Research Bulletin No. 3

EVALUATION OF FACTORS AFFECTING NATURAL REPRODUCTION OF FOREST TREES IN CENTRAL WESTERN OREGON

By

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A scene typical of much of the area covered in this study. Area logged and slash burned four to five years prior to the photograph. Relogging operation is now taking material not removed by the first cut. The scattered timber in the central part of the picture has been logged through and the trees would be classified as seed trees. The timber in the background would be classified as adjacent timber. This area already supports an adequate stand of established reproduction 2 to 5 years old.

TABLE OF CONTENTS

ACKNOWLEDGMENTS

The author wishes to acknowledge the assistance received from the personnel of the Research Section of the Oregon State Board of Forestry. John B. Woods, Jr., was in a large measure responsible for the instigation of the study. Wilbur Engstrom, Anthony Gruba, Harold Dixon and Buford Hayes spent much time in collecting and assembling the field data into usable tabular form.

Dr. George H. Barnes of Oregon State College advised in some phases of the analysis of data.

Evaluation of Factors Affecting Natural Reproduction of Forest Trees in Central Western Oregon

INTRODUCTION

One of the most puzzling problems confronting foresters is the apparent inconsistency with which a stand of reproduction appears following logging or fire. The conditions which influence the establishment of a new crop of seedlings are many. None apparently constitutes a single controlling factor in itself. Most areas

An example of the results of a logging operation in "second growth" timber in central western Oregon. Small residual trees not removed by the logging operation have succumbed to fire, exposure and insects. Even though the area was burned eight or nine years ago an "adequate" stand of reproduction has not been established; neither has an excessive brush cover captured the area. What is the reason this area has not restocked?

will, if provided with sufficient source of seed and protected from fire, restock within a reasonable length of time. There are areas, however, which now lie idle and unproductive even though conditions have appeared favorable for reproduction. These areas can be planted or seeded but, in spite of the advance being made in the field of artificial reforestation, the costs are still so high that these methods are limited for extensive use.

Considerable work has already been done on the subject of natural regeneration in the Pacific Northwest. Early in this century, western foresters were engaged in research to determine how best to assure a crop of trees by natural means after fire or logging. Their findings are available in numerous publications. These findings are in most instances quite accurate and comprehensive, but the field of investigation is so large and varied that no one man or organization could hope to cover all its ramifications at one time. This study is, therefore, undertaken not as a duplication of work already completed or work now in progress; but as supplemental research which, it is hoped, will augment the knowledge already available.

PURPOSE OF STUDY

This study was started in 1947 to investigate the value of various types and quantities of seed source in the establishment of reproduction on cutover land, and to determine the apparent effects of various man-made and natural factors upon the rate of restocking. The man-made and natural factors to be considered were degree of burn, amount of slash, vegetative competition and exposure.

REVIEW OF LITERATURE

There will be no attempt to review all the literature available on the subject of natural regeneration. A bibliography has been compiled and is included as part of the report. It is fairly complete and contains the reports on most of the important work done in this field by foresters during the past half century. Although the references are not limited to the Douglas fir forest type, it is there that the emphasis has been placed.

DESCRIPTION OF STUDY AREA

The Douglas fir forest type of western Oregon differs with geographical location, altitude and local conditions within general areas. For the purpose of this study it seemed neither practical nor desirable to include each and every variation of forest type. The variation in type is reduced by limiting the area of study to "Central Western Oregon".

The areas classified as "Central Western Oregon" (see Figure 1) are as follows:

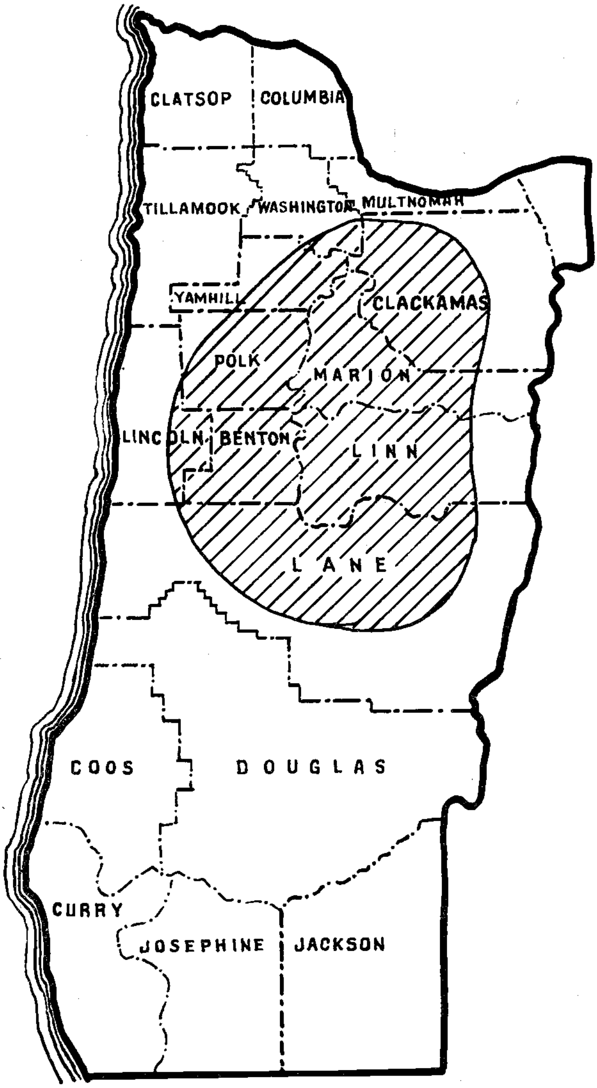
1. Central Coast Range—Portions of Polk, Lincoln, Benton, Lane and Douglas counties.
2. Willamette Valley—Portions of Clackamas, Multnomah, Washington, Yamhill, Polk, Marion, Benton, Linn and Lane counties.
3. Low Cascades—Portions of Hood River, Multnomah, Clackamas, Marion, Linn and Lane counties.

Stand composition and environmental factors in general were similar enough to warrant the processing of the data as a single group.

The timber in this area is a mixture of Douglas fir *(Pseudotsuga taxifolia)* and west coast hemlock *(Tsuga heterophylla)*, with Douglas fir as the dominant and codominant trees and west coast hemlock forming the understory. Western red cedar *(Thuja plicata)*, Sitka spruce *(Picea sitchensis)*, the true firs *(Abies spp.)*, Idaho white pine *(Pinus monticola)* and a variety of hardwoods occur in minor quantities. Excluding the natural reproduction of commercially important trees, the ground cover which becomes established in this area after logging or fire consists mostly of willow *(Salix spp.)*, maple *(Acer spp.)*, thimbleberry *(Rubus parviflorus)*, salmonberry *(Rubus spectabilis)*, trailing wild blackberry *(Rubus vitifolius)*, bracken fern *(Pteridium aquilinum)*, sword fern *(Polystichum munitum)*, fireweed *(Epilobium angustifolium)* and pearly everlasting *(Anaphalis margaritacea)*.

There are, of course, many other plants represented but the above named plants normally constitute one-half to three-fourths of all ground cover found during the first three to seven years after logging or burning.

The most common system of logging used in this area is high-lead, especially on the rougher ground. Crawler type tractors are used to some extent on the more favorable slopes. The majority of logged-over areas are clearcut with provision for a seed source in the form of uncut corners and blocks or adjacent uncut timber. Any single trees remaining on the cutting areas are usually left because of their submarginal value rather than through any intent of the operator to provide seed source by this means. During logging in second-growth stands, old non-merchantable trees of the virgin stand are often again rejected and may serve as seed trees for the third crop. The general practice is to broadcast burn the slash resulting from logging, but on many areas the slash is not burned and remains to decompose slowly.



"AREA COVERED BY STUDY" "CENTRAL WESTERN OREGON"

FIGURE 1.

COLLECTION OF FIELD DATA

The data on which this study is based were gathered on cutover areas selected to represent the entire range of man-made and natural conditions which were to be investigated. All of the cutover areas were the result of commercial logging operations. No attempt was made to control the actions of the operator.

The sample tracts selected are all typical cutover areas of Central Western Oregon. The following requirements were established for selection of suitable cutover tracts:

1. Tract must have been at least 160 acres.
2. The logging must have been completed within the ten years prior to examination.
3. Comprehensive data on logging and burning (if the area were burned) must have been available.

Although the tracts were selected as 160-acre units it was later found that the analysis of seed source required a breakdown into forty-acre sub-tracts, therefore, it was as four separate forty-acre sub-tracts that each original 160-acre tract was analyzed.

