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Title--SILVICULTURAL AND ECONOMIC ASPECTS OF REMOVAL OF SCATTERED OVERMATURE TREES FROM A WELL-STOCKED POLE STAND IN THE SITKA SPRUCE-WESTERN HEMLOCK TYPE

Abstract approved Redacted for Privacy
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Personnel of the Pacific Northwest Forest and Range Experiment Station, U. S. Forest Service, examined the effects of logging scattered remnants of an old-growth Douglas-fir stand upon the well-stocked 38-year old understory of western hemlock and Sitka spruce. Logging effects were examined on nine one-fifth acre plots systematically located within the 15-acre study area. The plots were affected by logging much less than the other six. Logging intensity, however, had little effect on growth of the understory. Growth was proportioned to residual volume, regardless of treatment. Decay of logging wounds had little effect on net growth. Brush encroachment did occur in skidroads and in openings formerly occupied by old-growth trees, imposing an additional

regeneration cost when the understory reaches harvest age.

Financial analysis revealed an economic advantage for immediate logging of the old-growth, whether damaged understory trees were also logged, or not.

SILVICULTURAL AND ECONOMIC ASPECTS OF REMOVAL OF SCATTERED OVERMATURE TREES FROM A WELL-STOCKED POLE STAND IN THE SITKA SPRUCE-WESTERN HEMLOCK TYPE

by

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INTRODUCTION

Forest land managers frequently must decide whether to remove old-growth (beyond rotation age) stand remnants from a well-stocked pole understory, or to leave the old-growth until the understory reaches harvest age.

Removal of the old-growth is favored by its present value. Unless its value increment percent exceeds the landowners best alternative investment rate of interest, failure to liquidate the old-growth and invest the proceeds in this best alternative means foregoing profits. This has the same effect on net profits as does incurring a cost. In addition, the old-growth may be deteriorating rapidly, and the understory may benefit from release.

On the other hand, the understory may be severely decimated by old-growth removal. Trees may be killed outright, and logging wounds on residual trees will be subject to decay. Openings created by skid roads, landings, and removal of old-growth trees may be invaded by brush, imposing an additional regeneration cost when the understory is harvested. Moreover, if the old-growth timber has retained its value for 100 or more years beyond rotation age, it might be expected to retain much of this value for the next 30-40 years, or until the understory is harvested, dependent on the natural longevity of the species.

The land manager's decision is also influenced by topography of the area, the ability of loggers available to him, and other factors, external to the trees themselves, having uncertain consequences. Research efforts intended to help land managers with this kind of decision are hampered by these hard-to-measure variables. An experiment designed with enough replications to isolate the effects of each factor would probably be prohibitively expensive for a single agency to undertake. The best hope for arriving at useful recommendations lies in combining the experience from numerous case studies to see if trends can be detected therein.

In 1948, personnel of the Willamette Research Center[1/], Pacific Northwest Forest and Range Experiment Station, recognized a timber sale on the Cascade Head Experimental Forest, Siuslaw National Forest, as an opportunity to examine some aspects of the above question. The sale involved the removal of scattered residual old-growth Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco.) and western hemlock (Tsuga heterophylla (Raf.) Sarg.) from

1/Now, the Silviculture Project, Forestry Sciences Laboratory a 38 year old stand of western hemlock and sitka spruce (*Picea sitchensis* (Bong.) Carr).

A study was planned to examine damage to and decay of residual understory trees as a result of the old-growth removal. Attention was paid to the possibility of removing or girdling damaged trees. The author expanded the objectives in 1961 by examining the impact of old-growth removal on regeneration difficulties to be expected when the understory reached harvest age.

THE STUDY AREA

The study area (fig.1) is located in sections 9 and 10, township 6 south, range 10 west, Willamette Meridian. Access is via the Sloan Creek road which leaves the paved road about 8 miles north of Otis Junction, Oregon. The area suitable for tractor logging and, therefore, included in the study is approximately 15 acres.

