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ECONOMIC DECISIONS IN THE MANAGEMENT OF SECOND GROWTH DOUGLAS FIR IN NORTHWESTERN CALIFORNIA

RESUME AND CONCLUSIONS

In northwestern California, tens of thousands of acres of cutover land exist for which landowners want to know the best land use. One of the more important uses, considering the economy of the area, is to grow timber, although the land may be used in many ways. The purpose of this report is to provide farm and ranch planners, forest technicians, and landowners with a series of methods with which they can compare three different timber management systems applied to a representative Douglas Fir region.

Each management analysis started with the same hypothetical hundred acres of Site Index 140 land. Thirty-five acres are presently in 10-year-old natural Douglas Fir reproduction, twenty acres of timber soils are bare or in grass, and forty-five acres are covered with tan-oak, madrone and various brushes. Rainfall averages 40 inches, and the elevation will exceed 3,500 feet. Slopes will range from nearly level to 80%.

An "average" acre concept was used in the study. Most timber lands have a variety of conditions existing which will affect both costs and returns. The average acre, as used in the study, consisted of 35% in a nature stand, 50% which could be replanted, and 15% considered too steep or rocky, or clearing costs too high, to be used for growing timber. In the main study, only Site Index 140 is analyzed, although some comparisons for Site Indexes 110 and 170 are shown in the appendix.

*Formerly Farm and Ranch Planning

Typical costs and returns are evaluated for three levels of management:

1. Evaluation I is merely to leave the cutover land "as is" and harvest the stand in a single clear-cut operation at some point in the future.

2. Evaluation II consists of clearing the land and planting trees so that the entire usable area will be growing timber. No management is applied after planting until a single harvest cut is made.

3. Evaluation III is for an intensive management program. From the start, the practices are designed to create the greatest volume of merchantable wood of the best quality in the shortest period of time. Proper spacing of trees is considered, best planting stock analyzed, and the effects of pruning and periodic harvest cuts investigated.

The length of rotation varies with the three programs, 60, 70 and 80 years, respectively, proved optimum. Interest was charged at 4%. The following summation presents the results:

Summary: Per Acre Accumulated and Average Annual Equivalent Costs and Returns by Management Levels:

A. Accumulated costs	Evaluation I	Evaluation II	Evaluation III
1. Clearing land	$ --	$ 146.37	$ 145.78
2. Planting	--	346.00	337.82
3. Pruning	--	--	205.33
4. Administration	11.22	11.22	38.17
5. Selection and marking harvest cuts	--	--	20.96
6. Arrangement for timber sales	4.00	5.00	9.87
7. Land tax	78.54	120.21	120.21
8. Timber tax	46.51	109.84	324.72
	$140.27	$738.64	$1202.86
Average annual equivalent cost	.59	2.03	3.30

B. Gross returns

1. Timber sales	$283.36	$772.68	$3016.50
Total average annual equivalent return	1.19	2.12	8.28

C. Net returns

1. Timber sales	$143.09	$ 34.04	$1813.64
Average annual equivalent	.60	.09	4.98

Where ACP payments are received and the owner realizes a labor income, the following table summarizes the average annual equivalent costs and returns:

Evaluation	Net Income	Labor, Management & ACP Reimbursable Income	Total Cash Income
I	$ .60	$ .06	$ .66
II	.09	1.13	1.22
III	4.98	1.66	6.64

Based on the framework presented in this study, forestry is a profitable enterprise for the typical "average acre" of Site Index 140 land if it is properly managed. It appears very questionable to restock an area and then not manage it. Only government subsidies make this a better buy than no management at all.

If capital is available, neither Evaluation I nor II is logical, as the investments will not yield an economic return. Evaluation III, however, appears to be a favorable investment program yielding a high financial return. In the event capital is limited, Evaluation I should be considered.

Each individual management decision has been found profitable when the entire program is used. (See appendix.) All practices are required to produce the maximum returns; yet, if applied individually, many of them would not pay. This indicates the value of a complete basic forest management plan as it affects the dollar income a landowner may expect.

The application of economic principles to woodland management will aid technicians in planning a complete forest management program. The basic thought of this report is that through an examination of "cause and effect" or input and its responses, a landowner will have better grounds for management decisions.

ECONOMIC DECISIONS IN THE MANAGEMENT OF SECOND GROWTH DOUGLAS FIR IN NORTHWESTERN CALIFORNIA

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PREFACE

This report contains an analysis of many of the items for which decisions are necessary when making an evaluation of applied woodland management. Its purpose is to serve as a general methodology guide to forest technicians, farm and ranch planners, and landowners wishing to compare alternatives in forest land use. The report will evaluate systems of woodland management and variations of management as to spacing, rate of growth, site, age of stand, length of cutting cycle, etc., to the extent that there is information available on the effects of variation in these factors of production. It gives working economic guides as to the margins of costs and prices in a system or systems of woodland management.

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ECONOMIC DECISIONS IN MANAGEMENT OF SECOND GROWTH DOUGLAS FIR

Timber and livestock products are the major sources of income in northwestern California. The economy of the individual landowner and the various communities scattered throughout the area is based almost entirely on income from sale of timber or livestock, their products, and jobs created through processing these products. 1 / California's two leading timber producing counties, Mendocino and Humboldt, are located

1 / Footnoted numbers refer to Literature Cited. (See page 25.)

in the heart of the area to which this study should be applicable. Since the second World War, millions of board feet of old growth Douglas Fir have been logged, and in the immediate foreseeable future, the remaining old growth will be removed. 2 / Much of the land has been cut over two or three times during the past fifteen years, leaving little commercial timber and limiting natural reproduction.

Private landowners now face the problem of what to do with this denuded land. Community interests encourage reforestation because timber is their lifeblood. Ranchers would like to see it converted to range uses and thus strengthen the livestock industry. Hunters and wildlife enthusiasts favor open brushland which serves as an excellent wildlife habitat. Speculators say hold it as is and sell it for cabin or recreation sites. Each land use has economic implications to everyone living in the area, yet consideration of all alternatives is beyond the scope of the project.

The Soil Conservation Service gives technical guidance to Soil Conservation District cooperators to obtain the best productive use of their land consistent with conservation of basic resources and economic costs and returns. One major phase of our work in northwestern California is with woodlands; so for purposes of simplification, only woodland use alternatives will be considered in this study. The purpose of the report is twofold. The first is to give general comparisons of estimated costs and returns for three situations: (1) The natural stand as it presently exists, (2) a restocked stand allowed to grow up unmanaged to a single harvest, and (3) a restocked, well managed timber stand where intermediate harvest cuts are made. The second purpose is to present illustrations of methods to evaluate individual management practices.

A single physical site is assumed as a common starting place for the varying woodland management programs. The site, while considered typical of thousands of acres in the Douglas Fir Region, is used for illustrative purposes only, as site conditions will vary considerably from place to place. The evaluation procedures can readily be adapted to different cover conditions once the percentages of native stands, planted stands, and inoperable lands are known for a particular management block. A hundred-acre management unit is assumed to facilitate cost and return computations, yet the results are shown on a per acre basis. In this way, the data is readily adapted to greater or lesser areas having similar conditions.

The average rainfall in the area is in excess of 40 inches, although summers are hot and dry. The elevation varies from about 500 feet to 5,000 feet. The study area land is classified as Douglas Fir Site Class III, Site Index 140, which is a medium value forest site. The soil is normally three feet deep and of medium texture. The underlying rock material can be penetrated by water and by tree roots. Slopes for this site range from nearly level to eighty per cent.