Nineteen tracts were selected on which 2,920 acres were examined. The data utilized in the study were collected in the field by the use of the standard line plot survey system of the Oregon State Board of Forestry (4).[1] In brief, this system consists of delineating on the ground circular plots of four milacres which in turn are sub-divided into quadrants of one milacre each. Each quadrant is examined carefully for reproduction and a record is made by species and number of trees for each quadrant.

A special form was devised for recording the field data taken on the line plot survey (see Figure 6). On this form data were recorded concerning the character of soil, exposure, stocking, ground cover, seed source, intensity of the slash fire, and density of residual slash.

In addition, the seed source within a half-mile of plot boundaries was plotted on cross-section paper (see Figure 10). Topographic sketches of the plots were made in areas where contour maps were unavailable.[2]

Office procedure consisted of transferring the data obtained in the field to various plats and summary sheets; the compilation of information on logging and slash burning; and the computation of seed source values.[3]

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[1] Numbers in parentheses refer to bibliography.

[2] A more detailed account of the collection and classification of field data is given in the appendix pp. 39-45.

[3] A more detailed account of office procedure is given in the Appendix pp. 45-49.

ANALYSIS OF DATA

One of the bases used by the State Forestry Department in evaluating the success of restocking on cutover lands is the proportion of milacre quadrants found to be stocked with one or more seedlings. In the analysis of data for this project it seemed desirable to conform to this standard. One of the analyses presented, therefore, is based on the stocked quadrant principle. Since the field observations actually included a count of the total number of trees on the milacre plots, it was also possible to compute the number of trees per acre for the sub-classes of any of the independent variables. Consequently, the data were also summarized this way. Stocked quadrant summaries and number of trees per acre summaries were made for the sub-classes of each major variable factor and are presented in tables in subsequent pages.

In compiling the tabular summaries, the data of all the milacre plots were combined without any regard to the separate tracts on which the observations were made. This non-recognition of the tracts could introduce some bias into the results, especially with respect to the exposure variable. In this instance the milacre plots of a single tract might tend to a small range in exposure. If this condition were coupled with an exceptionally good or poor seed source, the stocking on the few exposures represented by the tract could be influenced materially by the seed source. The other variables of classification would be less subject to such bias, since all of them tend to be more independent of the specific tract and seed source. For instance, with respect to the slash concentration variable, there is wide variation in the concentration of slash over each tract as a whole, and therefore, there will be a similar variation of slash concentrations among the plots of the tract. When the plots are classified according to concentration groups, the plots from all tracts become thoroughly mixed. Hence, the seed source values will tend to become equalized over the slash groups. Notwithstanding the limitations described, it is felt that reasonably valid comparisons may be made among the group values which are tabulated.

The tabulations which present stocking percentages represent the ratio of the number of milacres which were stocked to those which were not stocked. The actual numbers which were and were not stocked are well suited to chi-square tests for determinations of significant differences among the classes of each variable. This test was applied to the data for each pertinent variable in turn. Although the results given on the following pages are in terms of stocking percents (this is the usual method of stating the relationship of stocked to non-stocked samples) it should be remembered that the chi-square tests were actually made on the original enumeration data and not by using the percentage values. It should be understood, however, that this type of test is strictly applicable only to independent and random samples. In this instance, the data were derived from mechanical samples, which are not entirely independent of seed source. Nevertheless, since a relatively large amount of data is involved in the analysis, the dangers of erroneous interpretations are minimized.

There were such great differences between plots which had been burned and those which had not been burned that a comparison between these two was made in the same fashion as the comparisons of the other variables.

RESULTS

Stocking on Various Exposures

Variations in stocking among the different exposures were found to be greater than could have been expected to have occurred by chance alone. A significant chi-square value was obtained for Douglas fir reproduction, west coast hemlock reproduction and for the reproduction resulting from the total of all species.

Although all exposures were not represented by an equal number of samples examined (see Table I), even 0 exposure (level ground), which was found on only 1.73 percent of the total area examined, had a sufficient number of samples for an accuracy of ± 9 percent at the 95 percent confidence level.

TABLE I

Proportion of Milacre Plots Found to Be Stocked by Exposure in Percent of Total Number of Plots

Exposure	*Percent of Total Samples*	*Douglas Fir*	*West Coast Hemlock*	*Other Species*	*All Species*
NW	5.93	28.1	26.5	4.6	48.1
N	12.13	28.8	51.1	3.7	65.2
NE	3.83	35.1	46.4	8.9	66.6
E	12.86	25.5	15.4	3.0	38.7
SE	10.85	19.3	10.7	2.5	29.8
S	23.26	23.7	5.5	0.7	29.2
SW	16.78	29.8	10.9	1.4	36.1
W	12.63	30.0	10.8	1.2	39.0
0	1.73	27.6	7.9	0.0	32.9
AVERAGE		26.7	17.3	2.3	39.9

Variations in stocking percent by species on various exposures are also represented on a circular graph (see Figure 2). This is merely a graphical representation of the same information presented in Table I.

TABLE II

Number of Trees Per Acre by Exposure as Computed From Counts on Milacre Quadrants

Exposure	*Douglas Fir*	*West Coast Hemlock*	*Other Species*	*All Species*
NW	450	765	81	1,296
N	414	2,094	48	2,556
NE	564	1,148	156	1,868
E	364	304	32	700
SE	256	180	24	460
S	496	92	8	596
SW	616	236	24	876
W	576	152	12	740
0	436	224	0	660
AVERAGE	472	488	32	992

TABLE III

Exposures Arranged in Order of Greater to Lesser Stocking Percents

Species	*Above Average Stocking*	*Below Average Stocking*
Douglas Fir	NE, W, SW, N, NW, 0	E, S, SE
West Coast Hemlock	N, NE, NW	E, SW, W, SE, 0, S
All Species	NE, N, NW	W, E, SW, 0, SE, S

In general terms it may be said that when considering exposure alone, the higher stocking percents were found on the northerly exposures and the lower stocking percents were found on the southerly exposures (S and SE in particular). The stocking percents found on the remaining exposures were so closely grouped around the mean that they appeared to represent average conditions for exposure.

Stocking on Various Cover Types

Of the 53 possible cover combinations, only 10 were found in sufficient numbers to constitute an adequate sample.

The information on the amount of stocking found on those cover types which were well represented is presented in Tables IV, V and VI.

Chi-square tests showed that the amount of Douglas fir reproduction, west coast hemlock reproduction and reproduction resulting from all species each varied more among the cover classes than could be expected by chance.

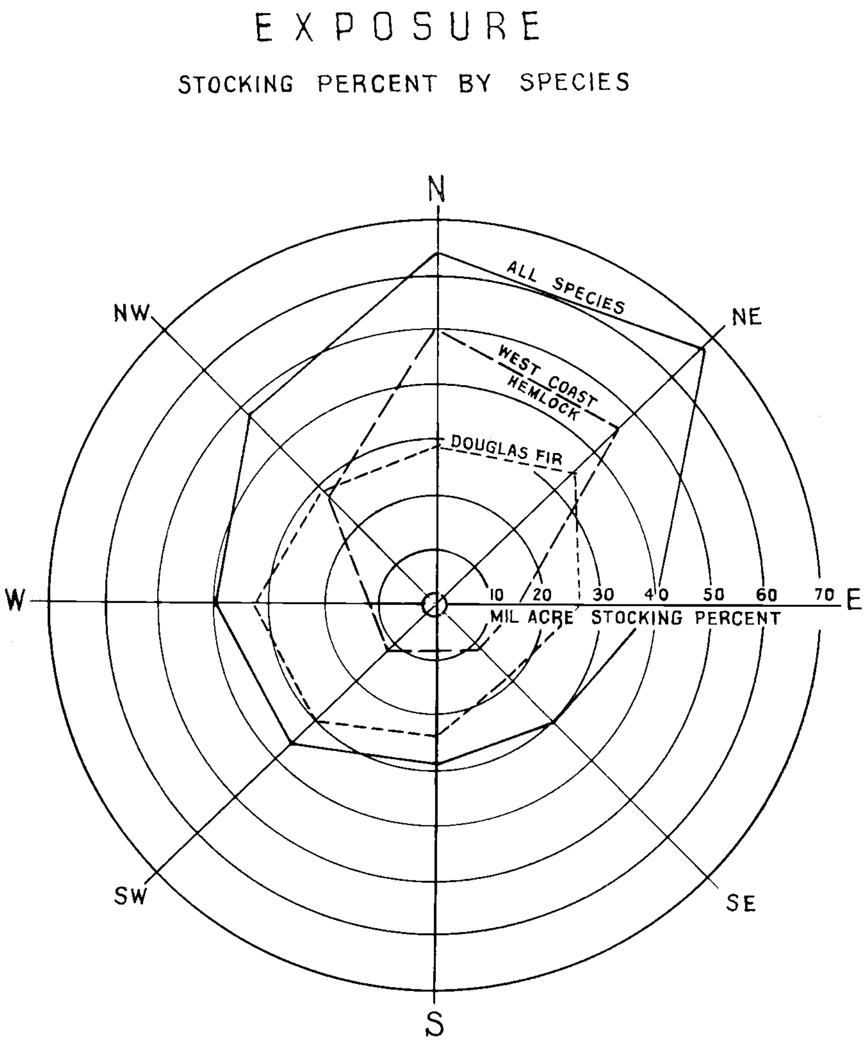

EXPOSURE
STOCKING PERCENT BY SPECIES
N
NE
E
SE
S
SW
W
NW
ALL SPECIES
WEST COAST HEMLOCK
DOUGLAS FIR
10
20
30
40
50
60
70
MIL ACRE STOCKING PERCENT

