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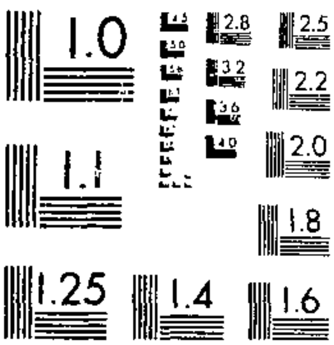

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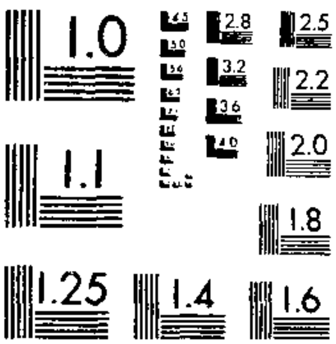

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Technical Bulletin No. 830 • August 1942

UNITED STATES DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.

Economic Management of Western White Pine Forests[1]

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CONTENTS

INTRODUCTION

For over a third of a century exploitation of the western white pine forests of northern Idaho has been based upon the harvesting of virgin timber. In recent years, however, with the end of this ready-made crop definitely in sight, interest in the growing of new timber crops has been increasing. Particularly within the last decade, large public investments, including expenditures for control of the white pine blister rust and for such forest-improvement measures as disposal of defective trees and thinnings have resulted in definite commitments toward growing timber on a long-time basis.

These heavy public forestry investments have given many people reason to pause and wonder, "Is it worth while?" No categorical answer can be given; it must be recognized that the values involved are affected by other than purely economic or technical considerations. Some forest benefits cannot be measured with realistic completeness in dollars or board feet. But surely, costs and values, to the fullest extent that they can be identified, have meaning in public as in private

[1] The material presented in this publication was offered to the University of Michigan in partial fulfillment of the requirements for the degree of Doctor of Philosophy and covers studies made by the author as a member of the Northern Rocky Mountain Forest and Range Experiment Station staff. Acknowledgment is made to W. S. Rosenberry and the late W. M. Keeler of the Winton Lumber Co. for generously and freely giving access to company records; H. E. Swanson and J. C. Evenden, Bureau of Entomology and Plant Quarantine, for original material on blister rust and insect control problems; and to D. M. Matthews of the University of Michigan for guidance in planning this study.

undertakings. Since unlimited capital resources are never available, it is as essential for the public as for the private investor to expend funds to obtain the greatest total benefit. The point of view and unit of measure often differ, but the fundamental purpose is the same. Careful and thorough economic investigations are necessary and useful aids in determining what public investments, relatively at least, are the most desirable.

Such is the viewpoint adopted in this study. Dollars and board feet are necessarily employed as units of measure—a truly meaningful social dollar or other unit of productive accomplishment has not yet been devised—and, since the best data available are used in the study, the results are of significance in absolute terms. But major emphasis throughout is placed on relative values; on getting the most out of every dollar available for timber management. No attempt is made to weigh timber production against the many other forest uses. The study is concerned only with timber growing on its own merits so far as this is a tenable viewpoint.

The western white pine region of northern Idaho and contiguous parts of eastern Washington and western Montana (fig. 1), in which timber production is a dominant forest use, is unusually suitable for such an investigation. The region is a fairly compact geographical and economic unit (fig. 2); yet one of sharp contrasts with a full quota of economic and silvicultural problems. Protection of the forests from fire, disease, and insects is as difficult as in any other forest region of the United States, and perhaps more expensive. The forests are composed of variable associations of five or more species of considerable silvical diversity and a broad range of values. Topographically, the region is characterized by sharp relief, creating wide variations in site quality within a small geographic compass (fig. 2). Some parts are highly productive, comparing favorably with other softwood-producing timberlands in the United States, while others often in close proximity are of very low site quality, supporting a forest cover of little commercial value. Although timber-growing costs are high, timber values are also high because of the valuable western white pine, of which the largest remaining supply in the United States is in this region. Other species, except western redcedar in minor quantities for transmission poles, normally have from negative to low positive stumpage values. The timber industry in the region is built around and made possible by the high value of western white pine (*7*).[2]

This study is divided into four parts. The first considers the best forest rotation and criterion of regulatory and economic policy. The second analyzes four types of forest stands exemplifying major silvicultural problems in the region to bring out the relative desirability of various silvicultural methods. The third gives a concrete account of past and present forest practices in a representative part of the region. National-forest and private cutting practices and the critical and dominating problems of protecting the white pine forests from fire, insects, and disease are considered. The fourth section brings the entire study together through an integrated analysis of the costs and returns of timber growing based on two specific alternative timber-management plans.

[2] Italic numbers in parentheses refer to Literature Cited, p. 77.

FIGURE 1.—A typical western white pine drainage, Burnt Cabin Creek, Coeur d'Alene National Forest, Idaho, viewed after logging. The cutting areas, mostly confined to the lower slopes, are dimly delineated by a more open forest canopy. (Courtesy of 116th Photo Section, Washington National Guard.)

Because of the considerable and unavoidable reliance on assumption and estimation in the development of the study, it is to be expected that it may meet with difference of opinion regarding the interpretations and the conclusions presented. The attempt is made, however, to present one point of view concretely and consistently, and to provide a framework for analysis that it is hoped will be helpful in further study of forest-management problems.

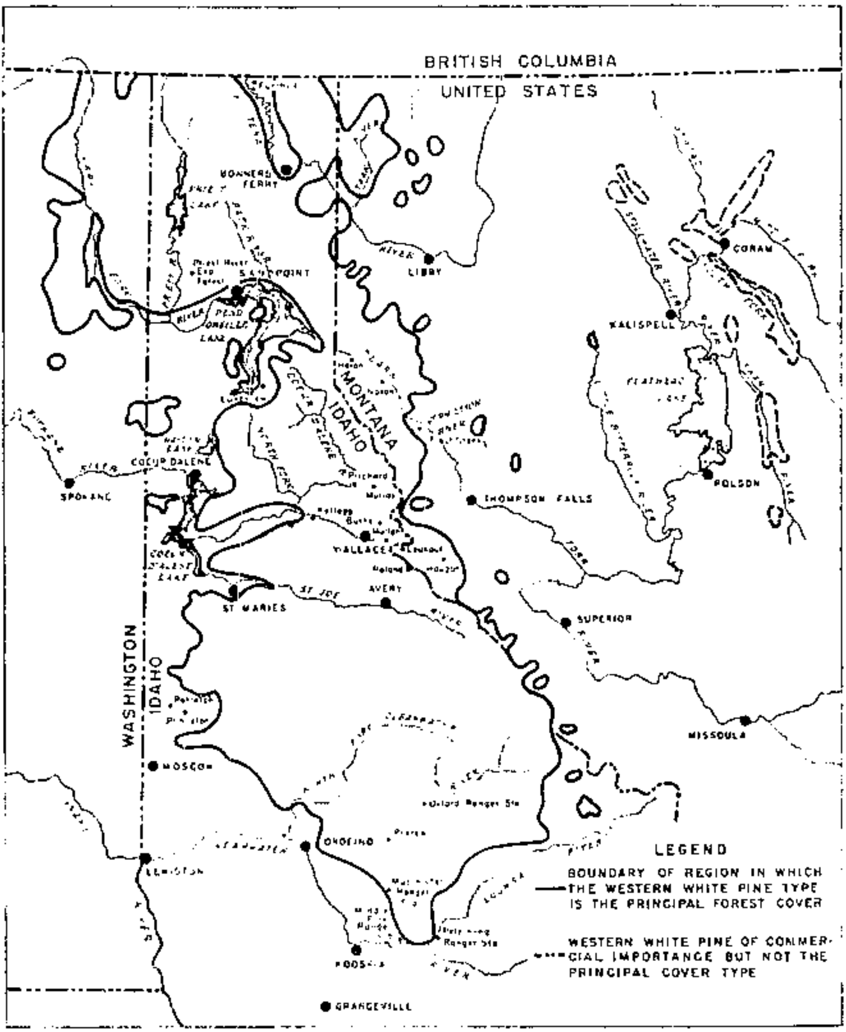

FIGURE 2.—The western white pine region.

ROTATION AND FINANCIAL POLICY

Of first and fundamental importance in investigating the timber-growing possibilities in a forest region is determination of the basic rotation. Markets, or what can be sold, and growth capacity, or what can be produced under stated conditions, by the financial policy adopted, determine the rotation.

Markets, or What Can Be Sold

The outstanding feature of the market for forest products in the western white pine region, both past and present, is that it is built upon the white pine sawlog. Continuance of this situation cannot be insured, but it is logical to believe that white pine sawlogs will continue to be the major product.

The future of western white pine is an intriguing speculation. On its present pedestal of relatively high value, it may be more vulnerable to technological changes than its lower-valued associates. Principal white pine uses are matches, millwork products, interior finish, woodenware, specialties, and sheathing. All of these uses are subject to sharp competition and it is a very wise or a foolish man who will undertake to predict the future outcome. Structural timbers and rough construction lumber, the principal uses of western larch and Douglas-fir, are more likely to withstand competition, especially for agricultural uses. A major use for western hemlock and grand fir is pulp and this use of wood is increasing. Western redcedar, largely used for transmission poles, shingles, and posts, is second to white pine in value and it is probably a little harder to find a substitute for it. In general, it seems that white pine will be pushed to maintain its present outstanding price superiority, while its associates have less to lose and more to gain.

Throughout this study costs and returns of timber growing will be based on present conditions, as being the best we know today and a logical starting point. This view accepted, white pine sawlogs are the major and controlling forest product, and market analysis is essentially a determination of the most merchantable size of white pine tree to grow. Production of other forest products must be fitted in around this major product.

The best criterion of desirable tree size is furnished by a logging and milling study of western white pine made by Rapraeger (*9*). In this study, the costs of logging and manufacturing trees of different sizes into lumber and match plank were compared with selling values. As about a quarter of the total annual cut of white pine in the region goes into match plank, and because the high value for match stock is a large factor in maintaining white pine stumpage prices, inclusion of this item is especially significant. The trees studied were cut on a tract considered typical of the white pine forests of the Clearwater district, in the southern part of the western white pine region. Figure 3, prepared from this study, gives selling values and manufacturing and logging costs when production is commercial lumber and match plank or commercial lumber only. These data are also combined to show the margin available for stumpage.

It may be seen in figure 3, *A* that the selling values per thousand board feet of lumber only and of lumber and match plank when cut together increase fairly steadily with tree diameter until trees of about

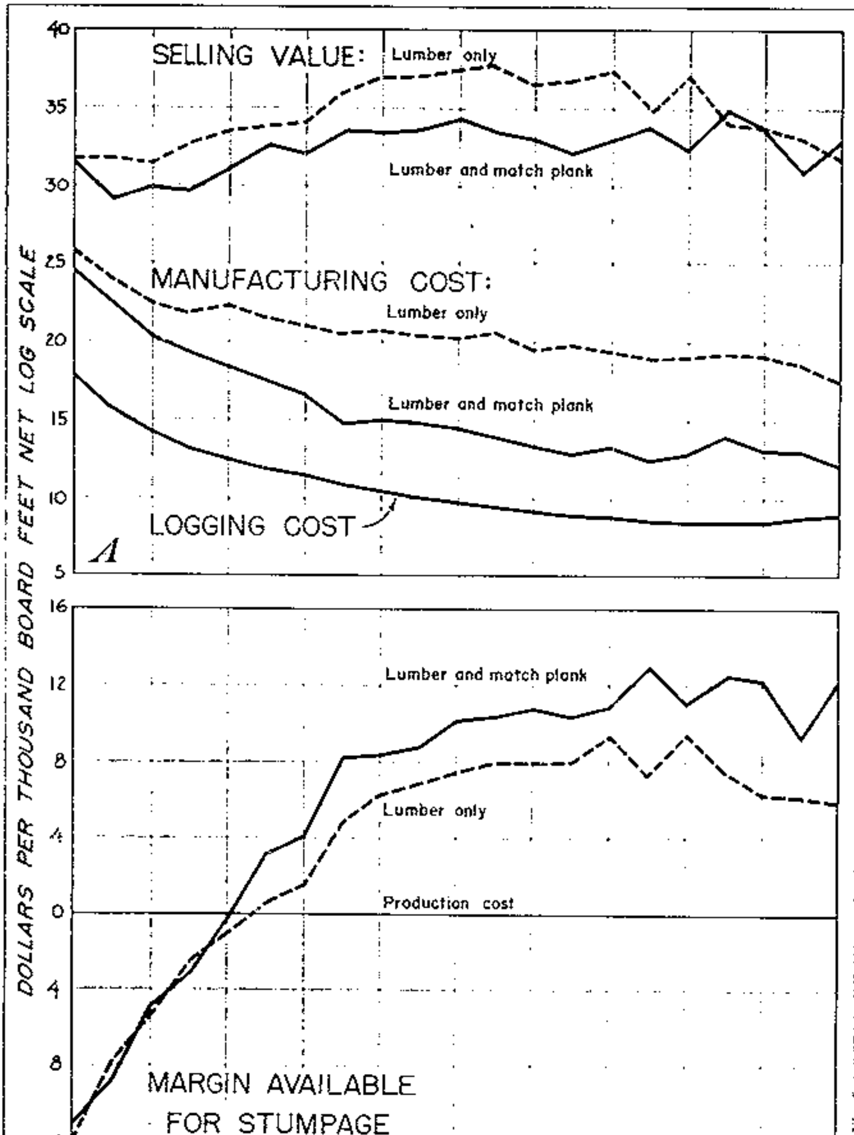

FIGURE 3.—A, Production costs and selling values, and (B) margin available for stumpage, when producing commercial lumber and match plank from western white pine trees.

18 inches d. b. h.[3] are reached. For larger trees values increase but little with diameter and even decrease for trees larger than about 26 inches. Large trees on the tract studied tended to be open grown and rough and did not give large yields of the higher grades of lumber.

It is also evident that manufacturing and logging costs, especially when logs are sawn for match plank as well as lumber, are more strongly and consistently affected by tree diameter than are selling values. When producing lumber and match plank manufacturing costs drop rather sharply at the rate of about one and one-third dollars per inch of tree diameter for trees between 10 and about 17 inches, and thereafter at a less rapid rate.

The logging-cost curve (which does not include the fixed costs of logging improvements) has much the same form as those for manufacturing costs. All these production-cost trends tend to be fairly stable in form, more so than trends for selling values, which are strongly affected by log quality and market conditions in addition to tree diameter.

In figure 3, *B*, showing the margin available for stumpage (including profit and risk, interest, and taxes on stumpage), or the difference between the selling value and production cost (manufacturing plus logging), zero stumpage diameter is between 14 and 15 inches.[4] Smaller trees have a rapidly increasing negative stumpage value; for larger trees the margin available for stumpage increases at the rate of about one and one-half to one and two-thirds dollars per inch of tree diameter up to about 20 inches, and thereafter levels off and even decreases above 26 to 28 inches. It should also be noted that the stumpage margin is greater when match plank and commercial lumber are produced than when only the latter is produced.

In conclusion, so long as the western white pine market remains exclusively for sawlogs, trees should be not less than 14 inches and preferably larger than 16 inches d. b. h. when cut. This puts a definite limit on the possibilities of short rotations. The desirability of producing larger trees is not so clear, since this market analysis does not in itself determine the most desirable rotation. Market values per stem as given have a strong influence on the length of the rotation, however. Although Rapraeger's study indicates little financial incentive to produce trees larger than 26 or 28 inches in diameter, it is probable that under good management the margin for stumpage could be sustained or even increased for such trees. This would tend to lengthen the rotation. Failure of conversion values in this study to increase materially with diameter is accounted for by the open-grown and rough character of trees larger than about 18 inches.

Growth Capacity, or What Can Be Produced

The relation between stumpage values of trees of various sizes and the physical capacity of forests of given age and site to produce

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[3] D. b. h.=diameter at breast height, or 4.5 feet up the stem.

[4] The exact tree diameter at which zero stumpage occurs varies somewhat according to the precise procedure followed in allocating production costs and selling values to individual diameter classes, and there is always some question as to how particular items should be handled. Moreover, for any existing operation, the zero margin diameter tends to be lower than for operations in general, for the reason that certain costs, particularly overhead costs, become fixed for a given operation already in progress that would be variable if there were complete fluidity in organization as was assumed in Rapraeger's study (9). These possible variations in the zero margin point are small, however, and do not affect to any degree the conclusions of this analysis.

values can be shown best by means of money-yield tables (*8*) constructed by applying the stumpage values to normal-yield tables as prepared by Haig (*3*). The actual process is somewhat tedious and need not be given in detail. Essentially, the procedure employed was to prepare, from the normal-yield tabular data, stock tables showing for given ages and sites the volume included in each diameter class. An experience allowance for cull or defect which increases with age was also made. The volume for each diameter class was then multiplied by the corresponding margin in dollars per M board feet available for stumpage when trees were sawed into commercial lumber and match plank as determined by Rapraeger's study (*9*). Values by diameter classes were then added to get the total stand value per acre. Since only trees having positive stumpage values (15 inches d. b. h. and larger) were included in the value computations, these give maximum values realizable.

The results of these computations, together with some other values to be discussed later, are given in table 1. The reader should not be disturbed by the high per-acre dollar-yield values given. Since their significance is relative rather than absolute, full yield-table values were used and the stand was assumed to be 100 percent western white pine. It would not have made the least difference, relatively, if all volumes had been reduced by some fixed arbitrary stocking and composition figure.

TABLE 1.—*Volume and value yields per acre realizable from trees 15 inches d. b. h. and larger in pure western white pine stands*

Stand age (years)	Net volume (Scribner rule)	Mean annual increment	Average value per M board feet	Gross value per acre	Estimated production costs per acre [1]	Net value per acre	Mean annual forest rent [2]	Soil value [3]
	M board feet	*Board feet*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
SITE 50 (FAIR)								
60	0.4	(4)	3.00	(4)	55	-55	-0.92	-17
80	2.0	25	5.00	10	65	-55	-.69	13
100	9.5	95	5.80	55	75	-20	-.20	-10
120	18.9	158	6.40	121	85	+36	+.30	-39
140	26.1	186	6.60	172	95	77	.55	39
160	27.8	174	6.70	186	105	81	.51	-40
SITE 60 (GOOD)								
60	1.1	18	4.10	5	55	-50	-0.83	-16
80	8.8	110	5.60	49	65	-16	-.20	-29
100	25.7	257	6.60	170	75	+95	+.95	-31
120	45.2	377	7.50	339	85	254	2.12	32
140	55.2	394	7.80	431	95	336	2.40	-35
160	60.4	376	8.20	493	105	388	2.42	-37
SITE 70 (EXCELLENT)								
60	4.1	68	5.40	22	55	-33	0.55	-12
80	22.4	280	6.70	150	65	+85	+1.06	29
100	52.8	528	8.20	433	75	358	+3.58	-19
120	73.0	608	9.20	672	85	587	4.89	22
140	83.2	594	9.60	799	95	704	5.03	29
160	87.0	544	9.80	853	105	748	4.68	-31

[1] Production costs arbitrarily estimated regardless of site at $25 per acre for fixed costs (costs incurred only once per rotation) and 50 cents per acre annual costs for fire protection, taxes, etc.
[2] Obtained by dividing the net value per acre by the age of the stand.
[3] Calculated with interest at 5 percent, using production costs as itemized in footnote 1.
[4] Negligible.

The very rapid increase in dollar values per acre between 60 and 100 years of age is worthy of careful study as an outstanding characteristic of western white pine stands. It represents the combined effect of two factors—the rapid increase in merchantable volume that takes place as trees attain merchantable diameter, and the rapid increase in stumpage value per M board feet from zero for 14-inch trees to about $8 per M for 18-inch trees as indicated by figure 3.

Both the exact age at which trees attain merchantable diameter and their rate of growth thereafter vary with site and stocking. Normal-yield-table data are conservative, since average rate of growth in fully stocked stands is consistently less than in natural partially stocked stands. Under management, growth rates should be bettered. It is important to bear in mind that, for a given age and site, normal-yield tables give a top-volume figure but do not indicate desirable stocking for future growth. With respect to best future growth, normal-yield tables picture overstocked stands. The rapid decrease in rate of growth to be observed between the ages of 80 to 100 years is without physiological necessity, but is mainly a consequence of stagnation from overstocking. Yield tables cannot be used directly in predicting growth, though they do state the maximum yield possible at a given age. Here, yield tables are used in this latter and meaningful sense of yields possible at given ages, and, as stated, present in relative terms a conservative picture. The advantage of normal-yield tables for such analyses is that they supply a unified and consistent body of data that include a range of sites and ages not duplicated by available empirical data.

The very wide differences between sites, in volume and value productivity, are brought out in table 2, computed from table 1. Site 70 (excellent) is taken as 100 percent. Differences in productivity are, as would be expected, somewhat greater in value than in volume. At 120 years, for example, site 50 is 26 percent as productive in volume and 18 percent as productive in value as site 70. The table also shows that disparity in productivity between sites is greater in young than in old stands.

TABLE 2.—*Comparative volume and value productivity by site quality*

Stand age (years)	Volume productivity for site index			Value productivity for site index		
	50	60	70	50	60	70
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
80	9	39	100	7	33	100
100	18	49	100	13	39	100
120	26	62	100	18	50	100
140	31	66	100	22	54	100
160	32	69	100	22	58	100

DETERMINATION OF THE ROTATION

Three separate determinants of the rotation have been given in table 1—quantity production, gross return less direct cost, and return per dollar invested. The question is which to adopt.

Quantity production, or the culmination of mean annual increment, is a rotation determinant familiar to all students of forest management. In white pine stands, the culmination of board-foot increment in trees 12.6 inches d. b. h. and larger occurs at about 120 years on an excellent site and at 140 years on fair sites (3). Cubic-foot increment, a better measure of quantity production, culminates between 100 and 120 years on all sites—the curves are very flat near their apex. A factor contributing to the generally indeterminate character of quantity production, as a rotation determinant which is only in part evident in normal-yield data, is the tendency for white pine to suffer rather heavy mortality soon after it reaches about 100 years of age. Insect mortality is particularly common at this time, especially in well-stocked stands containing a high proportion of the species. As a result, white pine growth levels off rather rapidly after about 100 years—often faster than growth of the stand as a whole as indicated by normal-yield tables. This circumstance tends to shorten the rotation slightly for white pine alone. Though indicative, none of these rotations of physical productivity are final determinants of the most desirable rotation. Questions of monetary value inevitably enter, and value and volume per acre often do not maximize at the same time.

The two other determinants given in table 1 exemplify two basically distinct value concepts meriting careful consideration. The first, mean annual forest rent (*1*), gives a measure of gross return less direct costs in dollars per acre. The absolute magnitude of these figures is not important; their significance is purely relative here. Neither is precision in the estimation of costs important; in fact, as long as costs are proportionate to area, as they rather closely are, deduction of costs does not affect the relative picture at all. The maximum value comes at 140 years on an excellent site and between 140 and 160 years on fair and good sites. This means that with a going concern, where a crop is harvested and certain expenses incurred each year, maximum dollar return per acre will be attained at these rotations. The rate of interest returned by the investment is not taken into account in determining this rotation.

In contrast, soil-expectation values[5] give a measure of the rate of return per dollar invested. Their computation assumes establishment of a forest on bare land and accumulation of charges at a specified compound-interest rate, 3 percent in this instance. While opinions vary regarding the business reality of compound-interest calculations extending over periods of a hundred years or so, such calculations, as an index or measure of value, point to two important facts. First, bare-land forestry in a region of such long rotations as prevail in the western white pine forests does not have a chance of returning a profit, of producing dollar values sufficient to offset the accumulation of interest charges. Only if acquired at market values considerably below full economic costs of production—as measured by accumulated interest charges—may a reasonably regulated going-concern forest make a good financial showing. Soil values are all negative even on excellent sites, indicating that forest-soil values alone are insufficient to permit growing a new forest from scratch on a commercial basis.