The present cover varies considerably within the hundred-acre block. As the land has been repeatedly cut over in the past fifteen years, only a few scattered Douglas Fir trees of little value are left. About thirty-five per cent of the area has ten-year-old Douglas Fir reproduction and is fully stocked. These trees came in shortly after logging was first done. Twenty per cent of the area has been scraped bare or is in grass or light brush. On the remaining 45% of the land area, brush and trees have encroached and the cover consists primarily of tanoaks, madrone and manzanita. Some of these trees are twenty to thirty feet high.

EVALUATION PROCEDURES USED

All evaluations are made on the same site, and physical conditions should affect each in the same way. Management with its subsequent effects of increasing merchantable timber yields is the major variable considered. For the unmanaged and semimanaged stands, computation of costs and returns is relatively simple. Only a brief description of the analysis results, combined with income and expense tables, will be required. For the semimanaged analysis, a detailed description will be made of the land clearing process, as this will also apply to the managed stand. Where full management is applied, many decisions must be made and evaluated. Some of the more evident choices are compared to see what the economic effect is. These are shown in the Appendix section. Although the analysis procedures are done for a specific site index, the procedures will apply to any site index and should fit other problems not considered here.

Probable Markets

A basic consideration in timber production is the probable market for timber products at a projected date in the future. Historically, California has had a saw log economy based on old growth timber. Also, until recently there existed only a limited market for Douglas Fir and then only the larger saw logs. 2/ As old growth is rapidly being used, the trend is toward utilization of smaller second growth stems. The smallest saw log of commercial value is eight to ten inches in diameter, with stems six to eight inches being used for a

limited post, pole, stud log or cordwood market. Smaller material has no commercial value.

It is conceivable that eventually a pulp market will develop which will aid considerably in disposal of the product of what is now considered a precommercial thinning. From an economic standpoint, one of the most significant problems facing forest researchers is to find a commercial use for young stems which will give landowners an income before the stand is thirty to forty years old. The earlier income is realized, the sooner costs are offset and interest charge effects reduced. Should such a market develop, the entire management concept may be altered.

Demand exists for high quality veneer logs. Pruned trees remaining in the stand long enough to reach 16" in diameter should receive a price premium. This is due primarily to the presence of more clear wood which produces a higher quality log.

Prices Received

Final decisions in the management of forest stands will be based on price relationships existing in future years. If a market develops for smaller stems, the stands may be cut sooner; if industry pays a greater premium for larger trees, then the rotation will tend to be extended. For planning purposes, however, the landowners will normally rely on estimates based on existing price relationships.

The average prices used in the study are based on data contained in "Markets for Woodland Products in California," 3/ issued by the Extension Service and the California Division of Forestry, and tempered by knowledge of recent timber sales in Mendocino County. It is assumed that all timber is sold as stumpage.

Based on the above information, stumpage prices assumed are: $14.00/MBM for 8" to 12" diameter logs; $23.00 per MBM for 12" to 16" logs, and $35.00 per thousand board feet for logs exceeding 16" in diameter. A stumpage value of $6.00 per cord is assumed for the 6-8" stud logs which may be used for a variety of purposes within the next thirty to forty years.

All costs and returns used in the analysis are based on present conditions, assuming a good quality product. This assumes that during the entire analysis period, prices paid for the various inputs and prices received for the product will have the same relationship to each other as exists now. It is felt that this is a conservative approach, as forest economists generally believe the upward postwar trend in timber demand and prices will continue and at a faster rate than rising costs. Future prices may be higher because of inflationary

tendencies of the entire economy; greater scarcity of good timber stands; and because of increased demand for paper products and for housing and other structures as the population increases. 4/

Use of Interest

An important factor in arriving at net incomes for woodlands is the use made of interest. It is especially important in forestry, as investments in woodland must be carried at compound interest until the investments are paid by future income. Forestry is a long-term venture, and its annual physical growth can be harvested only after it has accumulated for varying lengths of time. Costs commence with the initial land clearing and stand establishment, and then occur both annually and at intervals throughout the stand life. Both costs and income are accumulated at the same rate of interest, which tends to cancel out the costs as income becomes available to pay them.

The rate of interest to use for long-term investments of this type is determined by the rate earned by similar long-term investments with equal risk. The higher the rate, the lower the net income and the shorter the optimum financial rotation. A rate of 4% interest is used in the analysis, and contains a risk factor for fire, disease and insect infestation. The 4% interest tables are used to account for what the invested money or income would "earn" or be borrowed for were it used for other purposes. Annuity tables are necessary to convert all costs and expenses to a common time basis. The costs and income may be converted to present worth and then amortized over the life of the timber stand to obtain an average annual equivalent income. This income may then be compared with other land uses that produce yearly incomes.

Concept of Economic Net Income Per Acre

There is a difference between an "economic" net income and that received by an individual. The "economic" net income concept, as used in the report, includes all costs and returns regardless of who pays or receives them. All costs are treated as out-of-pocket expenses, and as if no government payments are available. The landowner, however, is concerned with his dollar income when part of the costs are his own labor, part are cash expenditures and part may be reimbursed by ACP payments. Adjustments will be made for each analysis to show the landowner's net and total cash incomes when current ACP allowances and returns to labor and management are received. Care should be taken in the use of ACP allowances in planning timber management, because they are government subsidies and are subject to change at any time.

Basic to the economic procedure of this report is the concept of a single productive acre or block of acres. Only by separating out the area on

which management is applied can the resulting productive response be adequately measured. Each acre or unit must pay its own bills. The comment is sometimes erroneously made that income from other sources, such as sale of timber in other parts of the timber holdings, is available to pay another area's improvement costs as they occur, so no interest needs to be paid. This is not considered a valid approach, as this outside income has other opportunities for investment, and so must forego any interest it would have earned.

EVALUATION I. UNMANAGED NATIVE STANDS

The easiest and least costly alternative for utilization of cut-over timber lands is to leave the land "as is" and harvest whatever crop exists, in a single clear-cut operation sometime in the future. The problem is to find out whether, under this program, there is a net income or a loss, and at what age the stand should be harvested.

Approximately forty-five per cent of the hundred-acre management unit is overgrown with brush, tanoak and madrone. At present there is no market for hardwoods, and even if one develops, the expected volume of usable timber grown in the seventy-year period is not large. Twenty per cent is in open forest land, and the remaining thirty-five per cent of the unit land area is in natural ten-year-old Douglas Fir reproduction and is considered fully stocked.

Although nothing is done to the stand, costs will be incurred that must be paid for by the sale of timber. These costs consist of land and timber taxes, and the labor involved in managing and selling the timber at the end of the rotation. The land tax used is 33¢ per acre per year, and is treated as an annuity of one. The land tax will vary with locality in the Douglas Fir region, and the 33¢ represents the higher range. The tax on the value of the merchantable timber starts with the forty-first year and varies with the value of the timber and the years away from harvest. These costs are compounded at 4% interest from the date they are incurred. Administration and selling costs are considered a labor item usually done by the landowner himself.

Table Ia shows the costs as they accumulate, by age groups, for individual items and as a total, based on the ten-year-old beginning age at year 0. The last column on the right is the average annual equivalent cost of the unmanaged forest production.

Table Ia, Accumulated Individual, Total and Average Annual Equivalent Costs per Acre for Natural Douglas Fir Stands (Site Index 140)**

	Cost of Production					
Age of Stand	Land Tax	Timber Tax	Administration Costs	Timber* Sales	Accumulated Total Costs	Average Annual Equivalent Cost
20	3.96	0	0	0	3.96	.33
30	9.82	0	0	0	9.82	.33
40	18.51	0	0	0	18.51	.33
50	31.36	9.12	2.40	(4.00)	46.88	.49
60	50.38	25.05	5.96	(4.00)	85.39	.56
70	78.54	46.51	11.22	(4.00)	140.27	.59
80	120.21	87.40	19.00	4.00	230.61	.63

Table Ib illustrates how the value of timber increases at ten-year intervals and what the value would be were the stand clear cut at any of the intervals. Both the total gross income and the average annual equivalent gross income are shown. At age 70 the diameter of the logs is large enough to bring the next higher log price, which accounts for the significant rise in average income. At eighty years the factor of interest reduces the average income, with this reduction becoming greater as stands get older.