FIGURE 2

TABLE IV

Proportion of Milacre Plots Found to Be Stocked by Cover Type in Percent of Total Number of Plots

*Cover Type*④		*Percent of Total Samples*	*Douglas Fir*	*West Coast Hemlock*	*Other Species*	*Species All*
Light weed	"w"	38.20	31.0	30.0	3.4	52.9
Heavy weed	"W"	13.10	18.5	16.1	0.7	32.0
Heavy deciduous	"H"	6.03	10.8	6.1	1.5	17.0
Light evergreen	"e"	6.03	36.0	25.2	2.0	51.5
Heavy evergreen	"E"	5.51	18.0	9.6	1.1	26.5
Light weed-evergreen	"we"	10.17	37.6	16.5	3.9	48.9
Light weed-diciduous	"wh"	6.28	27.7	21.2	7.4	47.5
Light weed-deciduous-evergreen	"whe"	3.76	34.7	5.7	1.6	38.8
No cover	"0"	8.40	24.0	30.0	5.5	49.6
Heavy weed-light evergreen	"We"	2.52	14.8	1.2	0.0	14.8
AVERAGE			27.3	21.8	3.0	43.9

TABLE V

Number of Trees Per Acre by Cover Type as Computed From Counts on Milacre Quadrants

Cover Type		*Douglas Fir*	*West Coast Hemlock*	*Other Species*	*All Species*
Light weed	"w"	610	964	48	1,622
Heavy weed	"W"	252	397	7	656
Heavy deciduous	"H"	175	88	15	278
Light evergreen	"e"	562	562	31	1,155
Heavy evergreen	"E"	221	130	11	362
Light weed-evergreen	"we"	636	346	58	1,040
Light weed-diciduous	"wh"	396	564	79	1,039
Light weed-deciduous-evergreen	"whe"	570	91	17	678
No cover	"0"	489	1,119	78	1,686
Heavy weed-light evergreen	"We"	173	12	0	185
AVERAGE		479	635	41	1,155

TABLE VI

Cover Types Arranged in Order of Greater to Lesser Stocking Percents

Species	*Above Average Stocking*	*Below Average Stocking*
Douglas Fir	we, e, whe, w, wh	0, W, E, We, H
West Coast Hemlock	w, 0, e	wh, we, W, E, H, whe, We
All Species	w, e, 0, we, wh	whe, W, E, H, We

In considering cover type alone, it was found that the reproduction varied more with the amount of cover than it did with the classes of cover. In all cases the capital letters, representing heavy cover, fall into the below average stocking class in Table VI.

④ See App. Page 42 for species in these classifications.

Stocking on Various Slash Concentrations

Chi-square values for Douglas fir reproduction and total reproduction of all species indicated that the heterogeneity was greater than would normally be expected by chance. The chi-square value for west coast hemlock reproduction for various slash concentrations, however, could have occurred by chance in one out of fifteen times and so was not considered significant. This means that although there were differences in reproduction of west coast hemlock among the various slash concentrations, the evidence is not sufficient to permit a confident statement about the effect of slash concentration on the extent of west coast hemlock reproduction.

Tables VII, VIII and IX contain the information on the stocking found on various slash concentrations.

TABLE VII

Proportion of Four-Milacre Plots Found to Be Stocked by Slash Concentration in Percent of Total Number of Plots

Slash Class		*Percent of Total Samples*	*Douglas Fir*	*West Coast Hemlock*	*Other Species*	*All Species*
Very Light	"VL"	47.98	42.1	27.7	9.6	57.2
Light	"L"	16.33	38.9	26.5	6.1	55.7
Medium	"M"	12.43	27.9	20.9	4.6	40.6
Heavy	"H"	14.59	21.7	25.7	5.9	39.6
Extreme	"E"	8.67	15.0	33.3	6.6	41.6
AVERAGE			34.5	26.8	7.6	51.0

TABLE VIII

Number of Trees Per Acre by Slash Concentration as Computed From Counts on Four-Milacre Plots

Slash Class		*Douglas Fir*	*West Coast Hemlock*	*Other Species*	*All Species*
Very Light	"VL"	290	300	73	663
Light	"L"	221	268	24	513
Medium	"M"	122	183	38	343
Heavy	"H"	84	304	45	433
Extreme	"E"	58	338	46	442
AVERAGE		208	284	54	546

TABLE IX

Slash Concentrations Arranged in Order of Greater to Lesser Stocking Percents

Species	*Above Average Stocking*	*Below Average Stocking*
Douglas Fir	VL, L	M, H, E
West Coast Hemlock	E	VL, L, H, M
All Species	VL, L	E, M, H

When considering slash concentrations alone it was found that the heavier the concentration of slash the fewer the seedlings found. This generalization did not apply to west coast hemlock. For this species there was no significant difference in stocking percent among the various slash concentrations. It is quite possible that the arrangement of concentrations in Table IX for west coast hemlock is a chance arrangement only.

Stocking on Various Burn Classes

Chi-square analyses for Douglas fir reproduction, west coast hemlock reproduction and for all species showed that the stocking percents found among the three burn classes for each of the above varied more than could have been expected by chance. For Douglas fir and for all species, the significant chi-square value was derived primarily from the much better stocking found on the light burn class. For west coast hemlock, the significant chi-square value arose primarily from the much poorer stocking found on the hard burn class.

Tables X, XI and XII contain the information on the stocking found on various burn classes.

TABLE X

Proportion of Four-Milacre Plots Found to Be Stocked by Burn Classes in Percent of Total Number of Plots

Burn Class	*Percent of Total Samples*	*Douglas Fir*	*West Coast Hemlock*	*Other Species*	*All Species*
Light	52.19	58.6	26.5	7.9	69.7
Medium	31.81	51.0	25.1	3.0	62.4
Hard	16.00	50.6	13.3	4.0	59.3
AVERAGE		54.9	24.0	5.7	65.7

TABLE XI

Number of Trees Per Acre by Burn Classes as Computed From Counts on Four-Milacre Plots

Burn Class	*Douglas Fir*	*West Coast Hemlock*	*Other Species*	*All Species*
Light	521	370	35	926
Medium	320	185	22	527
Hard	358	78	13	449
AVERAGE	431	265	27	723

TABLE XII

Burn Classes Arranged in Order of Greater to Lesser Stocking Percents

Species	*Above Average Stocking*	*Below Average Stocking*
Douglas Fir	Light	Medium, Hard
West Coast Hemlock	Light, Medium	Hard
All Species	Light	Medium, Hard

The general observation which can be made relative to degree of burn is that on the lighter burns more stocking was found and that as the burns became more severe the stocking percents dropped. Other things being equal one could definitely expect to find a significantly better stocking on light burn for Douglas fir and for the total of all species, and a significantly poorer stocking on hard burn for west coast hemlock.

A Comparison of Stocking on Burned and Unburned Areas

An inspection of Tables XIII and XIV would indicate that the better Douglas fir stocking would be found on burned areas; the better west coast hemlock stocking would be found on unburned areas; and the better stocking would be found on burned areas when considering the total of all species.