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[5] Soil values, based on the same cost assumption used in estimating mean annual forest rent, were calculated according to the usual formula:

$$S_e = \frac{Y_r - c\,1.0p^r - \dfrac{e\,(1.0p^r - 1)}{0.0p}}{1.0p^r - 1}$$

Where:

- S_e = expectation value of forest soil.
- c = cost of establishment of the new stand incurred once during the rotation.
- e = annual expenses, fire, taxes, etc.
- p = interest rate (3 percent in this instance).
- r = length of rotation in years.
- Y_r = value of final crop.

Second, the rotation of highest forest-soil rent will always, as long as any interest at all is charged, be shorter than the rotation of highest forest rent. The higher the rate of interest assumed, the shorter the indicated forest-soil-rent rotation. In most western white pine stands the highest rate of value growth occurs between 80 and 100 years and falls off rapidly thereafter. Costs pile up rapidly after about 100 years even with a low interest rate. As shown in table 1, the highest soil value, when using a 3-percent interest rate, comes at 100 years on an excellent site and at about 120 years on a good to fair site. The soil-rent rotation is thus about 40 years shorter than the forest-rent rotation.

The short rotations indicated by forest-soil-rent calculations have a serious practical weakness; they assume a market for large quantities of small-sized trees (or logs) at the price at which they could have been marketed in conjunction with larger trees. This is a most doubtful assumption, as the market structure would be likely to collapse and prices fall disastrously under a flood of small-sized products. To quote Matthews (*8*), "These lower prices immediately upset the calculation upon which the most profitable rotation was based, whereupon a longer rotation is found to be financially desirable."

Though indicative, none of these three rotation determinants is conclusive, and all must be tempered by more general considerations. In the western white pine region, the intensity and kind of timber management probable in the future presage continuance of the relatively long rotations indicated by these calculations. Lacking present or prospective markets for material of less-than-sawlog size, thinnings in pole-sized stands can seldom be made commercially. Without the stimulus of thinning, managed stands will not produce merchantable volumes appreciably sooner than natural stands, at between 65 and 90 years depending on site quality. Thereafter, however, through a system of partial cuttings constituting a shelterwood plan of management which will in part offset the tendency of white pine to suffer mortality in early maturity, it is probable that volume and value growth in managed stands can be maintained at a considerably higher rate than is indicated by normal-yield tables, which give a very conservative estimate in this respect. Maintenance of high average growth rates after trees have attained merchantable size will tend to lengthen the rotation, for, as Kirkland and Brandstrom (*6*) point out, no intelligent forester would willingly cut a tree so long as it is earning a satisfactory rate of return on the investment represented.

Under a shelterwood plan of management involving several partial harvest cuttings, the rotation, although it remains of basic over-all importance, loses much of its immediate significance. Trees are cut when they fall behind in productivity or become high mortality risks and not because they have reached a certain age.

Weighing volume and value productivity, rate of return, and possibilities of increased growth through management, a comparatively long rotation of 120 to 140 years, depending on site, is indicated for western white pine sawlog production. A good average figure is 130 years. For maximum cubic-volume production the rotation would be about 20 years shorter. Cutting might well be initiated as soon as stands begin to produce appreciable merchantable volumes—usually between 65 and 90 years—but final harvest cuttings made at any age less than about 120 years will not realize maximum value or volume returns.

FINANCIAL POLICY

The contrasting concepts of forest rent and soil rent have much deeper import than as measures of the rotation; they go to the very roots of financial policy in forest management.

The policy of seeking maximum forest rent ignores the rate of return on the investment. As Chapman (*1*) states, management for maximum net cash income per year regardless of interest earned "soon pushes the investment beyond the desirable point of economic balance indicated by the law of diminishing returns, even in public enterprises." With a forest-rent approach, capital would be invested in the form of more and more intensive forestry measures as long as the return, regardless of when expected, exceeded the direct cost.

With soil rent, the objective and criterion of desirability is to get the highest rate of return per dollar invested; obviously the businessman's approach. A businessman would convert a forest operated to give highest forest rent to one giving highest soil rent. For, again quoting Matthews (*8*):

> The fact is that when a forest operating on the rotation of highest forest rent is converted to the rotation of highest soil rent, a portion of the capital tied up in growing stock is released and can then be invested in other business ventures. If the funds thus released are invested in further forest properties operated on the rotation of highest soil rent, or in an equally sound manner, the total net income from the original capital will be materially increased.

Here we have the nub of the whole thing. For the private businessman the issue is clear; what about the public?

Why should not the public manage forest properties for the highest rate of value return, as the private individual does? The measure of value is different; social and more or less intangible values count heavily, as well as values directly measurable in money, but the basic purpose should be exactly the same. For example, it is possible that if some of the high capital values impounded in western white pine stands were released and invested in forest lands in the East near great centers of population and wood-using industries, a higher dollar return and a higher social return would be realized. If it could be definitely determined that the combined social and financial return on the public's forestry investment was low in one forest region as compared with another, the conclusion would be inescapable that, assuming limited financial resources, the highest economy would dictate decreasing the investment in the region of low marginal return and increasing it in the region of high return. The great difficulty is satisfactorily determining marginal returns, since so many other than purely monetary considerations enter in. But approximations of marginal differentials have been and constantly are being made and are an important consideration in interregional allocation of public funds.

It is not necessary, however, to seek a national application for this principle. Suppose the supervisor of a national forest in Idaho has a certain number of C. C. C. camps allocated to him, disregarding for the moment the various considerations that have influenced this allocation. With the total labor capital thus limited, choice in the allocation of manpower to alternative work projects is determined by relative desirability, and financial values at stake cannot be ignored. Should manpower be concentrated on white pine blister rust or insect control? Should cleanings in very young stands be favored over thinnings and improvement cuttings in older stands? Should forest planting be given preference over rehabilitation work in mature cut-over stands? The queries could be extended, but in every instance relative financial desirability, as fairly and broadly determined as possible, is the major consideration. The fact that such determination is difficult and that the results are often unsatisfactory if one wants a nice and simple solution, is no warrant for slurring over a searching appraisal. Unless the financial consequences of a given line of action are known within reasonable limits, intelligent and defensible decision regarding priority is impossible.

This view of the place of financial calculation is followed throughout this study. The general framework of social desirability and supply of capital available for a given forest enterprise, whether measured in dollars or C. C. C. man-days, is largely determined by external forces beyond the control of any one individual. But within this framework, alternative choices always exist, and to that extent straightforward and thorough financial calculations based on best existing information have a real place and often a deciding influence.

TIMBER-MANAGEMENT PROBLEMS AND POSSIBILITIES IN REPRESENTATIVE STANDS

The logical extension of this discussion of rotation and financial policy is an analysis of timber-management problems and possibilities in representative western white pine timber stands. To give point and statistical basis, the analysis is built around a specific high-quality stand consisting mainly of mature white pine, an average-quality mature stand of about half pine and half other species, a well-stocked pole-sized stand, and a group of young stands exemplifying the possibilities of intermediate cuttings.

High-Quality Mature Stand, Principally Western White Pine

Western white pine at its silvical best is represented by a block of very choice timber on a northeast slope on Ames Creek, on the Deception Creek Experimental Forest, Idaho, cut just previous to this study. A stand and stock table for an average acre is given in table 3. Figure 4 pictures the general character of the stand. The stand was closely even-aged, about 160 years old, and almost completely dominated by western white pine, which made up 79 percent of the total board-foot volume of 53,123 board feet (Scribner) per acre in trees 12 inches d. b. h. and larger. From all indications this stand developed much as did stands represented by normal-yield tables. Net growth per acre had been practically at a standstill for some time, although individual trees of good form and vigor were still making good growth at the time of cutting. Stumpage value per acre was probably increasing somewhat though at a steadily declining rate. Cull, mostly from decay caused by *Fomes pini*, was becoming important at a constantly accelerating rate. About 8 percent of the total white pine volume was unmerchantable (unmerchantable trees plus cull in merchantable trees).

TABLE 3.—*Number of trees and volume*[1] *per acre, by diameter class (d. b. h), of a high-quality, mature western white pine stand 160 years old*

Tree diameter class (inches)	Western white pine		Western larch, Douglas-fir		Grand fir		Western hemlock		All species	
	Trees	Volume	Trees	Volume	Trees	Volume	Trees	Volume	Trees	Volume
	No.	*Bd. ft.*	*No.*	*Bd. ft.*	*No.*	*Bd. ft.*	*No.*	*Bd. ft.*	*No.*	*Bd. ft.*
4	0.30				15.50		53.85		69.65	
6	2.43				7.90		59.45		69.78	
8	2.73				2.40		44.00		49.13	
10	5.76	426			1.50	37	23.00	782	30.26	1,245
12	3.87	453	0.23	11	1.74	143	13.88	1,055	19.72	1,632
14	6.71	1,303	.46	77	.76	129	6.90	913	14.86	2,613
16	7.88	2,504	.61	175	.98	251	3.11	588	12.58	3,518
18	10.31	4,610	.98	383	1.50	529	2.80	743	15.68	6,274
20	12.20	7,441	.99	481	1.11	469	1.06	408	15.30	8,789
22	11.98	9,471	.61	357	1.11	627	.91	405	14.61	10,860
24	8.31	8,481	.23	148	1.06	694	.76	371	10.39	9,697
26	2.95	3,526	.08	80	.15	71	.38	271	3.56	3,948
28	1.41	2,173			.53	195	.30	261	2.27	2,932
30+	1.21	2,115	.08	92	.51	375	.39	378	1.89	2,980
Total	78.14	42,575	4.27	1,804	36.70	3,781	210.79	6,208	329.90	54,368
12+ only	66.92	42,149	4.27	1,804	9.30	3,744	30.49	5,426	111.08	53,123

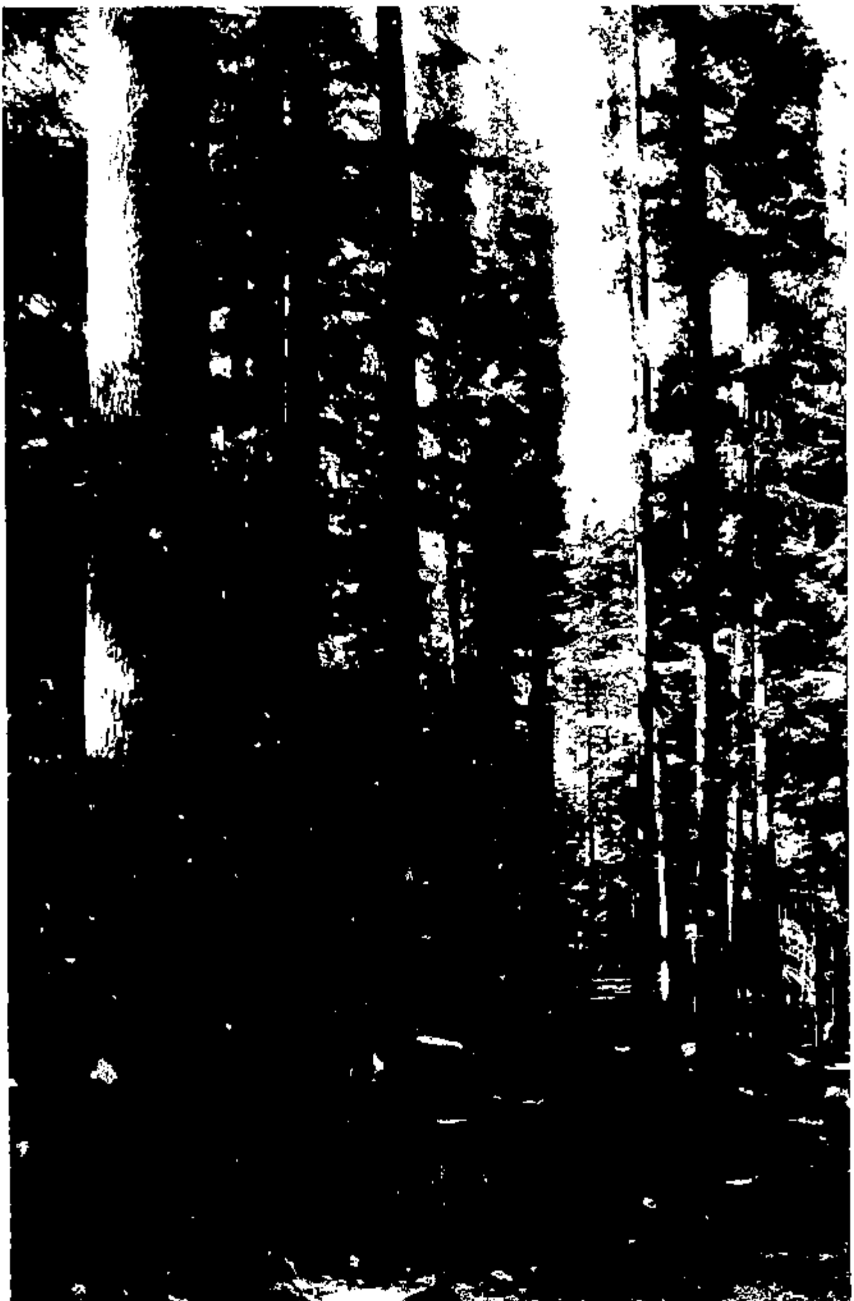
[1] Scribner rule.

The controlling management consideration in this stand was liquidation—release of high dollar values earning a low rate of return. Although fine possibilities for selective cuttings existed when the stand was younger, that time had definitely passed. Practically the entire white pine volume of the Ames Creek stand was highly merchantable; it had a cash-sale stumpage value of about $7.50 per M board feet, or a per-acre value of nearly $300, based on a net merchantable volume of about 39 M feet per acre. To anyone who has to pay the cost of keeping these dollars idle, tied up in standing timber, the pressure for liquidation is intense. Gross growth is being made in the stand at the rate of about 3 percent annually. But this gross growth is balanced by losses and there is no practicable possibility of making current harvest cuts to anticipate these losses and thus realize on the growth being made annually. Also contributing to liquidation pressure is the undeniable fact that such stands are more or less a perishable commodity. Although considerable blocks of timber of this character could probably be held in storage for a number of years, such stands are susceptible to fire, insects, disease, and windthrow, and every tree lost represents a direct and appreciable dollar loss. Regardless of ownership, public or private, prompt liquidation of as much of the values impounded as possible is the only practical course from a purely financial standpoint.

For an owner animated solely by the desire to realize maximum immediate returns, the obvious course of action in such a situation is to clear-cut all merchantable timber and completely liquidate the investment. For the owner committed to keeping forest lands permanently productive, the matter is not quite so simple. The problem of regeneration must be faced, and this is more of a problem—financially rather than silvically—than it at first appears.

REGENERATION METHODS

Two alternative regeneration methods are possible in such stands. They can be clear-cut and planted, or reproduced naturally. Either



(F-351743)

FIGURE 4. High-quality, nearly pure stand of 160-year-old western white pine, on Deception Creek Experimental Forest, Idaho.

method requires a rather large cash investment that can be realized upon only by growing a second timber crop.

Some believe that the cheapest and most practical course in such stands is to clear-cut all merchantable material, fell the rest, broadcast burn, and plant. While there are circumstances where this is undoubtedly true, there are also several items on the other side of the ledger to consider.

Planting is by no means as assured a procedure as is sometimes believed. The cost of artifically established forests is higher than is commonly realized either by foresters or laymen.

Artificial establishment of a well-balanced forest of more than one species is not at present well understood or much applied.

Certain aesthetic and silvical objections to extensive clear cutting followed by broadcast burning must be recognized.

All in all, therefore, planting, though one possibility, is by no means the only course.

Natural regeneration is generally considered the most desirable method. This necessitates reservation of seed trees and the problem immediately becomes how many? The answer depends essentially on whether regeneration only or regeneration plus growth on residual trees is the aim.

In the type of stand under consideration, natural regeneration is believed the main consideration for the following three reasons:

1. The few unmerchantable white pine trees present, those 14 inches d. b. h. and smaller, are the suppressed trees, the runts. They produce practically no seed, are liable to windthrow or other causes of mortality, and are capable of making little growth following release. Consequently, there is comparatively little to be gained by reserving them.

2. Although many merchantable white pine trees left from cutting (those over 14 inches) are individually capable of growing at the rate of about 3 percent a year, they will not earn their financial keep as a group. Their response to release is relatively slow; more than an average of 1 inch in diameter growth per decade cannot be relied upon. Studies in cut-over stands show that, on the average, mortality of western white pine seed trees approximately balances growth during the first decade following cutting. During the second decade a net gain of a scant 2 percent is made. An average rate of 1 per cent per year for the first 20 years is an unsatisfactory return on the capital values represented by these trees.

3. Unmerchantable species in a stand of such high quality might not be thought much of a problem, but this is not borne out by analysis. Of the total volume of 54,368 board feet per acre, 22 percent was of unmerchantable species at the time of cutting (table 3). This volume is appreciable, but even more significant is the fact that nearly two-thirds of the total number of stems were less than 12 inches d. b. h. Most of the smaller trees were hemlock and grand fir, comprising an understory (fig. 5) that cannot be ignored in getting reproduction. Suppressed understory hemlock and grand fir trees have an astonishing ability to accelerate growth following release. Following complete or partial removal of the overstory, they will promptly expand their crowns, take over the site, and prevent the successful development of reproduction. Moreover, though usually appearing fairly sound, they often contain decay or incipient decay that will more than keep

(F 31495)

FIGURE 5. High-quality western white pine overstory and suppressed hemlock understory in Ames Creek stand, Deception Creek Experimental Forest, Idaho.

pace with growth. Any kind of partial cutting in such stands that does not include removal of the understory will effectively and indefinitely convert the stand to a hemlock-grand fir forest which at present has little if any commercial value. Understories are more prevalent and more troublesome on good than on poor sites; hence the better the site, the more promptly and surely will this conversion take place.

Taking into account the understory problem and the financial undesirability of reserving merchantable white pine trees, the obvious cutting procedure if the land is to be kept producing commercial timber is to leave only enough good seed trees, mostly of western white pine, to provide for natural regeneration, and to remove most of the understory. On national-forest timber sales in such stands, about 90 percent of the pine volume in trees 16 inches d. b. h. or larger is cut and 10 percent is reserved, mainly in 2 to 6 well-spaced seed trees per acre, selected for their seed productivity and wind firmness. White pine trees less than 16 inches are also reserved, though not for seed production, and most sawlog-size but unmerchantable trees of other species. The understory is largely removed by a supplemental cultural operation. The regeneration period is normally about 10 years.

A variation in methodology is to leave seed trees in groups or strips, clear-cutting the rest. This method offers promise of some saving in cost through permitting broadcast burning of the clear-cut strips.

REGENERATION COSTS

Both clear-cutting of the entire area, followed by broadcast burning and planting, and leaving seed trees for natural regeneration with removal of most of the understory, are effective methods of getting reproduction. It is the cost of applying these methods that creates the real problem.

Average costs of executing clear-cutting and natural-regeneration methods in stands as found on Ames Creek (table 4) are based on actual day-labor costs of 40 to 50 cents an hour and do not overestimate what has been spent on national-forest timber sales in such stands. That the total cost by any method is high, will be conceded at once. All items of cost are self-explanatory and based on a fairly solid factual foundation except the item for seed trees. This is an interest charge on the value of the seed trees reserved, plus an estimated loss of $1 per M board feet through higher logging costs in later salvaging these trees. If the trees could not be later salvaged, the cost would be the stumpage value of the seed trees reserved and would range from $30 by the scattered seed-tree method to nearly $50 per acre by the clear-cut-in-strips method. The reader may prefer to exclude this cost entirely as is done in the bottom line of the table. It is a difficult item to determine. Excluding this seed-tree charge, the combination method of clear-cutting in strips gives the lowest cost per acre.

Table 4 reveals another item of major importance; about half the total cost is for regeneration and is not necessary merely to keep the forest green. This presents very clearly the issue between timber harvesting and timber growing. If keeping the forest green were the only objective, all pine volumes would be cut and a stand of hemlock and grand fir left that would indefinitely give excellent site protection. Slash disposal to reduce the fire hazard would be the only necessary cost additional to logging, and by cutting a few corners it probably could be kept down to not more than $20 per acre or approximately 50 cents per M board feet cut. A private owner not able to look forward to a long-time program of timber growing would obviously adopt this harvesting plan. It is the regeneration of such stands, the attempt to keep them growing merchantable timber, that is expensive

TABLE 4.—*Comparative costs per acre of slash disposal and regeneration by different cutting methods applied in a high-quality western white pine stand*

Item of cost	Clear-cut, broadcast burn, and plant	Scattered seed-tree cutting [1]	Clear-cut in strips leaving alternate seed-tree strips [2]
	Dollars	*Dollars*	*Dollars*
Slash disposal. Pile logging slash at 60 cents and burn at 8 cents per M board feet	0	24.50	6.50
Disposal of defective and unmerchantable trees by pile-and-burn methods. Cut and pile at $27 per acre; burn at $1 per acre	0	28.00	11.20
Seed trees [3]	0	11.30	22.90
Broadcast burning			
Fell residual stand (mostly small timber)	16.00	0	9.60
Firebreak, burning, patrol ($8 per acre when clear-cutting everything, $11 per acre when clear cutting in strips)	8.00	0	6.60
Planting: Estimated cost of an artificially established forest: first cost plus partial replanting	15.00		
Total cost	39.00	63.80	56.80
Total cost excluding seed tree cost	39.00	52.50	33.90

[1] Total white pine volume of 40 M board feet per acre assumed. Cut 90 percent or 36 M, leaving 4 M per acre in seed trees.

[2] 60 percent of area clear-cut. On remaining 40 percent of area, 60 percent of white pine volume cut, leaving 16 M per acre on 40 percent of area or an average of 6.4 M per acre over the entire area. Per-acre costs also apply to the entire area cut-over.

[3] Assume seed trees left for 10 years and then salvaged, recovering same volume left at time of cutting but with value reduced from $7.50 per M board feet at time of logging to $6.50 per M when recovered. Cost shown is the sum of this loss in stumpage plus interest at 3 percent on the value of seed trees reserved.

Thus, in high-quality mature white pine stands, values are high and earning power is low, urging prompt liquidation. If all merchantable volumes are cut, the unmerchantable trees, principally in an understory, will suffice to keep the forest green, but at the cost of converting a highly productive site promptly and more or less permanently to noncommercial forest stands. To maintain productivity of merchantable timber, a portion of these high values, sometimes as much as $30 per acre, more than a minimum cost of slash disposal alone, must be reinvested to obtain adequate regeneration. High-grade sites both demand and respond to fairly intensive management.

AVERAGE-QUALITY MATURE STAND OF WESTERN WHITE PINE AND ASSOCIATED SPECIES

Most logging in the western white pine region is currently done in stands about half white pine and half associated species. An area near Orofino, Idaho, exemplifying timber-management problems in such stands was studied in detail by Rapraeger (*9*), who determined logging and milling costs and selling values for trees of different sizes. The purpose here is to review his study and extend the management analysis.