Table Ib, Accumulated, Periodic and Average Annual Equivalent Gross Income per Acre from Unmanaged Douglas Fir Stands (Site Index 140) (Per MBM)

Age of Stand (Year)	Merchantable*** Timber in B.F. (Board Feet)	Price Expected (Dollar)	Total Income (Dollar)	Average Annual Equivalent Income (Dollar)
30	105	14.00	1.47	.05
40	1,575	14.00	22.05	.39
50	4,340	14.00	60.76	.64
60	8,330	14.00	116.62	.76
70	12,320	23.00	283.36	1.19
80	15,995	23.00	367.88	1.01

* Sales fee applies only if timber is sold at that age.
** Costs adjusted to starting with a 10-year-old stand.
*** Adjusted for 35% stocking from Technical Bulletin #201, Scribner Rule.

Comparing the average annual equivalent cost and gross income columns in Tables Ia and Ib, it is evident that stand age 70, or sixty years from today (the stand was 10 years to start with), is the most economical point to clear cut the timber, with eighty years a poor second:

Age	Annual Income	Annual Cost	Annual Net Income per Acre
60	.76	.56	.20
70	1.19	.59	.60
80	1.01	.63	.38

The average annual equivalent costs or income are easily derived. For a given age of stand, the accumulated costs or clear-cut income are merely discounted back to the present, and then amortized over the same period they were discounted for. This can also be done through the use of a sinking fund factor. When the age of the stand is different from the years from today, this correction must be made. For this analysis, the optimum age stand proved to be age 70, or 60 years in the future. The total accumulated cost of $140.27, discounted at 4% for 60 years (.09506) equals $13.33. This figure amortized for 60 years at 4% (.04420) equals $.59 average annual equivalent cost. This process may also be applied to individual cost of production or incomes at any particular age.

Net income is the first measure of production, and labor and management income the second. If the landowner does his own administration and sales contacts, he is entitled to an additional .06 so that total cash income is .60 + .06 (discounted and amortized management and labor cost) = .66 per acre per year when timber is cut at age seventy.

Net income, as used in the report, is the result of paying all operational costs involved in the production of the timber. It is the amount available to the landowner as a return to land and as a pure net income. Earned interest on the investment in land is not considered a direct cost of production, but results from the production; so it is not to be included in the budget. It is a very real cost, however, and the individual landowner should account for it as best fits his individual conditions. Many landowners may wish to compute an estimated "land rent cost" (return on investment in land) and charge it against timber production. As this is an annual charge, it can be subtracted directly from the net income. One common way to arrive at this charge is to assume the land is actually worth either its assessed value or the price paid for it, and then assess the going rate of interest. Assuming the land was assessed at (or sold for) $25.00 an acre, it would require an annual charge of $1.00 to pay 4% interest on the investment.

As the net income is less than this, and is all that is available to pay it, the landowner would have to be satisfied with a lesser return to land and no net income.

EVALUATION II. UNMANAGED RESTOCKED STANDS

The second alternative is clearing the land and planting trees so that the entire usable area will be growing timber. No management is applied after planting until a single harvest cut is made. Except for the cost of land clearing, tree planting, timber sales, and increased timber taxes, the costs should remain the same. As trees are now being planted, the rotation covers eighty years with 35% of the area (the native stand) being 90 years old at the harvest cutting. The inoperable portion, consisting of non-commercial forest and brush, will make up the remaining 15% of the management block.

In northwestern California, if natural revegetation does not occur within 5 to 10 years following logging, it generally will not occur for many years. The first 2 or 3 years after logging the soil is stirred up, and competition at a minimum, creating ideal conditions for young seedlings to become established. This ideal condition for natural reforestation is transitory, however, as rapid encroachment of brush and hardwoods soon takes place. Much cutover land in Humboldt and Mendocino Counties has reached the point where a good, natural seed source is not available, and dense brush and hardwoods would severely limit seedling survival.

Clearing the land is the first step in the re-establishment of the timber stand. This can be, and is, done in a number of ways, using different sizes and types of equipment. The following procedure is one of the more common ways that the smaller landowner could do the job.

As only part of the100-acre block needs clearing, a stocking survey should be conducted to mark areas to be cleared. The existing reproduction is not disturbed, and those areas inoperable because of slope, creeks or being covered with large tanoak or madrone, are avoided. While it is physically possible to clear even the large trees, it is not commonly considered economical, as it would double the clearing costs. The remaining 50% of the area is in lighter brush, young trees and grass, and can be cleared rapidly and with much less expense.

The clearing work should start in the summer when it is dry. A D-6 tractor with blade will knock down the existing cover and push it into piles to be burned or to inoperable areas where it no longer will be a

problem. After the first fall rains the brush and trees can be burned, if necessary, at a minimum of cost. These operations are summarized as follows:

1 - Pre-clearing stocking survey and marking areas to be cleared: 16 manhours @ $2.00 = $32 per 100 acres.

2 - Clearing brush, 30% of total area: D-6 plus blade $12.50/hour x 1.75 hours per acre = $21.67 per acre cleared.

3 - Clearing bare open area, 20% of total: D-6 plus blade $12.50 x 1 hour per acre = $12.50 per acre cleared.

4 - Brush burning: 4 manhours @ $2.00 = $8.00 per 100 acres.

5 - Summary, weighted per acre cost of clearing.

a. Stocking survey, $32/100 acres = .32/acre

b. Land clearing:

(1) 35% in fir trees =	0
(2) 15% remains inoperable =	0
(3) 30% brush cleared, $21.67 x 30% =	6.50/acre
(4) 20% bare-open area, $12.50 x 20% =	2.50/acre

c. Brush burning, $8/100 acre = .08/acre

Per Acre Total = $9.40

Once the land is cleared the next step is to plant the trees. As a minimum of management is desired here by the landowner, the stand is established with the single planting -- no replanting will be done. A complete evaluation of the cheapest way to get an established stand is shown in the Appendix. In this evaluation a 6 x 8 planting is made to put 907 trees per acre in the ground, of which 453 are expected to survive. This is done on one-half the land area at a cost of $44.44 per full acre established, or a weighted cost of $22.22 for each acre in our management unit.

Once the trees are planted, nothing more is done to the stand until it is ready for the harvest. The timber is expected to grow in a pattern such as unmanaged stands depicted in U.S. Technical Bulletin No. 201. 5/ Table IIa itemizes the input costs as accumulated individual costs, total costs and average annual equivalent costs at any given age. Table IIb shows the yield of merchantable timber, the price received, and the total and average annual equivalent net incomes. These tables take into account the inoperable areas and differences in age of the native and planted trees.

Table IIa, Accumulated Individual, Total and Average Annual Equivalent Costs by Time Periods for Unmanaged Planted Stands of Douglas Fir (Site Index 140) (Per Acre)

Age	Land Clearing	Stand Planting	Land Tax	Timber Tax	Administration	Timber* Sales	Total Costs	Average Annual Costs
0	9.40	22.22	.33	0	0	0	31.99	33.09
10	13.91	32.89	3.96	0	0	0	50.76	4.23
20	20.60	48.68	9.82	0	0	0	79.10	2.58
30	30.49	72.07	18.51	0	0	(5.00)	126.07	2.25
40	45.13	106.68	31.36	2.04	0	(5.00)	190.21	2.00
50	66.80	157.91	50.38	11.48	2.40	(5.00)	293.97	1.92
60	98.88	233.75	78.54	35.88	5.96	(5.00)	458.01	1.92
70	146.37	346.00	120.21	109.84	11.22	(5.00)	738.64	2.03
80	216.67	512.17	181.91	255.46	19.00	5.00	1,190.21	2.16

*Sales fee applies only if timber is sold at that age.