TABLE XIII

Proportion of Four-Milacre Plots Found to Be Stocked on Burned and Unburned Areas in Percent of Total Number of Plots

Class	*Percent of Total Samples*	*Douglas Fir*	*West Coast Hemlock*	*Other Species*	*All Species*
Burned	57.51	54.9	24.0	5.7	65.7
Unburned	42.49	34.5	26.8	7.6	51.0
AVERAGE		46.2	25.2	6.5	59.4

TABLE XIV

Number of Trees Per Acre on Burned and Unburned Areas As Computed From Counts on Four-Milacre Plots

Class	*Douglas Fir*	*West Coast Hemlock*	*Other Species*	*All Species*
Burned	431	265	27	723
Unburned	208	284	54	546

In order to determine whether the differences observed in Tables XIII and XIV were true differences or whether they were chance differences (sampling error) a chi-square test was applied to determine the significance of the differences.

TABLE XV

Result of Chi-Square Test to Determine Significance of Differences in Stocking Between Burned Areas and Unburned Areas

Species	*Significantly More Stocking*	*No Significant Difference in Stocking*	*Significantly Less Stocking*
Douglas Fir	Burned		Unburned
West Coast Hemlock		Unburned, Burned	
All Species	Burned		Unburned

Therefore it may be said that for Douglas fir and for all species a significant difference in stocking was found on the burned areas. Stocking found on burned and unburned areas did not show a significant difference for west coast hemlock.

Effect of Seed Source on Stocking

In order to make any comparison among the various types and amounts of seed source it was necessary to do several things. First, since it had become evident that there was such a great difference between those areas which had been burned and those which had not, these two categories were separated and analyzed independ-

A clear cut area with adjacent timber on the left and a long corner of timber on the right. This area has a heavy accumulation of unburned slash on the ground. In spite of what appears to be an adequate seed source, it would not be expected that this area would restock adequately in a reasonable length of time unless the slash were burned.

ently. Next, it was necessary to devise a numerical rating system which would assign values to the seed source of each sub-tract in ratio to the quantity and quality of such seed source. Inasmuch as no such rating system was in existence, it was decided to construct one based on the requirements of the Oregon Forest Conservation Act. It was hoped that this would make such a rating more understandable as it could be compared with an already familiar standard, and would also facilitate other phases of this study. These were to evaluate the effectiveness of the amount of seed source required by the Conservation Act and to determine the ratio between amount of seed source and resulting stocking. Details of the computation of the actual seed source values are covered in the Appendix pp. 45 to 49. The system is based on the following standard:

Seed Source Characteristic of Sub-tract	*Assigned Seed Source Value*
2 seed trees per acre	100
2 acre seed block	100
1320 feet of uncut timber edge within ¼ mile of sub-tract center	100
3960 feet of uncut timber edge between ¼ and ½ mile of sub-tract center	100

Basic data for the sub-tracts used in this study are found in Tables XVI and XVII.

TABLE XVI

Basic Data on Burned Sub-Tracts

Sub-tract No.	*Years Available For Restocking*	*Primary Exposure*	*Average Burn Class*	*Seed Source* — *No. of Seed Trees Per Acre*	*Seed Source* — *Acreage of Seed Blocks*	*Seed Source* — *No. of Feet of Edge of Adjacent Uncut Timber* — *Within ¼ Mile*	*Seed Source* — *No. of Feet of Edge of Adjacent Uncut Timber* — *¼ to ½ Mile*	*Stocking Percent* — *Milacre*	*Stocking Percent* — *Four Milacre*
601 SW	1	SE	L–M	1.00	0	2772	1716	40	71
403 NE	1	SE	M–H	0.05	0	1716	2640	48	83
403 NW	1	S	M–H	0.01	0	0	7920	28	63
403 SE	1	E	M–H	0.01	0	0	1980	23	60
403 SW	1	S	M–H	0.01	0	0	5016	13	40
601 NE	2	SW	L–M	1.60	0	0	5412	40	74
601 NW	2	SE	L–M	1.00	0	2112	3960	35	61
601 SE	2	SE	L–M	1.20	0	1320	2630	38	63
911 SE	2	S	L	0.20	6.0	0	7260	38	73
911 SW	2	S	L	0.30	6.0	1484	1980	26	40
912 NE	2	S	L	0.10	3.0	1320	5940	34	75
912 NW	2	S	L	0.10	3.0	264	5280	22	53
912 SE	2	S	L	0.10	12.0	1980	5280	30	57
912 SW	2	S	L	0.10	3.0	1056	6336	34	58
913 NE	2	SW	L	0.60	0	1056	6336	33	73
913 NW	2	SW	L	0.70	0	1452	1584	38	65
913 SE	2	SW	L	0.40	0	0	7920	36	60
913 SW	2	SW	L	0.50	0	2376	0	27	57
602 NE	3	E	M	0.65	0	0	0	27	55
602 NW	3	E	M	0.50	0	0	0	23	55
602 SE	3	NE	M	0.45	0	0	0	22	53
602 SW	3	E	M	0.60	0	0	0	25	58
906 NE	3	W	M–H	0.20	0	2904	3960	33	61
906 NW	3	SW	M–H	0.15	0	0	3300	28	50
906 SE	3	SW	M–H	0.10	0	0	3960	33	78
402 NE	4	N	L–M	0.40	8.8	0	3036	44	76
402 NW	4	N	L–M	0.20	2.2	0	3036	31	72
402 SE	4	N	L–M	0.50	2.2	2112	2640	48	77
402 SW	4	NW	L–M	0.20	2.2	2112	2640	51	82
901 SE	4	SW	M	0.30	0	0	1980	19	46
901 SW	4	SW	M	0.10	0	0	2904	12	38
902 NW	4	NW		0.50	0	0	924	48	85
903 NE	4	NE	L	1.20	0.8	0	3168	46	77
903 NW	4	N	L	0.90	0.8	396	5148	41	72
903 SE	4	SE	L	1.20	3.0	0	2772	44	70
903 SW	4	SE	L	0.50	0.8	2112	0	44	83
907 NW	4		M	1.10	0	0	3960	31	68
910 NE	4	N–S	L–M	0.10	0	3036	924	46	77
910 NW	4	N	L–M	0.25	0	1716	2244	63	76
910 SE	4	N	L–M	0.10	0	792	4488	74	97
910 SW	4	N	L–M	0.20	0	0	3564	73	100
911 NE	4	S	L	0.40	9.0	0	2640	24	53
911 NW	4	S	L	0.20	11.0	132	2640	35	66
907 SE	5	W	M	0.70	0	0	0	47	85
907 SW	5	W	M	0.70	0	0	3036	54	87
909 NE	6	E–W	L	0.40	0	0	0	68	97
909 NW	6	W	L	0.40	0	0	660	48	83
909 SW	6	W	L	0.20	0	0	1320	48	79

TABLE XVII

Basic Data on Unburned Sub-Tracts

				Seed Source					
						No. of Feet of Edge of Adjacent Uncut Timber		Stocking Percent	
Sub-tract No.	*Years Available For Restocking*	*Primary Exposure*	*Average Slash Class*	*No. of Seed Trees Per Acre*	*Acreage of Seed Blocks*	*Within ¼ Mile*	*¼ to ½ Mile*	*Milacre*	*Four Milacre*
404 SE	3	S	M	.74	2.0	1320	1320	11	23
404 SW	3	S	L	.91	2.0	0	2112	24	51
901 NE	3	S	M	.15	0	2112	1320	17	29
901 NW	3	SW	M	.12	0	1584	1320	13	28
404 NE	4	S	M	.40	8.0	792	2640	10	23
902 NE	4	N		.60	0	660	2244	43	87
902 SE	4	N		.70	0	1848	660	40	75
902 SW	4	NW		.60	0	0	2900	35	85
401 NE	5	N	L	1.40	3.9	0	0	47	71
401 NW	5	N	L	2.70	5.9	0	2244	18	37
401 SE	5	SW	M	1.70	3.9	0	0	14	32
401 SW	5	SW	L	1.10	14.2	924	0	24	48
908 NE	5	N	M–H	.50	2.9	0	2640	27	50
908 NW	5	N	M–H	.70	1.0	0	1188	19	45
908 SE	5	N	M–H	.50	2.2	792	2640	15	38
908 SW	5	N	M–H	.50	1.0	0	1188	19	58
909 SE	6	W	H	.30	0	0	0	41	74

As soon as seed source values had been computed for all sub-tracts and listed in tabular form opposite the stocking percents it became obvious that there would be no correlation between these stocking percents and either amount or type of seed source. When stocking percents were plotted over seed source values the lack of correlation between the two was very evident but at the same time it was just as evident that much of the heterogeneity was due to the fact that high stocking percents were resulting from favorable factors such as north exposure and medium burn and low stocking percents were resulting from the opposite unfavorable factors.