A stand and stock table for an average acre is given in table 5, and a representative portion is shown in figure 6. Tree ages ranged from 90 to 195 years (except for one 315-year-old veteran), averaging 141 years. Numerous small fires in past years, killing scattered groups of trees, were apparently responsible for the many-aged character of timber on the tract. Evidences were found of five such fires occurring within 70 years, together with new reproduction developing in even-aged groupwise fashion after each fire. Site was quality II, or good. The white pine, which made up 55 percent of the total board-foot volume, was of fair but not first quality, since much of it did not develop in close even-aged stands. This was especially true of the larger trees, which tended to be rough and limby. Douglas-fir was of only fair quality and much evidence of a high rate of mortality indicated that it was going out of the stand. Although some of the grand fir was of good sawlog quality, many trees were totally unmerchantable, decay probably being more rapid than growth. The redcedar-sawlog volume was not important, but there were about 11 cedar poles per acre collectively worth about $7 on the stump. Western hemlock was absent and the understory problem was not critical. Natural reproduction, including a good representation of white pine, was present in most openings though making little growth. Natural regeneration is normally easy in such stands.

Table 5.—*Average stand of mature western white pine and associated species, by diameter class (d. b. h.)*

Diameter class (inches)	Western white pine		Western larch, Douglas-fir		Grand fir		Western redcedar		All species	
	Trees	Volume	Trees	Volume	Trees	Volume	Trees	Volume	Trees	Volume
	No.	*Bd. ft.*	*No.*	*Bd. ft.*	*No.*	*Bd. ft.*	*No.*	*Bd. ft.*	*No.*	*Bd. ft.*
4	0.10		0.07		31.08		25.67		60.70	
6	1.77		.21		20.86		10.55		38.69	
8	2.86		.26		13.70		6.98		23.80	
10	4.83	391	.56	13	7.19	267	4.48	72	17.06	743
12	7.95	747	.52	51	4.85	522	4.61	209	17.93	1,532
14	7.91	1,366	1.77	251	4.99	1,041	2.76	304	17.46	2,962
16	5.36	1,709	1.25	318	2.45	845	2.02	337	11.08	3,209
18	7.88	2,617	2.30	895	2.29	1,102	1.19	276	13.66	4,890
20	6.71	3,790	1.61	824	.94	628	.63	197	9.91	5,439
22	4.06	3,822	1.40	910	.84	715	.62	257	6.97	5,704
24	3.94	4,111	1.50	1,206	1.29	1,187	.37	295	7.17	6,829
26	3.52	3,485	1.09	1,039	.83	992	.16	282	5.60	5,798
28	1.77	2,108	.78	896	.67	947	.31	327	3.53	4,208
30	1.40	1,890	.21	264	.41	667	.05	41	2.07	2,862
32+	.36	703	.88	1,705	.26	302	.20	256	1.70	2,944
Total	53.12	25,088	14.39	8,474	95.57	9,278	66.30	2,744	229.36	45,574
12+ only	43.76	24,497	13.31	8,162	19.82	9,111	12.82	2,661	89.71	44,670
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
	19	55	15	18	22	21	14	6	100	100

MANAGEMENT POSSIBILITIES

It is evident that such a stand, containing considerable volumes of sound but unmerchantable timber but without a critical understory problem, offers selective-management possibilities. One not personally acquainted with the stand could easily, by noting the good range of tree diameters shown in the stand table and the known variation in tree ages, conclude that the stand could be economically and more or less permanently managed under a selective-logging plan. Such a conclusion would be based, however, on an inadequate understanding of the management problem.

Rapraeger (9), studying the stand primarily from a liquidation point of view, came to three major conclusions as regards possible cutting plans:

1. A liquidating operator with small timber holdings would have no interest in any partial-cutting scheme, as he would profit most by

FIGURE 6. Mature stand of western white pine and associated species near Orofino, Idaho. White card on fine-quality western white pine. Tree just to left of it is an apparently sound grand fir of good quality. In right foreground are two small, suppressed, and probably defective grand firs. Western redcedar near white pine in right background.

cutting only merchantable white pine trees 13.6 inches (14-inch class) and larger and the cedar poles. Reproduction filling the openings made in the stand would be deficient in white pine because of lack of seed trees and dominance of other species. Under such treatment timber values as now reckoned would practically vanish.

2. A liquidating operator with large holdings, who because of limited markets could sell only a constant volume per year, would make the most money by raising the minimum diameter limit a few inches. Increased annual returns resulting from shortening the liquidation period and restricting the cut to a constant volume of the larger and higher-value trees would up to a certain point more than offset the value of merchantable timber in smaller trees left in the woods. This raising of the lower diameter limit would not exceed about 3 inches over the zero margin of 13.6 inches, however, even for a 45-year liquidation plan, and this would not appreciably affect regeneration of the white pine.

3. Large operators interested in a second cut, if not in sustained yield—the two are unfortunately often confused—might well consider some form of area or group selection. The best 25 percent of the area supports 44 percent of the total white pine volume. If the first cut took all the white pine on this quarter of the area plus a few of the best and most accessible trees on other parts, this would aggregate about half of the total white pine volume. As Rapraeger points out, such a procedure would concentrate cutting where timber values are the highest, and, with proper planning and coordination of the logging operation, log-production costs would not be increased appreciably thereby. Roads put into the tract at this time would carry over much of their value to a second cut. The second cut would take the remainder of the white pine, together with merchantable trees of other species.

ADVANTAGES OF TWO-CUT PLAN

After the second cut, what? It is right here that a selective-logging plan for this or any similar tract breaks down, and the great difference between a short-time selective-logging plan and a long-time genuine selection system, often loosely implied, becomes apparent. It is often possible to set up a partial-cutting plan that will show financial superiority over a single-cutting plan for the first two cutting cycles when the value of the cut is sustained by high-grade, old-growth merchantable timber. By about the third cycle, however, the merchantable pine will be gone and the hard question of whether or not in such a forest type values can be sustained permanently by a selection system must be met. Selective-logging advocates have a tendency to draw a veil of pious hope over the third and subsequent cuts, assuming that improved markets or something will maintain values. It is undoubtedly possible to maintain forest conditions by the selection method, but it is impossible in the face of active competition by the more tolerant species to maintain an abundance of western white pine in the stand by cutting that species only.

To maintain a forest dominated by western white pine, a species characteristic of a subclimax stage in forest succession, present knowledge indicates that man will have to do just as nature does in getting reproduction—open up the stand severely. This means that one or not more than two major harvest cuts must be made, markedly opening up the stand, yet leaving a seed source in white pine and other seed trees. Recognizing these requirements for successful regeneration to white pine and also realistically facing the fact that economic conditions preclude 100 percent success, the probable results of a two-cut plan are well worth looking into.

On the part of the area clear-cut or nearly so by removal of the white pine from about the best 25 percent, abundant natural reproduction would without doubt become established after the first cut, including a good representation of white pine. Group clear-cuttings create conditions especially favorable for white pine reproduction and much of the reproduction resulting from this first cutting will have sufficient space to grow satisfactorily. The first cutting would, consequently, adequately regenerate about 25 percent of the area.

At the time of the second cut, some but not a great deal additional white pine reproduction can be expected from (1) seed in the duff at the time of cutting; (2) seed from the few cull white pine trees that would not be cut under any cutting plan; and (3) established seedlings that would be given release by cutting.

By both cuts about a third or possibly a little more of the total area would be satisfactorily regenerated to white pine and associated species, with no special effort other than reasonably good slash disposal. Associated species would be held for whatever the future might bring, and some reproduction would probably develop on the other two-thirds. This is not an ideal state of affairs, certainly, but is preferable to a single destructive cut removing at one time practically all the pine.

With variations, such is the situation in logging most mature stands containing approximately a third or more of species other than western white pine. Lacking a market for these species, no form of partial cutting can profitably be continued permanently. Complete regeneration to white pine can be obtained only by making a heavy dead-weight investment in growing timber for the future and by destroying considerable volumes of sound but currently unmerchantable timber a procedure of doubtful wisdom. With forest land as abundant and as cheap as at present in northern Idaho and with the future of mixed species uncertain, powerful economic objections can be raised against a policy aimed at complete regeneration to white pine in mixed stands.

A two-cut plan in such stands, while not giving the best results, has financial possibilities and is definitely preferable to a destructive single cut. True, much of the regeneration problem is passed on to the future but that is true of many forest problems. The Federal Government can and does go farther than the private owner in attempts to obtain reproduction after cutting in such stands. In many mixed stands defective trees have been removed to give new reproduction growing space at a dead-weight expense of $20 to $40 per acre. This constitutes a definite commitment to long-time timber growing which so far only the Federal Government has undertaken. It should be clear without laboring the point that, where the volume of associated species is mainly defective, improved markets will never solve the problem. In such stands the Forest Service has often clear-cut all merchantable timber, felled the rest, broadcast burned, and usually planted (*2*).

Young, Well-Stocked Stand; Possibilities of Partial Cutting

The best opportunity for the practice of constructive timber management in the western white pine forests is in young, well-stocked stands soon after they have begun to produce merchantable-sized trees in appreciable numbers. In white pine stands between 65 and 90 years of age, board-foot volume accretion is very rapid, even though diameter growth has already begun to slow down as a result of competition. Competition, which is intense in most white pine stands, has, however, produced a tree of fine commercial form, the bole being straight and clear of all but a few dead branch stubs for at least the first 16-foot log. If a series of partial cuttings at 15- to 20-year intervals is started at about this time, volume and value yields during a given rotation period can be materially increased in two main ways: First, by maintaining a faster average rate of growth by removing slow-growing trees and concentrating growth on faster-growing choice trees. Second, by salvaging some of the timber ordinarily lost through mortality and never harvested. The possibility of recovering in this way much of the total growth made in natural stands is often unrecognized. Normal-yield tables show clearly that a great reduction in the number of dominant and codominant stems per acre must take place between 80 and about 120 years of age. Many of the slower-growing and weaker trees passing naturally out of the stand are of merchantable size and through intelligent selection could be logged before their death.

Table 6.—*Growth in average diameter and volume made by dominant and codominant western white pine trees growing in managed and unmanaged stands on a good site (site 60)*

Kind of stand and tree age (years)	Average diameter breast high	Average volume per tree	Increase made during preceding decade in— Average diameter breast high	Average volume per tree
Unmanaged stand:[1]	*Inches*	*Board feet*	*Inches*	*Board feet*
50	7.7		1.8	
60	9.5	75	1.6	55
70	10.8	106	1.5	31
80	12.3	163	1.5	57
90	13.6	222	1.3	59
100	14.8	288	1.2	66
110	15.8	355	1.0	67
120	16.5	409	.7	54
130	17.0	448	.5	39
140	17.3	475	.3	27
150	17.5	491	.2	16
160	17.7	507	.2	16
Managed stand:[2]				
80	12.3	163	1.7	57
90	13.7	228	1.4	65
100	15.0	302	1.3	74
110	16.2	386	1.2	84
120	17.4	482	1.2	96
130	18.6	588	1.2	106
140	19.7	688	1.1	100
150	20.7	780	1.0	92
160	21.7	870	1.0	90

[1] Values taken from normal yield tables for western white pine stands.
[2] Partial cuttings were assumed to begin when stand was 80 years of age. Estimates based on studies of growth rate in cut-over stands.

The higher average growth rates believed obtainable through partial cutting may be illustrated by comparing average growth rates of dominant and codominant white pine trees in fully stocked natural stands as indicated by normal-yield tables (*3*) with estimated rates of growth under management based on growth actually made in cut-over stands (table 6). The growth rates assumed under management are conservative. Note how slowly average diameter increases in fully stocked stands, particularly after about 100 years, despite much better growth made by individual trees. There is no physiological necessity for such a slackening; it is mainly a consequence of over-density. In managed stands no increase is assumed, but only partial prevention of this decline in rate of growth.

A PARTIAL-CUTTING PLAN

The increase in volume and value realizable over a rotation, resulting from maintaining a better average growth rate and commercially harvesting part of the natural mortality, can best be demonstrated by means of a specific example. This is afforded by an analysis of a representative 75-year-old forest on Benton Creek, Priest River Experimental Forest, Idaho, for which a stand and stock table is given in table 7 (figs. 7 and 8). This forest is about 70 percent stocked in terms of normal-yield-table values. The dominant stand is western white pine, western larch, with a little Douglas-fir. There is an understory of western redcedar and western hemlock. Stands with white pine and larch in the overstory and redcedar in the understory constitute the most valuable species combinations to be found in the western white pine region. Considerable areas of such stands occur on the Kaniksu and Coeur d'Alene National Forests.

TABLE 7.—*Number of trees and volume per acre of a well-stocked, 75-year-old stand of western white pine and associated species*

Diameter (inches)	Western white pine		Western larch, Douglas-fir (mostly larch)		Grand fir and western hemlock (mostly hemlock)		Western redcedar		All species	
	Trees	Volume	Trees	Volume	Trees	Volume	Trees	Volume	Trees	Volume
	Number	*Board feet*	*Number*	*Board feet*	*Number*	*Board feet*	*Number*	*Board feet*	*Number*	*Board feet*
1	7.2				12.2		481.8		501.2	
2	50.0		7.2		51.2		232.0		340.4	
3	28.0		27.1		39.1		112.4		206.6	
4	39.6		30.2		24.9		36.9		131.6	
5	11.8		28.9		14.2		47.8		102.7	
6	10.9		48.5		8.0		8.9		76.3	
7	31.1		21.3		6.2		3.6		62.2	
8	28.4	995	16.9		4.0		1.8		51.1	995
9	21.1	1,191	15.1		5.4		4.3		45.9	1,191
10	22.2	2,022	8.9	245	1.8	118			32.9	2,385
11	17.3	2,115	7.6	406	.9	56			25.8	2,577
12	12.9	2,023	9.7	821	.5	64			23.1	2,908
13	8.0	1,544	6.2	735					14.2	2,279
14	4.4	1,056	5.5	832	.4	62			10.3	1,950
15	3.6	1,003	.4	88	.9	213			4.9	1,304
16	.9	294	1.8	425					2.7	719
17	.9	344	.9	256					1.8	600
Total	331.6	12,867	205.8	3,808	197.1	513	896.5		1,631.3	17,188
6+ only	193.0	12,867	112.4	3,808	25.8	513	15.6		348.8	17,188

It is at once apparent from table 7 that this particular stand is not old enough for a commercial cutting. Most of the board-foot volume is in trees of submerchantable size. Most merchantable-sized trees should be reserved for future growth. A sawlog cutting made at this time, if removing sufficient volume to make the operation commercially practicable, would seriously curtail the future growth possibilities of the stand. A thinning and improvement cutting could not be expected to pay its way because of high cost; nor should it be undertaken, since in a comparatively few years it should be possible to remove some at least of the material commercially that if cut earlier would have to be left on the ground for lack of a market. As a matter of fact, some of this stand was thinned and the timber cut had no commercial value whatever. It is estimated that this stand would not have been ready for commercial cutting until it was about 90 years old.

To investigate partial-cutting possibilities in this stand, a plan was drawn up providing for four cuts at 20-year intervals, the first coming at 90 years. Procedure and objectives for each of these four cuts are as follows:

First cut (90 years). Remove such of the largest trees in the stand as tend to be limby, rough, and not capable of making future quality growth. Anticipate heavy mortality in the 10- to 14-inch classes by cutting most of the trees of these diameters that have definitely fallen behind in crown development and that under natural conditions would probably die in the next 20 years. Such trees are of excellent quality for their size, usually straight and well cleaned of branches. Though below the zero-margin point as determined in logging and milling studies made in mature stands, these trees undoubtedly would be merchantable, given a road system and assuming logging methods adapted to handling small logs. In addition, some of the understory hemlock and superfluous redcedar should be destroyed. These trees are small and many of them can be eliminated at low cost by ax work incidental to the logging operation. The volume and value of this first cut will inevitably be low. That it must pay for itself is the first criterion; little profit can be expected. Slash disposal is not believed necessary at this first cut.

Second cut (110 years). Remove slow-growing, unhealthy, and damaged trees of any diameter to anticipate mortality and to maintain a high average growth rate for the remaining trees. If there is a market for larch mine timbers or small-dimension lumber, this species should be cut heavily to increase the proportion of residual white pine. The overwood will be opened up appreciably but the remaining understory will still restrict reproduction. Undesirable understory trees should be destroyed at this cut to prevent them from taking over the site as fast as the overstory is removed. The understory problem must be largely met during the first two cuts. The timber removed at this second cut will be of fair size and quality. Slash disposal should be confined to hazardous accumulations along skid trails and roads. The rest should be left unburned.

Third cut (130 years). Make this the major harvest cut, taking most of the merchantable volume of all species, including cedar as poles, and leaving an open shelterwood of fast-growing high-quality trees. Some further work and expense will probably be necessary at this cut to dispose of remaining undesirable understory trees. Most of the timber removed at this cut will be of choice quality. About two-thirds of the slash should be piled and burned according to current Forest Service standards.

(F-270848)

FIGURE 7. Dense, vigorous, 75-year-old stand of western white pine and western larch with understory of western redcedar and western hemlock, on Benton Creek, Priest River Experimental Forest, Idaho.

Fourth cut (150 years). Cut all merchantable trees. Remaining unmerchantable trees, unless more than 12 per acre, can safely be ignored. Nearly all timber removed at this cut should be of high quality and large size. Slash disposal should be limited to the heavier accumulations along skid trails and roads. The reproduction will soon close over the rest. A cleaning operation in the reproduction stand, which at the time of this final cut will be from 10 to 20 years old, will probably be advisable soon after this final cut to control species composition.

The cutting plan outlined was applied in detail to the stand given in table 7. Growth and mortality were estimated. Hypothetical cuttings as defined were applied to the stand, an attempt being made to picture the stand, almost stage by stage, as it developed over the years. Stumpage values realizable at each cut were estimated by individual diameter classes on the basis of differential values given by Rapraeger (*9*). The actual computations were somewhat drawn out and tedious and will not be given in detail. The essential features were as follows:

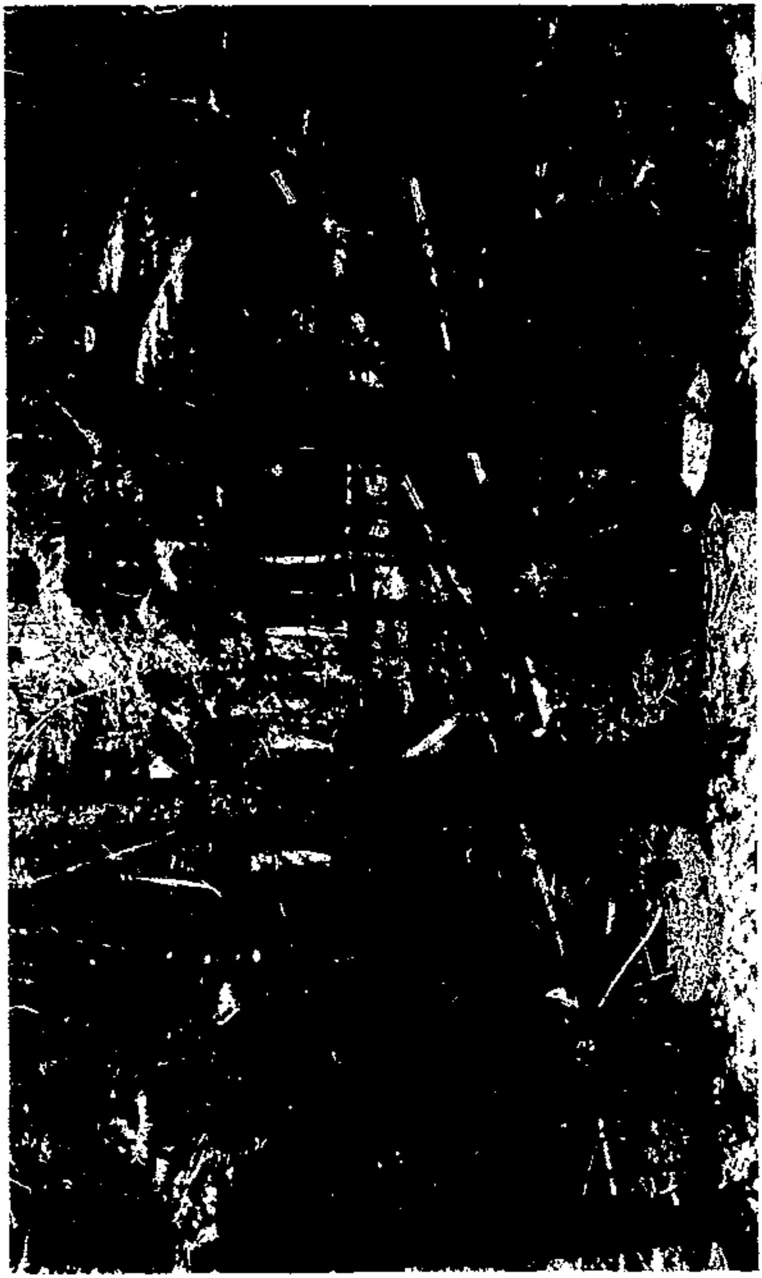
1. Portions of the stand had been thinned when it was 75 years old and stand tallies made in thinning furnished a basis for segregating trees of final-crop possibilities from the rest of the stand, which was assumed to absorb the heaviest mortality. Additional allowance for mortality was, however, made in the crop stand.

2. Diameter-growth estimates were made for the crop stand only. Assumed average growth rates at various ages, based on growth actually made in cut-over stands (table 6, column 5), were applied to the various diameter classes on a differential basis that took into account the fact that at any given age large trees tend to grow faster and small trees slower than the average rate of diameter growth for the stand. The basis for the tree-diameter-growth differential was empirical judgment checked by normal-yield tables and data from cut-over area studies. The results obtained seem entirely reasonable and are believed to be conservative.

3. The stand was first stepped up from 75 to 90 years, when the initial hypothetical cut was made. In making this and succeeding cuts an attempt was made to visualize the stand as it would probably be and mark it as closely as possible in accordance with the silvicultural objectives set up. Throughout the process, empirical checks on the reasonableness of the results were made by comparison with known stands of similar age growing on similar sites.

4. Volume computations. From normal-yield tables (*3*), an average height-over-diameter curve related to age was plotted for average dominant and codominant western white pine trees on a good site (site 60). From this curve, using the second-growth Scribner volume table given in the same reference, an average diameter-volume curve was drawn that was uniformly used in computing volumes. While this process is naturally subject to some error, it has the advantage of simplicity and uniformity and seemed to give entirely reasonable results.

5. Value computations. Stumpage values were determined by multiplying the estimated volume cut in each diameter class by the stumpage value of that class as determined by Rapraeger (*9*). The resulting values were then summed and a weighted average stumpage value determined. A deviation from this method was made for the



(F-356696)

FIGURE 8.—Interior of stand of western white pine and associates on Benton Creek, Priest River Experimental Forest, Idaho. This especially fast-growing portion of stand was selectively cut when 65 years old, removing 8,800 board feet per acre of the larger trees. During the 10-year period following, the stand grew at the rate of 645 board feet per acre per year.

90-year cut where a $2 stumpage value was assumed, which is in excess of the computed value. This was done because positive stumpage values for timber of this character are known to exist and it is believed the value assumed could be realized on an operation planned to handle small logs. The precise applicability of Rapraeger's data to stands of different ages is open to question, but they were the only data of their kind available and reflect in fairly accurate terms the known fact that harvest cuts mainly of small trees have less stumpage value per M board feet than cuts mainly made up of large trees.

Similar computations were made for western larch, the only other species sufficiently represented in the overwood to make a stand table analysis practicable. Lump estimates were made for the relatively small amounts of hemlock, grand fir, and redcedar present, which occur mostly as an understory. Present information on redcedar is too scanty to estimate with any degree of reality the possibilities of producing poles from a cedar understory such as occurs in this stand. Cedar yields were estimated on the basis of what apparently similar stands have actually yielded, using information given by Cummings and Varney as a guide.[6] It is probable that cedar values in this stand have been considerably underrated.

RESULTS OF PARTIAL CUTTING

The results of the partial cutting analysis are summarized in tables 8 and 9.