Table IIb, Yield of Merchantable Timber, Total and Average Annual Equivalent Gross Income per Acre by Time Periods for Unmanaged Planted Stands of Douglas Fir (Site Index 140) 1/

Age of Stand	Yield in Board Feet of Timber: 35% Area* (10 yrs. at date of Seeding)	50% Area	Total	Price per MBM (Dollars)	Total Income per Interval (Dollars)	Average Annual Gross Income (Dollars)
0	0	0	0	0		
10	0	0	0	0		
20	105	0	105	14	1.47	.05
30	1,575	150	1,725	14	24.15	.43
40	4,340	2,250	6,590	14	92.26	.97
50	8,330	6,200	14,530	14	203.42	1.33
60	12,320	11,900	24,220	23 & 14	449.96	1.89
70	15,995	17,600	33,595	23	772.68	2.12
80	19,250	22,850	42,100	23	968.30	1.76

1/ Technical Bulletin No. 201 -- Scribner Rule.

* Native stand.

Comparison of Tables IIa and IIb indicates that only at age seventy is a net income realized, and then a mere 9¢ per acre per year. The average

annual gross income and costs of production are discounted and amortized in the same manner as was done in the previous evaluation. There is a significant additional income to the landowner, however. Under the current government subsidy program, eighty per cent of the cost of land clearing and tree planting is reimbursed through ACP payments. In addition, when the landowner does his own work, he is entitled to a return for his administration and labor throughout the stand life. The ACP payments may be treated as a reduction in total cost, and thus become a noncash cost to the landowner. As the costs no longer have to be paid out of his future income, the actual total income is increased and, in effect, the ACP payments, if received, will become an income. Assuming an 80% ACP reimbursement for land clearing and tree planting, plus the labor income, the revised income will be increased by $1.13 (discounted and amortized data from Table IIa, age 70) to a total income of $1.22 per acre annually.

At the optimum cutting date of seventy years, the landowner will realize an average annual equivalent cash income of $1.22 per acre, as compared to $.66 in the analysis of conditions without restocking. This represents nearly an 85% increase in the income-producing ability of the 100-acre analysis block, but only if he receives ACP assistance in clearing and planting, plus his management and labor incomes. In a situation such as this, it appears that the landowner is merely "buying himself a job" and the return to the investment in land (land rent) is nearly "0", if not a negative value.

EVALUATION III. MANAGED RESTOCKED STANDS

The third evaluation is for an intensive management program to be applied to the hundred-acre unit. An entirely different management concept is used. From the start, the practices are designed to create the greatest volume of merchantable wood of the best quality in the shortest period of time. Proper spacing of trees is considered, best planting stock analyzed, and the effects of pruning investigated. Also, periodic harvest cuts will be made. Emphasis is placed on the cause-and-effect type of analysis for individual practices, as well as a determination as to whether over-all management is a good buy.

Periodic Intermediate Cutting

Of all the practices instituted, commercial thinning is the most important. This practice results in several marked effects which have important economic aspects. Major results are: (1) Producing income for the landowner at an earlier date, (2) relieving competition so that pristine vigor is maintained and trees grow at the rate of dominants and co-dominants, (3) salvaging what is normally

considered a loss by mortality in unmanaged stands, and (4) producing larger diameter trees having a greater volume of merchantable timber at any given age.

This concept of management on which the harvest thinnings are made is based on SCS-TP-132 by Krauter and Baker 6/ which states: ". . . based on the thesis that the competitive status of a uniformly stocked stand is reflected by the total basal area and number of stems per acre. When basal area is reduced by removing stems, there is an increase in the average growth rate of remaining stems released from competition. Therefore, from the standpoint of management, the important point in the reduction of basal area is that point at which competition is just eliminated. The objective is to give the stand just the growing space needed, so that the basal area would increase back to the control point by the end of the cutting cycle adapted for management."

Under an intensive management program, trees are spaced initially, and then are never allowed to grow into competition and become retarded. At age thirty, and periodically thereafter, harvest thinnings are made with the weakest or deformed trees being cut first. Remaining trees are growing higher and to larger diameters than average trees in unmanaged stands of like age. An important point is that the total volume of growth for a given acre of trees is not increased, but it will be produced on fewer stems. 9/ The periodic harvest cuts are based on a basal area of a minus 60 square feet. (See Table IIIa, Site Index 140.)

Timber Yields for Managed Stands

The expected yields of merchantable timber from managed stands of Douglas Fir have not been established. As second growth management has not been extensively practiced until recently, only limited data have been recorded. There is, however, little doubt that more merchantable timber can be produced in a limited time -- how much is still an open question.

The starting point in discussions of yields is U. S. D. A. Technical Bulletin No. 201 entitled "The Yield of Douglas Fir in the Pacific Northwest," by McArdle and Meyer. 5/ This study was conducted on unmanaged, even-aged stands growing in heavy competition. Sizes of these trees varied tremendously in height and diameter, even though the trees were the same age. On managed sites, however, all trees should be growing at a rate equal to that of dominant and co-dominants. This raises the average diameter growth rate by as much as 50% over that of the unmanaged stands. Average height is also increased, as well as the volume of merchantable timber at any given age. An additional growth increment may be realized if the trees, when able to grow free of competition, will grow faster than the dominants and co-dominants of unmanaged stands do

Table IIIa - Calculated Thinning and Production Schedule per Acre for Young Douglas Fir Stands Based on 50% Increase in Diameter Growth Rate and a Management Control on Basal Area of a Minus 60 Square Feet Below That of a Normal Stand 1/

Age Class (Years)	Average Diameter (Inches)	Average 2/ Height (Feet)	Trees Removed (Number)	Trees Remaining (Number	Basal Area Remaining (Square Feet)	Volume 3/ Removed (Board Feet)	Volume 3/ Remaining (Board Feet)
			SITE INDEX 110				
40	7.6	70	106	288	91	11.4 Cds	31.1 Cds
50	9.8	82	64	224	117	2,560. BF	8,960. BF
60	12.0	92	39	183	144	4,250.	19,950.
70	14.0	101	24	159	170	4,270.	28,300.
80	15.6	107	159	0	187	38,790.	0.
			SITE INDEX 140				
30	7.2	67	143	281	79	12.9 Cds.	25.3 Cds.
40	10.0	89	75	206	112	4,500. BF	12,360. BF
50	12.8	104	45	161	144	6,840.	24,470.
60	15.5	116	30	131	172	8,010.	34,980.
70	18.0	127	20	111	196	7,940.	44,060.
80	20.3	136	111	0	0	60,710.	0.
			SITE INDEX 170				
30	8.8	81	86	196	83	1,980 BF	4,500. BF
40	12.4	107	53	143	120	8,210	22,160.
50	16.0	126	31	112	156	9,860	35,620.
60	19.3	140	19	93	189	9,970	48,830.
70	22.3	153	19	74	200	14,740	57,420.
80	25.2	164	74	0	0	79,840	0.

1/ As determined by Technical Bulletin No. 201.

2/ Based on increased height growth rate of 10% over normal rate for dominants and co-dominants (TB No. 201).

3/ Scribner Rule.