Inasmuch as the relative effect of these variables had already been measured in the earlier part of this study, it was decided to use the already available information to compensate for such effects. As has already been pointed out in the analysis of data section these variables of exposure, burn and slash were analyzed as though they were independent variables, which in fact they are not. Their use as correction factors, although not mathematically indisputable, is, nevertheless, based on what is believed to be quite sound logic. Due to the fact that the effects of these variables were derived from pooling information from the milacre samples of the entire study without regard to sub-tract (40 acre unit) and that the sub-tract stocking percents and seed source values relate to specific sub-tracts it was felt that such a procedure would not force a correlation. Only if a true correlation existed between seed source value and stocking percent should it become apparent. This is further substantiated by the fact that the process when applied equally to burned and unburned sub-tracts actually resulted in a measurable correlation of one and not the other. Table XVIII lists the correction factors which were used for exposure, burn and slash. Variation in stocking percents due to exposure varied the same on both burned and unburned plots. For this reason the correction factors for exposure listed in Table XVIII were computed from data pooled from all plots and were used on both the burned and unburned sub-tracts.

TABLE XVIII

Correction Factors for Exposure, Burn and Slash

Exposure	*Correction Factor* ①	*Burn Class*	*Correction Factor* ①	*Slash Class*	*Correction Factor* ①
NE	.58	Light	.90	Very Light	.71
N	.59	Light–Medium	.95	Light	.73
NW	.80	Medium	1.00	Extreme	.98
W	.99	Medium–Heavy	1.03	Medium	1.00
E	1.00	Heavy	1.05	Heavy	1.03
SW	1.07				
SE	1.30				
S	1.33				

① These factors were computed from the information found in Tables I, VII and X and reflect the relative amounts of restocking found on the various exposures, burns and slash concentrations as found in this study.

When the stocking percents were multiplied by these correction factors it gave the effect of all sub-tracts having eastern exposure and either medium burn or medium slash concentration. There still remained, however, the difference in stocking due to which years and how many years were available for restocking. Inasmuch as the years involved, 1943 to 1949, occur in a variety of overlapping patterns on the various sub-tracts (for example, 601 NE had 1945 and 1946, 602 NE had 1944, 1945 and 1946 and 906 NE had 1945, 1946 and 1947) it was possible to compute factors which indicated the relative efficiency of each year in producing seedlings. Table XIX gives these correction factors.

TABLE XIX

Correction Factors for Years Available for Restocking

Year	*Correction Factor*
1943	1.15
1944	1.10
1945	1.11
1946	.79
1947	.96
1948	.95
1949	1.05

The method of computing these correction factors has a modifying influence on the extremes so that the best year (1946) will not appear as good as it really was and the poorest year (1943) will not appear as poor as it really was.

With this last correction factor applied it was then possible to make a comparison among the various sub-tracts. The corrected stocking percents (see Tables XX and XXI) were plotted as the dependent variable with the total seed source value assigned to the sub-tract as the independent variable. Upon analysis it was found that there was no significant relationship between seed source value and stocking percents.

TABLE XX

Seed Source Values and Adjusted Stocking Percents on Burned Sub-Tracts

Sub-tract Number	*Seed Source Values*					*Milacre Stocking Percent Corrected for Exposure, Burn and Assuming 5 Years Available for Restocking*
			Adjacent Timber			
	Seed Trees	*Seed Blocks*	*¼ Mile*	*½ Mile*	*Total*	
601 SW	50.0	0	210	40	300.0	88
403 NE	2.5	0	130	60	192.5	100
403 NW	0.5	0	0	200	200.5	68
403 SE	0.5	0	0	50	50.5	43
403 SW	0.5	0	0	130	130.5	32
601 NE	80.0	0	0	140	220.0	67
601 NW	50.0	0	160	100	310.0	72
601 SE	60.0	0	100	60	220.0	77
911 SE	10.0	178	0	180	368.0	79
911 SW	15.0	176	120	50	363.0	55
912 NE	5.0	124	100	150	379.0	71
912 NW	5.0	124	20	133	282.0	45
912 SE	5.0	252	150	133	540.0	62
912 SW	5.0	124	80	160	369.0	71
913 NE	30.0	0	80	160	270.0	55
913 NW	35.0	0	110	40	185.0	64
913 SE	20.0	0	0	200	220.0	60
913 SW	25.0	0	180	0	205.0	45
602 NE	32.0	0	0	0	32.0	32
602 NW	25.0	0	0	0	25.0	32
602 SE	23.0	0	0	0	23.0	18
602 SW	30.0	0	0	0	30.0	35
906 NE	10.0	0	220	100	330.0	44
906 NW	8.0	0	0	85	93.0	40
906 SE	5.0	0	0	100	105.0	47
402 NE	20.0	214	0	76	310.0	30
402 NW	10.0	108	0	76	194.0	21
402 SE	25.0	108	160	66	359.0	32
402 SW	10.0	108	160	66	344.0	48
901 SE	15.0	0	0	50	65.0	24
901 SW	5.0	0	0	75	80.0	16
902 NW	25.0	0	0	25	50.0	46
903 NE	60.0	56	0	80	196.0	29
903 NW	45.0	56	30	130	261.0	27
903 SE	60.0	125	0	70	255.0	61
903 SW	25.0	56	160	0	241.0	61
907 NW	55.0	0	0	100	155.0	36
910 NE	5.0	0	230	25	260.0	37

TABLE XX—Continued

Seed Source Values and Adjusted Stocking Percents on Burned Sub-Tracts—Continued

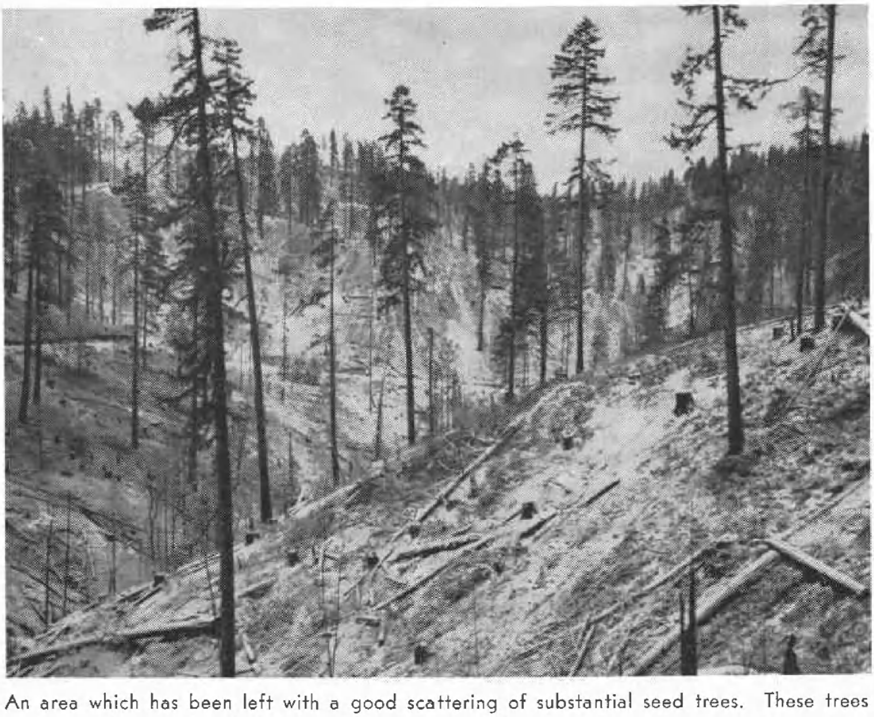
Sub-tract Number	*Seed Source Values*					*Milacre Stocking Percent Corrected for Exposure, Burn and Assuming 5 Years Available for Restocking*
			Adjacent Timber			
	Seed Trees	*Seed Blocks*	*¼ Mile*	*½ Mile*	*Total*	
910 NW	13.0	0	130	56	199.0	38
910 SE	5.0	0	60	113	178.0	46
910 SW	10.0	0	0	90	100.0	45
911 NE	20.0	360	0	66	446.0	31
911 NW	10.0	364	10	66	450.0	45
907 SE	35.0	0	0	0	35.0	48
907 SW	35.0	0	0	76	111.0	55
909 NE	20.0	0	0	0	20.0	55
909 NW	20.0	0	0	16	36.0	38
909 SW	10.0	0	0	33	43.0	38