Before appraising these results it should be made clear that the purpose of this analysis is to bring out the silvicultural possibilities of partial cutting and not at this stage to present an integrated plan of management and attempt to show that it pays. That will be attempted later. Here, the dollar sign is introduced only to show approximate stumpage values believed produceable under such a plan of management.

TABLE 8.—*Number of trees and volume per acre of western white pine trees harvested under a four-cut shelterwood plan of management*

Diameter class (inches)	90-year cut		110-year cut		130-year cut		150-year cut		Total all cuts		
	Trees	Volume	Trees	Volume	Trees	Volume	Trees	Volume	Trees	Volume	
	No.	*Bd. ft.*	*No.*	*Bd. ft.*	*No.*	*Bd. ft.*	*No.*	*Bd. ft.*	*No.*	*Bd. ft.*	*Pct.*
10	17.0	2,510	4.0	330	8.0	710	6.0	600	35.0	4,150	7
12	9.0	1,500	10.0	1,630	9.0	1,720	1.0	150	29.0	5,000	10
14	6.0	1,150	5.0	1,580	5.0	1,100	2.0	470	18.0	4,370	10
16	1.0	290	4.0	1,180	8.0	3,050	1.0	580	14.0	5,250	12
18	.7	270	5.0	2,050	5.0	3,620	1.0	160	11.7	6,100	14
20	1.3	880	.9	660	4.0	5,000	2.0	1,280	8.2	7,820	13
22			1.0	800	3.0	2,700	2.0	1,680	6.0	5,180	11
24					2.0	2,150	4.0	4,400	6.0	6,550	14
26					1.1	1,220	1.0	1,500	2.1	2,720	6
28											
30							1.0	1,570	1.0	1,570	3
Total	32.8	5,730	29.9	9,010	45.1	18,470	21.0	12,280	128.8	45,640	100

[6] CUMMINGS, L. J., and VARNEY, R. M. WESTERN REDCEDAR POLE RESOURCES IN NORTH IDAHO AND NORTHEASTERN WASHINGTON. Forest Survey Release No. 16. Northern Rocky Mountain Forest and Range Expt. Sta. 36 pp., illus. 1938. [Processed.]

TABLE 9.—*Total volume and value produced per acre per rotation by a four-cut shelterwood plan in comparison with a single major harvest cut*[1]

Stand age (years)	Western white pine sawlogs: Volume	Western white pine sawlogs: Value per M	Western white pine sawlogs: Total value	Western larch-Douglas-fir sawlogs: Volume	Western larch-Douglas-fir sawlogs: Value per M	Western larch-Douglas-fir sawlogs: Total value	Western hemlock, grand fir, western redcedar sawlogs: Volume	Western hemlock, grand fir, western redcedar sawlogs: Value per M	Western hemlock, grand fir, western redcedar sawlogs: Total value
	Board feet	*Dollars*	*Dollars*	*Board feet*	*Dollars*	*Dollars*	*Board feet*	*Dollars*	*Dollars*
90	5,850	2.00	12	2,170	0.50	1	0	0	0
110	9,010	4.00	36	3,220	1.50	5	800	.50	0
130	18,170	7.00	129	5,880	2.50	15	1,000	1.00	1
150	12,280	9.00	111	3,240	3.00	10	2,000	2.00	4
Total yield, 4 cuts	45,310	6.36	288	14,510	2.14	31	3,800	1.32	5
130, 1 cut	30,000	7.00	210	9,000	2.25	20	4,200	.75	3

Stand age (years)	Total sawlogs: Volume	Total sawlogs: Value	Western redcedar poles: Trees	Western redcedar poles: Total volume	Western redcedar poles: Value per tree	Western redcedar poles: Total value	Total cut, all species: Volume	Total cut, all species: Value
	Board feet	*Dollars*	*Number*	*Board feet*	*Dollars*	*Dollars*	*Board feet*	*Dollars*
90	8,020	13	0	0	0	0	8,020	13
110	13,030	41	5	430	.70	4	13,460	45
130	25,050	145	15	1,290	.80	12	26,340	157
150	17,520	125	8	950	.90	7	18,470	132
Total yield, 4 cuts	63,620	324	28	2,670	.82	23	66,290	347
130, 1 cut	43,200	233	18	1,800	.80	14	45,000	247

[1] An estimate based on what natural stands of similar stocking on comparable sites have actually yielded in a single major harvest cut, as now commonly practiced.

Following are major items in this partial-cutting analysis that merit discussion:

Number of cuts. There is no vital necessity for just four cuts spaced exactly 20 years apart. Many adjustments and modifications to meet changing conditions could and would inevitably be made in actual practice. Four principal reasons for the adoption of a four-cut plan as a desirable general pattern are: (1) The first cut should come as soon as the stand is old enough to permit a commercial cut of trees not needed for future growth. Eighty to 90 years is a fair figure for average sites. (2) The major harvest cut should come at about 130 years, as the optimum rotation age for western white pine sawlog production. Also, one heavy cut is necessary to open up the stand sufficiently to insure prompt natural reproduction that will include an abundance of white pine. (3) Provision must be made for a continuing seed source after the major harvest cut. Seed requirements can advantageously be met by keeping a few of the best trees in the stand past the average rotation age to produce high-quality timber. Note that the basic rotation is 130 years despite the fact that some trees are left until 150 years of age. Reproduction comes at 130 years. (4) Repeated cuts are necessary to maintain a high average rate of growth and to anticipate natural mortality effectively. Twenty years is probably a maximum interval and would not permit salvage of all mortallity. Cuts at other than 20-year intervals would be necessary to salvage mortality from sudden diasters as fire, disease epidemic, or blowdown. Salvage of all mortality would necessitate ability to log any part of the area at any time at a profit—a procedure probably never entirely practicable. With a permanent utilization-road system and good markets much of the current mortality could be salvaged.

Volume growth. As shown in table 9, the total volume per acre of all species yielded by partial cutting is estimated at 66,590 board feet, as compared to 45,000 board feet from a one-cut plan (seed-tree method) for the same rotation. The yield of western white pine was increased 15,610 board feet per acre. These are estimates, to be sure, but reasonably result from harvesting most of the natural mortality, concentrating growth on the faster-growing stems, and periodically increasing the growing space for these stems.

Value growth. Table 9 shows that the total stumpage value of all cuts was increased $100 an acre by partial cutting. And this despite the fact that the value of the first two cuts was low and the average stumpage value of all cuts was computed to be $6.34 per M feet as compared to $7 estimated for a single-cut plan. The value advantage of partial cutting comes through increased volume production rather than increased unit value; a point often not appreciated. Some very high-quality material is produced by partial cutting; but this is balanced, when the management plan as a whole is considered, by comparatively large volumes of low-quality material that must be disposed of to make production of this high-quality material possible. The range in value of material produced under partial cutting is certainly increased, but the evidence developed here does not indicate that the average quality is increased. The estimates were possibly too conservative in this respect, because, for a given diameter class, stumpage values were applied uniformly for all cuts with no allowance for a probable increase in unit quality of the last two cuts, the last especially.

Treatment of understory. Successful application of a partial-cutting plan necessitates positive action to prevent the development of an undesirable understory which, unless checked, will tend to take over the site as the overstory is removed. If the understory is not controlled, a series of partial cuts is the best possible method of hastening a natural transition in the dominant species from white pine, larch, and Douglas-fir to hemlock, grand fir, and redcedar. The understory problem is to favor the better cedar but suppress the hemlock and grand fir. This should not be either difficult or expensive if the problem is faced squarely and action is taken to meet it, mainly at the time of the first two cuts.

Blister rust. Always to be considered is the probable effect of a given management method on the ribes suppression necessary to control white pine blister rust. From what is known of ribes ecology,[5] the 90- and 110-year cuts will not favor ribes establishment. Some germination will occur but seedling mortality will be high and development poor because of the generally closed canopy. A good share of the ribes seed normally stored in the duff will probably be exhausted by futile germination. The 130-year cut will stimulate the germination of viable ribes seed stored in the duff and will create conditions generally favorable for seedling development. Ribes appear and flourish under approximately the same circumstances as does conifer reproduction. Ribes eradication will probably be necessary 3 or 4 years after this cut. The 150-year cut will probably bring in few ribes because the ribes seed supply should be previously exhausted.

[5] DAVIS, KENNETH P., and MOSS, V. D. BLISTER RUST CONTROL IN THE MANAGEMENT OF WESTERN WHITE PINE. Northern Rocky Mountain Forest and Range Expt. Sta. Paper No. 3. 34 pp., illus. 1940. [Processed.]

Following the 150-year cut, conditions for ribes growth will become very unfavorable as conifer reproduction will soon close over the ground.

INTERMEDIATE CUTTINGS

POSSIBILITIES

Development of most present-day silvicultural headaches could have been prevented by proper and timely cultural cuttings applied during the youth of the stand.[8] Overdense and stagnated stands, dominated by undesirable species, or made up of trees of desirable species but of undesirable average quality, would never have developed had the stands been under management from infancy. Existing stands must be taken as they are and the problems they present must be faced. But in looking forward to the future, the extent to which present-day silvicultural problems in the western white pine region can be avoided through application of intermediate cuttings in immature stands merits careful consideration. Because of the long-range predictions that must be made to appraise this class of work, it is impossible to make a detailed stand-table analysis. The analysis must, therefore, necessarily be in fairly general terms.

It is a fact well known that to get the greatest benefit from intermediate cuttings, as weeding, thinning, and pruning, they must be begun very early in the life of the stand and often repeated. One has to read only a little European timber-management literature to become thoroughly impressed with this fact. Another equally important fact is that where intermediate cuttings have been systematically applied, profitable utilization of the products removed has been a major inducement. In the commercial forests of the western white pine region where markets, present or potential, for the products of intermediate cuttings are lacking, the problem boils down to one of getting the greatest possible benefit at the time of final harvest from one or perhaps two cuttings applied at dead-weight expense during the youth of the stand.

It seems reasonable to insist that intermediate cuttings be regarded as a business proposition; that their value can and must be measured rather completely in terms of dollar-value increment. In the western white pine region there is no reason to believe that intermediate cuttings will have an appreciable net effect one way or the other on erosion, stream flow, or aesthetic values. They will, however, have some effect on blister-rust control as will be brought out. Accepting that the principal worth of intermediate cuttings must be sought in increased final harvest values, the next step is to see how these values may be influenced by intermediate cuttings.

The effect of intermediate cuttings on final harvest values may be broken down as follows:

1. They may increase the total value in dollars per acre realizable at the time of final harvest cutting or cuttings. This may result from increases in:

A. Net merchantable volume, which can be accomplished by:

(1) Increasing the proportion of merchantable species in the stand.

(2) Decreasing proportion of cull material of all spec....

(3) Increasing total volume per acre of all species through better spacing and reduced mortality.

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[8] DAVIS, KENNETH P. STAND IMPROVEMENT MEASURES FOR THE WESTERN WHITE PINE TYPE. Northern Rocky Mountain Forest and Range Expt. Sta. 63 pp., illus. 1936. [Processed.]

B. Unit value—value per M board feet, which can be accomplished by:

(1) Producing trees of larger average diameter by concentrating the growth capacity of the site on the faster growing stems. Large trees of a given species, other things being equal, are always worth more per board foot than small trees.

(2) Producing trees of higher average quality by concentrating growth on quality stems. This may or may not be related to volume increases either per tree or per acre.

2. They may reduce the regeneration cost of the new stand. Possibilities here are usually ignored, but if permanent forestry is to be practiced, such a saving represents a true value increase. It is brought about through increasing the merchantable proportion of the overstory and preventing the development of a worthless understory. The high cost of disposing of such material otherwise, usually around $30 per acre, has been brought out in the analysis of a high-quality mature stand.

Any proposed cultural operation should be carefully analyzed as to its probable results. A simple hypothetical example is presented in table 10, showing the estimated effects on final harvest values of a crown thinning applied once in a representative 30-year-old mixed stand of western white pine and its common associates. Changes indicated in volume, composition, and stumpage values result from increasing net merchantable volume by removing crooked, injured, and potentially defective trees; increasing the average size and quality of final crop trees, and hence stumpage value per M, through the early selection and release of crop-tree possibilities; and improving composition by removing trees of low-value species that compete with sound trees of more valuable species.

TABLE 10.—*Estimated increase in stand value per acre at time of final harvest resulting from thinning a representative stand of western white pine and its associates*

Item	Merchantable volume per acre, all species	Volume composition		Stumpage value per M board feet		Total value		
		Western white pine	Other species	Western white pine	Other species	Western white pine	Other species	Total
	M board feet	*Percent*	*Percent*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
Without thinning	30	50	50	6.50	1.50	97.50	22.50	120.00
With thinning	33	65	35	7.00	2.00	150.15	23.10	173.25
Effect of thinning (increase or decrease)	+3	+15	–15	+.50	+.50	+52.65	+.60	+53.25

The increase in total value of the stand of $53.25, resulting from these individually rather small increases, is really surprising. To this could be added at least $10 per acre for reduction in the regeneration cost of the new stand, making a total increase, assuming continued forest production, of about $63 per acre. While there can, of course, be many a slip between estimate and performance, this analysis illustrates a method of approach that brings out specifically the financial results of changes in volume, stumpage value, and species composition resulting from treatment, and squares with existing silvicultural knowledge and market conditions. Some such analysis must be made before any projected operation can be rationally appraised.

APPLICATION

Following the procedure just outlined of estimating the financial merits of a given cultural operation in terms of its probable effect on the final dollar yields, estimates were made of the probable accomplishments of a number of specific stand-improvement projects in the western white pine region in which cleanings and thinnings only were included. Pruning, which promises to be an economically sound measure, was not included because of insufficient factual basis for appraisal. Redcedar poles are also left out of account for the same reason, though some increase in yield could be expected without affecting the results materially.

The estimates were based on the following five factors:

1. Site quality as determined by height growth.
2. Actual yields on similar sites
3. Actual growth rates, as determined by studies in fully and partially stocked stands.
4. Developmental trends in western white pine stands as indicated by fairly extensive information on the silvical characteristics of the associated species and how they grow together.
5. Current stumpage rates, no dependence being placed on high future stumpage values.

The results of this analysis are given in table 11, which is indicative of accomplishment on the type of projects listed. Financial returns per acre at time of final harvest and average direct treatment costs, using day labor paid between 40 and 50 cents an hour, can be roughly summarized as follows:

Low-type thinnings, including more or less complete slash disposal:		
Cost	$60	$120
Returns	20	40
Crown-type thinnings, including partial slash disposal:		
Cost	30	80
Returns	20	40
Cleanings with no slash disposal:		
Cost	7	20
Returns	30	60

Low-type thinnings make an extremely poor financial showing for two main reasons.

First, low-type thinnings provide relatively small opportunity for stand improvement. There is a strong tendency to select for treatment well-stocked pole stands with a good representation of white pine in the overstory, which without any treatment at all would yield fairly high values at maturity. This was true in general of all examples cited in table 11. No great and permanent increase in rate of volume or quality of growth of such stands can be expected from a single rather disruptive treatment. The major improvement possible is in species composition and this cannot be greatly altered in stands more than 40 years of age without a heavy sacrifice of growing stock that might actually reduce total volume yield at 120 to 130 years. The estimated average increase in the proportion of white pine at maturity effected by treatment (difference between columns 4 and 5), for the five examples of low-type thinnings given, was only 11 percent. Also worth noting is that the younger the stand the greater the estimated increase. Going down the table in which the five projects are arranged in descending order as regards age, these percentage increases are 5, 8, 10, 12, 18, respectively. It is obvious that much of the total-value increase attributed to thinning is due to an estimated

TABLE 11.—*Estimated results at specific intermediate cutting projects in the western white pine region*

LOW TYPE OF THINNING COMBINED WITH GENERAL IMPROVEMENT CUTTING

Name of area, description of stand, and treatment given	Age when treated	Approximate site quality	Estimated proportion of white pine at maturity		Estimated total merchantable volume per acre at maturity				Estimated total values[2] per acre at maturity				Increase in value per acre due to treatment
					Without treatment		With treatment		Without treatment		With treatment		
			Without treatment	With treatment	Western white pine	All species	Western white pine	All species	Western white pine	All species	Western white pine	All species	
Benton Creek:													
Thrifty, wellstocked stand dominated by larch and white pine with understory of cedar and hemlock. White pine, larch, and cedar favored in thinning. Upper crown canopy thinned but not much opened	*Years* 75	Good site 60	*Percent* 67	*Percent* 72	*M board feet* 30.0	*M board feet* 47.0	*M board feet* 33.8	*M board feet* 47.0	*Dollars* 240	*Dollars* 248	*Dollars* 237	*Dollars* 270	*Dollars* 22
Upper Sands Creek:[4]													
Thrifty, very densely stocked stand mainly dominated by white pine, with white fir, Douglas-fir, and some lodgepole pine and larch: White pine favored by increased growing space	65	Fair site 50	72	80	25.9	36.0	30.1	38.0	181	201	213	228	27
Beauty Creek:[5]													
Thrifty, wellstocked stand dominated by white pine, western larch, and Douglas-fir: White pine favored, cutting mostly in lower crown classes, some in dominant stand	40-50	Fair to good site 55	58	68	23.2	40.0	28.6	42.0	162	191	200	227	36
Luby Bay:[6]													
Extremely dense, stagnated "dog hair" stand from single burns; 24,000 stems per acre 0.6 inch d. b. h. and larger; half of dominant stand white pine: White pine released	80±	Good site 60	75	67	20.9	38.0	28.8	43.0	136	176	202	227	51
Uncle Sam's Spring:[7]													
Vigorous and dense stand of white pine and larch with cedar and hemlock understory: White pine favored, much dominant larch cut	35	Fair to good site 55	60	78	22.8	38.0	29.6	38.0	160	190	207	224	34

CROWN TYPE OF THINNING COMBINED WITH GENERAL IMPROVEMENT CUTTING

Upper Deception Creek:[6] Dense, lower north-slope stand, hemlock mainly dominant, white pine generally codominant or intermediate: White pine favored; most of dominant hemlock removed	40	Fair to poor site 17	45	50	10.5	30.0	16.8	28.0	68	92	109	123	31
Demorest Creek:[5] Very dense stand; about half dominated by white pine, with white fir, Douglas-fir, and a little lodgepole pine: White pine favored; many competing dominants removed	17	Fair; $6.50	60	73	21.6	35.6	25.6	37.0	147	171	179	195	24

CLEANINGS

McGoldrick sale area:[7] Well-stocked reproduction stand, white pine, white fir, larch, Douglas-fir, hemlock, with some advance-growth hemlock from parent stand. White pine slightly less than half dominant seedling stand: Principal competitors of better pine seedlings removed	10	Fair to good site [illegible]	17	50	19.3	14.6	40.1	15.0	135	182	211	237	55
Lower West Branch Road:[8] Dense reproduction stand of larch, white pine, hemlock, cedar, and a little Engelmann spruce. Almost entirely dominated by larch: Most dominant larch removed	8	Fair to good site [illegible]	15	68	26.2	15.0	12.0	17.0	141	203	221	262	59

[3] Estimated that final cut would come at about 130 years.
[4] White pine stumpage valued at $6.50 to $7 per M, depending on the area and value of nearby mature stands. It was assumed that the stumpage value of white pine would not be increased by a single treatment. Other species valued at $1.25 to $2.70 per M depending on species and estimated quality.
[5] Priest River Experimental Forest.
[6] Deception Creek Experimental Forest.
[7] Coeur d'Alene National Forest.
[8] Kaniksu National Forest.

increase in the proportion of white pine in the stand and would be practically nullified if white pine lost its present value superiority.

Secondly, low-type thinning projects were very costly, owing to the exploratory and experimental nature of much of the work and because most areas treated were comparatively small, making effective systemization of the work difficult. It is doubtful, however, if costs could be reduced sufficiently to equate benefits. One has to see one of these myriad-stemmed western white pine stands to appreciate what a job it is to cut everything but trees selected as final-crop possibilities. Such a stand is shown in figure 9, *B*. So much inflammable fuel results from cutting that some slash disposal, at least along roads and trails, is practically mandatory. Complete slash disposal costs about as much as cutting alone.

Crown-type thinnings seem to offer greater possibilities of producing returns commensurate with cost, though present experience with this type of cutting is very limited. Applied only once and in the same type of stand, total value accretion would probably not be much greater than that resulting from a low-type thinning. The superiority lies principally in reduced costs, due first to the smaller amount of cutting. Fewer crop-tree possibilities are chosen and cutting is limited to their liberation. Much of the tangle of understory trees is left alone. In addition, less slash disposal is necessary as a consequence of less cutting and less opening of the stand.

Crown-type thinnings have the added advantage over low-type thinnings that there is much less tendency to select for treatment stands which cannot be greatly improved by a single cutting—those already largely dominated by desirable species; selection is rather made of stands in which desirable crop trees need and lack necessary growing space. By cutting all corners possible in field technique, keeping slash disposal to a minimum, and selecting for treatment only stands in which a marked improvement in composition is possible, say an increase of 20 percent or more, this class of work probably can be made to show a small margin of benefit over out-of-pocket cost.

Cleanings, which are made in stands less than about 20 years of age, make by far the best showing, producing a future benefit in excess of direct cost. In the first place, cost of treatment is low; from 1 to not more than 5 man-days per acre are required. Only small trees are removed that require only one snip of powerful nippers or one blow of a hatchet or brush knife (fig. 9, *A*). Slash disposal is not necessary.

Secondly, benefits are large, primarily because the proportion of western white pine can be most effectively augmented in reproduction stands. Most reproduction stands in this region contain enough white pine stems to make that species an important component of the mature stand, if the associated species are not too abundant and aggressive. The balance of power can be most effectively tipped in favor of one species or another during this early period of stand development. Early stagnation due to excessive stand density can also be prevented. To put it another way, the possibility of improving a stand is greatest when it is less than 20 years, preferably less than 10 years old.