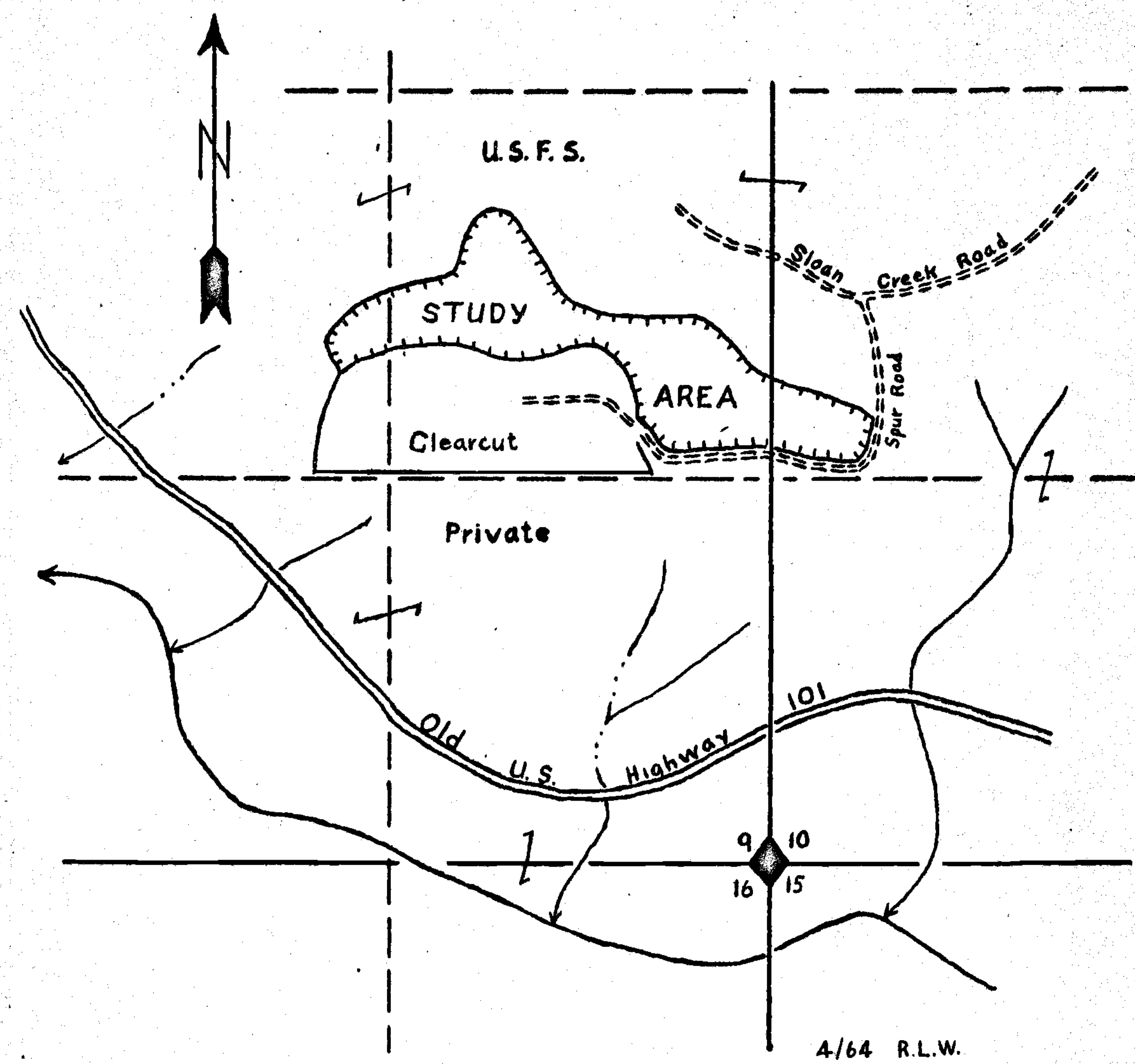
The area received enough fire damage in the early 1900's to kill approximately 90 percent of the old-growth Douglas-fir and western hemlock stand. Western hemlock and sitka spruce seeded in naturally with the spruce contributing about 25 percent of understory cubic volume in 1948, at stand age 38.

At the time of sale preparation, the old-growth averaged 3.1 trees per acre, and total volume on the 15 acre tract was approximately 212,000 board feet, Scribner.

The area is primarily ridgetop, with one-half the area being level and the other half having an average slope of 20 percent and a southerly aspect. There is heavy ground cover where the tree canopy is broken. The principal groundcover species are salmonberry (*Rubus spectabilis*), red alder (*Alnus rubra*) and salal (*Gaultheria shallon*). The soil is a deep sandy loam with good drainage.

FIG. 1, CASCADE HEAD SALE NO. 2

Scale: 8 inches = 1 mile Sec. 9, 10 T 6 S, R 10 W, W.M.



The understory was 38 years old, in 1948 when the study was established. Some statistics of the stand at that time are tabulated below.

Stand Characteristic	Value	Normal Value 1/	Percent Normal
Site index	140		
Number of trees/acre	485	918	52.7
Average diameter--------inches (by basal area)	8.5	7.1	119.7
Basal area/acre---------sq.ft.	192.5	241.6	79.7
Volume/acre-------------cu.ft.	5411	7220	74.9

1/ Values from tables 3, 5, 7, and 12 in U. S. D. A. Technical Bulletin 1273 (1, p. 9, 11, 13, 18)

METHOD

Ten 1/5-acre circular plots were systematically established in the 15-acre area prior to cutting of the overstory in 1948. On these plots, all understory trees 2.5 inches d. b. h. and larger were tagged with metal tags at breast height and diameters were measured with steel tape to the nearest 0.1 inch. Height measurements were made on 8-9 trees per plot with steel tape and Abney level to the nearest foot. Height measurement trees sampled the diameter range of the understory stand.

After logging the old-growth, residual understory trees were rated for damage according to location on the tree and a subjective numerical index from 1 to 10, indicating severity. Damaged trees were not girdled or removed.

Measurements in 1961

The author made diameter breast high and height measurements on all plots, in the same manner as in plot establishment, on the same trees. There was no ingrowth to the 3 inch d. b. h. class.

The information provided by Wright and Isaac (8) in their publication on decay of wounds in several western conifers was useful in evaluating logging damage to the residual stand. They presented regression equations which predict decay volumes according to age and original surface area of scars. In this case, the age of logging scars was known. The author estimated and tallied the surface area of all visible logging scars on the plots. A sample of logging wounds within reach on the trunk was bored to determine the incidence of decay.