TABLE XXI

Seed Source Values and Adjusted Stocking Percents on Unburned Sub-Tracts

Sub-tract Number	*Seed Source Values*					*Milacre Stocking Percent Corrected for Exposure, Slash and Assuming 5 Years Available for Restocking*
			Adjacent Timber			
	Seed Trees	*Seed Blocks*	*¼ Mile*	*½ Mile*	*Total*	
404 SE	37	100	100	30	267.0	15
404 SW	45	100	0	53	198.0	23
901 NE	7	0	160	30	197.0	23
901 NW	6	0	120	30	156.0	14
404 NE	20	204	60	67	351.0	14
902 NE	30	0	50	60	140.0	26
902 SE	35	0	140	15	190.0	25
902 SW	30	0	0	70	100.0	29
401 NE	70	140	0	0	210.0	20
401 NW	130	174	0	60	364.0	8
401 SE	85	140	0	0	225.0	15
401 SW	55	284	70	0	409.0	18
908 NE	25	122	0	60	207.0	16
908 NW	35	70	0	30	135.0	11
908 SE	25	108	60	60	253.0	9
908 SW	25	70	0	30	125.0	11
909 SE	15	0	0	0	15.0	40

An inspection of the seed source values led to the belief that possibly the lack of relationship was due to an incorrect assignment of values to the various types of seed sources (i.e., seed trees, seed blocks and adjacent uncut timber). It appeared on the surface that areas which had a majority of seed source value in seed trees had higher than average stocking percents and that those areas which had a majority of seed source in seed blocks had lower than average stocking percents. An investigation on this basis led to results shown in Table XXII. In this table the column "Percent of Total Seed Source Value" represents the ratio, expressed in percent, of seed source values assigned to any one type of seed source to the total seed source value assigned to all sub-tracts. The column "Percent of Total Stocking" represents the amount of stocking, expressed as a percent of the total, attributable to each type of seed source. This is based on the assumption that seed sources assigned equal values should produce equal amounts of stocking. For example, if one sub-tract was assigned seed source values of seed trees 80 and seed blocks 80 it would be assumed that seed trees were responsible for half the stocking found and seed blocks were responsible for half the stocking found. The stocking percents for each sub-tract were divided up in this manner and then the totals for each type of seed source were expressed as a percent of the stocking found for all types of seed source on all sub-tracts.



An area which has been left with a good scattering of substantial seed trees. These trees have withstood the slash fire and it is expected that this area will restock quite rapidly.

TABLE XXII

Effectiveness of Type of Seed Source

Type of Seed Source	*Percent of Total Seed Source Value*	*Percent of Total Stocking*
Seed trees	23.65	51.00
Seed blocks	15.08	5.00
Adjoining timber within ¼ mile	18.52	8.00
Adjoining timber between ¼ mile and ½ mile	42.75	36.00
TOTAL	100.00	100.00

The following ratios were obtained by assuming that the ratio of "Percent of Total Seed Source Value" to "Percent of Total Stocking" reflected the relative restocking ability of each type of seed source. Actually this assumption cannot be truly accurate as it is impossible with the data available to measure the interaction effects of combinations of different types of seed sources or the effects of the many other variable influencing the rate and amount of restocking.

seed trees	2.16
seed blocks	.33
uncut timber edge within ¼ mile of sub-tract center	.43
uncut timber edge between ¼ and ½ mile of sub-tract center	.84

These ratios, although not absolutely accurate, are, nevertheless, the best measure available at the present time of the restocking ability of the different types of seed sources in the area covered by this study.

Using these figures it would seem that a more nearly correct evaluation of seed source should be based on seed source values as assigned in Table XXIII.

TABLE XXIII

Corrected Seed Source Values

Type and Amount of Seed Source	*Seed Source Value*
1 seed tree per acre	100
6 acres of seed block per 40 acre sub-tract	100
3300 feet (50 chains) of uncut timber edge within ¼ mile of center of 40 acre sub-tract	100
4620 feet (70 chains) of uncut timber edge between ¼ mile and ½ mile of center of 40 acre sub-tract	100

An example of an area which is dependent upon adjacent timber for its entire seed supply. Most of the area up to one-half mile out from the seed source is quite well stocked. Some of the area further removed was not up to minimum standards and has been artificially reforested.

Effect of Amount of Seed Source on Stocking

Total seed source values were recomputed (see Tables XXIV and XXV) using the newly derived values for types of seed source. First the burned sub-tracts were checked. The seed source values were plotted as the independent variable against corrected stocking percents as the dependent variable. A straight line curve was fitted to the points by method of least squares, a rectilinear regression equation computed and the significance of the regression tested (see Figure 3). The test showed this regression to be highly significant (i.e., significant at the .01 level). This curve (Figure 3) therefore represents the percent of stocking that could be expected in the region covered by this study for various amounts of seed source. It should be remembered that this is based on the following assumptions:

1. Five years have elapsed since slash burn.
2. Exposure is east (or corrected equivalent).
3. Area had a medium burn (or corrected equivalent).

4. Unit of investigation is 40 acres.
5. Seed source values computed using standards shown in Table XXIII.

TABLE XXIV

Burned Sub-Tracts Recomputed Seed Source Values Based on Table XXIII

Plot Number	*Recomputed Seed Source Values*				
	Seed Trees	*Seed Blocks*	*Adjacent Uncut Timber*		*Total*
			¼ Mile	*¼ to ½ Mile*	
601 SW	108		90	34	232
403 NE	5		56	50	111
403 NW	1			168	169
403 SE	1			42	43
403 SW	1			109	110
601 NE	173			118	291
601 NW	108		69	84	261
601 SE	130		43	50	223
911 SE	22	59		151	232
911 SW	32	59	52	42	185
912 NE	11	41	43	126	221
912 NW	11	41	9	112	173
912 SE	11	83	66	112	272
912 SW	11	41	34	134	220
913 NE	65		34	134	233
913 NW	76		47	34	157
913 SE	43			168	211
913 SW	54		77		131
602 NE	69				69
602 NW	54				54
602 SE	50				50
602 SW	65				65
906 NE	22		95	84	201
906 NW	17			71	88
906 SE	11			84	95
402 NE	43	71		64	178
402 NW	22	36		64	122
402 SE	54	36	69	55	214
402 SW	22	36	69	55	182
901 SE	32			42	74
901 SW	11			63	74
902 NW	54			21	75
903 NE	130	18		67	215
903 NW	97	18	13	109	237
903 SE	130	41		59	230
903 SW	54	18	69		141
907 NW	119			84	203
910 NE	11		99	21	131
910 NW	28		56	47	131
910 SE	11		26	95	132
910 SW	22			76	98
911 NE	43	119		55	217
911 NW	22	120	4	55	201
907 SE	76				76
907 SW	76			64	140
909 NE	43				43
909 NW	43			13	56
909 SW	22			28	50

TABLE XXV

Unburned Sub-Tracts Recomputed Seed Source Values Based on Table XXIII

Plot Number	Recomputed Seed Source Values				
	Seed Trees	Seed Blocks	Adjacent Uncut Timber ¼ Mile	Adjacent Uncut Timber ¼ to ½ Mile	Total
404 SE	80	33	43	25	181
404 SW	97	33		45	175
901 NE	15		69	25	109
901 NW	13		52	25	90
404 NE	43	67	26	56	192
902 NE	65		22	50	137
902 SE	76		60	13	149
902 SW	65			59	124
401 NE	151	46			197
401 NW	281	57		50	388
401 SE	184	46			230
401 SW	119	94	30		243
908 NE	54	40		50	144
908 NW	76	23		25	124
908 SE	54	36	26	50	166
908 SW	54	23		25	102
909 SE	32				32

Next the unburned sub-tracts were checked. The seed source values and stocking percents were plotted on graph paper (see Figure 4) only to show a trend which could be considered an absurdity. If anything, these points tend to show that the more seed source the less stocking. It is felt that this could result from two things; first, the lack of sufficient samples, and second, the probability that stocking on unburned areas is influenced greatly by some variable either not considered in this study or not correctly measured. As far as this study is concerned there was no measurable correlation on the unburned sub-tracts between seed source value and stocking percent.

Effectiveness of Amounts of Seed Source Required by the Oregon Forest Conservation Act

In view of the fact that there was no correlation established in this study between amounts of seed source and resultant stocking on unburned areas, it was not deemed advisable to attempt to analyze the effectiveness of amounts of seed source required by the Oregon Forest Conservation Act on such areas. The following analysis, therefore, concerns itself only with the findings on the burned sub-tracts.