A minimum qualification in appraising the financial desirability of any intermediate cutting is that expected return, however measured, must not be less than direct cost. Above this minimum, that operation is the most desirable that yields the highest rate of return on the investment. With the long rotations prevailing in the western white pine region and with treatment given at dead-weight expense, the rate of return inevitably will be low. For example, on the McGold-

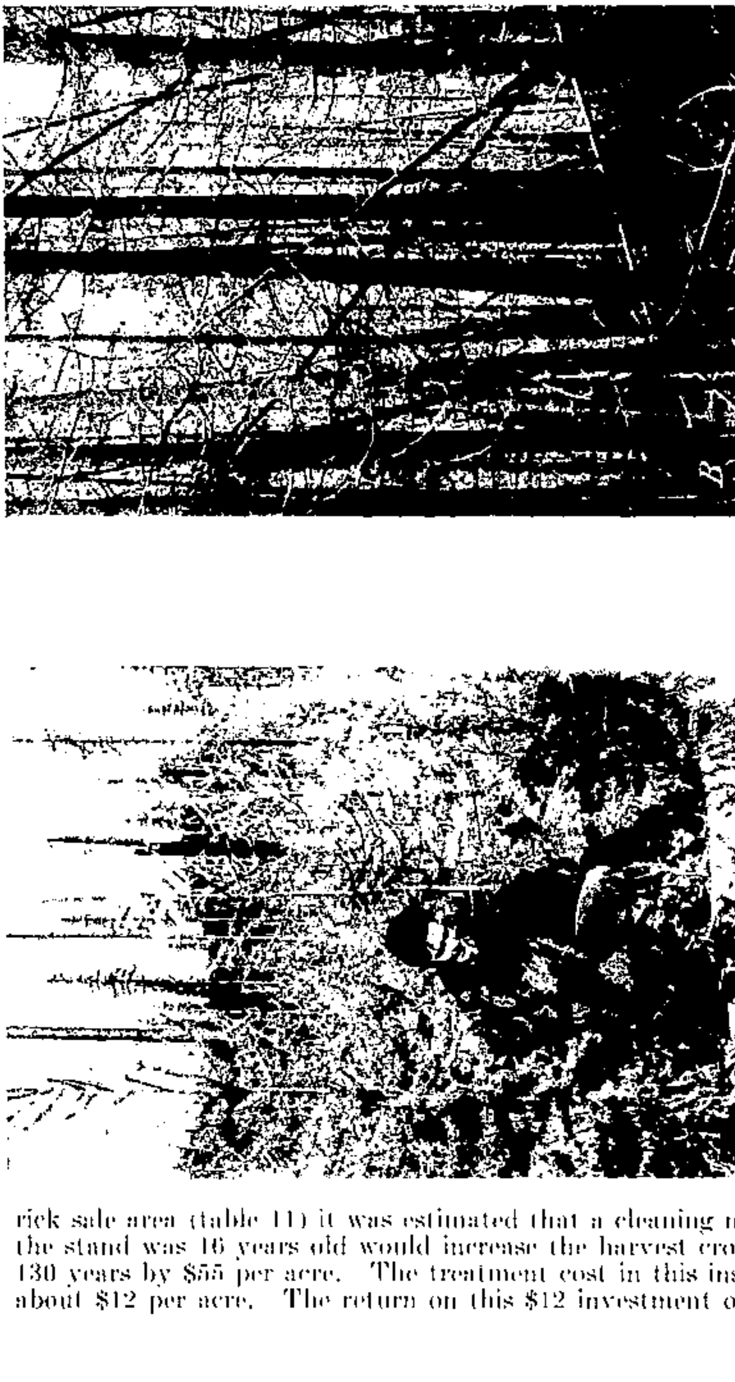

FIGURE 9.—Inexpensive cleanings applied to the 8-year-old stand (*A*) to release western white pine from severe competition (by western larch in this instance) will prevent the development of over-dense, partially stagnated stands of undesirable species composition, similar to (*B*), a 35-year-old stand, which can be effectively treated only at great expense.

rick sale area (table 11) it was estimated that a cleaning made when the stand was 16 years old would increase the harvest crop value at 130 years by $55 per acre. The treatment cost in this instance was about $12 per acre. The return on this $12 investment over a 114-

year period (16 years less than the rotation age of 130) is consequently 1.3 percent compound interest or 3.1 percent simple interest.

Present knowledge indicates that intermediate cuttings properly applied will not add appreciably to the cost of white pine blister-rust control. Blister-rust control requirements, that cutting, disturbance of the forest floor, and slash burning be kept to a minimum, fortunately coincide almost exactly with silvical and economic requirements.

In reviewing this analysis of the place of intermediate cuttings in a long-time program of growing western white pine forests, it is clear that, as long as the products of intermediate cuttings continue to have no commercial value, the objective should be to increase the value of final harvest cuttings as greatly as possible by one or two treatments applied in the youth of the stand.

Also, it should be realized that greatest value returns accrue from increasing the proportion of merchantable species in the stand. Important total-volume and unit-value increase cannot be expected without repeated treatments which are not financially practicable. As western white pine is the most valuable species, production of stands containing a high proportion of white pine is indicated.

Lastly, cleanings are recommended as being more effective in increasing the proportion of western white pine in the stand and much less expensive than are thinnings and improvement cuttings in older stands. It is estimated that cleanings give a return definitely in excess of direct cost and consequently offer a low but definite return on the investment.

TIMBER-MANAGEMENT PRACTICE[8]

The purpose of this section is to bring down to earth and to show the practical significance of the preceding somewhat generalized discussion of criterions or guides to regulatory and financial policy and the possibilities and problems arising in the management of certain kinds of western white pine stands. This can best be done by presenting a cross section of actual harvest cuttings and considering critical problems of protection against fire, insects, and disease as these affect management practice.

Cutting Practice in the North Fork of the Coeur d'Alene River—A Sample Area

Discussion of cutting practice will be focused on a specific area of 109,300 acres, the drainage of North Fork of the Coeur d'Alene River within the Coeur d'Alene National Forest (fig. 2), as representative of the better white pine drainages in this region. Figure 10 shows land ownership, drainage features, and status of cutting.

For a number of reasons this drainage is especially suitable for study. Timber production is the predominant land use and the area has been a focal point in the development of Federal management policy in the region; almost everything has been tried there. Both public and private lands have been logged extensively and furnish much material

[8] For the development of silvicultural practice in the western white pine type as a whole, see (5). A good account of the development of the lumber industry and the present status of forestry in northern Idaho is given by Hutchinson (51); and Northern Idaho Forest Resources and Industries, by S. Blair Hutchison and R. K. Winters, a progress report of the Forest Survey, Northern Rocky Mountain Forest and Range Expt. Sta. 1942.

on methods and costs. Silviculturally, the drainage offers a rather full range of technical problems common to the white pine region. In ownership it is dominated by the Coeur d'Alene National Forest covering 80 percent of the area, and one private holding, 15 percent. The

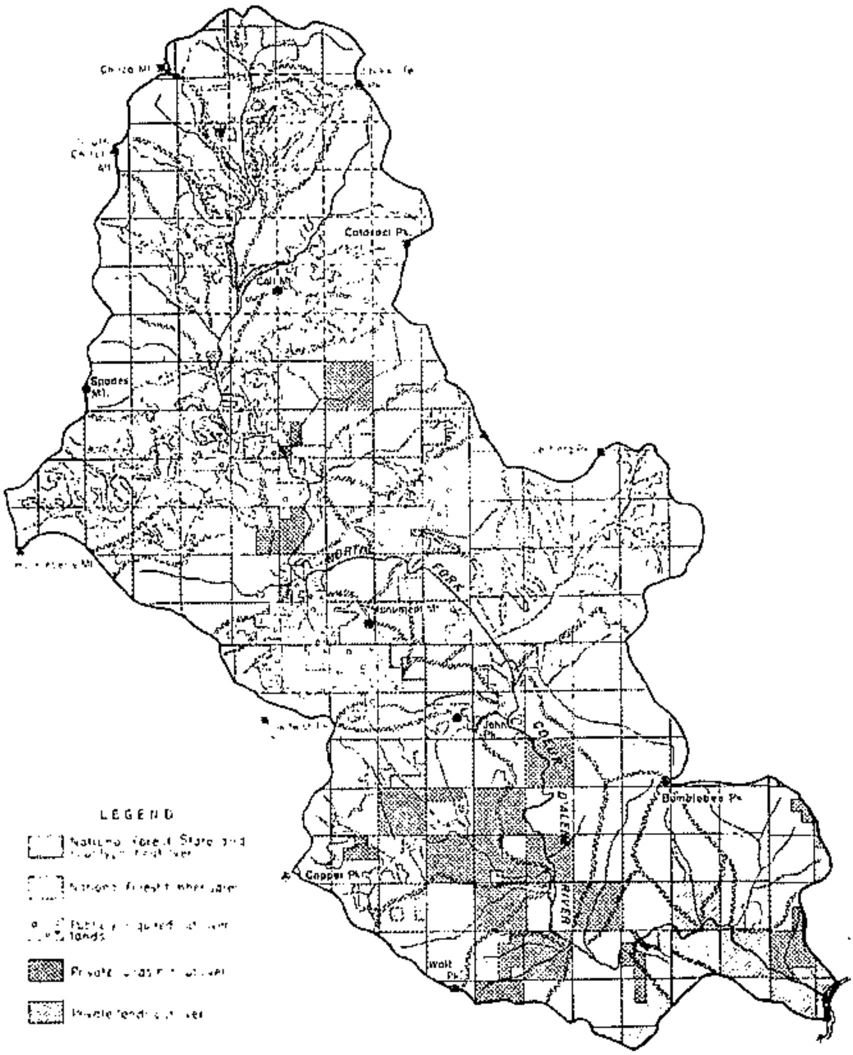

FIGURE 10. Ownership and status of timber cutting in the North Fork of the Coeur d'Alene River, Idaho.

remaining 5 percent is in State, county, and private holdings. Analysis is greatly simplified by this unified ownership. Topographically, the drainage is representative of the mountainous terrain of much of the white pine region. It is a compact geographical unit. Protection problems against fire, insect, and blister rust are critical, yet at the same time techniques of control have been well developed and extensively applied in this drainage. For example, not a single logging fire of consequence has marred the history of North Fork logging by either private or public agencies.

NATIONAL FOREST TIMBER SALES

A brief review of the highlights in the development of Federal timber-cutting practices on North Fork will aid greatly in understanding regional management problems. Gross accomplishments in timber sales in the drainage from the inception of cutting in 1909 to 1938 are summarized in table 12.

TABLE 12.—*Summary of national forest timber sales made in the North Fork of Coeur d'Alene River from 1909 to 1938, inclusive*

Item		Early sales 1909–10	Intermediate sales 1915–22	Big sales 1923–38	Total all sales
Sales	number	12	32	15	59
Cut-over area	acres	290	5,729	13,172	19,191
Total cut:					
Western white pine	M board feet	4,197	84,377	219,574	308,148
Other species	do	1,872	26,359	20,736	48,967
All species	do	6,069	110,736	240,310	357,115
Cut per acre:					
Western white pine	do	14.5	14.7	16.7	16.1
Other species	do	6.4	4.6	1.5	2.5
All species	do	20.9	19.3	18.2	18.6
Volume white pine in total cut	percent	69	76	91	86
Total stumpage receipts:					
Western white pine	dollars	18,101	371,768	1,471,197	1,861,066
Other species [1]	do	6,968	8,626	17,210	32,804
All species	do	25,069	380,394	1,488,407	1,893,870
Stumpage receipts per acre	do	86.44	66.40	113.00	98.69
Slash disposal:					
Cost per M board feet logged	do	.36	.69	.84	.79
Cost per acre cut-over	do	7.57	13.30	15.39	14.65
Supplemental cultural measures (cost per acre cut-over) [2]	do	0	2.90	9.20	7.18

[1] Actually, practically all stumpage receipts can be credited to white pine. Other species have seldom shown a positive value when appraised independently, being "carried" by white pine.

[2] Girdling, disposal of low-value species, etc. This work was usually done on only a portion of the total area cut-over. The area actually treated is unknown; hence average cost per acre actually treated cannot be determined. As determined by individual cost studies, however, the cost usually ranged from $25 to $40 per acre treated.

Here, sales made in the drainage have been placed in three groups, 1909–10, 1915–22, 1923–38. The early sales were all rather small affairs, never getting far from the river (the only means of log transport) and aggregating only 6 million board feet. The star of white pine had not yet risen and it was sold for the most part at the same stumpage rate as other species—about $4 per M. On several sales the operator was required by the contract to take dead mixed timber (though he took little enough) at the same rate as green material. It was a period of beginnings and of gropings for successful timber-management methods. Little was known of the silvical characteristics of the various species associtated in the type. From the first, however, the prime aim in cutting was to remove the parent stand in such a way as to get reproduction. Silvicultural zeal was high in those days; in fact, the zeal of the forester to practice forestry sometimes exceeded the ability of the timber purchaser to make the operation pay out. Several cutting methods were tried, such as clear cutting in strips—really, only small patches cut out of a solid mountainside of timber; a shelterwood cutting; an attempt at a selection cutting; and several types of seed-tree cuttings. The only silvicultural improvement measure practiced was piling and burning logging slash.

After a lull of a few years, largely occasioned by the demoralizing effect of the great 1910 fires, cutting was resumed on a much larger scale. A large group of sales was made in 1915 and 1916, Leiberg and Cathcart Creeks being the major sale areas opened up at this time. This period marked the real development of timber-management practice in the region and the upsurge of white pine to a commanding price superiority as the species gained recognition in national markets. Based quite largely on the findings of organized research begun in 1911, cutting practices were materially changed from the earlier attempts. With the first cuttings in this intermediate sale period, main reliance for regeneration was placed on seed stored in the duff, with seed trees reserved mainly as seed insurance. Not until the late 1920's was the true role of seed in the duff evaluated and the unreliability of this seed source definitely established. Thereafter, main reliance for seed was placed on seed trees.

Although the seed-tree type of cutting was generally employed during this intermediate period, the net result, because of the usual presence of numerous trees other than the selected white pine seed trees, more resembled a rough shelterwood. Merchantable white pine seed trees were consciously reserved for seeding purposes; but whether or not the cutting constituted a seed-tree cutting as silviculturally defined depended on how many trees of other species were left.

To cope with the ever-troublesome problem of getting rid of unmerchantable trees several disposal methods were tried. Most of them involved girdling defective grand fir and hemlock or burning it standing at a total cost of about 15 cents per M board feet of timber logged. This work was mainly a supplement to slash disposal and there is no reliable record of the cost per acre actually treated. Slash disposal evolved from early and rather crude work at about 40 cents per M feet logged, to a well-developed practice, costing from 60 to 90 cents per M.

The third group of sales, from 1923 to 1938, is characterized by the advent of the well-financed match companies and, as the commercial exploitation of large bodies of merchantable timber really got under way, by big sales. This group was ushered in by the big Burnt Cabin Creek sale, begun in 1923 and completed in 1931, which netted $780,558 in stumpage on a cut of 81,285 M board feet from 3,065 acres.

Throughout this period, white pine was undisputed king. Earlier attempts to force other species on an unwilling market by making white pine absorb the deficit were dropped, and the cut of white pine jumped from 76 percent of the total in 1915–22 to 91 percent in 1923–38 (table 12). Values, as before, were practically 100 percent due to white pine. Logging in the drainage has been possible only because of the high value of white pine; values for other species were nominal.

Up to this time all major log transport had been by river drive, but this period marked the beginning of railroad logging. More recently, truck hauling has come into the picture.

This latest group of sales was marked by the development and application of supplementary cultural measures to remove defective trees, sound trees of currently unmerchantable species usually being retained. This work grew from an incidental to a fairly large-scale activity as the silvicultural necessity for such treatment became better appreciated. Girdling was abandoned as creating too great a fire hazard in favor of the more direct, complete, but also more expensive method of felling undesirable trees and piling and burning slash. This work usually cost between $25 and $40 per acre treated and was done on only a portion, usually between a third and a quarter, of the total area cut over. Logging slash was disposed of by pile-and-burn methods as before, the only change being that a more thorough and careful job was done. The average cost rose from 69 cents for the second group of sales to 84 cents per M board feet logged (table 12).

With no material change in cutting methods, the seed-tree type of cutting became more crystallized, and as the necessity for seed trees became increasingly evident their number and character were more definitely specified. From 2 to 6 well-formed white pine trees, perferably 16 inches d. b. h. and larger and constituting about 10 percent of the merchantable white pine volume, were ordinarily reserved.

CASE HISTORY OF A LARGE WHITE PINE TIMBER SALE

To amplify the preceding discussion by bringing out items that can best be presented and appreciated in connection with a specific cutting, and to supply case data for use in a later analysis, it will be helpful to investigate thoroughly a representative Forest Service timber sale.

The Burnt Cabin Creek sale, operative from 1923 to 1931, will serve this purpose, not so much because it was a banner sale in point of volume cut and value received for the timber, as because the timber-management policy consistently followed throughout was typical of practice on Federal cuttings.

The ground plan of the sale is shown in figure 11, and an aerial view in figure 2. Main features of the sale are summarized as follows:

Area. Outstanding is the fact that a little less than half (44 percent) of the gross area in the drainage was actually logged over (table 13). Twelve percent of the total area supports immature age classes of merchantable species that probably can be logged sometime. In all, therefore, 56 percent of the gross area can be considered as being currently or potentially loggable at the time the cutting was made.[10] The boundaries of the cutting area were drawn to include all timber considered merchantable. As shown, the ground pattern of the sale is most irregular.

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[10] From 50 to 60 percent is probably a fair figure for most mountain drainages. A similar check made for the Leiberg Creek sale, another large cutting in the drainage, showed 40 percent of the gross area logged over and another 15 percent probably loggable under present conditions, or 55 percent in all. Truck and tractor logging have tended to increase the proportion of total area than can be cut over for virgin timber. However, a distinction should be made between the area than can be logged over once in such drainages and the area that can be considered as permanently productive of merchantable timber. Some logging has been and is being done on poor and exposed sites that might better be cut over very lightly if at all, and which in any event yield comparatively little timber volume. The proportion of the total area that can be considered as the effective basis for permanent production naturally will vary from drainage to drainage and according to economic conditions.

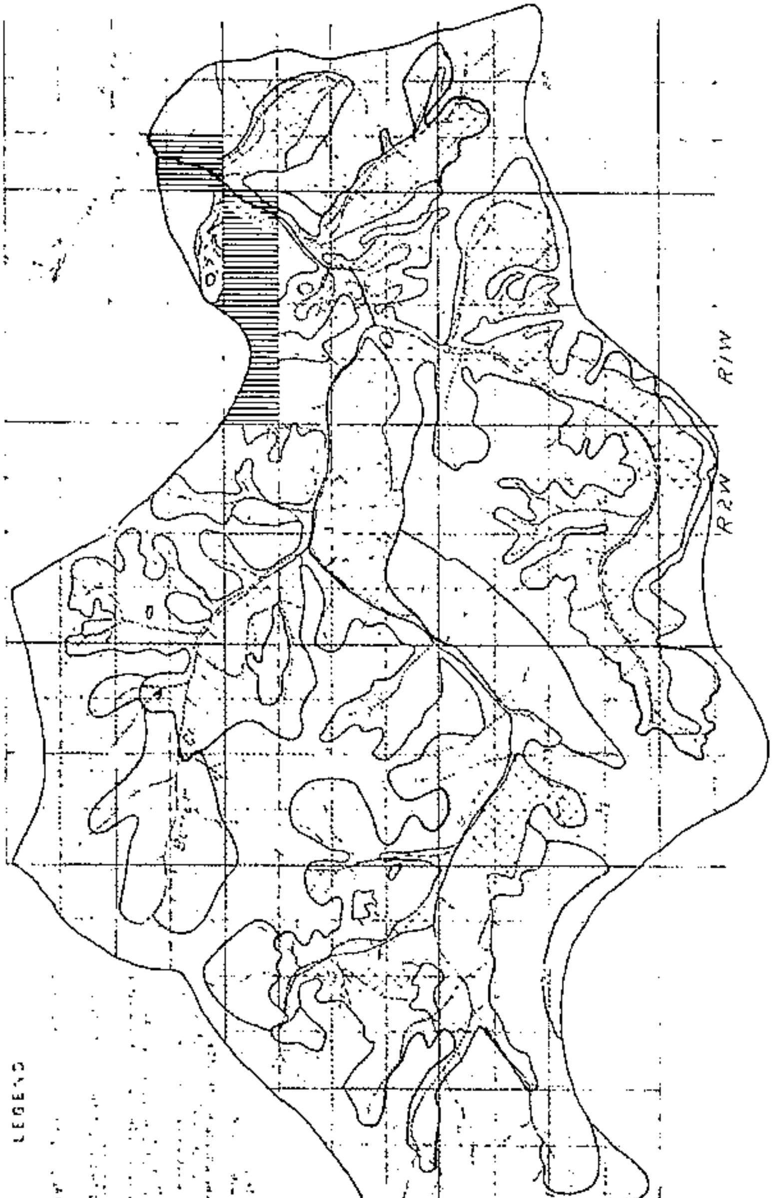

FIGURE 11.—The Burnt Cabin Creek sale area.

TABLE 13.—*Areas logged and not logged on Burnt Cabin Creek drainage*

Description	Area	
	Acres	*Percent*
Areas logged:		
With disposal of defective and unmerchantable trees in addition to slash disposal	1,200	17
Slash disposal only	1,865	27
Total	3,065	44
Areas not logged:		
Immature timber, loggable at next cut	820	12
Not loggable at next cut	3,115	44
Total area in drainage	7,000	100

Timber.—The original stand within the cutting boundaries contained about 34 M board feet per acre averaging 73 percent western white pine—a high proportion for so large a unit. Of the remaining so-called mixed species, grand fir and western hemlock made up 20 percent, larch and Douglas-fir 6 percent, and Engelmann spruce 1 percent. In age, 15 percent of the area supported stands over 200 years old, 75 percent 161 to 200 years, 6 percent 121 to 160 years, and 4 percent 81 to 120 years. Within age classes, stands were quite closely even-aged. Volumes cut and left per acre, the latter as determined in 1936 about 8 years after the average cutting date, are given in table 14.

Values.—Financially, the sale was a great success (table 15). Aiming not only for the Burnt Cabin Creek timber but for a strategic toe hold on the rest of the timber in the upper North Fork, the successful bidder paid the hitherto unheard of average price of $11.22 per thousand for white pine. In addition, an average of $1.33 per thousand feet of all species scaled on the sale was deposited by the purchaser with the Forest Service to cover the cost of slash disposal and supplementary cultural measures.

TABLE 14.—*Timber volumes cut and left per acre on the Burnt Cabin Creek drainage, Coeur d'Alene National Forest, Idaho*

Species	Timber cut		Timber left [1]	
	Board feet	*Percent*	*Board feet*	*Percent*
Western white pine (green and dead)	22,800	86	1,800	24
Western larch, Douglas-fir	400	2	1,700	23
Western hemlock, grand fir	3,000	11	3,900	53
Engelmann spruce	300	1		
Total	26,500	100	7,400	100

[1] As determined by a cruise made 8 years after the average cutting date; consequently, these volumes are not what was left on the ground at the time of cutting and cannot be added to volumes cut to get the original stand. Heavy mortality is known to have occurred over parts of the area. An estimated total of 1,496,000 board feet of white pine seed trees or nearly 500 feet per acre was estimated to have died between logging and the time the cruise was made. The volume of white pine remaining at the time of cutting was thus about 2,300 board feet per acre, constituting 9 percent of the total pine volume. These figures include white pine, larch, and Douglas-fir down to 14 inches and western hemlock and grand fir down to 12 inches d. b. h.

TABLE 15.—*Stumpage receipts from the Burnt Cabin Creek timber sale*

Species	Average stumpage rate per M	Total stumpage value	Total value per acre
Western white pine (green)	$11.22	$772,250	$251.96
Western white pine (dead)	2.25	2,064	.67
Larch, Douglas-fir, grand fir, and western hemlock	.50	5,273	1.72
Engelmann spruce	1.00	971	.32
Total or average	9.60	780,558	254.67

Slash disposal and cultural measures. Slash disposal was thorough over the entire area. In addition, on about 1,200 acres, or 39 percent of the logged area, the most defective and least valuable trees in the residual stand, including most of the hemlock understory, were felled and the slash piled and burned. Practically all of this work was done on north and east slopes, where the residual stand was the densest. The purpose was to open up an overdense residual stand sufficiently to permit natural regeneration. Total and average acre costs for slash disposal and this stand-improvement work are as follows:

Slash disposal (3,065 acres):	
Total cost	$69, 195. 00
Average cost per M board feet logged[11]	. 83
Cost per acre treated	22. 58
Partial disposal of defective and undesirable trees (1,200 acres):	
Total cost	39, 185. 00
Cost per acre treated	32. 65

[11] Based on a total cut of 83,291 M board feet, which includes some timber used in construction for which stumpage was not charged.

Silvicultural objectives and results. The major objective was not only to harvest the mature crop of timber but also to get natural regeneration that would include a good proportion of western white pine. In marking, two to six well-formed western white pine seed trees per acre, preferably 16 inches d. b. h. or larger, were left for seeding purposes, amounting to about 9 percent of the white pine volume. A defect in the marking policy as applied on the ground was that little distinction was made between north and south slopes. As a result, many of the southerly slopes were cut so heavily that the site was overexposed and reproduction came in but sparsely. On northerly slopes given supplementary cultural treatment, regeneration is generally excellent and includes a satisfactory proportion of white pine. Some untreated areas have not reproduced satisfactorily, however.