Mortality occuring in the 13 year period was classified into three classes: (1) suppression, (2) direct action of logging and (3) delayed effect of logging damage. No mortality, caused primarily by insects or pathogens, was observed.

The author examined prospective regeneration difficulties in addition to timber harvest considerations. Stocking was examined in 1961 with 4-milacre quadrats at 1 chain intervals on strips 2 chains apart. To be considered stocked, a quadrat was to have one hemlock or spruce seedling at least 2 years old, or be occupied by the canopy of the understory.

Segregating the ten study plots into three catagories followed an intensive examination of the area by the author.

Plot number 3 was out of the treatment area and contained a stand structure different from the other nine plots. It was not included in any analyses, but served as a measure of environmental influences on stand growth as indicated by variations in average diameter increment during the observation period.

Plots 1, 5, and 10 were in the general treatment area, but were classed as untreated. No old-growth timber was removed from them; there were few skid-roads through them; and, judging by the position of old-growth stumps, they were under little suppressing influence from old-growth trees. Because of their similar stand structure, they provided useful growth comparisons for the treated plots.

The remaining plots, 2, 4, 6-9, were used to measure the effects of removal of the old-growth.

The yield information for even-aged stands of western hemlock (1) was used to determine rotation age and yield values resulting from treatment.

Evaluating management alternatives

In order to determine the significance of findings of damage to and decay of residual trees, the author evaluated these findings from the position of a land manager having three alternative courses of action. The alternatives considered are:

(1) Removal of the old-growth, leaving entire residual stand to rotation age.

(2) Removal of the old-growth, with removal of damaged understory trees immediately afterward.

(3) Leaving the entire stand, including the old-growth, to understory rotation age.

Other alternatives, of course, are possible. The data in this study and the present state of knowledge of western hemlock silviculture, however, limit the range of alternatives that can be evaluated effectively here.

Alternative 1

This alternative involves leaving trees damaged by logging until harvest age. To evaluate the results of this alternative, it was necessary to project average volume for released plots to rotation age. Decay volume resulting from logging wounds was calculated at rotation age, and this volume was subtracted from the average projected released plot volume.

Rotation age was determined as being that age where culmination of mean annual increment (board feet International 1/4 inch rule) occurs. The values in table 18 of U. S. D. A. Tech. Bult. 1273, for site index 140, indicated a rotation age of 70 years for this stand. Harvest date would be the year 1980.

Considerable thought was given the rate of interest to be used in projecting values of timber removed in 1948 to the end of rotation in 1980. Long term loans, such as household mortgages, afford a useful comparison. The rate of interest for these loans is around 6 percent and the interest accruing is subject to the full federal income tax. Timber depletion enjoys the benefits of capital gains provisions in the income tax laws, resulting in considerable savings. Thus, a rate lower than 6 percent applied to timber investments might be expected to yield the same income as a 6 percent real estate loan.

However, timber raising is recognized as having a high degree of risk from fire, insects, disease, windthrow and climate. A rate of interest commensurate with the risk, but mitigated by the capital gains provision is indicated. It is the author's opinion that the increased risks of timber growing, relative to the risks inherent in real estate loans, are balanced by benefits accruing from capital gains treatment.

Long-term loans, as a rule, depreciate in the presence of inflation, whereas wood product values should follow the inflationary trend. It appears, therefore, that timber investments, working at a slightly lower rate than long-term mortgages, should yield the same return. A five percent interest rate was used in this study in projecting values to rotation age.

Inflation can be expected to influence stumpage rates in the future as it has in the past. The Economic Almanac (3, p.110) indicates an annual increase in the price index (1947-49 = 100) for lumber and wood products, from 1950 to 1960, of 1.03 percent per year. Stumpage prices in 1980 are accordingly calculated as 133 percent of

1948 prices. No attempt is made to predict any change in the real value of stumpage. This seems impossible in view of changing labor costs and shifts in the relative status between wood and competing raw materials such as aluminum and steel.

Old-growth volume removed from the partial cut area was not reported separately in 1948, but was included with the volume removed from an adjacent clearcut. Therefore, the partial cut volume was estimated in 1961 from stump measurements. A tally, by one inch diameter classes, was made of all stumps on the area. The stump diameters were converted to one inch d. b. h. classes as recommended by Bones (2, p.2). Heights for trees of these d. b. h. classes were assumed to be the same as average heights of trees of corresponding diameters, as noted on the cruise cards used in 1948. This procedure resulted in a total volume estimate for old-growth Douglas-fir of 188.7 M board feet, and for mature western hemlock of 23.4 M board feet, Scribner rule.

Board foot volume for the understory was projected to 1980 (end of understory rotation) according to the instructions in U. S. D. A. Technical Bulletin 1273 (1, p.41) (see appendix A, B, and C, pages 29, 30, 31). Plot values recorded in 1961 furnished the projection base, rather than the values of 1948, because of the shorter projection period involved and because the treated plot data could be expected to reflect any treatment effects resulting from alternative 1.

The work of Wright and Isaac (8, p.27) served to predict logging wound decay volumes at rotation age. A sample of scars was bored, and the cores examined to determine the incidence of decay. The percentage of scars with decay--58--came fairly close to the average decay percent--64--found by Wright and Isaac, though the difference in percentage is highly significant (u = 4.839).