NOTE: This is the table on which the entire management system for this study is developed. If other calculated thinning and production schedules are used, it will not affect the evaluation procedure, but merely change the numbers used.

now. Intermediate and suppressed trees do use plant nutrients before they die, and if they were never there (proper initial stocking), or were removed, a portion of these nutrients would be available for use by the crop trees. Certainly, average crown development should be greater in a stand managed from an early age, and this will aid in tree growth.

From the above discussion, it becomes apparent that intermediate harvest cuttings substantially increase the yields of merchantable timber in a limited period of time. 7 / Experience in the Northwest indicates that 100% increase in average diameter growth of native stands is a reasonable, and possibly even conservative, expectation. 8 / In this report we are assuming that a 50% increase in average diameter growth, and a 10% increase in height growth will result from management. (See Table IIIa, Site Index 140.) This is merely harvesting mortality in a saleable form, and developing a larger average tree containing a greater percent of merchantable timber in a shorter time.

Steps in the Management Program

Land Clearing

Evaluation Unit III has the same starting situation as Unit II. A portion of the management unit must be cleared before the trees can be planted; part of the area is inoperable, and part is in young Douglas Fir reproduction.

Once the land is cleared, the next step is to plant the trees. Satisfactory stocking of a forest site depends on the yields and type of products the landowner wishes to produce. Good management is designed to give the maximum usable product in the shortest time and at the least cost. In this analysis, a saw log is the first real commercial product, although salvage thinnings at thirty years will yield merchantable stud logs or cordwood. A thinning before this time is considered to have no income value. In this management program, an 8' x 8' initial planting, with a replanting, is used. A full discussion of the reasons for the various management decisions is shown in the Appendix.

By proper initial stocking of the planted stand, only the natural stand (growing in a normally dense block) will require a precommercial thinning to assure maximum growth. A first concern to the landowner will be to thin at the least cost. As the stems presently range from 5 to 15 years of age, some will have a market as Christmas trees. To simplify the evaluation, it is assumed that sale of part of the thinned stems for this purpose will offset the entire thinning

cost. After the initial thinning, management of the two portions of the stand should be the same, except for the 10-year age difference.

Pruning of trees which will remain in the stand until they are at least 16" in diameter, is considered a good forest management practice. This is done to 125 trees per acre to produce high quality veneer logs commanding premium prices. These trees should be marked so that they can be identified later in the rotation. The trees are pruned in two stages -- at ages 20 and 30 -- to heights of 12' and 18', respectively. A full discussion of the economic aspects of pruning is contained in the Appendix.

Periodic intermediate harvest cuts are made at 10-year intervals, as explained earlier in this section. This work entails selection and marking of trees to be cut, and increased amounts of management and bookkeeping in arranging for timber sales and supervising the cutting. Land taxes accumulate from year one, and the timber tax commences at age 40. A summary of production costs follows:

Summary of Timber Production Expenditures

1. Land Clearing

a. Preclearing stocking survey (100 acres)	$ 32.00
b. 35% in fir trees	0
c. 15% remains inoperable	0
d. 30% brush cleared (per cleared acre)	21.67
e. 20% open grass area (per cleared acre)	12.50
f. Brush burning (per 100 acres)	8.00

2. Tree Planting 8 x 8 spacing -- 50% survival (per planted acre)

a. Tree stock, 681 trees @ .9¢	6.13
b. Planting labor, 681 trees @ 4¢	27.24
c. Replant, 170 trees @ 5.9¢	10.03
Cost per planted acre	$ 43.40

3. Pruning (per pruned acre)

a. Selection and marking (100 acres)	$ 44.00
b. Age 20, 125 trees pruned to 12' @ 8.82¢	11.02
c. Age 30, 125 trees pruned to 18' @ 22.58¢	28.22

4. Administration (per acre)

Starting at age 20 -- an annuity of 1 per year $ .25

5. Harvest Cuts Selection and Marking (per acre)

Age 20 -- .85 per acre	Age 60 -- .45 per acre
Age 30 -- 1.90 per acre	Age 70 -- .30 per acre
Age 40 -- 1.05 per acre	Age 80 -- 0 per acre
Age 50 -- .65 per acre	

(charge each 10-year cycle)

Summary of Timber Production Expenditures (Cont'd)

6. Arrangement for Sales (per acre)

Age 20 --	$ .30 per acre
Age 30 --	.80 per acre
Age 40 --	.70 per acre
Age 50 to 80 --	.35 per acre

(charge each 10-year cycle)

7. Land Tax (per acre)

Years 1-80 @ .33 per acre per year -- $ .33

8. Timber Tax, varies on formula as follows:

a. Current volume of merchantable timber.
b. Multiplied by current stumpage price.
c. Multiplied by 25% for assessed value.
d. Discounted by 5% (.73 safety factor) and number of years from harvest.
e. Multiplied by tax factor -- 6.62%/$100 remaining value.

The above list of costs is converted to a common acre basis and weighting is given to the two different ages of stands. The native stand is ten years older; so costs and harvested volumes are adjusted accordingly. For each acre, 50% will be a planted stand, 35% will be a native stand and the remainder is considered inoperable because of slope or clearing difficulties. As expenses and income occur at different intervals, and in different amounts through the stand life, they are both carried at compound interest. This essentially means that as it occurs, the income is used to pay some of the costs incurred to that date, yet it is not necessary to say which ones, how much, or when.

Computing Average Annual Equivalent Net Income

Table IIIb itemizes the various production costs, accumulates them at 4% interest to a final rotation date of 80 years, and also totals the costs on a rotation or time interval. This last is done to help determine at what point it is most beneficial to "clear cut" and start over.

Table IIIc shows the weighted per acre yields expected under good management, both in board feet and as its value if it were sold at any given age. Periodic incomes are brought forward at 4% interest to a final harvest at 80 years. As yields are shown in the Table, the top figure at a given age is the production from the planted portion, and the bottom of the two is for the native stand. Incomes from the two are subtotaled for each harvest cut. As the native stand is 10 years older, the first income at age 20 is entirely from it.

Table IIIb - Accumulated Individual, Total and Average Annual Equivalent Costs per Acre by Time Periods for Intensively Managed Douglas Fir. Site Index 140 1/

Age Class (Years)	Land Clearing (Dollars)	Stand Planting (Dollars)	Pruning (Dollars)	Administration (Dollars)	Selection & Marking Harvest Cuts (Dollars)	Arrangement for Timber Sales (Dollars)	Land Tax (Dollars)	Timber Tax (Dollars)	Accumulated Costs to Age Interval (Dollars)	Average Annual Equivalent per Acre (Dollars)
0	9.40	21.70	--	--	--	--	.33	--	31.43	31.43
10	13.91	32.12	3.47	--	--	--	3.96	--	53.46	4.45
20	20.59	47.54	19.37	.25	.85	.30	9.82	--	98.72	3.31
30	30.47	70.37	42.78	3.00	3.16	1.24	18.51	--	169.53	3.02
40	44.95	104.16	63.32	7.44	5.73	2.54	31.36	5.64	265.14	2.79
50	66.54	154.18	93.72	14.02	9.13	4.11	50.38	41.95	434.03	2.84
60	98.49	228.22	138.72	23.76	13.96	6.43	78.54	131.37	719.49	3.02
70	145.78	337.82	205.33	38.17	20.96	9.87	120.21	324.72	1,202.86	3.30
80	215.78	500.05	303.94	59.50	31.02	14.96	181.91	595.80	1,902.96	3.45

1/ Costs have been adjusted for two different ages of trees and for an area requiring only partial land clearing and planting and management practices at different time periods.