A reproduction survey made by the Coeur d'Alene Forest in 1936, using a 4-milacre-stocked-transect method,[12] reveals that none of the untreated slopes, with the possible exception of the north-northeast, can be considered satisfactorily restocked (table 16). The treated slopes are all well stocked. The total difference in favor of the treated slopes is undoubtedly greater than that shown, since some of the reproduction on the untreated areas has come in under an overwood density too great to permit satisfactory subsequent development of the reproduction stand. Though the data are limited, the extremely poor regeneration occurring in creek bottoms is noteworthy and characteristic of western white pine cuttings. Owing principally to rapid development of sod-forming vegetation and shrubby growth, creek-bottom sites seem to be the most difficult of all to regenerate. In fact, it is believed better not to try but rather to leave a good timber cover for both aesthetic reasons and watercourse control.

In review, the Burnt Cabin Creek sale is a good concrete example of a white pine cutting operation carried out under an avowed and con-

[12] Transects 13.2 feet wide were run across the area at intervals of a quarter mile. The presence or absence of white pine reproduction on each consecutive 13.2-foot square (4 milacres or 1/250 acre) was noted. This gives a fairly good measure of the presence and distribution of the reproduction on the area in general.

sistently followed policy of keeping the land growing white pine. That the regeneration cost, including the value of the merchantable seed trees, is high cannot be denied. Neither can it be denied, however, that the objective was in the main successfully carried out.

TABLE 16.—*Natural reproduction in terms of 4-milacre stocking on the Burnt Cabin Creek sale as affected by cultural treatment and aspect*

Condition and aspect	Quadrats tallied	Quadrats stocked with—		
		White pine	Other species	Any species
Treated:	*Number*	*Percent*	*Percent*	*Percent*
N–NE	1,292	78	91	95
W–NW	881	63	83	90
Untreated:				
N–NE	1,014	52	76	83
W–NW	1,089	21	60	67
S–SW	1,230	19	43	53
E–SE	1,451	18	45	58
Creek bottoms	221	5	9	12

PRIVATE CUTTINGS

The story of private cuttings in the North Fork drainage can be briefly told. The main purpose has been to harvest the crop, without the added objective of getting white pine reproduction. Instead of the latter, the controlling consideration has been an immediate dollar profit on a large and definite cash investment. As a result, practically nothing but white pine has been cut on private lands and silvicultural measures have been limited to excellent slash disposal.

Private cutting did not begin on an important scale until 1925, when an operating company purchased practically all the privately owned timberland in the drainage, about 21,000 acres. Most of this land originally came into private ownership through railroad grants. A series of splash dams for log driving were built on the river and cutting was undertaken on a fairly large scale, a little over 100 million board feet of white pine being logged by the end of 1930. The original intention was to cut over the entire area in about 5 years, but the 1929 depression effectively halted rapid conversion and in 1939 nearly a fifth of the volume remained uncut.

Skidding has been done by horses mainly to trailing chutes. Only one flume (Picnic Creek) was privately built. Major log transport was by river drive to Lake Coeur d'Alene and the mill at Coeur d'Alene. In 1938 and 1939, however, a rapid change in logging method took place, the truck supplanting the river drive, and to a large degree the chute. In all probability, the last log drive the North Fork will ever see came out in the spring of 1937. All indications pointed to a permanent shift to truck transport.

Trees were usually cut to about a 12-inch lower diameter limit, somewhat lower than on national-forest sales. As most of the timber was 140 years of age or more, white pine was as a consequence virtually eliminated. Practically no other species were cut. There was a tendency to skid logs farther on company lands than on national-forest sales. As shown in figure 3, sale boundaries on national-forest sales were drawn to coincide closely with the limits of what was considered accessible and merchantable timber. On company lands, however, since the timber was paid for whether cut or not, there was more of a tendency to go back after the last tree. Inevitably, however, some "back forties" had to be left, partially accounting for the actual cut underrunning the company buying cruise by 6.8 percent.

The average cut on privately owned lands was 13,600 board feet of white pine per acre. The average species composition by volume of stands cut-over was

	Percent
White pine	50
Larch and Douglas-fir	24
Grand fir	18
Other species, mainly western hemlock	8

Fire protection since 1929 has been handled on a cooperative basis with the Forest Service, at an average annual cost of a shade under 8 cents per acre, including both presuppression and actual fire suppression.

Taxes have been a large item. Based entirely on the general property-tax plan, they have been levied directly against an arbitrary appraised value of the timber. Land values as such do not exist. The essentials of the tax situation as actually faced by the owner from 1925 to 1937, inclusive, are these:

Average annual tax per acre on uncut timber lands	$0.71
Average annual tax per thousand board feet of loggable white pine (the real tax base) figures on an actual average cut of 13,600 board feet per acre	.052
Average annual tax per acre on lands cut over for white pine with other species left	.10

That taxes at this rate run into real money is apparent. On several sections of land (640 acres) in the drainage, more than $10,000 has been paid in taxes since the land first came into private ownership. The annual tax bill per uncut section is often over $500. In the 15 years since these lands were purchased by the operating company, over $10 per acre or nearly 80 cents per M feet of loggable white pine timber has been paid on timberlands still uncut. This is without interest. Including interest, say 4 percent compounded, the 15-year tax cost of holding this timber is about $14 per acre and $1 per thousand board feet. It should not be necessary to labor the point that taxes have been a contributing cause of pressure for early liquidation. A tax of 10 cents per acre per year on cut-over lands is still fairly high, considering the low and problematical values at stake.

In summary, private timber-cutting operations in the drainage have been harvesting operations only. No investment in timber growing has been made nor is there any real incentive to do so. Nearly 5,000 acres of these cut-over timberlands have already passed into national-forest ownership via the exchange route and it seems inevitable that most of the rest will follow sooner or later. The main consideration retarding the process is the possibility that a good truck route into the area, now being developed by the Forest Service, plus a little better market in the near future, may permit profitable logging of some of the remaining mixed species. Once this timber is gone no private owner can afford to hold the land to grow another crop.

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CUTTING PRACTICE IN REVIEW

The era of large cuttings in the North Fork drainage is nearly over; in a few years the last of the big blocks of merchantable timber in the drainage will probably be cut and the scene of large-scale cutting operations will shift to other portions of the Coeur d'Alene National Forest. But the drainage is still green from end to end and in the aggregate there will remain much Federally owned timber of sawlog size.[13] With the development of truck-road outlets and consequent improved possibilities for marketing species other than white pine, logging on a reduced scale can be continued indefinitely to economic and silvicultural advantage.

Viewing the progress of cutting in the drainage as a whole, two things stand out: (1) The one-species market—it has been white pine and white pine alone that has made commercial logging possible here—and, largely a result of this, (2) the high cost of obtaining adequate regeneration. The problem in a nutshell is how to confine the cut mainly to white pine in a naturally mixed forest type and get adequate white pine reproduction. There is no satisfactory answer; it cannot be done.

From this stubborn fact stem most timber-growing difficulties in the white pine region. If white pine reproduction is desired, and only white pine is merchantable, sufficient of the least valuable of the white pine associates—notably defective hemlock and grand fir—must be disposed of at dead-weight cost to permit satisfactory regeneration. There is no other way. The Forest Service avoids wastage of sound but currently unmerchantable timber wherever possible by not cutting stands containing considerable volumes of such timber. Where such timber is necessarily present, it is mostly left standing, even at the sacrifice of adequate reproduction. An optimistic and liberal view of future values for timber at present unmerchantable is taken. But in cutting high-value white pine stands, where without supplemental cultural measures little or no white pine reproduction can be expected, a portion of the stumpage receipts has been ploughed back in to keep the area producing white pine.

Whether or not the decision to back western white pine is a wise one only time will tell. Some maintain that an age of cellulose and wood plastics is coming, point out the rise of many wood substitutes, favor large forest areas in other and more accessible portions of the United States, and cite the many instances of species once despised as forest weeds that later became merchantable. Against this, one may set the patent fact that since the first cuttings were made in New England, white pine has always been in high demand, and ask whether there is any convincing reason why white pine should lose its long-standing superiority over its associates. One can also point out the undeniable fact that the forest industry in the western white pine region has been founded on white pine. Finally, and this is an argument seldom raised, white pine is one of the most silvically amenable and volume-producing species in the white-pine forests. High timber

[13] In the 1936 revision of the Coeur d'Alene management plan it was estimated the drainage contained about 391 million feet of merchantable timber in zone 1 (area believed to be commercially operable). About one-third of this was western white pine. Approximately 50 million feet of pine have been cut between 1936 and 1939 and much of the remainder, especially the mixed, is of doubtful merchantability.

volumes are usually associated with a high proportion of western white pine. This does not mean that white pine is ecologically essential to maintain a good forest cover; only that it is an inherently desirable species as a cellulose-producer aside from its present high value. The difficulty with white pine is its susceptibility to disease and insect attack; more of this later. Decision whether or not to continue to grow white pine simmers down to a forecast of the future. The Forest Service is definitely committed to growing white pine as a major crop in this forest region. If this is accepted as a reality, as it has been in this study, then the costs of growing it must also be faced.

Forest Protection

Protection of the western white pine forests from fire, insects, and disease includes some of the most widely known and crucial of western white-pine management problems. The magnitude of these problems and their limiting influence on timber management deserves special consideration.

FIRE CONTROL AND USE

The following are, in summary form though not necessarily in order of importance, the essentials of the fire situation as it affects timber management.

Cost

Western white-pine forests are notoriously fire-susceptible and it is common knowledge that adequate protection from fire is costly. The average annual direct fire-preparedness cost on the Coeur d'Alene National Forest from 1935 to 1938, inclusive, was about 5 cents an acre. Suppression costs are, of course, highly uncertain. For the same period, which included no disastrous fire situations, they averaged about 1 cent an acre per year. Preparedness plus comparatively very light suppression costs consequently cost 6 cents per acre per year for this particular forest and period of time. This cost does not, however, include the large item for maintenance and depreciation charges for roads, trails, telephones, lookout towers, etc., used primarily for fire control. On four national forests in the western white-pine region for fiscal years 1936, 1937, and 1938, the total fire-control cost, including these items but without any allowance for actual fire damage, is estimated (table 17) at an average of almost 20 cents an acre. This figure is indicative of average costs under present conditions.

TABLE 17.—*Total fire control costs per acre protected, including maintenance and depreciation, on 4 national forests in the western white pine region,*[3] *1936–38*

National forest	1936	1937	1938	Average
Kaniksu	$0.2215	$0.2927	$0.2030	$0.2391
Coeur d'Alene	.1398	.1987	.1670	.1685
St. Joe	.1657	.1729	.1612	.1666
Clearwater	.2002	.2303	.1941	.2082
Average	.1818	.2236	.1813	.1957

[3] Taken from United States Forest Service Activity Cost Statements. The years included are the only ones for which costs of this character are available.

Effectiveness

The probable fire loss and its net effect on timber yields in merchantable stands, assuming a fire-control organization as it existed in 1940, are exceedingly difficult to estimate. Present fire-loss statistics given no measure of effective fire loss in such stands. A 5- to 10-percent loss in net yield from fire would seem to be ample. In general, managed stands do not represent critical fuel types and have been protected rather successfully. It is believed that timber stands such as that in the North Fork can and will be protected to such a degree that fire loss will not be an upset factor in management.

A pertinent and often-asked question about effectiveness of fire control is this: To what extent can the fire organization be capitalized upon in planning timber-management measures? Slash disposal is usually a major item of cost. Whether or not a given operation will pay, often hinges on the thoroughness of slash disposal necessary. In partial cuttings in young merchantable stands and in thinnings and improvement cuttings, little or no slash disposal is necessary for strictly silvicultural reasons. From a fire-control standpoint how much is essential? A specific answer is not possible. Yet, inescapably, it must be given within certain limits as the cost of complete slash disposal is often prohibitive and not essential in all instances. Without going into details—this is a full-sized subject in itself—it is believed that in the future, especially on the national forests, where hazardous fuel types are being broken up and where cuttings will probably tend to be individually smaller and more scattered than at present, the tendency will and should be to reduce slash disposal and rely more on the fire-protection organization. A concrete application of this policy is given in the following section, analyzing the cost of growing white pine.

Responsibility

Fire protection is more and more recognized to be a public requirement and responsibility. It seems safe to say that, regardless of ownership or timber productivity, drainages like the North Fork will be given protection from fire. The matter of responsibility and public interest has ramifications often not appreciated. If the North Fork belonged to a private concern whose major if not entire interest was timber growing, then the entire fire-protection cost would have to be borne by the timber produced. As has been brought out, only a little over half of the gross area is actually usable for commercial timber production, even in this relatively productive drainage. Consequently, for every acre of commercially productive land, approximately another acre of nonproductive land would have to be protected and fire cost per productive acre would be nearly double the cost per acre necessarily protected. In view of the general public interest in keeping watersheds forested, it would seem that private timber owners, who in general can realize only on commercial timber values, should bear only a portion of the total cost. Such indeed is the present trend.

Uses of Fire in Timber Management

Because of the great weight necessarily placed on protection of the forest from fire, there is a tendency to overlook the important constructive tasks that fire properly directed can perform. For that reason it is desirable to discuss briefly, in connection with fire protection, the uses of fire in timber management.

Properly controlled and directed, fire is an effective and useful tool. It is the only physical means of disposing of or reducing large quantities of slash and other dangerously large fuel volumes in the white pine forests, and it has important sanitative effects. Although excessive use of fire induces site retrogression and erosion, moderate use usually brings about site conditions favorable for regeneration of white pine; in fact, white pine owes its present abundance in the region largely to past fires. Climax forests in the region contain comparatively little white pine, being composed mainly of more tolerant species, principally "cedar," hemlock, and grand fir. Fire breaks up these climax stands and permits the reestablishment of white pine and other more or less intolerant species, mainly Douglas-fir and larch. Although the role of fire in silvicultural management differs, of course, from that in natural succession, fire, controlled and directed, undoubtedly will continue to play an important part in white pine management.

INSECT CONTROL [14]

The most extensive efforts to control insect attacks in the western white pine region have been made on the Coeur d'Alene National Forest. From the inception of extensive insect-control measures in 1929 through 1937, a total of approximately 53,900 white pine trees, aggregating about 27 million board feet, has been cut and treated in insect-control projects on this forest at a total cost of around $334,000.[15] This is exclusive of the cost of insect-control reconnaissance surveys.

What these control efforts have meant in timber values saved is impossible to say with certainty. Those directing the work believe, after comparing losses on treated and similar untreated areas on the Coeur d'Alene Forest, that many more million feet of timber were saved than were cut in control projects. An epidemic beginning in 1929 had all the earmarks of being a bad one and there was no reason to expect a natural decrease in the epidemic through 1930. Yet in the summer of 1930, following an extensive control campaign in the spring, the intensity of infestation was estimated to have been reduced 40 percent over that in 1929. The success of control measures is most difficult to estimate, but it seems reasonable to insist that, if such measures are to be justified, greater values must be saved than are expended.

Practically all material cut in the control efforts was highly merchantable white pine, much of which, with a good forest transport system, could have been logged. It is undoubtedly going too far to assume, however, that a transport system could be justified that would permit prompt and profitable logging of all bug-infested timber. There are many practical difficulties; for one thing insect-attacked trees blue-stain very quickly, causing a degrade in log values. For another thing, insect susceptibility of western white pine trees cannot at the present time be predicted with any accuracy by external characteristics. But certainly, in drainages on the Coeur d'Alene Forest such as Steamboat, Big, Yellow Dog, Deception, and Cascade Creeks,

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[14] Most of the material included here has been obtained from various unpublished reports on file at the Forest Insect Laboratory, Bureau of Entomology and Plant Quarantine, Coeur d'Alene, Idaho, and from personal conference with J. C. Evenden, in charge.

[15] Cost estimate is based on an average cost per treated tree of $6.20 when using day labor paid between 40 and 50 cents an hour. Some of this work was done by the CCC and other emergency agencies but is here estimated on the basis of what it would have cost using day labor paid at going rates.

which contain large bodies of merchantable and valuable white pine timber that will be logged in a comparatively few years, development of a utilization road system in advance of the main logging operation would be a thoroughly desirable undertaking. This would permit partial cuts particularly directed to salvage of timber that would otherwise be lost. Most of the insect-control work undertaken has been in just such drainages at dead-weight expense.

On the Deception Creek Experimental Forest it is estimated that with a permanent road system permitting low-cost skidding from any portion of the forest to a road, practically all white pine timber of merchantable size currently dying for one reason or another, insect attacks included, can be commercially logged. This means that little money need be set up for insect control as it will in part pay its own way.

Much the same thing undoubtedly would be true in other drainages. With a good road system much cutting of insect-attacked trees could be done in conjunction with commercial logging activities which would partially but not entirely obviate the necessity for out-of-pocket insect-control expenditures.[36] Considering not only the third of a million dollars spent in past control operations but an average annual loss estimated by the Forest Insect Laboratory at 9 million board feet of merchantable white pine timber in the 8 years ending with 1938, it is evident that in the aggregate considerable values have been and are at stake.

By and large, insect-control requirements constitute another strong reason for bending every effort to develop a permanent forest transport system to the end that control can be made to pay part of its own way through commercial utilization.

BLISTER-RUST CONTROL

The progress of the white pine blister rust constitutes a large question mark in the future of western white pine. It is maintained that without control the disease will make continued commercial production of the species impossible. Vigorous and aggressive control measures have been undertaken and, provided sufficient funds are made available when needed, the disease is susceptible to control through suppression of members of the genus *Ribes* (currents and gooseberries), alternate hosts with the white pine of the causal organism (*Cronartium ribicola*).

The justification for control is almost wholly economic. There is little reason to believe that, from the standpoint of erosion or stream-flow protection, white pine is essential to maintain a satisfactory forest cover in the region. Without protection, existing merchantable stands can, and at the present rate of cutting will be harvested before appreciable losses occur. It is the commercial future of the species that is at stake. Investment in blister-rust control, therefore, constitutes a wager on the future of white pine; it is a timber-growing cost.

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[36] Construction of utilization roads in advance of logging is now being pushed by the Forest Service as fast as available funds will permit. Under existing governmental regulations it is not fiscally possible directly to divert stumpage receipts from profitable salvage operations to help pay for unprofitable insect control projects. Economically, however, the possibility of offsetting losses with gains is of significance. It must also be recognized that even with roads a fair share of the cost of insect control still remains. "Spotting," that is, finding the infested trees, has in past control operations constituted about half the total cost of treatment.

The real argument for blister-rust control is that the white pine industry cannot be sustained without white pine and that the industry is worth perpetuating. In other words, the regional outlook, all factors considered, is believed to be enough better with western white pine than without it to justify the cost of control. This might be argued from a national viewpoint but the argument would be inconclusive and would not alter the fact that administrative decision to protect white pine has been made. Commitment to a program of blister-rust control is here accepted as a fact; the purpose is to arrive at a reasonable cost figure.

The major cost in blister-rust control is initial establishment, mainly in young stands, of a sufficiently ribes-free condition to arrest appreciable spread of the disease. Once this condition is established, the problem becomes one of maintenance, which it is believed will be relatively inexpensive. The total cost of this work per commercially productive acre, the true criterion, depends essentially on three factors: the gross area that must be worked, the number of times areas must be worked to establish maintenance conditions, and the cost per acre of first, second, and third workings. The following estimates apply to mountainous western white pine drainages, of which the North Fork of the Coeur d'Alene River is generally representative.

Area to Protect

Some of the gross area of a drainage can be excluded as not supporting sufficient white pine to justify the cost of control and being too isolated for infection to spread to valuable white pine. In the North Fork area, 19 percent of the total worked area was so excluded in 1938. Through sharper definition of white pine areas worth protecting, and reduction in the width of the encircling protective zone necessary, the proportion of the total gross area excluded from control has been subsequently increased. In 1941, 25 percent was an average figure for drainages such as the North Fork. Not all of the area within control units is effective timberland. As was brought out in the analysis of the Burnt Cabin Creek sale, between 50 and 60 percent of the gross area in mountainous drainages can ordinarily be considered as the effective basis for permanent production of merchantable timber. Assuming 60 percent, then, for every acre of productive timberland about an acre and a quarter must be protected from blister rust. This means that the control cost per productive acre is about one and a quarter times the cost per acre given treatment.

Number of Workings

It is difficult to state the number of times an area must be worked to establish initial control. Ribes suppression is a problem in applied ribes ecology. The blister-rust-control organization (*10*) recognizes four broad ecological types and difficulty of control varies greatly with each.[17] Taking all types together as they occur, on the average,

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[17] The four types recognized are as follows:

Type 1, Newly disturbed or denuded areas, upon which the young conifer stand has only recently started, representing conditions favorable to the appearance and persistence of ribes. This type represents areas upon which the ribes population is still increasing.

Type 2, Conifer stands of pole and merchantable size in which the forest density is so light as to permit the continued growth of ribes. In general, within this type the ribes population has reached an equilibrium, showing little tendency to increase or decrease.

Type 3, Conifer stands of pole and merchantable size in which the forest density is so heavy as to preclude the occurrence and reproduction of ribes. In this type it is frequently found that the ribes population is decreasing.

Type 4, The narrow belt along streams over which the conifer canopy is broken, permitting the permanent occurrence of brush, and favoring the reproduction and natural increase of ribes.

it is estimated that of all areas given an initial working about half will need no further attention until the area is disturbed by logging or fire (*10*). The other half or thereabouts will need a second working and some of this a third and possibly even a fourth working.

Cost per Working

As would be expected, the cost per acre of working upland and stream-type areas is highly variable, and experience in achieving and maintaining control has not been sufficient to furnish more than a general guide. Average costs applicable over a wide range of conditions are:[18]

	Cost per acre
Upland types:	
First working	$4.50
Second working	4.00
Third working	4.00
Stream type (all workings)	40.00

Second and third workings in upland areas have in the past cost more than first workings because they were mostly in areas where the ribes population is relatively large and working conditions are especially difficult. At first, such areas were given high control priority because of the generally high disease hazard they represent. However, the control organization is over the hump in cleaning up these difficult areas, with the result that present and estimated future costs of second and third workings are substantially lower. This is recognized in the average costs just given. Stream-type work, though confined to 5 or 6 percent of the total worked area requiring disease control, is usually very expensive because of high ribes concentrations and difficult working conditions. Many of these stream-type areas have been cleared of all growth by means of a specially equipped bulldozer. A number of these cleared areas have been seeded to grass and converted to productive hay lands.

An estimate of the cost of initial ribes control in drainages such as the North Fork, taking into account the necessity for repeated workings on parts of the area, the high cost of stream-type work, and the fact that more area must be protected than is commercially productive, is given in table 18. Though item by item the estimates are conservative, the total cost of $11.79 per productive acre, assuming 60 percent of the total area to be commercially productive on a permanent basis, is larger than commonly appreciated. If it is accepted that the white pine forests are protected from blister rust primarily for commercial reasons, then control costs on these unproductive acres must be carried by the productive acres. As pointed out, however, every effort is being made to reduce the unproductive area to a minimum. In addition to the cost of initial establishment of control conditions, by far the major cost, some yearly maintenance is necessary. The cost has been very roughly estimated at 3 cents per acre per year exclusive of areas disturbed by logging. On logged-over areas, where the disturbance causes an influx of new ribes, one and usually two workings will be necessary to reestablish control conditions.

[18] Estimates by the Bureau of Entomology and Plant Quarantine, Division of Plant Disease Control.