Alternative 2

This alternative involves removal of merchantable damaged understory trees immediately after the old-growth is logged. Average per acre volume for damaged trees was subtracted from the treated plot average volume of 1948 to arrive at a projection base. Study treatment did not involve removal or girdling of damaged trees on any plots. Therefore, there are no 1961 plot values to reflect alternative 2 and to serve as basis for a shorter projection period. Prediction was according to yield table recommendations as in alternative 1.

Alternative 3

This alternative involves leaving the old-growth trees to understory rotation age. The author assumed that the Douglas-fir and hemlock overstory was in a state such that, at the worst, mortality was offset by growth.

According to King (5, p.769), a 350 year old Douglas fir stand in the Wind River Natural Area lost only 0.27 percent (171 board feet, Scribner) of a beginning volume of 63,036 board feet in a 12 year period. During this period, the stand suffered heavily from bark beetle and wind throw mortality. Ring counts on stumps in the study area indicated the old-growth Douglas-fir was approximately 250-300 years old, the old-growth hemlock about 120 years old. Stumps contained very few traces of decay and a lack of cull logs following the logging operation indicated a thrifty condition for the old-growth. It seems logical to assume that old-growth volume in 1980 would have been at least the same as volume in 1948, in view of the lack of any evidence indicating deterioration of the overstory.

These three alternatives are evaluated by comparing yield values resulting therefrom at understory rotation age. Yield values occurring in 1948 are projected for 32 years at 5 percent compound interest.

RESULTS

A summary of agerage per acre values for the treated and untreated plots, before and after the logging operation, is given in table 1. The relation of these average values to normal values is given in table 2. These values are the basis for projection to rotation age for all three alternatives. Projected values, in volume and dollar value, are presented in table 3. Timber values harvested in 1948 were accumulated at 5 percent compound interest to arrive at the values indicated for 1980. 1948 values are those from the timber sale re-appraisal, (6).

Mortality figures in table 1 indicate part of the basis for grouping the plots as the author did. The untreated plots suffered much less logging damage; an indication of their undisturbed state, relative to the treated plots.

It is difficult to draw inferences in regard to cubic volume growth, resulting from treatment, from the cubic volumes indicated in table 1 for 1948 and 1961. As can be seen in table 2, all plots were lightly stocked in number of trees per acre. In addition, figure 2 indicates that cubic volume increment is a linear function of initial cubic volume. The correlation coefficient is highly significant ($r = 0.906$ with 7 d. f.). As can be seen on the figure, initial cubic volume bears

Table 1. -- Stand summary for treated and untreated plot averages 1948 and 1961 -- per acre basis.

Second-growth stand	Plots 2, 4, 6-9 (treated)				Plots 1, 5, 10 (untreated)			
	All species			Hemlock & spruce	All species			Hemlock & spruce
	Trees	Aver. diam.	Basal area	Cubic volume	Trees	Aver. diam.	Basal area	Cubic volume
	Number	Inches	Sq. ft.	Cu. ft.	Number	Inches	Sq. ft.	Cu. ft.
Live-1948 before old-growth removed	536±43.8	8.2	195.2±12.7	5,415±439.8	385±59.6	9.4	187.4±15.0	5,405±2,013.8
After old-growth removed	405±45.0	8.2	163.1±10.5	4,678±402.0	373±56.0	9.5	185.0±15.0	5,371±2,023.0
If damaged 2nd growth also removed	341±49.0	8.2	124.0±12.0	3,259±353.5				
Mortality 1948-1961 logging damage	200±51.2	7.1	54.7±14.6	1,244±306.3	15±7.6	8.5	5.9±4.0	119±101.9
Suppression	49±23.6	4.6	5.7±2.7	136±63.5	85±32.8	5.1	12.3±3.9	302±126.2
Live - 1961	285±34.1	11.9	218.5±12.0	7,714±498.3	266±31.9	12.6	232.7±19.7	8,578±2,838.4

Table 2. -- Relation of treated and untreated plot average values to normal, 1948 and 1961.