Table IIIc - Per Acre Yield of Merchantable Timber, Total and Average Annual Equivalent Gross Income by Time Periods for Intensively Managed Stands of Douglas Fir, Site Index 140 1/

Age of Stand (Years)	Price Received $/MBM	Volume of Merchantable Timber Removed 2/ (Board Feet)	Income per Cutting Cycle (Dollars)	Income Compounded at 4% (Dollars)	Remaining Merchantable Timber 2/ (Board Feet)	Value of Remaining Timber (Dollars)	Total Income by Cutting Interval (Dollars)	Average Annual Equivalent Income (Dollars)
20	6.00	4.5 Cds.	27.00	0	8.86 Cds.	53.16	80.16	2.69
30	6.00	6.4 Cds.	38.40		12.6 Cds.	75.60		
30	14.00	1,575.0	22.05		4,326.0	60.56		
			60.45	100.42		136.16	236.58	4.22
40	14.00	2,250	31.50		6,180	86.52		
40	23.00	2,394	55.06		8,564	196.97		
			86.56	235.20		283.49	518.69	5.46
50	23.00	3,420	78.66		12,235	281.40		
50	23.00	2,804	64.49		12,243	281.59		
			143.15	491.30		562.99	1,054.29	6.90
60	23.00	4,005	92.12		17,490	402.27		
60	35.00	2,779	97.26		15,421	539.74		
			189.38	916.62		942.01	1,858.63	7.81
70	35.00	3,970	138.95		22,030	771.05		
70	35.00	21,248	743.68		0	0		
			882.63	2,239.45		771.05	3,016.50	8.28
80	35.00	30,355	1,062.42	4,377.34	0	0	4,377.34	7.94

1/ Yields have been adjusted on the basis of 35% natural stand, 50% planted stand and 15% unproductive. The natural stand is 10 years older than the planted one.

2/ Scribner Rule -- Yields based on data shown in table IIIa.

A comparison of the two tables shows that the 70-year rotation maximizes net income at $4.98 per acre. The 60-year rotation follows closely with a per acre net income of $4.79. This clearly points out the effect that rapidly increasing taxes and compounding interest have over a lengthening time period.

Maximizing Income by Rotation Length

Average Annual Equivalent Incomes and Expenses

Age	Production Costs	Gross Income	Net Income
30	$ 3.02	$ 4.22	$ 1.20
40	2.79	5.46	2.67
50	2.84	6.90	4.06
60	3.02	7.81	4.79
70	3.30	8.28	4.98
80	3.45	7.94	4.49

The forest budget for an intensively managed stand of Douglas Fir was prepared to include all items that go into production of timber, except, of course, the return to the investment in land. This is to be paid out of the net income as discussed in Evaluation I. Forestry, however, may have hidden incomes to an individual landowner in the form of labor income and ACP payments. To illustrate the value of these, assume ACP pays for 80% of land clearing and tree planting, and 75% of pruning. Additionally, the landowner does his own work and receives a labor income for administration done, the selection and marking of harvest cuts, and arrangement of timber sales. The remaining 25% of the pruning cost may or may not be farmer labor. The average annual equivalent costs are computed by discounting the accumulated costs at the end of the rotation to present worth, and then amortizing them over the same length of rotation. The ACP payments and return to labor and management

are the percentage as listed above. If this description fits the landowner's situation, then the annual costs which become a cash income are:

Average Annual Equivalent Costs -- 70-yr. Rotation

Item	Total Cost	Labor Management & ACP Reimbursed Costs
Land Clearing	$ .40	$ .32
Stand Planting	.93	.74
Pruning	.56	.42
Administration	.10	.10
Selection, Marking for Harvest	.06	.05
Arrangement of Timber Sales	.03	.03
Land Tax	.33	.0
Timber Tax	.89	.0
Total	$ 3.30	$ 1.66

Total income received by the landowner for the 70-year rotation equals the net income of $4.98 plus the additional income of $1.66, or a total cash income per year of $6.64 per acre of the management block. For Site Index 140 and a situation such as has been described, the returns to full management are nearly 1,000% greater than if the stand is left unimproved. This represents an increase of $600 per 100-acre block in additional income each year.

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APPENDIX

Most management decisions have economic ramifications. Once a landowner makes the decision to plant a timber stand, it is important that he know how best to do this "economically" as well as physically. In the following section, a series of comparisons are shown, of alternative methods of doing various management jobs. The purpose is to illustrate how easily a "commonsense" use of economics can be applied to individual management decisions when the physical data are available. Any of the procedures can be used on local data in a manner similar to that shown here.

Number of Seedlings Required

The number and spacing of planted seedlings are dependent on the maximum number of trees allowable up to the time a saleable product can be produced. For Site Index 140, and under our assumed management program, 424 trees can normally be carried up to 30 years, at which time 143 should be thinned and sold as stud logs or cordwood. (See Table IIIa.) To obtain maximum income from the stand under this management, 424 trees should be established and survive to age 30.

In establishing a fully stocked stand, the landowner must make several decisions after the site has been prepared. Each of these decisions will have an effect on either costs or returns, or both. In the following analysis, based on material and experience of forest technicians, comparisons are made of some of the management alternatives.

Spacing of Seedlings

Based on the objective of 424 trees per acre, at 30 years of age, three common planting spacings, 6' x 6', 6' x 8', and 8' x8' should be considered. Each stocking has certain advantages and disadvantages, and will vary from the others in cost. In order to compare them monetarily, the following criteria were established as average:

1. Most common seedling stock used: 2-0.
2. Average seedling survival rate for 2-0 stock is 50%.
3. Cost of Seedlings

   Cost of trees at State nursery: $8.00 per 1000 trees.
   Estimated cost of getting trees to site: $1.00 per 1000 trees.
   Cost per tree to plant is $.09.

4. Labor of Planting

   In a 9-hour day, one man can plant an average of 500 trees, or 18 hours per 1000 trees.

4. Labor of Planting (Continued)

   $36.00 x 10% (for overhead) = $39.60 -- use $40/1000.
   Cost of labor to plant = $.04 per tree.

5. Labor of Replanting -- 25% increase (estimated)

   $0.04 x 125% = $0.05 per tree.

6. Rate of Precommercial Thinning is approximately 60 trees per hour, or 3.3¢ per tree.

Per Acre Cost of Establishment at Various Stocking Rates

Production Items	6x6 (1210 trees)	6x8 (907 trees)	8x8 (681 trees)
Trees, 2-0 @ $.09	$ 10.89	$ 8.16	$ 6.22
Planting labor - $.04/tree	48.40	36.28	27.24
Subtotal	59.29	44.44	33.46
Replant, 170 trees x $.06	-	-	10.20
Total	$ 59.29	$ 44.44	$ 43.66
Trees surviving at 30 years	605	453	425

Using a 6x6 spacing and a 50% survival, the stand will be overstocked by 181 trees. A precommercial thinning would be required at an estimated cost of $5.97 (181 trees x 3.3¢). This cost, when discounted 20 years, brings the total cost of establishing a fully stocked stand to $62.02. The high per acre cost should eliminate this as an economic alternative.

The 6x8 spacing is overstocked by only 29 trees at age 30. If the surviving seedlings were well distributed over the area, the excess trees would not be a problem. Mortality may be localized so that in some areas stocking will be too dense, and in others too sparse. As an average, the 29 trees x 3.3¢ = $.96 is shown as a token cost. Tree planting and subsequent discounted precommercial thinning costs total $44.95, which makes this economic alternative well worth considering.

The 8x8 initial planting and 25% spot replanting should give the most evenly distributed stand of the three alternatives as the mortality "holes" are replanted. The resulting stand will be essentially fully stocked at 30 years, and no precommercial thinnings are required. This is the least costly alternative, and should produce the best balanced acre of trees. This method has the further advantage that in the few good survival years, no replanting would be necessary, thus reducing costs. In the 6x6 and 6x8 spacings, increased survival means increased precommercial thinnings, thus raising costs.