TABLE 18.—*Estimated cost of establishing initial control of blister rust on 1,000 acres of timberlands such as found in the North Fork of the Coeur d'Alene River*

Item	Proportion of total area of 1,000 acres	Area to work	Estimated cost per acre worked	Total cost
	Percent	*Acres*	*Dollars*	*Dollars*
Area excluded from control units	25	0	0	0
Stream types (5 percent of area in control units)	1	10	160.00	1,600
Upland types:				
First working (all the remaining area)	74	710	4.50	3,195
Second working (55 percent of first working)	39	390	4.00	1,560
Third working (25 percent of first working)	18	180	4.00	720
Total area and cost of work		1,320		7,075
Cost per acre given treatment (75 percent of gross area)				9.43
Cost per acre of commercially productive timberland (estimated 60 percent of gross area)				11.79

A CASE ANALYSIS OF THE COST OF GROWING WESTERN WHITE PINE FORESTS

In the foregoing, the materials for a long-range appraisal of timber-growing possibilities in the western white pine forests have been presented severally. To integrate them it will be necessary to set up a hypothetical case. Objections can be raised against such an excursion into the realm of the theoretical, since any long-range estimate is uncertain and involves assumptions that can be factually substantiated only in part. In this instance, however, it is believed that a theoretical, built-up case will give the most direct and helpful answer to the problems at hand.

What follows, then, is frankly a hypothetical case. It is an attempt to vertebrate the assortment of facts that are known today. Assumptions will be clearly labled and the reader is welcomed and encouraged to substitute his own ideas and values wherever he chooses. The framework of the analysis has been designed to facilitate modification to meet changing situations.

MANAGEMENT POLICY AND OBJECTIVES

GENERAL SET-UP AND POLICY

Timber growing is defined here as comprising all operations and expenses up to the actual cutting of the tree, including a permanent road system and slash disposal. In other words, it includes whatever would be the concern of a public or private organization permanently engaged in producing stumpage to sell.

To establish a limiting case, a fully regulated forest of the general character of that found on Burnt Cabin Creek, or, more generally, on the North Fork of the Coeur d'Alene River, in the Coeur d'Alene National Forest, is assumed operating on a sustained-yield plan under present-day market and cost conditions. By this is meant a forest in which all age classes are represented in optimum proportions. No such forest actually exists, though the productive portions of the Coeur d'Alene National Forest, taken as a whole, do not come so far from it.

Making such an assumption serves two very useful purposes. First, it brings out immediately the long-range consequences of present policy by showing results that could be obtained from a fully regulated forest operated under present conditions. Second, by assuming a going concern, financial calculations are greatly simplified, as almost everything can be put on a pay-as-you-go basis. There is considerable reality in such a view. Actually, no organization, public or private, can or would consider seriously the growing of timber as a financial proposition unless it had, or could acquire, something like a fully regulated forest and could look forward to a sustained operation.

The purpose in this general set-up is to array costs against expected returns to determine the financial possibilities of timber growing. It is a limiting case on the favorable side; a goal toward which management policy might be directed. Costs would be higher and returns less in an unbalanced forest leaning either to the cut-over or to the uncut side, because of increased carrying charges and lowered returns arising from the necessity of waiting for immature timber to grow to maturity in the first instance, or because of excessive capital investment in mature timber in the second instance.

MANAGEMENT OBJECTIVES

The objective is to grow saw timber with white pine as the principal species. Next in order of relative desirability come western redcedar, western larch, Douglas-fir, grand fir, and western hemlock. Much as it may be hoped that the future will bring less dependence on white pine as the pay species, such is not now the case, and to adhere to the stated intent of developing the case on present-day conditions, there is no alternative but to build it around white pine.

It should be pointed out, however, that, short of the elimination of white pine by blister rust, a lessening of the value superiority of white pine over its associates through increase in the value of the latter—a real decrease in white pine values seems unlikely—would not change the situation nearly as much as might be expected. As has been brought out, white pine is a desirable species not only on account of its present high dollar value but because of its silvical desirability. High volumes per acre and a high proportion of white pine in the stand are usually concomitant. Managed stands would in all probability include a large proportion of this species even though the species lost much of its value superiority. It is also true that saw-timber production on a 120- to 130-year rotation overshoots but little the rotation of greatest volume production. Increased values for white pine associates would be felt mainly in reduction of the dead-weight expenditures now necessary to remove defective and unmerchantable timber, and in increased gross receipts that would help in carrying the heavy fixed costs of timber growing.

MANAGEMENT METHODS

Two alternative plans are considered. One is a one-cut plan employing the seed-tree method of cutting. The major harvest cut is made at 130 years, leaving about 10 percent of the white pine volume for 10 years or so for seeding. It is assumed that these seed trees will be cut after they have fulfilled their function with no net change in volume (growth balancing mortality); hence total merchantable pine volumes produced on a 130-year rotation will be considered realizable.

The other plan is a four-cut system, as described in the section on partial cutting. Harvest cuts are made when the stand is approximately 90, 110, 130, and 150 years of age. The major volume is cut at 130 years with a shelterwood stand of high-quality trees being left to make rapid value increment for about 20 years, while reproducing the area.[19] The rotation is 130 years under both plans, as the reproduction period begins at a stand age of 130 years for both. These two plans compare the logical outcome of present cutting practice in mature stands with a partial cutting plan that from all angles seems a more flexible, productive, and generally desirable system.

In both plans, white pine composition will be held at approximately 70 percent of the total merchantable volume. This proportion is maintained principally by a cleaning operation applied under each plan when the reproduction stand is between 10 and 20 years old. Observation indicates that this proportion of white pine is a practicable objective. This proportion has occurred naturally over fairly extensive areas—the Burnt Cabin Creek drainage previously described is an example—though on most areas logged the proportion of pine to total stand volume has been between 50 and 60 percent. It is not believed that the growing of a higher proportion should be attempted.

Area and Yield

To furnish a statistical basis for calculations, a gross area of 60,000 acres of the same general character as found in Burnt Cabin Creek is assumed. The precise area is not important, as all results given are per acre or per thousand board feet. It is further assumed that 60 percent of the gross area or 36,000 acres can be counted on for permanent timber production. The other 40 percent is made up of intermingled poor sites and unmerchantable cover types. One must be realistic about this; 60 percent is about all that actually has been loggable in such terrain and it is doubtful whether the proportion of permanently productive area will be appreciably larger under existing and anticipated economic conditions. It may be possible to log a larger area once for virgin timber. However, to include a larger area in a permanent timber-growing plan probably would necessitate inclusion of areas of relatively low productivity, on which the cost of production would exceed the return. Management cannot make a good site out of a poor one. As was brought out in the section on the financial rotation, physical productivity falls off very rapidly as site quality decreases; a fair site (site quality 50) being only about a fourth as productive as an excellent site (site quality 70). In a mountainous area such as the Burnt Cabin Creek drainage, it seems almost inevitable that continued commercial-timber production must be confined to the better sites. Fair to poor sites should be cut lightly if at all and in no event will they contribute appreciable volume in the aggregate. They cannot, however, be ignored, as will be brought out when protection costs are considered.

[19] Although a certain amount of formality and rigidity is unavoidable in long-range planning such as this, it should be stressed that in actual practice much flexibility is both possible and desirable. No one would expect to make cuts at exactly 20-year intervals, or leave a perfectly uniform stand over the entire area. At the 130-year cut, for example, some areas might well be clear cut, leaving seed trees only around the margins.

As with areal assumptions, yields are based on what actually has been produced under moderately favorable conditions rather than upon hopeful estimates. There is no reason to suppose that under the extensive management assumed here gross yields will be increased greatly over Nature's best efforts.

For the one-cut plan, yields at 130 years are approximately as realized in the Burnt Cabin Creek sale previously described. For the four-cut plan, yields are estimated at the same general level but in the ratio of yield of a single cut at 130 years to the total yield of four partial cuts as developed in table 9.

Yields assumed for the two plans are given in table 19. No western redcedar is included, mainly because this species does not occur in commercial quantities in the entire North Fork drainage; also, present knowledge is too scanty to permit an estimate of yields with any degree of confidence. Redcedar, if present, would be an added incentive to practicing a multiple-cut plan and under management would tend to displace hemlock. It would add to receipts without adding to costs. The reader can, if desired, add to the yields a cedar-pole crop about as estimated in table 9 without changing in any way the rest of the case.

TABLE 19.—*Cut per acre and per year estimated as obtainable from a tract of 36,000 loggable acres operated under a 1-cut and a 4-cut plan of management*[1]

Plan and cut	Western white pine		Larch–Douglas-fir		Grand fir	
	Per acre	Total annual	Per acre	Total annual	Per acre	Total annual
	Board feet	*M board feet*	*Board feet*	*M board feet*	*Board feet*	*M board feet*
1-cut plan (130-year cut)	23,800	6,592	5,100	1,413	3,100	859
4-cut plan:						
90-year cut	4,700	1,302	1,100	304	500	139
110-year cut	7,200	1,994	1,800	499	1,600	443
130-year cut	14,400	3,989	3,000	831	700	194
150-year cut	9,700	2,687	1,700	471	0	0
Total 4-cut	36,000	9,972	7,600	2,105	2,800	776

Plan and cut	Western hemlock		Engelmann spruce		All species	
	Per acre	Total annual	Per acre	Total annual	Per acre	Total annual
	Board feet	*M board feet*	*Board feet*	*M board feet*	*Board feet*	*M board feet*
1-cut plan (130-year cut)	1,700	471	300	83	34,000	9,418
4-cut plan:						
90-year cut	700	194	0	0	6,800	1,884
110-year cut	600	166	0	0	11,200	3,102
130-year cut	400	110	100	28	18,600	5,152
150-year cut	0	0	200	55	11,600	3,213
Total 4-cut	1,500	415	300	83	48,200	13,351

[1] Annual cut for 1-cut plan comes from 36,000 ÷ 130 or 277 acres cut over annually. Annual cut for 4-cut plan based on acreage of 90-, 110-, 130-, and 150-year cuts each coming from 277 acres.

TIMBER-GROWING COSTS

Costs of protection, silvicultural measures, improvements, and overhead involved in growing white pine and its associates under one-cut and four-cut management plans are estimated in table 20. Protection and silvicultural costs as there presented are fairly definite, are tied closely to the ground, and can be estimated with reality. But in the estimation of improvement, tax, and general overhead costs, many things besides the timber-growing enterprise itself are involved, making difficult the segregation of the prorata share of these costs chargeable to the timber enterprise.

FIRE CONTROL

Although, as has been brought out, it is an open question what fire control, including what may be called a normal amount of actual fire suppression, really costs and how much should be charged to a given timber operation, certainly a straight timber-growing operation, either privately or publicly owned, should not and cannot bear the full cost of fire protection. Other forest values must bear a share. In the present example the cost has arbitrarily been set at 10 cents per acre per year, or approximately half the cost to the Forest Service. Total cost is assessed against the entire 60,000 acres rather than the 36,000 acres assumed loggable. No allowance for fire losses has been made, successful protection of commercial timberlands being assumed.

INSECT CONTROL

No cost for insect control has been included and the following is advanced in explanation.

Yields estimated for the one-cut plan are approximately those obtained in the past without control. If insect control is claimed successful, then it seems fair to argue that the value of timber saved must at least offset costs. That is, successful control should increase white pine yields by at least enough to cover expenditures for control.

With the four-cut plan, insect control can in part be integrated with cutting operations. The larger total yields estimated as obtainable with the partial-cutting plan rest in part on the assumption that some of the natural mortality can be harvested at a profit. Some mortality of merchantable trees will continue, however, and has been allowed for.

BLISTER-RUST CONTROL

The major cost in blister-rust control is initial establishment of ribes-free conditions, necessitating a heavy capital investment within a relatively short period that can be realized upon only many years in the future. There is no wholly satisfactory method of distributing such an investment, particularly by the public, against a yearly operation. More than one solution is possible, depending on the point of view. The view taken here is that of an owner of a regulated forest faced with this new thing—blister rust. The method employed is the normal business procedure of computing the interest and amortization cost of a long-time loan to cover the initial investment. A 3-percent interest rate and a 75-year amortization period are used. The total blister-rust cost is considered as a financing charge on this heavy initial investment, estimated at \$9.43 per acre treated or \$11.79 per commercially productive acre (table 18). On long-time loans, amortization is not, relatively, a large item. Interest is the major cost, constituting in this instance 89 percent of the total annual financing charge. Theoretically, this loan would be paid some time.

TABLE 20.—*Estimated annual costs of growing western white pine and associated species on a 60,000-acre tract under a 1-cut and a ¼-cut plan of management* [1]

PROTECTION

Item of cost and management plan	Cost assumptions	Area or volume involved	Unit cost	Total cost		Cost per M board feet cut: Cutting western white pine only	Cost per M board feet cut: All species
		Acres	*Dollars*	*Dollars*	*Percent*	*Dollars*	*Dollars*
Fire:							
1-cut	Cost chargeable to the timber-growing operation for the entire gross area	60,000	0.100	6,000	9.6	0.91	0.64
¼-cut		60,000	.100	6,000	8.1	.60	.45
Insect control (1-cut and ¼-cut)	No net cost; allowance for insect losses made in calculating annual cut; insect control not undertaken unless increased yields at least equal control cost						
Blister rust:							
Initial work:							
1-cut	Initial eradication of ribes on 75 percent of gross area to cost $9.13 per acre treated; annual cost 5 percent of first cost plus 75-year amortization charge	15,000	.758	11,288	22.8		
¼-cut		15,000	.758	11,288	14.2		
Reestablishment of control after cutting:							
1-cut	Reestablishment of control on area logged annually	277	8.00	2,216	3.5		
¼-cut	Work on logged areas after—						
	130-year cut	277	8.00	2,216	3.0		
	170-year cut	277	3.00	831	1.1		
Maintenance:							
1-cut	Annual maintenance of control on unlogged area	14,724	.098	1,443	2.2		
¼-cut		11,116	.12	1,333	1.8		
Total blister-rust costs:							
1-cut				17,817	28.5	2.71	1.89
¼-cut				18,667	25.1	1.87	1.40

SILVICULTURAL MEASURES

Item of cost and management plan	Cost assumptions	Area or volume involved	Unit cost	Total cost		Cost per M board feet cut: Cutting western white pine only	Cost per M board feet cut: All species
Cleanings:							
1-cut	One cleaning 10 to 20 years after major cut, to maintain white pine at 70 percent of total stand	277	8.00	2,216	3.5	0.34	0.24
¼-cut		277	8.00	2,216	3.0	.22	.17
Unmerchantable timber disposal:							
1-cut	Necessary to treat 60 percent of area logged annually	166	20.00	3,320	5.3	.50	.35
¼-cut	Treatment on 50 percent of area cut over after:						
	110-year cut	138	6.00	828			
	130-year cut	138	10.00	1,380			
	Both treatments			2,208	2.9	.22	.16

Slash disposal		*M board feet*					
1-cut	Pile and burn most but not all of slash	9,118	50	4,709	7.5	71	.50
	Slash disposal after						
	90-year cut	1,884					
4-cut	110-year cut	5,102	10	310			
	130-year cut	3,152	50	2,064			
	150-year cut	3,213	90	964			
	All treatments	13,451	27	[illegible]	4.5	33	.25
Woods-planning system							
1-cut	[illegible]	9,118	10	[illegible]	6.0	57	.40
4-cut	Same, but a more complex technical job, costing more per M	13,451	[illegible]	7,[illegible]	9.9	.71	.55

IMPROVEMENTS AND OVERHEAD

Road construction and maintenance							
1-cut	[illegible]			4,730	7.7	0.72	0.50
4-cut	[illegible]			[illegible]	13.7	1.02	.76
Taxes							
1-cut	Based on actual payments of [illegible]			[illegible]	22.9	2.17	1.52
4-cut	[illegible]			17,[illegible]	23.7	1.77	1.32
General overhead							
1-cut	[illegible]			[illegible]	9.3	.86	.61
4-cut				[illegible]	9.4	.68	.51

SUMMARY

Protection				
1-cut	23,847	38.1	3.62	2.53
4-cut	21,667	35.2	2.47	1.85
Silvicultural measures				
1-cut	14,092	22.4	2.13	1.49
4-cut	17,102	20.5	1.54	1.13
Improvements and overhead				
1-cut	24,730	39.5	3.72	2.63
4-cut	31,569	36.5	3.17	2.50
All costs				
1-cut	62,587	100.0	9.49	6.65
4-cut	71,338	100.0	7.15	5.57

1 1-cut plan: Annual cut 9,118 M board feet, log scale, of which 6,592 is western white pine; 4-cut plan: Annual cut 13,451 M board feet, log scale, of which 9,972 is western white pine. According to 4-cut plan, cuttings are at 90, 110, 130, and 150 years.

2 See text for calculation of costs.

3 About 5 cents per M board feet of white pine and 10 cents per cut-over acre.

probably before the end of the first rotation, and the blister-rust cost would reduce to that of maintenance only. Conceivably the average annual cost might be reduced somewhat for this reason. It seems, however, more in accordance with a businesslike appraisal of the actual situation, to assume that regardless of what the future might bring, this financing charge must be faced now and, as table 20 shows, be recognized as a major item of cost in growing western white pine.

Once control is established, the job scales down to one of reestablishing control on cut-overs and maintaining it on the acreage as yet unlogged. The reworking of areas disturbed by logging is expensive but essential—estimated at $8 per acre to cover the cost of one or two workings under the single-cut plan and $11 under partial cutting. General maintenance over the large unlogged portions of the area is estimated at 3 cents per acre per year.

SILVICULTURAL MEASURES

A cleaning operation 10 to 20 years after the major harvest cut is assumed necessary to maintain an average of 70 percent white pine in the stand and to prevent excessive stagnation due to overstocking. Done regularly and efficiently, cleaning should not cost more than $8 per acre treated.

Disposal of unmerchantable timber at time of harvest cuttings to clear the ground for reproduction is more difficult to figure. It would be convenient to say that under management this problem will take care of itself, but past experience gives little support to such a belief. Some but not all of the problem would be avoided by the application of cleanings. A market for cordwood would solve most of the remaining problem but such is not assumed here.

With the one-cut plan, it is assumed that 60 percent of the area logged annually would need treatment of the general type given at present at an estimated cost of $20 per acre treated. With the four-cut plan, much of this work could be done concurrently with the four cutting operations at considerably less additional cost in the aggregate. It is estimated that the cost will be $6 per acre at the time of the 110-year cut and $10 per acre at the time of the 130-year cut.

Slash disposal has been included in table 20 as a silvicultural cost because it is believed to be a definite part of the timber grower's rather than the logger's job. On national-forest sales, slash disposal is almost entirely handled by the Forest Service, even though the operator pays for it. The view is taken that an increasingly effective fire-control organization will make it possible to leave a certain amount of slash unburned. In this way, under the one-cut plan, the cost for piling and burning logging slash should be reducible to about 50 cents per M feet logged. With the four-cut plan, greater savings are possible because partial cuttings leave less slags and consequently create less hazard at any one time (table 20). No disposal is considered necessary after the first cut, and only a little along roads and skidways with the second, at a cost of 10 cents per M feet logged. A more extensive but still partial disposal after the third and fourth cuts would be necessary, costing 40 and 30 cents per M feet respectively. The total cost under partial cutting is estimated at 25 cents, or half the unit cost of slash disposal with the one-cut plan. The absolute accuracy of these estimates may be questioned but, relatively at least, slash disposal under a partial-cutting plan should cost materially less than after a single major cut.

Direct woods administration is also included as a silvicultural cost. This includes mapping, cruising, marking, scaling, and general woods supervision of the operation. Careful records of marking, scaling, and general woods supervision kept throughout the life of the Burnt Cabin Creek sale gave an average cost of about 30 cents per M. For the one-cut plan this cost was raised to 40 cents to cover mapping and cruising. Costs were further arbitrarily increased to 55 cents for the four-cut plan to allow for the definitely more complex technical job involved.

ROAD CONSTRUCTION AND MAINTENANCE

Roads are coming more and more to be accepted as a permanent part of the forest rather than of the immediate logging plan and they are so considered here. The tremendous public investments in transportation systems that have been made in and near the white pine forests will benefit directly or indirectly any timber-growing enterprise, public or private. Consideration here is limited to roads directly necessary to transport logs out of the woods. A main-line forest highway or county road from the tract to market is assumed as one of the things that the operator gets from paying taxes. Utilization roads within the tract must be constructed by the operator and charged to the timber operation. On the Coeur d'Alene Forest, although there is a rather extensive road system (about a half mile of road per 640 acres of national-forest land), it is built mainly for fire control and comparatively little of it promotes forest utilization. Many of the roads are constructed on a subutilization standard and located on ridges or up the bottoms of major drainages only. Utilization roads would have to be built for most timber-producing units that could be set up.

With a one-cut plan, the logical procedure is to build utilization roads only as currently needed. It would be financially impracticable to build and currently maintain roads into all parts of the area bearing mature timber just to permit salvage operations. One partially compensating benefit goes with this, however. Road spacings and construction standards should be adapted to the volume cut per acre and the logging method, and where roads are built as needed they can be harmonized with current conditions.

With a partial-cutting plan, a permanent road system permitting quick and easy access to most if not all parts of the merchantable stand is, as Kirkland and Brandstrom (6) bring out so clearly, a first essential. The whole plan of management is built around and made possible by this transportation system, which must be built in advance of cutting and cannot be changed except at additional expense. As a going concern is assumed here, the problem is to estimate a fair annual carrying cost for the road system.

Planning an efficient utilization-road system is a highly complex and technical matter that cannot be gone into here; present needs will be served by a rough approximation. Assumptions and computations of road costs for the one-cut and four-cut plans that follow may safely be skipped unless the reasonableness of the net result, shown in table 20, is questioned.

One-Cut Plan

Roads will be constructed as needed and abandoned after a relatively short period of use. Secondary utilization roads costing about $2,300 per mile would be built up the main creek bottoms as required by the current logging plan. These would be fed by spur roads costing $900 a mile spaced to keep the maximum skidding distance down to 800 feet. It is estimated that for the annual average cutting area of 277 acres, 3 miles of spurs and two-thirds mile of secondary road would be constructed annually. The calculation of the annual road cost is then as follows:

Construction 3 miles spur roads at $900	$2,700
Construction 2/3 mile secondary road at $2,300	1,530
Annual maintenance of 5 years' supply of spurs and 15 years' supply of secondary road at $20 a mile	500
Total annual cost	4,730

Four-Cut Plan

From a map analysis of 53,000 acres in 16 tributary drainages of the North Fork of the Coeur d'Alene River, it was estimated, still assuming 60 percent of the gross area to be loggable, that 1 mile of secondary creek-bottom road, tributary to the main line or primary transportation system supposed to be already extant, would be needed for every 520 loggable acres, or 70 miles for the assumed 36,000 loggable acres. Practically all of this road mileage would have to be constructed and currently maintained to carry out effectively a partial-cutting plan. Some reduction in maintenance costs might be made by temporarily abandoning certain portions not currently giving access to merchantable timber and reconstructing the road when cutting was resumed. Age classes would be rather throughly scrambled on the ground, however, and comparatively little road abandonment and saving in cost would be possible. Here, as in the case of blister-rust control, the annual cost is mainly the interest on the initial investment.