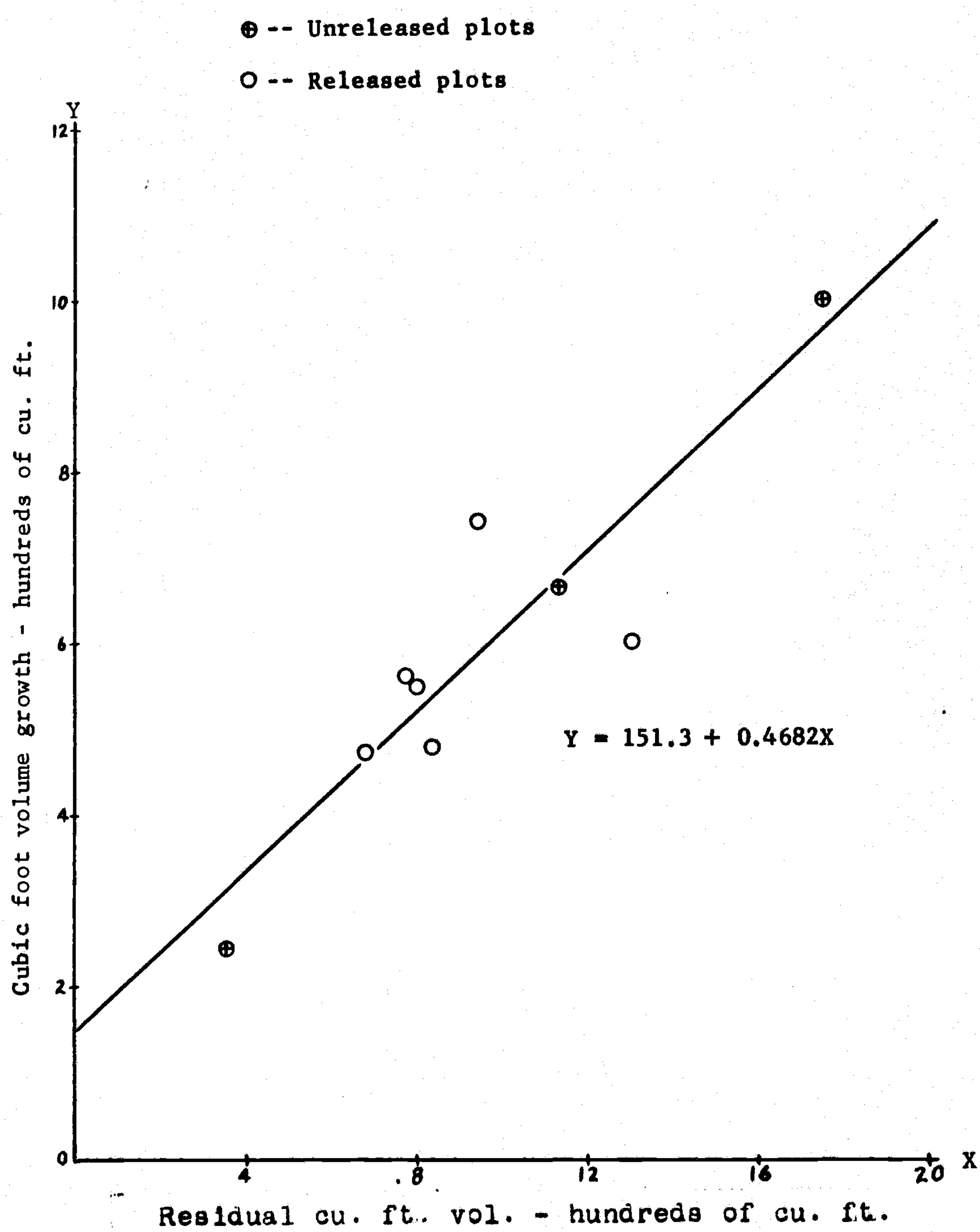
Second-growth stand	Plots 2, 4, 6-9 (treated)				Plots 1, 5, 10 (untreated)			
	All species			Hemlock & spruce	All species			Hemlock & spruce
	Trees	Aver. diam.	Basal area	Cubic volume	Trees	Aver. diam.	Basal area	Cubic volume
	- - - Percent of normal - - -				- - - Percent of normal - - -			
<u>1948</u>								
Before old-growth removed	58.4±4.8	113.9	80.8±5.2	75.0±6.1	41.9±6.5	130.5	77.6±6.2	74.9±27.9
After old-growth removed	44.1±4.9	119.4	67.5±4.4	64.8±5.6	40.7±6.1	131.9	76.6±6.3	74.4±28.0
If damaged 2nd-growth also removed	37.1±5.3	113.9	51.3±5.0	45.1±4.9	no measurement			
<u>1961</u>	68.1±8.1	107.2	77.2±4.2	69.4±4.5	63.7±7.6	113.5	82.3±7.0	77.1±28.0

Table 3.--Financial alternative summary

Management Plan	At time of harvest: Scribner volume	At time of harvest: Value – Stump	At time of harvest: Value – Total	Final value 1980: Total	Final value 1980: Treatment total
	M bd.ft.	- - Dollars - -		- - Dollars - -	
Alternative 1					
Old-growth removed 1948	14.14	12.32	174.20	[1]830	
2d-growth retained to 1980	69.3	5.52	382.54	382	1,212
Alternative 2					
Old-growth removed 1948	14.14	12.32	174.20	[1]830	
Damaged 2d-growth removed 1948	6.6	4.15	27.39	[1]130	
2d-growth retained to 1980	68.7	5.52	379.22	379	1,339
Alternative 3					
Old-growth retained to 1980	14.14	16.38	231.61	232	
2d-growth retained to 1980	75.7	5.52	417.86	418	650

[1] 1948 value accumulated at 5% compound interest for 32 years

FIG. 2. REGRESSION OF CUBIC FOOT VOLUME GROWTH ON 1948 RESIDUAL CUBIC FOOT VOLUME - ALL PLOTS.



no relation to treatment. The indication is that the experiment is not sensitive enough to separate treatment effects from effects reflecting the heterogeneity of stocking in the total stand prior to logging.