Does it Pay to Stock a Stand Fully?

A major decision facing landowners in areas of poor survival is whether it pays to spot replant in an area once it has been initially stocked. Blanks in growing trees are readily apparent, yet loss of future income is difficult for the landowner to measure. This is not an involved procedure, however, as it entails merely a comparison of cost inputs with reduced saleable products or foregone income.

The previous analysis shows the 8x8 spacing to be the most economical, even with a $10.20 cost per acre for a replant operation. The question is: Did it pay to spend the extra $10.20 to obtain full stocking? With 8x8 spacing and 50% survival, 340 trees per acre will be in the stand at 30 years. This is 84 trees short of full stocking. Table IIIa shows that at 30 years, 12.9 cords of wood are produced from 143 trees, or .09 cords per tree with adequate stocking on Site 140. As this stand is 84 trees short, 7.56 cords of wood per acre will not be produced. This is a reduction of income of $45.36 thirty years from now, if no replanting is done.

Returns due to replanting	= $ 45.36
Costs of replanting @ 4% accumulated 30 years $10.20 x 3.24339	= 33.08
Net return per acre 30 years from now	= 12.28
Net return for each dollar spent	= 1.37

Replanting in this case is obviously a good investment. After paying 4% interest for 30 years on money spent today, the landowner will still receive $1.37 for each dollar spent.

Selection of Age of Planting Stock

Most of the Douglas Fir seedlings available from the State nursery are 1-0 and 2-0 material. This means that the seedlings have spent either a year or two years in the nursery. Experience of local forest technicians indicates this material has an average survival rate of 50%. Recently, a few landowners have experimented on a small scale with transplanting 2-0 stock in a furrow in a garden spot for a year before planting. Limited results were gratifying, as a minimum 65% to 70% survival was obtained. If survival of an 8x8 planting was raised even to 60 percent, nearly a full stand would be achieved. Although 2-0 stock is used in the study, a hypothetical problem is

is suggested for analysis: Whether it would pay to plant 2-1 stock. The assumptions are based on very limited data, and more research will be needed before recommendations could be made in this regard.

1. Cost of 2-0 stock on farm -- $9.00 per 1,000.
2. Extra cost -- 1 hour or $2.00/1,000 required for handling in transplanting and digging for field planting.
3. Total cost -- $11.00 per 1,000, or 1.1¢ per tree.
4. Labor of planting increased -- 20-30% over 2-0 stock $.04 x 125% = $.05 per tree.
5. Using 8x8 spacing:

Trees, @ 1.1¢ x 681 trees	=	$ 7.49
Planting, @ $.05 x 681 trees	=	34.05
Total Planting Cost		$ 41.54

If the assumptions above are a reasonable average, planting 2-1 stock is a good management decision, saving $2.12 per acre initial cost.

Pruning

As part of an intensive management program, pruning of crop trees may be recommended. The pruning will yield an improved quality of log. The result is that when the diameter size of the pruned stems exceeds 16 inches, the logs can be sold as peelers and for a higher price.

The first step necessary is the selection and marking of trees to be pruned. Based on the trees remaining in the stand at 16 inches, 125 trees are selected. Trees should be permanently marked so that they can be identified later in the rotation. This survey is estimated to require four hours of a forest technician's time, and sixteen hours of the landowner's labor, at three and two dollars an hour, respectively. The total cost will be $44 per 80 acres surveyed, or 55¢ per acre for the management unit.

The second common management decision is whether to prune in one or two operations. Some feel that it is cheaper to do the operation all at once and at an earlier age. Others feel that to prune eighteen feet of a tree all at once removes too much crown and retards tree growth. They prefer to partially prune at the early age, say 20 years, and then complete the operation at 30 years, even though the second pruning costs are more than if done when the stem was smaller. Aside from whatever physical reactions there may be, one of the two methods may have

a definite economic advantage. Based on the following framework, the two methods are compared:

1. From a sample case, it requires:
   a. 7.5 hours @ $2.00 to prune 170 trees 12 feet high, or 8.82¢ per tree.
   b. 16 hours @ $2.00 to prune 170 trees from 12 to 18 feet high, or 18.82¢ per tree.
   c. If trees are pruned at the same time, the cost is 27.64¢ per tree.
2. If trees are pruned at 2 intervals, it requires 20% more time to do the 12-18 ft. pruning.
   a. First pruning -- 8.82¢ per tree.
   b. Second pruning 18.82 x 120% = 22.58¢ per tree.
3. Costs will be compared at 30 years, using 4% compound interest, as required.

Summary of Pruning Costs

1. Selection and marking at age 20 - $ .55 per surveyed acre.
2. Pruning - age 20, to 12 ft. 11.02 per acre.
3. Pruning - age 30, to 18 ft. $28.22 per acre.

Single Pruning Method

1. At age 20, prune 125 trees 18 ft. high @ 27.64¢ = $34.55.
2. Carried at 4% compound interest for 10 years.
   $34.55 x 1.48024 = $51.14 total cost at age 30.

Two-Stage Pruning Method

1. At age 20, prune 125 trees 12 ft. high @ 8.82¢ = $11.02.

1a. Carried at 4% compound interest for 10 years.
   $11.02 x 1.48024 = $16.31 at year 30.

2. At age 30, prune 125 trees to 18 ft. high @ 22.58 = $28.22.
3. $16.31 + $28.22 = $44.53 total cost at age 30 years.

An economic comparison shows that the landowner would save $6.63 per acre if he were to do his pruning in two steps. The compounded interest would be substantially greater than the added labor required

for pruning at an older age. Actually, the labor could be 45% more, and the two-stage pruning method would still be slightly cheaper.

Does it Pay to Prune at All?

Although pruning is recommended as a good forest management practice, it should be examined for each site to see if the added price will pay the cost of pruning plus compound interest for 40 or 50 years. This comparison can easily be made by assuming that if pruning wasn't done, the price on Table IIIc would remain at $23.00, or a loss of income of $12.00 per thousand board feet sold, for the 70-and 80-year cuttings. This lost income can be compared with the 30-year cost of pruning carried at compound interest for 50 years, as it would have resulted from pruning. Based on volumes listed in Table IIIa, the following analysis can be made:

Returns - due to pruning:

Age 70, 7,940 b.f. x $12.00 = $95.28	
$95.28 x 1.48024 (4% compound interest for 10 years) . . . . . =	$141.03
Age 80, 60,710 b.f. x $12.00 = $728.52	728.52
Total Returns due to pruning	$869.55

Pruning Cost -- $45.08

$45.08 x 7.10668 (4% compound interest for 50 years) . . . . . =	$320.37
Net return per acre -- 50 years from final pruning	549.18
Return for each dollar spent	$ 2.71

It is readily apparent that pruning is a good investment for this site. Not only will the money spent on it earn 4% interest, but each dollar spent will return $2.71.

Costs and Returns for a Fully Planted Acre

In the main study, it was determined that for the illustrative site as described, management was a good investment. This may not be true for all sites, however, and especially if a natural stand does not exist on any part of the area. In order to determine the income for varying site conditions, three site indices (170, 140, 110) representing the midpoints of forest site classes II, III and IV were chosen for analysis.