In addition to the secondary road system, an estimated 2½ miles of new spur roads would be constructed annually (assuming a somewhat wider road spacing than with the one-cut plan on account of the lighter cuts made at any one time with partial cutting) and 20 miles currently maintained. The cost of maintaining spur roads over the entire tract would be prohibitive. Cost calculations follow:

	Cost per year
Secondary roads:	
Interest at 3 percent on construction of 70 miles at $2,300 per mile	$4,830
Amortization of initial investment in 75 years at 3 percent	591
Annual maintenance of 70 miles at $30 per mile	2,100
Spur roads:	
Construction annually of 2½ miles at $900 a mile	2,250
Maintenance of 20 miles at $20 a mile	400
Total annual cost	10,171

TAXES

One way of estimating the tax item is to base it on the approximate annual tax actually paid by owners of private lands under the present assessment policy of the local county assessors.[30] A large company operating in the North Fork of the Coeur d'Alene River pays an annual tax of about 5 cents per M board feet of white pine on uncut lands (cruise estimate) and 10 cents per acre on cut-over lands supporting

[30] Under the Idaho Reforestation law passed in 1929, reproduction can be assessed at $1 per acre and a yield tax of 12½ percent of full stumpage value paid at time of logging. Taxes under this plan would be somewhat less than estimated here. However, this law has been but little applied (only 11,000 acres under it in 1938) and has not yet been a factor appreciably affecting the tax situation.

stands of mixed timber. It is assumed here that lands supporting merchantable stands (approximately 60 years of age or older) are taxed at 5 cents per thousand feet of white pine. Immature stands under 60 years of age are assumed to bear a tax of a flat 10 cents per acre per year. A charge of 4 cents per acre per year is arbitrarily assumed for nontimber-producing lands included in the management unit. Though their income-producing capacity is very low, such lands are never entirely tax free. On this basis, annual tax costs for the one-cut and four-cut plans are as follows:

Per loggable acre:	
1-cut plan	$0.398
4-cut plan	.490
Per M feet cut (all species):	
1-cut plan	1.52
4-cut plan	1.32

Taxes at these rates, though their application is manifestly arbitrary and perhaps inequitable in theory, are probably not far from what an operator would actually pay on a regulated forest under existing conditions. They closely approximate the present 25 percent of stumpage receipts that the Government turns back to the local counties in lieu of taxes. In this sense, the Government pays taxes; in no sense can the item be ignored.

GENERAL OVERHEAD

Some allowance must be made for general overhead expense. Because it is impossible to say with certainty what this item would or should be, it has been set arbitrarily, but with a rough check from experience figures, at 10 percent of the total or other timber-growing costs.

RECAPITULATION

With the completion of these estimations and calculations, comes the more interesting part of comparing costs with anticipated revenues. Revenues are estimated in table 21. In table 22 these revenues are combined with the summary of costs developed in table 20, giving in condensed form the significant results of the whole analysis.

In interpreting these results, one thing is obvious at the outset — the figures in table 22 result from a series of assumptions and estimations. They are not "hope" figures, however, being based on present costs and values. They carry to its logical conclusion the stated intention of investigating the long-range consequences of two contrasting timber-growing policies applied under existing conditions, in a certain portion of the western white pine region. No one knows what the future will bring. But from the vantage point of the present, there is no definite indication that market conditions will change markedly for the better or worse. Continuation of present conditions consequently seems a reasonable forecast. It is believed that the results given are likewise reasonable and, what is more important, that relatively they are of significance.

TABLE 21.—*Estimated annual returns of growing western white pine and associated species under a 1-cut and a ¼-cut plan of management on 36,000 loggable acres*

Plan and cut	Western white pine			Larch—Douglas fir			Grand fir		
	Volume	Value per M [3]	Total value	Volume	Value per M [3]	Total value	Volume	Value per M [3]	Total value
	M board feet	*Dollars*	*Dollars*	*M board feet*	*Dollars*	*Dollars*	*M board feet*	*Dollars*	*Dollars*
1-cut plan (130-year cut)	6,592	8.70	57,350	1,413	2.95	4,168	859	1.45	1,246
¼-cut plan:									
90-year cut	1,302	3.70	4,817	304	1.20	365	139	.70	97
110-year cut	1,994	5.70	11,366	499	2.20	1,098	443	1.20	532
130-year cut	3,989	8.70	34,704	831	3.20	2,659	194	1.70	330
150-year cut	2,687	10.70	28,751	471	3.70	1,743	0		0
Total cut	9,972	7.99	79,638	2,105	2.79	5,865	776	1.24	959

Plan and cut	Western hemlock			Engelmann spruce			All species		
	Volume	Value per M [3]	Total value	Volume	Value per M	Total value	Volume	Value per M	Total value
	M board feet	*Dollars*	*Dollars*	*M board feet*	*Dollars*	*Dollars*	*M board feet*	*Dollars*	*Dollars*
1-cut plan (130-year cut)	471	1.45	683	84	3.20	269	9,418	6.77	63,716
¼-cut plan:									
90-year cut	139	.70	97	0		0	1,884	2.85	5,376
110-year cut	166	1.20	199	0		0	3,102	4.25	13,195
130-year cut	110	1.70	187	28	3.20	90	5,152	7.37	37,970
150-year cut	0		0	55	3.20	176	3,213	9.55	30,670
Total cut	415	1.16	483	83	3.20	266	13,351	6.53	87,211

[3] Stumpage values as given in table 9 credited by adding 70 cents per M for road costs and $1 per M for slash disposal and stand improvement on western white pine, and 70 cents per M for slash disposal only on other species. Approximately these values were included as logging costs in determining these stumpage rates. In the costs of timber growing as developed in table 20, these items were included as timber production rather than logging costs and hence must here be added to stumpage values.

[4] Volumes as given in table 19.

The general superiority of the partial-cutting over the single-cutting plan of management is outstanding. Whether white pine only or white pine with an admixture of other species is cut, the partial-cutting plan shows (table 22) a small but positive net investment value.[21] This value measures what one could pay per acre for loggable lands if 3 percent is considered a satisfactory return on the investment. The absolute level of these figures cannot be verified and will change with circumstances. The relative difference in favor of the partial-cutting plan is, however, believed to be indicative and fairly stable. This difference arises because the materially greater volume yields obtainable under partial cutting more than offset slightly lower average stumpage prices (table 21) and somewhat increased costs.

[21] These values will be recognized as the expectation value of a regulated forest according to the general formula

$$Fe = \frac{Y - C}{0.0p}$$

Where Fe = forest expectation value in dollars; Y = annual yield in dollars; C = annual costs in dollars; p = interest rate.

TABLE 22.—*Estimated annual costs and returns per M board feet of growing western white pine and associated species under a 1-cut and a 4-cut plan of management, and corresponding capital value per productive acre*

Item	1-cut plan: Cutting white pine only	1-cut plan: All species		4-cut plan: Cutting white pine only	4-cut plan: All species	
Costs:						
Protection:	*Dollars*	*Dollars*	*Percent*	*Dollars*	*Dollars*	*Percent*
Fire	0.91	0.64	9.6	0.60	0.45	8.1
Blister-rust control	2.71	1.89	28.5	1.87	1.40	25.1
Silvicultural measures:						
Cleanings	.34	.24	3.6	.22	.17	3.0
Disposal of unmerchantable timber	.50	.35	5.3	.22	.16	2.9
Slash disposal	.71	.50	7.5	.33	.25	4.5
Woods administration	.57	.40	6.0	.74	.55	9.9
Improvements and overhead:						
Roads	.72	.50	7.5	1.02	.76	13.7
Taxes	2.17	1.52	22.9	1.77	1.32	23.7
General overhead	.86	.61	9.1	.68	.51	9.1
Total costs	9.49	6.65	100.0	7.45	5.57	100.0
Returns	8.70	6.77		7.96	6.53	
Profit or loss	-.79	+.12		+.51	+.96	
Annual cut per productive acre (mean annual increment)	*Board feet* 183		*Board feet* 262	*Board feet* 277		*Board feet* 371
Value produced annually per productive acre	*Dollars* -0.14	+.03		*Dollars* +0.15	+0.36	
Capital value at 3 percent per productive acre (60 percent of gross area)	-4.67	+1.00		+5.00	+12.00	

Equally outstanding and significant is the much better financial showing made when all species are included than when all costs are charged to and all values based upon white pine, even though white pine accounts for about 90 percent of the total stumpage values under either plan. As shown with the one-cut plan, management for white pine only is a losing proposition while with other species assumed marketable, though in limited quantity, the operation breaks about even if nothing is charged for timberlands. An even greater relative difference in the same direction shows up in the four-cut plan. The reason, of course, is that receipts from these species, since they do not increase costs, contribute directly to net income. To put it another way, they help carry the heavy fixed costs. The same total cost base applies, whether the merchantable crop is all white pine or white pine and associated species, since practically all of these costs (table 20) will continue whether mixed species are sold or not. In fact, in selling white pine alone, costs would be greater because of the increased expense of weeding out unmerchantable timber. This analysis exposes very clearly the well-known financial weakness and vulnerability of a one-species crop in a naturally mixed forest type and points to the great advantages of diversified markets, even though some species carry relatively low values.

Blister-rust control and taxes are the major items of total cost under the four-cut plan, making up 25 and 24 percent, respectively. The bulk of the blister-rust cost, which is a timber-growing charge and nothing else, is the financing charge on the heavy investment necessary for initial work. Although the exact size of the blister-rust item is difficult to ascertain, it cannot be doubted that it is a major item in the cost of growing white pine. Taxes estimated on what a private operator would actually pay, must be paid in some form, whether the operation is run privately or by the public. Government ownership does not obviate the necessity of supporting local communities and, as previously mentioned, the Forest Service now turns over 25 percent of its gross receipts to local governments in lieu of taxes. Fire-control costs are heavy, even the half that is charged to the timber-growing enterprise. Other items are more or less inherent in any timber-growing enterprise and are self-explanatory. It is a sober fact that timber-growing costs in the white pine forests are high, but forest values are proportionately high as long as white pine maintains its present level of abundance and value.

Who Can Grow Western White Pine?

As costs and returns of growing white pine forests are estimated to balance approximately in the long run, it would seem that timber growing in the white pine forests offers an opportunity for public investment for several reasons.

The public has a broad and vital interest in forest perpetuation that is best protected by public ownership. Forest lands must be protected and given some sort of management whether commercial timber is grown or not. Harmonization of timber production with other forest uses can, it is believed, be most effectively accomplished by public ownership and management in this forest region.

The margin of return over cost being small or nonexistent, public operation would not compete with private enterprise.

Certain indirect benefits of little value to the individual investor accrue to the public from the perpetuation of an already established industry. In supplying the market for western white pine a large number of people directly or indirectly derive support. The social cost to these people of closing down this industry, in terms of relief expenditures, resettlement costs, and repercussions on other industries from additional capital and people seeking employment, not to mention human suffering, would be very great as parallel experience has shown. The mere fact of an approximately break-even investment propostion does not necessarily imply the desirability of public investment—there may be other and still more desirable alternatives. But when the cost of a major dislocation and the general shortage of more desirable alternatives are considered, growing western white pine forests as a public undertaking looks much better. The indirect but none the less real advantages go far toward outweighing the apparent financial shortcomings of the proposition.

Timber growing creates many man-days of productive employment. It can be calculated from table 20 that, under a partial-cutting plan of management, approximately $1.25 per gross acre is annually expended in timber production. Estimating $5 per man-day as the weighted average daily wage of those employed in timber production from the top down—from a very small share of the Regional Forester's or general manager's time to the undivided attention of the cook's flunky in a slash-disposal camp—this means a quarter of a man-day of permanent and productive employment per acre annually. To increase the scale a bit, this means 250 man-days per 1,000 acres, or, multiplied by thousands of acres, an important contribution to local employment, especially when it is remembered that the employment thus directly created supports a long chain of secondary or service employment. This is in addition to employment created by logging and subsequent processing. Various estimates can be made of what all this employment means in general welfare; it is only possible here to indicate the importance of the matter. This whole timber-growing analysis can be regarded as an earnest attempt to investigate one means of promoting human welfare on a sound and permanent basis.

What about the private investor? What are his opportunities for timber growing as a permanent proposition? Although, judging from table 22 alone, his case is not promising, there are a few alleviating factors. Blister-rust control, the largest single item of cost, is being assumed in the main by the Federal Government on both publicly and privately owned lands. This cost can be almost entirely omitted from private business calculations. It is probable that in the future an increasing share of the fire-control cost will be borne by the public. Such is the present tendency and there is no reason to doubt its continuance. Taxes are a large item and will continue to be. It is true that the present policy in assessment, based on liquidation rather than income values, is inequitable in principle for a sustained-yield forest. Whether or not the actual rates paid are inequitable can be determined only through careful analysis of specific cases. At present, taxes are probably not an upset factor in deciding the private investor against permanent investment in timber growing. A decrease in the wage level, if not accompanied by a corresponding decrease in prices, would greatly increase the profitableness of timber growing, since about four-fifths of the cost is paid directly in wages. Wages in this forest region were comparatively high up to about 1940, common woods labor usually receiving between 40 and 50 cents an hour. While a general decrease in real wage level might occur, such an event seems rather unlikely and could not be counted upon. The trend since 1940 has been upward.

A number of important factors adversely affecting long-time private investment in western white pine timber growing deserve special consideration.

Private owners have made heavy investments in timberlands on which annual charges must be paid. This financial pressure tends to force an immediate liquidation of private timber holdings and makes it extremely difficult to shift from a liquidation plan to a sustained-yield plan that inevitably involves a foregoing of immediately realizable and currently needed income.

A fully regulated forest was assumed in this analysis, thus setting up a limiting case on the favorable side an ultimate objective. Actually, no such forest now exists and, as has been pointed out, costs would be higher for any forest not perfectly regulated. Obviously, if a perfect forest cannot make a favorable financial showing, nothing less will, and this was a major reason for developing the analysis on this basis. In practice, one must deal with forest properties falling far short of the ideal.

With possibly one exception, existing private timber operators in the western white pine region do not own and cannot acquire or control holdings approaching a balanced forest. Private holdings tend to be made up of either mature timberlands or cut-over lands, the latter usually supporting considerable volumes of mixed species at present unmerchantable. Reproduction present is mostly less than 25 years of age. There is a great deficiency in intermediate age classes, a condition that also obtains to some extent on the national forests. For this reason, a simon-pure private timber-growing operation on a sustained-yield basis could not be organized even if desired. The best possibility is to consolidate public and private holdings into sustained-yield working circles under some sort of long-time cooperative agreement.

Fire losses have not been considered, successful control being assumed. While the average loss in commercially valuable timber is and undoubtedly will be held to a rather low level, fires will probably continue to escape control occasionally and, lacking a general system of forest-fire insurance, no one private operator can chance being the unlucky victim. Only with large public holdings are risks sufficiently spread to withstand an occasional heavy loss. Even though fire control on commercially valuable lands may be entirely successful in the future, the possibility that it may not be would still be a deterrent to the private investor. Generally speaking, this forest region has a bad fire record to live down.

Blister-rust and insect control, as a purely practical matter, cannot be assured. Physically, blister-rust control is entirely possible, but who can guarantee that sufficient funds will be forthcoming from public sources when and where needed effectively to control the disease? The same applies to insect depredations.

Neither can the future market value of western white pine be assured although approximate continuance of present market values seems probable. As has been pointed out, white pine is in some respects in a more vulnerable position as regards possibility of substitution than its less valuable associates. The whole financial framework erected in this study would collapse without high white pine values.

It is not possible here to explore further the factors enumerated above. To deal effectively with the first three would require detailed investigation of specific cases rather than a generalized analysis as developed here. No satisfactory answer can be given to the last three. Looking at the matter as a whole, it seems that under existing conditions and considering the various risks involved, only the public, primarily the Federal Government, can undertake timber growing on a long-time basis in the western white pine region. Only the Federal Government has a sufficiently wide and vital interest permanently to undertake forest management with timber production one important forest use. Or, to put it another way, the Government, through general citizen benefit, can get a great deal more out of these forests than the private owner, both in tangibles and intangibles, giving a broader income base against which to spread costs. Such, indeed, is the general consensus at the present time and the possibilities of financial profit as brought out in this study, even granting considerable public subsidies in forest protection, roads, and taxes, do not warrant claims to the contrary.

SUMMARY AND CONCLUSIONS

With the end of abundant virgin timber in the western white pine forests of northern Idaho definitely in sight, and with mounting public investments in forest protection and administration involving definite commitments in timber-growing policy, the long-time economic aspects of growing timber in the region, as expressed in costs and returns, are of concern in public as well as in private undertakings and should be appraised and measured as accurately as possible. Though the units of measurement and bases for reckoning values differ, the over-all objective of both public and private endeavor is to obtain the highest possible rate of return for the money or effort expended. Monetary valuation, admittedly an imperfect measure of value, nevertheless gives valuable indices of the relative desirability of one undertaking as compared with another and is freely used in this study as a measuring stick.

The present forest industry in the region is and will probably continue to be built around the western white pine sawlog tree, which in general should be between about 16 and 28 inches d. b. h. The maximum rate of value production, with white pine trees of this size as the main crop, necessitates a rather long rotation of 120 to 140 years, depending on site, averaging 130 years. Under a definite partial-cutting plan, harvest cuttings might well be begun before this age, but major harvest cuttings in younger stands, as sometimes advocated, will fall distinctly short of obtaining a maximum rate of value production.

Case analyses of timber-management problems and possibilities in representative western white pine stands were built around three specific stands selected as representative of major timber-management problems in older stands, and a group of immature stands illustrating possibilities of various intermediate cuttings.

In high-quality, mature stands largely white pine, the dominant management considerations are (1) liquidation of the high and rather perishable stumpage value—sometimes as much as $300 per acre—which is appreciating little if any in value, and (2) regeneration.

Liquidation offers no difficulties if maintenance of a forest cover is the primary objective, reasonably adequate slash disposal being the only silvicultural cost necessary. An understory mainly of western hemlock, present in this and most such stands, will take over the site indefinitely following removal of the white pine overwood and afford a complete though almost entirely unmerchantable forest cover. Regeneration to white pine, necessary to keep the site producing the values of which it is capable, is not silvically difficult but is expensive, as commercially valuable seed trees must either be reserved and most of the understory removed, or else the entire stand must be clear-cut, broadcast burned, and planted. Adequate regeneration is a cost of growing timber, not merely harvesting it and protecting the site, involving a long-time commitment in timber growing, a commitment that the private owner does not and cannot make at the present time. The Federal Government, however, reinvests a portion of the stumpage values received from timber sales on such areas to keep the land commercially productive.

In an average-quality mature stand of the most typical sort, about half white pine and half associated species, only white pine and western redcedar, the latter mainly in the form of transmission poles, have a positive stumpage value under existing market conditions and can be profitably logged. Commercial harvest of such stands in such a way as to assure full regeneration, including a satisfactory proportion of western white pine, is practically impossible. There is no inexpensive method of disposing of large volumes of defective and unmerchantable timber to clear the ground for regeneration. Data were presented to show the probability that in many such stands a two-cut installment plan of harvest is commercially practicable. Satisfactory natural regeneration can be obtained over about a third of the area by such a plan and some reproduction over the remainder, and at the same time currently unmerchantable timber is reserved for whatever the future might bring.

In a young, thrifty, well-stocked stand of western white pine and associated species just reaching merchantable size, considerable partial-cutting possibilities seem to exist, primarily because a portion of the natural mortality can be commercially harvested and a consistently higher average rate of growth maintained than occurs in unmanaged stands. A detailed and specific partial-cutting plan was worked out for this stand that provided for four harvest cuts at approximately 20-year intervals, the last being the removal of an open shelterwood of select trees from over an even-aged stand of established natural reproduction. Though conservative growth rates were employed, and what seemed a generous allowance for mortality made, the analysis indicated that rotation yields could be increased nearly 50 percent in volume and 40 percent in value by application of this partial-cutting plan.

The possibilities and application of cleanings, improvement cuttings, and thinnings in reproduction and pole stands were analyzed with the conclusion that the greatest benefit at least expense was obtained from one or two cleanings applied in reproduction stands less than about 20 years of age. Improvement in stand composition and density in stands past the cleaning age can be had only at high expense and at a heavy sacrifice in growing stock. Lacking markets for small-sized products, intermediate cuttings in the western white pine region must be made at dead-weight expense. As long as this situation continues, stands should be let alone after cleaning until partial harvest cuts of saw logs can be made.

A cross section of forest practices in the region was given by an account of public and private cuttings in a representative drainage. Significant features of all Forest Service timber sales were summarized and brought to sharp focus by a case analysis of a single large cutting. The objective on Federal cuttings has been to harvest at a single cut as much as possible of the crop of mature merchantable timber and to get natural reproduction that will include a high proportion of western white pine. Regeneration has been expensive; on 13,172 acres cut over between 1923 and 1938, about $25 per acre was expended on slash disposal and supplementary cultural measures to dispose of defective and unmerchantable timber. This supplemental work was done on only a portion of the total area logged over at a cost of from $25 to $40 per acre actually treated. The wide gulf between growing timber and merely harvesting it was brough out by analysis of cuttings on privately owned lands in the drainage. Here the objective has been to harvest the white pine and leave the rest, the only silvicultural measure observed being slash disposal at minimum cost. Privately-owned cut-over lands in the drainage are just as green as Federally-owned cut-over lands; the difference is that most of the former support a residual stand of currently unmerchantable and often defective timber with little new reproduction, while most of the latter are producing another merchantable crop.

Crucial protection problems of fire, insects, and disease in the region were briefly evaluated from a timber-management point of view. Exclusive of fire damage but including depreciation and maintenance charges on improvements, fire-control costs the Federal Government about 20 cents per acre per year. It is believed that present efficiency of Federal fire control is such that the fire-control organization can be capitalized upon by appreciable reduction in the thoroughness of slash disposal.

The justification of insect control is that greater values are saved than are expended. It is believed that the most practical possibility of reducing insect-control costs is to develop a permanent utilization road system permitting partial commercial utilization of insect-attacked trees in combination with general forest salvage and improvement cuttings.

The large question mark in the future of western white pine is the control of the white pine blister rust, which is almost wholly a cost of growing white pine for the future. Without it, continued commercial exploitation of the species is considered impossible. The justification for protection is entirely economic and rests basically on the assumption that the regional outlook is enough better with white pine than without it to justify control. The major cost in blister-rust control is initial suppression of ribes, alternate hosts of the causal organism. Based on past costs, the average cost of initial suppression was conservatively estimated at $11.79 per loggable acre. After initial suppression, annual maintenance of control conditions is necessary but represents a relatively small annual charge.

A case analysis of the cost of growing western white pine forests on a long-time basis was presented. Based on actual yields of present day stands and employing present costs and timber values, the costs and returns of operating a fully regulated forest on a single-cut and a four-cut partial-cutting plan was worked out in detail. Significant conclusions from this analysis are:

1. The general superiority of a partial-cutting over a single-cutting plan of management. As determined by this analysis, the most promising method of growing forests in the western white pine region is to get abundant and even-aged reproduction by a shelter-wood cutting; improve species composition and partially alleviate over-density by cleanings applied before the stand is 20 years old; develop quality by growing in fairly dense stands until merchantable size is reached; and harvest by a series of three or four partial cuts designed to maintain high average growth rates, to utilize a portion of the natural mortality, and to produce some very high quality timber.

2. The financial difficulties resulting from a market for only one species, western white pine, in a forest of several species. Even nominal values for mixed species tremendously aid a forest-growing enterprise. The financial success of any forest-growing plan in the region depends in large part on some market for all important species normally present.

3. The complete dependence on western white pine as the pay species in the region. The entire financial framework erected in this study is sustained by the high value of white pine and would collapse without it.

4. With a fully regulated forest operated on a partial-cutting plan, estimated returns slightly exceeded direct costs, indicating that in the long run the public, primarily the Federal Government, can grow white pine forests on a no-profit basis. Offsetting this lack of financial profit is the desirability of maintaining an already extant industry. The costs of shifting industry are high to the public in terms of mounting relief costs, resettlement, and repercussions on other already well-filled industries, and still higher to the individual in terms of financial loss and personal suffering.

5. Opportunities for private investment in long-time timber growing are slight, despite the fact that costs of blister rust and insect control and part of fire protection are largely being assumed by the public.

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U. S. GOVERNMENT PRINTING OFFICE: 1942

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