Number of trees, basal area, and average diameter, in table 1, resulted from the diameter breast high measurements on all trees, including hardwoods. A second-degree least squares equation relating total height to d. b. h. was calculated for hemlock and spruce separately. Local volume tables, for each species at each measurement, were constructed by reading values for the diameters and calculated heights from tables 52, 56, and 71 in Agricultural Handbook No. 92 (4, p. 52, 56, 71). Volume estimates for the hardwood species are not available as they were not sampled by height measurements.

Stocking

Four percent of the area is non-productive because of swampy conditions. Non-stocked productive land is 22 percent of the total area. Nearly all (85 percent) of this non-stocked productive land is occupied by dense salmonberry and/or red alder which seeded into openings created by skidroads and removal of old-growth.

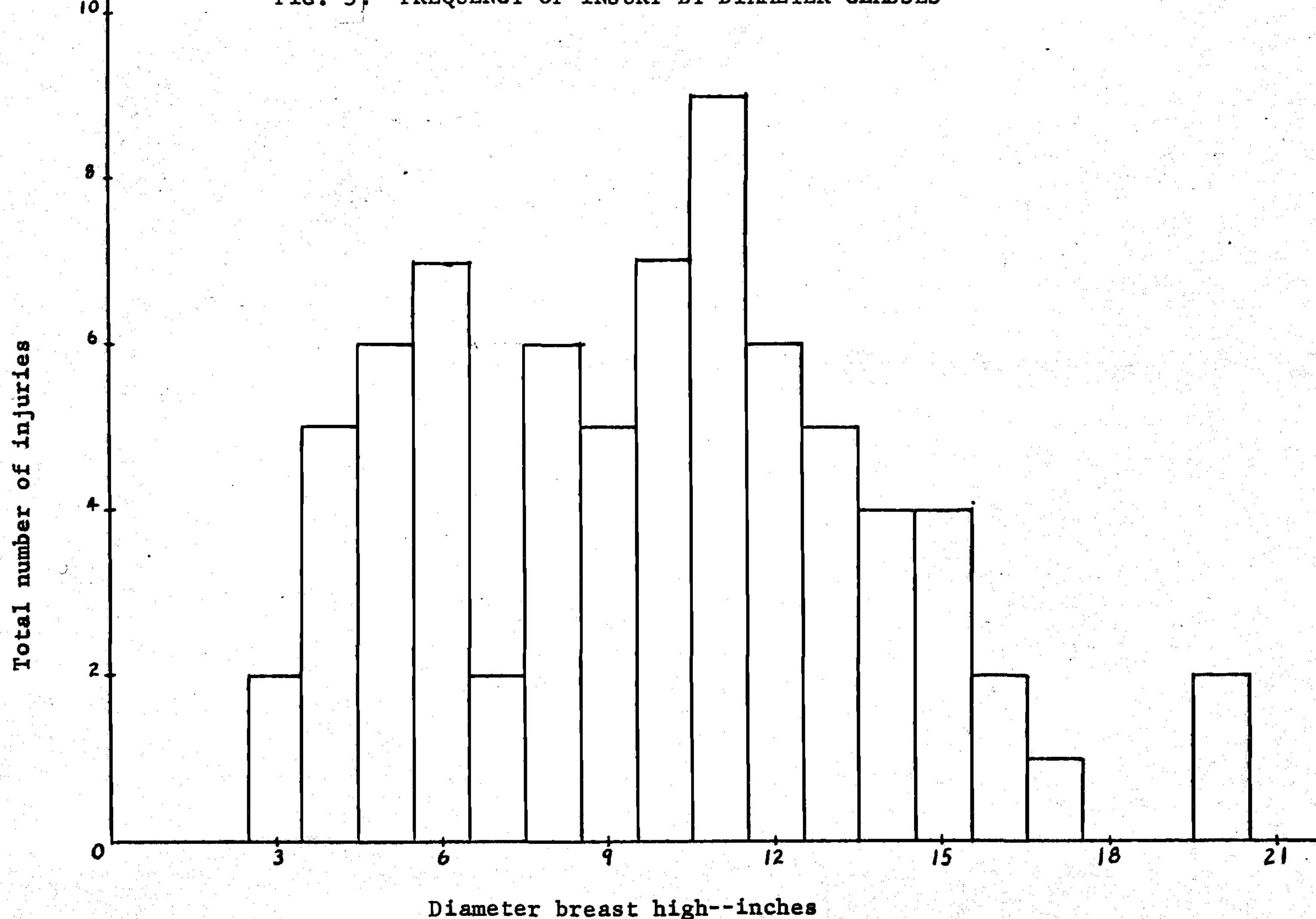
The brush will present an obstacle to regeneration, when the understory is harvested, if it is not obliterated by logging and slash burning. The author's experience has been that brush is not eliminated by these actions.

Approximately three acres of the 15 acre study area will have to be treated for brush control at rotation age if adequate regeneration is to be secured. If treatment costs thirty dollars per acre, this would impose an added cost averaging six dollars per acre to alternatives 1 and 2.

Occurrence of injuries

The author's tally of all visible logging damage to residual trees on the measured plots revealed a frequency distribution as shown in fig. 3. Injuries predominate on trees having diameters above the average for the treated plots.