All references to adequate stocking in this section relate to the definition used in the administration of the Oregon Forest Con-

MILACRE STOCKING PERCENTS ON BURNED SUB-TRACTS PLOTTED BY SEED SOURCE VALUES

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	D.F.	Σ SQS.	M.SQS	F.OBS	F.TAB
REGRESSION	1	4977	4977	19.36 >	7.21**
ERROR	46	11835	257		
TOTAL	47	16812			

** SIGNIFICANT AT THE .01 LEVEL

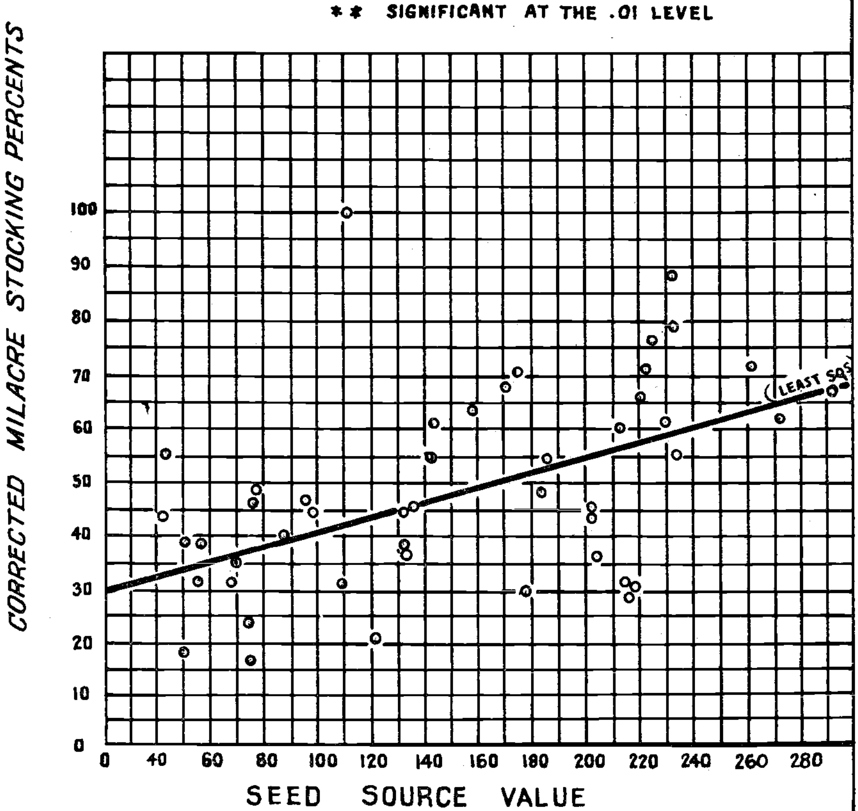


FIGURE 3.

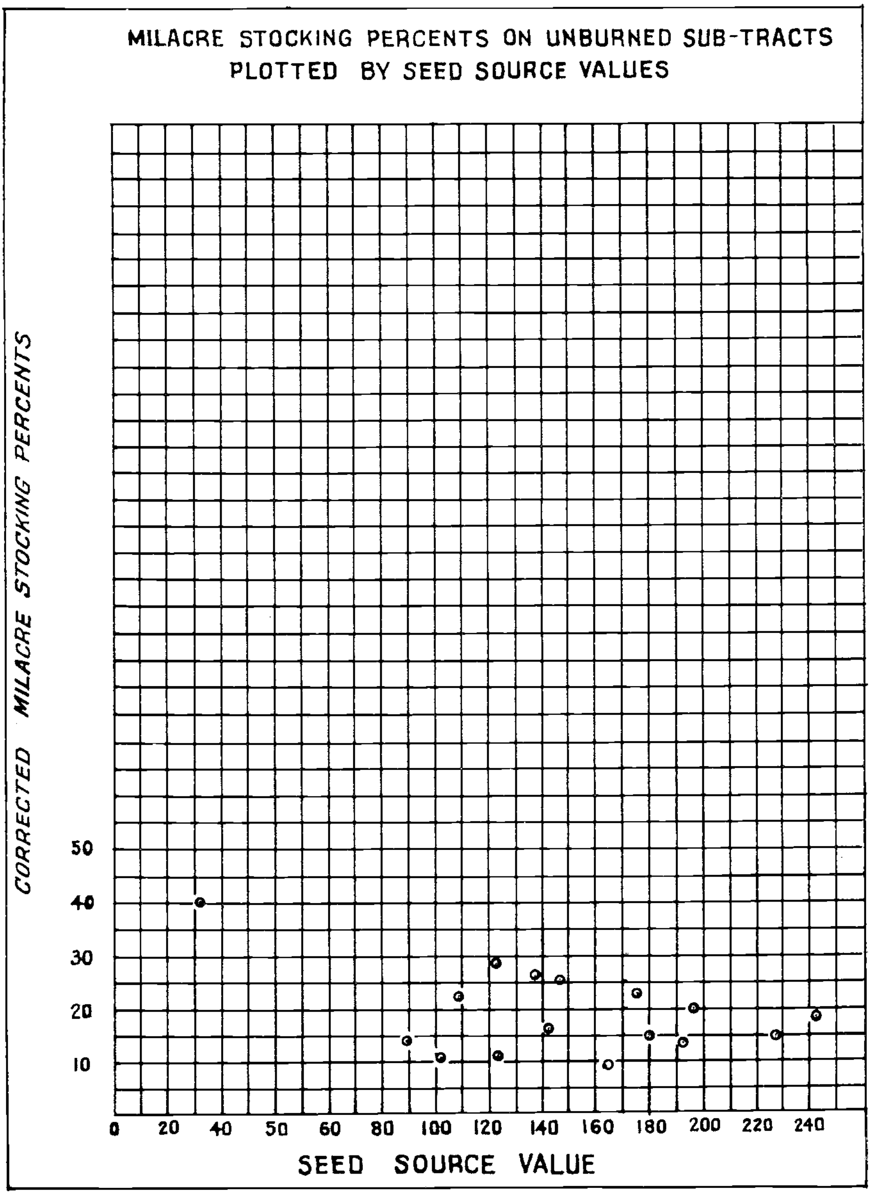

MILACRE STOCKING PERCENTS ON UNBURNED SUB-TRACTS
PLOTTED BY SEED SOURCE VALUES
CORRECTED MILACRE STOCKING PERCENTS
50
40
30
20
10
0
20
40
50
60
80
100
120
140
160
180
200
220
240
SEED SOURCE VALUE

FIGURE 4

servation Act; minimum stocking five years after the completion of harvesting is that which provides at least 300 trees per acre, 100 of which are spaced well enough to provide for normal growth and development. This condition is assumed to be met when an area is stocked 30 percent by milacre quadrants and 40 percent by four-milacre samples.

The effectiveness of the amounts of seed source required by the Oregon Forest Conservation Act has been considered in two distinctly different ways.

The first approach was the most direct in that each sub-tract was determined to be either in compliance with or in violation of the law and such condition was compared to the results in terms of stocking (either present or expected). The results of these comparisons follow:

1. Of all sub-tracts, 69 percent were found to be in compliance with the law. Ninety-one percent of these sub-tracts were adequately stocked, as defined in the law, or it could be expected that they would be adequately stocked within five years of the date of completion of harvesting.

2. Of the 31 percent, which were in violation of the law, 93 percent were adequately stocked or could be expected to restock adequately within the five year period.

3. All of the sub-tracts which were not adequately stocked and could not reasonably be expected to restock within the five year period were either extreme south or southwest exposure.

4. These data indicate that except on severe southern exposures the amounts of seed source required by the Act have been sufficient. At present there is no evidence supporting any idea that additional seed source would insure, or even hasten, restocking on these critical southern exposures.

The second approach was to convert the minimum seed source requirements into seed source values and then predict what could be expected from such seed source values. This prediction was based on what has actually happened on the sub-tracts covered in this study.

Compliance by two seed trees per acre gave an adjusted seed source rating of 200. This seed source rating would be expected to produce an average milacre stocking of around 55 percent in five years (see Figure 3).

Compliance by a centrally located eight acre seed block in the quarter section (this would amount to an average location for all forty-acre sub-tracts in the quarter section) gave an adjusted seed source rating of 33. This rating would be expected to produce an average stocking of around 31 percent by milacres in five years (see Figure 3).

Thus it appears that on this somewhat more theoretical basis, the amounts and types of seed source required by the Oregon Forest Conservation Act will satisfy minimum stocking standards. It is also evident that the operator who complies with the minimum requirements of the law by leaving seed trees can expect considerably better stocking results than the operator who complies with the law by leaving the minimum requirements in a seed block.

