0
46	931.87	327.14	39,449	36,761.3	12,905.3
47	451.30	0.0	13,979	6,308.7	0.0
48	627.57	0.0	20,218	12,688.2	0.0
50	820.03	0.0	25,618	21,007.5	0.0
51	1145.44	405.91	47,514	54,424.4	19,286.4
52	425.93	0.0	12,670	5,396.5	0.0
53	694.06	0.0	21,365	14,828.6	0.0
54	1738.43	777.91	11,418	19,849.4	8,882.2
55	803.87	0.0	25,713	20,670.0	0.0
56	1316.73	550.70	25,895	34,096.7	14,260.4
57	727.89	0.0	6,188	4,504.2	0.0
58	1060.63	660.42	6,213	6,589.7	4,103.2
59	1029.01	0.0	21,707	22,336.7	0.0
60	1322.39	0.0	17,017	22,503.1	0.0

Stand Number	Financial NPV ($/acre)	Opportunity Costs ($/acre)	Acreage (acre)	Total NPV ($1000)	Total Opportunity Costs ($1000)
61	1172.30	0.0	10,354	12,138.0	0.0
62	1371.90	848.88	7,968	10,931.3	6,763.9
63	1354.59	0.0	28,648	38,806.3	0.0
64	1597.79	0.0	15,585	24,901.6	0.0
65	2015.71	0.0	16,144	32,541.6	0.0
66	1850.97	0.0	95,640	177,026.8	0.0
67	3092.68	0.0	25,105	77,641.7	0.0
68	1520.89	0.0	55,108	83,813.2	0.0
69	3408.05	0.0	60,968	207,782.0	0.0
70	1769.50	0.0	21,589	38,201.7	0.0
71	46.54	38.78	26,641	1,239.9	1,033.1
72	145.68	129.77	65,140	9,489.6	8,453.2
73	319.62	171.05	24,927	7,967.2	4,263.8
74	192.59	157.69	97,758	18,827.2	15,415.5
75	495.51	0.0	177,875	88,138.8	0.0
76	472.17	0.0	180,961	85,444.4	0.0
77	514.55	0.0	20,407	10,500.4	0.0
78	365.57	0.0	140,404	51,327.5	0.0
79	632.23	0.0	62,109	39,267.2	0.0
80	640.49	0.0	185,390	118,740.4	0.0
81	767.02	0.0	13,397	10,275.8	0.0
82	374.20	217.04	38,807	14,521.6	8,422.7
83	424.37	0.0	102,281	43,405.0	0.0
84	692.35	0.0	30,291	20,972.0	0.0
85	951.90	0.0	194,485	185,130.3	0.0
86	917.54	0.0	12,728	11,678.4	0.0
87	482.28	293.58	69,770	33,648.7	20,483.1
88	1191.48	0.0	25,154	29,970.5	0.0
89	603.63	0.0	82,832	49,999.9	0.0
90	736.87	0.0	40,339	29,724.6	0.0
91	735.69	0.0	201,645	148,348.2	0.0
92	735.53	598.34	22,051	16,219.2	13,194.0
93	558.80	348.76	136,603	76,333.8	47,641.7
94	1283.54	0.0	81,113	104,111.8	0.0
95	371.96	350.65	149,720	55,689.9	52,499.3
96	1130.15	0.0	274,915	310,695.2	0.0
97	1071.17	0.0	700,137	749,965.8	0.0
98	377.45	189.72	15,852	5,983.3	3,007.4
99	266.53	220.87	13,941	3,715.7	3,079.1
100	477.93	0.0	25,520	12,196.8	0.0
101	677.04	83.99	18,698	12,659.3	1,570.4
102	418.63	0.0	31,699	13,270.2	0.0
103	973.52	0.0	10,663	10,380.6	0.0
104	658.05	0.0	29,534	19,434.8	0.0
105	497.55	316.02	25,465	12,670.1	8,047.4
106	442.12	0.0	27,944	12,354.6	0.0
107	746.10	0.0	29,896	22,305.4	0.0
108	899.89	0.0	8,349	7,513.2	0.0
109	788.97	0.0	35,614	28,098.4	0.0
110	1155.06	0.0	11,646	13,451.8	0.0
111	606.71	172.26	21,096	12,799.2	3,634.0
112	853.32	0.0	30,095	25,680.6	0.0
113	738.15	0.0	114,860	84,783.9	0.0
114	1217.98	0.0	44,678	54,416.9	0.0
115	454.51	0.0	59,732	27,148.8	0.0
116	1339.95	0.0	100,653	134,870.0	0.0
117	1118.09	0.0	125,699	140,542.8	0.0
108 stands			5,852,348	5,110,214.9	416,734.4