FIG. 3. FREQUENCY OF INJURY BY DIAMETER CLASSES



DISCUSSION

It may be argued that 5 percent is too high a rate of interest to be applied in comparing the management alternatives in this study. Nevertheless, a land manager could choose alternative 3 only if his best investment opportunity elsewhere did not exceed one percent interest. This is the interest rate which, applied to the revenues of alternative 2, would make the 1980 value of this alternative equal to that of alternative 3. A one percent rate of interest is unacceptable to most investors.

It is difficult to evaluate the effects of logging damage on residual trees in alternative 1. The projection of stand volume to 1980 is liberal in that allowance was made only for volume of decay. There is no way to predict how many trees will break off or succumb to other secondary agents as a result of the decay. This uncertainty lends support to alternative 2, requiring removal of damaged trees, as opposed to alternative 1. Favoring alternative 1 over alternative 2, however, is the evidence presented by fig. 3. Injuries are concentrated in trees above the average diameter for the released plots. These are trees making more rapid growth, perhaps growing radially more than the decay or, at least, maintaining adequate support to rotation age. This uncertainty may balance the previous uncertainty.

Effect of Using Soil Rent Rotation

The reader might well question the practice, as used here, of determining rotation age through maximization of mean annual increment. A more practical approach, in the business sense, is to determine at what age maximum "soil rent" occurs.

It is difficult to calculate a single soil rent rotation that is generally applicable to the various land management circumstances and objectives because of the several variables that must be considered in addition to those used in determining rotation age by maximization of mean annual increment.

The author attempted (see Appendix D, page 32) to calculate a "soil rent" rotation with underlying assumptions comparable to those used in determining rotation length by culmination of mean annual increment. No allowance was made for constant annual costs, such as ad valorem taxes, as these occur regardless of rotation length. Also, the market for small products is extremely spotty thus far, with respect to western hemlock, making it hazardous to assume that revenue from thinnings can be relied on in management plans to increase total financial yields. No thinning revenues were included in this "soil rent" calculation.

As can be seen, considering only normal yields and assuming a regeneration cost of 15 dollars per acre (a figure quoted to the author by several land managers as representative of their helicopter aerial seeding costs), rotation length in this case could be shortened by ten years, basing it on "soil rent". This would call for harvest of the understory in 1970 rather than in 1980.

The overall effect of this procedure is to reduce all values in the last column of table 3 by 20-30 percent. The relative standings of the alternatives are unchanged.

CONCLUSION

The values in table 3 leave no doubt that it is financially advantageous to harvest old-growth Douglas-fir remnants in the sitka spruce-western hemlock type if a well stocked stand of these latter species has been secured and harvest of partial cuttings can be accomplished by tractor skidding.

Without replication, this study was unable to examine effects of different loggers on the residual stand. It was obvious, however, that the operator in this case exercised little care with respect to preservation of the understory. Windfalls were bulldozed out of skidroads full-length, rather than after receiving a bucking cut. No effort was made to fall old-growth trees into existing openings in the stand rather than into the understory. In spite of this treatment, released plots averaged 78 percent of normal cubic foot volume growth with an average growing stock of 65 percent of normal volume. A more careful logging operation would have damaged the residual stand less and this could only reinforce the arguments for removing the old-growth trees without delay.

The added costs, at understory rotation age, for the control of brush in skidroads and other openings created by old-growth removal, must be considered by the land manager. In this case, however, the anticipated brush control cost of six dollars per acre, which might be avoided by postponing harvest of the old-growth until 1980, is negligible when compared with the profits to be gained by immediate harvest of the old-growth.

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APPENDIX

A

PREDICTING 1980 SCRIBNER VOLUME FOR RELEASED PLOTS, DAMAGED 2ND-GROWTH RETAINED (1, p.41)

Alternative 1

Av. # trees per acre-1961	285
Av. diameter	11.9"
Age in 1961	51
Actual height/normal ht. ratio, as with total stand	.909
% stocking = actual # trees/normal # trees = 285/374	76.2
Stocking after 19 years (table 29)	86.5
Av. dia. in 1980 (age 70) (table 5, SI 180)*	17.2"
From table 27, normal Scrib. vol. for 17.2" = 91.2 M bd. ft.	
Actual 1980 Scrib. vol. = 91.2 X .909 X .865 =	71.6 M
Subtract volume for decayed logging wounds	-2.3 M
	69.3

* The assumption is made that stand after logging, leaving injured trees, will grow like stand before logging because logging destroyed small suppressed trees, which exert little influence on the rest of the stand in any case.

B

PREDICTING 1980 SCRIBNER VOLUME FOR RELEASED PLOTS, DAMAGED 2ND-GROWTH REMOVED (1, p.41)

Alternative 2

Av. # trees per acre-1948	341
Av. diameter	8.2"
Age in 1948	38
Actual height/normal ht. ratio, as with total stand	.909
% stocking = actual # trees/normal # trees = 341/697	48.9
Stocking after 32 years (table 29)	82.8
Av. dia. in 1980 (age 70) (table 5, SI 180)	17.2"
From table 27, normal Scrib. vol. for 17.2" = 91.2 M bd. ft.	
Actual 1980 Scrib. Vol. = 91.2 X .910 X .828 =	68.7 M

C

PREDICTING 1980 SCRIBNER VOLUME FOR RELEASED PLOTS, TOTAL UNDERSTORY (1, p.41)