For each site, a fully stocked, even age stand is used, and the management controlled by the data contained in Table IIIa. Data for the three sites are summarized in Tables IVa and IVb. The costs involved were

Table IVa: Per Acre Yields of Merchantable Timber, Total and Average Annual Equivalent Gross Income by Time Periods for Managed Fully-Stocked Stands of Douglas Fir by Site Indices

Age of Stand (Years)	Price Received (Per 1000 B.F.)	Volume of Merchantable Timber Removed (Board Feet)	Income per Cutting Cycle (Dollars)	Income Compounded at 4% (Dollars)	Volume of Merchantable Timber Remaining (Board Feet)	Value of Remaining Timber (Dollars)	Total Income per Cutting Cycle (Dollars)	Average Annual Income (Dollars)
				Site Index 110				
40	(cord) 6.00	11.4	68.40	68.40	31.1	186.60	225.00	2.37
50	14.00	2,560	35.84	137.08	8,960.	125.44	262.53	1.72
60	23.00	4,250	97.75	300.66	19,950	458.85	759.51	3.19
70	23.00	4,270	98.21	543.26	28,300	650.90	1,194.16	3.28
80	23.00	38,790	892.17	1,696.32	0	0	1,696.32	3.08
				Site Index 140				
30	(cord) 6.00	12.9	77.40	77.40	25.3	151.80	229.20	4.09
40	14.00	4,500	63.00	177.57	12,360.	173.04	350.61	3.69
50	23.00	6,840	157.32	420.17	24,470	562.81	982.98	6.44
60	23.00	8,010	184.23	806.18	34,980	804.54	1,610.72	6.77
70	35.00	7,940	277.90	1,471.24	44,060	1,542.10	3,013.34	8.27
80	35.00	60,710	2,124.85	4,302.64	0	0	4,302.64	7.80
				Site Index 170				
30	14.00	1,980	27.72	27.72	4,500	63.00	90.22	1.61
40	23.00	8,210	188.83	229.86	22,160	509.68	739.54	7.78
50	35.00	9,860	345.10	685.35	35,620	1,246.70	1,932.05	12.66
60	35.00	9,970	348.95	1,363.43	48,830	1,709.05	3,072.48	12.91
70	45.00	14,740	663.30	2,018.20	57,420	2,583.90	4,602.10	12.63
80	45.00	79,840	3,592.80	6,580.22	0	0	6,580.22	11.93

Table IVb: Accumulated Individual, Total and Average Annual Equivalent Costs per Acre by Time Periods for Managed Douglas Fir Sites

Age Class	Clearing	Planting	Pruning	Administration	Selection & Marking of Harvest Cuts	Arrange for Sales	Land Tax	Timber Tax	Total Costs	Average Annual Costs
					Site Index 110					
0	18.45	39.94	xxx				.33		58.72	58.72
10	27.31	59.12					3.96		90.39	7.53
20	40.42	87.51					9.82		137.75	4.62
30	59.83	129.53					18.51		207.87	3.71
40	88.56	191.73		.25	.44	1.00	31.36		313.34	3.30
50	131.09	283.81		3.00	.97	2.48	50.38	9.72	481.45	3.15
60	194.04	420.10		7.44	1.75	4.17	78.54	42.60	748.64	3.14
70	287.22	621.84		14.02	2.75	6.67	120.21	133.31	1,186.02	3.25
80	425.15	920.47	xxx	23.75	4.15	10.37	181.91	294.22	1,860.02	3.37
					Site Index 140					
0	18.45	43.66					.33		62.44	62.44
10	27.31	64.62					3.96		95.89	7.99
20	40.42	95.65	11.02				9.82		156.91	5.30
30	59.83	141.58	44.53	.25	.44	1.00	18.51		266.14	4.74
40	88.56	209.57	65.91	3.00	.97	2.48	31.36		401.85	4.23
50	131.09	310.21	97.56	7.44	1.75	4.17	50.38	30.32	632.92	4.14
60	194.04	459.18	144.41	14.02	2.75	6.67	78.54	109.07	1,008.68	4.24
70	287.22	679.69	213.76	23.75	4.15	10.37	120.21	293.16	1,632.31	4.48
80	425.15	1,006.10	316.41	38.16	6.18	15.35	181.91	664.20	2,653.46	4.81
					Site Index 170					
0	18.45	34.20					.33		52.98	52.98
10	27.31	50.62	12.34				3.96		94.23	7.84
20	40.42	74.92	49.87				9.82		174.83	5.87
30	59.83	110.89	73.81	.25	.44	1.00	18.51		264.73	4.72
40	88.56	164.14	109.25	3.00	.97	2.48	31.36		399.76	4.20
50	131.09	242.96	161.71	7.44	1.75	4.17	50.38	71.34	670.84	4.39
60	194.04	359.63	239.36	14.02	2.75	6.67	78.54	242.38	1,137.39	4.78
70	287.22	532.33	354.31	23.75	4.15	10.37	120.21	607.53	1,939.87	5.32
80	425.15	787.97	524.46	38.16	6.18	15.35	181.91	1,287.15	3,266.33	5.92

computed in the same manner as shown, except that they are adjusted for even-aged, fully stocked areas. Yields are also based on a fully stocked stand. They are determined by a 50% increase in diameter growth and a 10% increase in height growth over that shown for unmanaged stands in U. S. D. A. Technical Bulletin 201. Harvest thinnings are based on a basal area of a minus 60 square feet below that of an unmanaged, fully stocked Douglas Fir stand.

Site 110

Site 110 is generally not considered a productive site, as the trees are very slow growing. Also, the site will support fewer stems of a given size per acre. The main effects of the slower growth are to delay management practices by 10 or more years, decrease the amount of stems planted per acre, and make pruning uneconomical. Clearing and planting costs are adjusted to a full acre; and the costs of administration, selection and marking of harvest cuts, and arrangement for sales, are adjusted to the initial harvest date. The timber tax will vary with the volume produced.

For Site Index 110 a comparison of annual costs and income is as follows:

	Average Annual Equivalent		
Age	Costs	Gross Income	Net Income
40	$3.30	$2.37	$- .93
50	3.15	1.72	-1.43
60	3.14	3.19	.05
70	3.25	3.28	.03
80	3.37	3.08	- .29

Management on such a low site is a marginal practice. Only at ages 60 and 70 is a net income realized, and then little more than breaking even. Where applicable, the farmer may receive a labor and management income or government reimbursement, in addition to the net income. This may be computed in the same way as was done in the study.

Site 140

The management used on this site is exactly the same as was used in the study Evaluation III. The difference is that in the study there was a partially stocked two-age stand, and now the costs and yields are based on a fully stocked, even-age stand. As with Sites 110 and 170, the entire area is cleared and replanted, which raises these costs materially. The remaining costs and yields are computed on the same basis as before.

On this site a reasonable net income is realized at ages 50 through 80. The optimum financial rotation earns $3.79 per acre per year through a 70-year rotation.

Age	Average Annual Equivalent		
	Cost	Gross Income	Net Income
30	$4.74	$4.09	$ - .65
40	4.23	3.69	- .54
50	4.14	6.44	2.30
60	4.24	6.77	2.53
70	4.48	8.27	3.79
80	4.81	7.80	2.99

Site 170

This is a highly productive site. Not only is a greater volume of merchantable timber produced, but it can be harvested at an earlier age. As the data in Table IIIa does not show the yield at age 20, we cannot include this income. The planting costs were adjusted, however, to the trees remaining after the initial cut, thereby partially offsetting the unclaimed income. All costs tied to the initial harvest cut are also adjusted to age 30. As sites improve and growth rates increase, it pays to prune more trees, as more will reach the larger diameter sizes, and thus bring peeler prices if pruned.

Site Index 170 produces a good net income at each interval, except 30 years of age. Net income is maximized at 50 years of age. Rapidly increasing timber taxes account for the shorter financial rotation on this site.

Age	Average Annual Equivalent		
	Cost	Gross Income	Net Income
30	$4.72	$ 1.61	$ -3.11
40	4.20	7.78	3.58
50	4.39	12.66	8.27
60	4.78	12.91	8.13
70	5.32	12.63	7.31
80	5.92	11.93	6.01