Appendix 7

Sample Harvest Value Adjustment

The estimated stumpage value for Douglas-fir used in this study was \$46.11/MBF. This is an on-site residual value, i.e., market bids recognize logging, stand and accessibility conditions. The estimated 1976 Westside Region 1 average stand and accessibility conditions are shown in Table 1.

Table 1. Region 1 Westside average stand conditions, 1976.

Slope	30%
Defect	12%
Scale defect	6%
Volume/acre	12MBF
Logs/MBF	18
Haul distance	38 miles

Log values, on the other hand, are measured at the point of utilization and should cover stumpage values plus logging costs and any other costs associated with harvesting. When basic logging, stand and accessibility conditions change, so does the residual stumpage value. Since log values are presumed constant, any change in the average stand conditions given in Table 1 would have an impact on the residual Douglas-fir stumpage value of \$46.11/MBF.

The average logging cost for 81 timber sales during FY 1976 on three northern Idaho national forests was \$86.80/MBF. If this cost is applied to Douglas-fir stumpage value, the implicit average delivered log value is \$132.91/MBF. Since stumpage value equals delivered log value minus collection costs, a production cost decrease implies an increase in stumpage value, or vice versa.

The following example illustrates how stumpage values may be affected where tree size is larger than average.

In Table 1 the stand averages 18 logs/MBF. If a stand mean is 16 logs/MBF, trees are larger than average, so collection costs should be adjusted by the linear approximations in Table 2.

Table 2. Effect of tree size on operating costs (computed from USFS R1 stumpage appraisal tables).

Felling	% adj = -371.9 + 20.95 (logs/MBF), r^2 = .96 (this linear approximation holds only between 16 and 20 logs/MBF)
Skidding	% adj = -52.4 + 2.84 (logs/MBF), r^2 = .99
Loading	% adj = -71.1 + 3.76 (logs/MBF), r^2 = .99
Hauling	% adj = -34.0 + 1.89 (logs/MBF), r^2 = .99

Table 3 gives the adjustments in collection costs when all other factors are held constant. The adjustment factor is 1.0 plus the percent adjustment derived from the above equations. An 11 percent decrease in logs/MBF (larger logs) results in a cost decrease of 37 percent in felling, 7 percent in skidding, 11 percent in loading and 4 percent in hauling, for a total cost decrease of 9 percent/MBF. Therefore, stumpage is increased by \$8.14, or 18 percent.

Table 3. Logging cost adjustments.

Operation	Average Price/ MBF[a]	Adjustment Factor[b]	Adjusted Price/MBF
Felling	\$14.34	.633	\$ 9.07
Skidding	26.63	.930	24.77
Loading	8.88	.891	7.91
Hauling	22.00	.962	21.16
Overhead	3.95	1.000	3.95
Protection	11.00	1.000	11.00
	\$86.80		\$77.86

[a] Source: USFS 2400-17 reports [b] Adjustment factor = 1.0 + % adj/100 from Table 2

Assuming the \$77.86/MBF cost figure is applicable in perpetuity for this stand, rather than the average \$86.80/MBF, then the optimal SEV for the stand should also be adjusted. Regenerated stand 12 (Table 4.7) is used to demonstrate the adjustment in SEV. The previous optimal SEV for the stand was \$85.90. Since stumpage has increased 18 percent, the adjusted SEV can now be estimated, using the formulation given in Chapter 5.

Adj SEV = Previous Optimal SEV + \$0.75 (% stumpage change)
= \$85.90 + \$0.75 (+18) = \$99.40.