Alternative 3

Av. # trees per acre	536.5
Av. diameter	8.2"
Age in 1948	38
Ratio-ht. of 8.2" tree vs. table 27 height = 70/77 =	.909
% stocking = actual # trees / normal # trees = 536/697	76.9
Stocking after 32 yrs. (table 29)	91.3
Av. dia. in 1980 (age 70) (table 5, SI 180)	17.2"
From table 27, normal Scrib. vol. for 17.2" = 91.2 M bd. ft.	
Actual 1980 Scrib. vol. = 91.2 X .909 X .913 =	75.7 M

D

CALCULATION OF ROTATION BY MAXIMIZATION OF SOIL EXPECTATION VALUE

Sitka spruce-western hemlock type--Site index 140

An assumption is made here that certain components of the soil expectation value formula are constant regardless of rotation age. These components include initial regeneration cost and fixed annual costs such as taxes and insurance. Only the variable component is analyzed.

As explained in the text, a five percent rate of interest is deemed appropriate. Yields by International 1/4 inch rule are from table 18 of U. S. D. A. Technical Bulletin 1273 (1, p. 24). The following are assumed values for the variable costs in the soil expectation value.

Stumpage per M bd. ft. in 1980	$ 5.52
Reforestation, per acre	$15.00

Trial 1--Age 70

$$R_{70} \text{ S.E.V. component} = \frac{\$469.20-\$15.00}{(1.05)^{70}-1} = \frac{\$454.20}{29.43} = \$15.43$$

Trial 2--Age 60

$$R_{60} \text{ S.E.V. component} = \frac{\$380.88-\$15.00}{(1.05)^{60}-1} = \frac{\$365.88}{17.68} = \$20.68$$

Trial 3--Age 50

$$R_{50} \text{ S.E.V. component} = \frac{\$226.32-\$15.00}{(1.05)^{50}-1} = \frac{\$211.32}{11.47} = \$20.20$$

A rotation age of 60 years is indicated

Table 4. Stand Summary for treated and untreated plots, 1948 -- per acre basis.

Plot	All Species			Conifers
	No. Trees	Average Diameter	Basal Area	Cubic Volume
Treated Plots				
2	593	7.9	200.0	4,920.1
4	635	7.2	180.5	5,571.0
6	450	7.6	140.5	4,281.0
7	655	7.9	221.0	5,663.5
8	390	10.2	220.5	7,338.5
9	495	9.0	211.5	4,717.5
Untreated Plots				
1	370	8.9	159.5	1,775.5
5	290	11.2	197.5	8,732.0
10	495	8.8	209.0	5,707.0

Table 5. Stand summary for treated and untreated plots; 1961 -- per acre basis.

Plot	All Species No. Trees	Average Diameter	Basal Area	Conifers Cubic Volume
Treated Plots				
2	400	11.1	268.6	8,249.4
4	355	10.4	208.5	8,440.5
6	315	10.4	186.5	6,582.5
7	255	12.8	201.5	6,681.5
8	195	14.9	236.0	9,559.5
9	220	13.2	209.0	6,774.5
Untreated Plots				
1	260	11.7	193.5	2,979.0
5	215	14.7	253.0	13,756.0
10	325	11.9	252.0	9,001.0

Table 6. Logging damage and suppression mortality by plots, 1948-1961. Per acre basis.

LD=Logging Damage; S=Suppression

Plot	All Species		Conifers
	No. Trees	Basal Area	Cubic Volume
Treated Plots			
2 LD	114	27.9	907.9
S	164	20.0	457.9
4 LD	200	49.5	1,080.5
S	80	7.0	184.0
6 LD	70	16.0	445.5
S	65	8.0	206.0
7 LD	425	118.0	2,652.5
S	5	0.5	8.0
8 LD	165	58.0	1,486.5
S	30	5.0	98.5
9 LD	250	67.0	1,162.5
S	20	4.5	96.0
Untreated Plots			
1 LD	20	4.5	35.5
S	90	10.0	159.5
5 LD	0	0.0	0.0
S	75	8.5	192.5
10 LD	25	13.5	322.0
S	105	21.0	553.5

Table 7. Relation of plot values to normal values, 1948.

Plot	All Species No. Trees	Average Diameter	Basal Area	Cubic Volume
Treated Plots				
2	64.6	109.7	82.8	68.1
4	69.2	100.0	74.7	77.2
6	49.0	105.6	58.1	59.3
7	71.3	109.7	91.5	78.4
8	42.4	141.7	91.3	101.6
9	53.9	125.0	87.5	65.3
Untreated Plots				
1	40.3	123.6	66.0	24.6
5	31.6	155.6	81.7	120.9
10	53.9	122.2	86.5	79.0

Table 8. Relation of plot values to normal values, 1961.

Plot	All Species			Conifers
	No. Trees	Average Diameter	Basal Area	Cubic Volume
Treated Plots				
2	95.6	100.0	94.9	74.2
4	84.8	93.7	73.7	75.9
6	75.3	93.7	65.9	59.2
7	53.8	115.3	71.2	60.1
8	46.6	134.2	83.4	86.0
9	52.6	118.9	73.9	60.9
Untreated Plots				
1	62.1	105.4	68.4	26.8
5	51.4	132.4	89.4	123.7
10	77.7	107.2	89.1	80.9