The leaving of adjacent (outside a legal quarter section) seed source may constitute compliance with the Oregon Forest Conservation Act only when such practice is accompanied by an approved prior harvesting plan. The question then arises as to how much adjacent seed source should be left to assure adequate restocking at the end of five years.

In order to maintain a seed source value of 100 (this will give an average milacre stocking of 41 percent, and will assure milacre stocking values of 30 percent or better about 78 percent of the time) it would be necessary to leave 3300 feet of frontage of uncut timber within 1/4 mile of the center of the forty in question or 4620 feet of frontage of uncut timber between 1/4 and 1/2 mile of center of forty in question, or a suitable combination of the two.

SUMMARY

This study attempts to ascertain the relative restocking abilities of various types and quantities of natural seed source and to determine the effects of various man-made and natural factors upon natural regeneration. Consideration is also given to the restocking abilities of the amount of seed source required under the Oregon Forest Conservation Act.

The data for the study were gathered in the Douglas fir type of the north central section of Oregon, west of the Cascades, embracing a portion of the Coast Range, the Willamette Valley, and the lower elevations of the Cascades. Within this region cutover tracts were selected for stocking examinations. The following requirements were established for selection of a tract:

1. The tract must be situated in a cutover area of 160 acres or larger.

2. Logging must be completed (or slash burned) not earlier than ten years prior to the date of examination.

3. A complete annual history of the logging operation and any subsequent slash burning must be available.

Each of the tracts selected was examined for reproduction by the standard procedure used by the Oregon State Board of Forestry on all stocking surveys. This system is based on the stocked plot principle. Among all the tracts a wide variety of conditions were

represented as to amount of seed source, concentration of slash, type of ground cover, degree of slash burn and exposure. The stocking data were analyzed in relation to the variations of each of the conditions named.

The method of analysis of the data collected consisted of classifying the plot data into a number of subclasses of the independent variable under examination. For instance, exposure was divided into the subclasses N, NE, E — NW and the number of plots found to be stocked and not stocked were compiled for each subclass. The stocked plots in each subclass were subsequently expressed as a percentage of the total number of plots in the subclass. Tests of significance were made by chi-square analysis.

The results of these chi-square tests provided the following information:

1. More than average Douglas fir stocking was found to exist where the following factors were present:
   a. Northeast exposure
   b. Light cover classes
   c. Light burn

2. Less than average Douglas fir stocking was found to exist where the following factors were present:
   a. South or southeast exposure
   b. Heavy cover classes
   c. Medium to extreme slash classes

3. More than average west coast hemlock stocking was found to exist where the following factors were present:
   a. A northern or an eastern exposure
   b. Light weed cover, light evergreen cover or no cover

4. Less than average west coast hemlock stocking was found to exist where the following factors were present:
   a. South exposure
   b. Heavy cover classes
   c. Hard burn

5. Total stocking was better than average where the following factors were present:
   a. Northern exposures
   b. Light weed cover
   c. Light burn

6. Total stocking was poorer than average where the following factors were present:
   a. South or southeast exposure
   b. Heavy cover classes
   c. Medium or heavy slash

A test of burned vs. unburned plots showed that there was a significant difference between the two, with more stocking found on the burned plots for Douglas fir and for all species combined. This did not hold true when considering west coast hemlock alone. Here there was no significant difference between burned and unburned plots.

By applying correction factors, derived from the information developed by the first part of the study, it was possible to arrive at some conjectures concerning the relative merits of the various types and amounts of seed source which were left on the areas covered in the sampling. The following types and amounts of seed sources appeared to have approximately equal values in terms of stocking produced:

1 seed tree per acre
6 acres of seed block per 40 acres
3300 feet (50 chains) of uncut timber edge within ¼ mile of center of 40 acres
4620 feet (70 chains) of uncut timber edge between ¼ mile and ½ mile of center of 40 acres

A study of the factors of type and amount of seed source, considering the foregoing information, led to the following observations:

1. There appeared to be a measurable relationship between amount of seed source and amount of stocking on slash burned tracts (see Figure 3).

2. There appeared to be no measurable relationship between amount of seed source and amount of stocking on unburned tracts. Apparently there was some unmeasured variable or some interaction between those variables considered which became the controlling factor in the natural restocking of these tracts.

3. Burned tracts restocked in a more orderly and predictable manner than did unburned tracts. Burning slash in this area produced more stocking than not burning slash where the same amounts of seed source were present.

4. Providing other factors were reasonably favorable, the amounts of seed source required by the Oregon Forest Conservation Act proved to be adequate. By adequate it is meant that stocking percents of 30 percent by milacre quadrants and 40 percent by four-milacre samples were found on these tracts.

5. Where a combination of unfavorable conditions existed, especially unfavorable exposure, stocking was not always forthcoming. This was true even with seed sources greatly exceeding those required by the Oregon Forest Conservation Act. There was no indication that any large increase in seed source would compensate for a combination of unfavorable conditions.

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APPENDIX

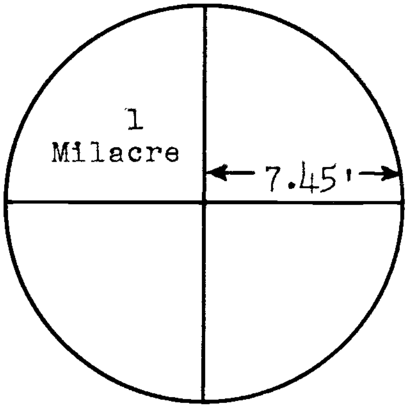
Field Procedures

General: Plot location information was entered on a plot establishment data sheet (see Figure 5).

A special form (see Figure 6) was used in the collection of field data. This form accommodates information on soil, exposure, stocking, ground cover, location of seed trees by classes, location of seed blocks and long corners, burn classification and slash classification.

A survey of adjacent seed source (all seed source within one-half mile of exterior boundaries of plot) was made on cross-section paper (see Figure 10). Topography, when taken in the field, was also taken on cross-section paper. Wherever accurate topographic maps already existed, an enlarged tracing was made.

Sampling Methods: The field data were taken in a uniform manner on all plots. The information was gathered on 1/250 acre samples. These 1/250 acre samples were selected by the use of a regular sampling system. The 1/250 acre samples were laid out as circles with a radius of 7.45 feet, and were divided into quadrants each one milacre in size (see Figure 7). These samples were located on four equidistant compass lines running east and west and four running north and south through each quarter section. The first sample on each line was taken one chain in from the boundary of the plot.



1/250 ACRE SAMPLE

Figure 7

The remaining samples were taken at two chain intervals. All distances were measured by pacing.

NATURAL REGENERATION STUDY
Plot Establishment Data

Plot Established by: DIXON & HAYES Date 1/28/48 Type Unit No. 4 Plot No. 403

Location: County LINCOLN

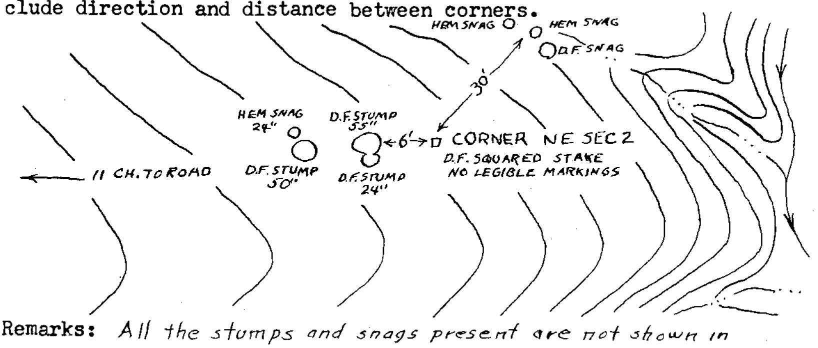
Subd. NE Sec. 2 Twp. 8S Rge. 9W

General Instructions for access to plot (roads, trails, tags, and land marks) Take main Western-Valsetz logging road down Siletz to junction with Gravel creek road. Cross bridge and turn right up gravel creek road. Stay on main gravel creek road approx 1½ mi. to fork of gravel creek (rd 200) and (rd 214) where right fork is taken to storage shed at milepost 7. Take right fork approx ½ mi to next fork and take sharp left uphill on rd 215 which will lead into NE of Sec 2.

Original Stand Douglas Fir – West coast hemlock

Fire History Slash burned in 1945 – No fire since.

Description and sketch of Land Office corner used in plot establishment (include bearing trees, tags, or any other descriptive material on the area). If plot corner and land corner are not the same, include direction and distance between corners.



Remarks: All the stumps and snags present are not shown in this sketch

FIGURE 5

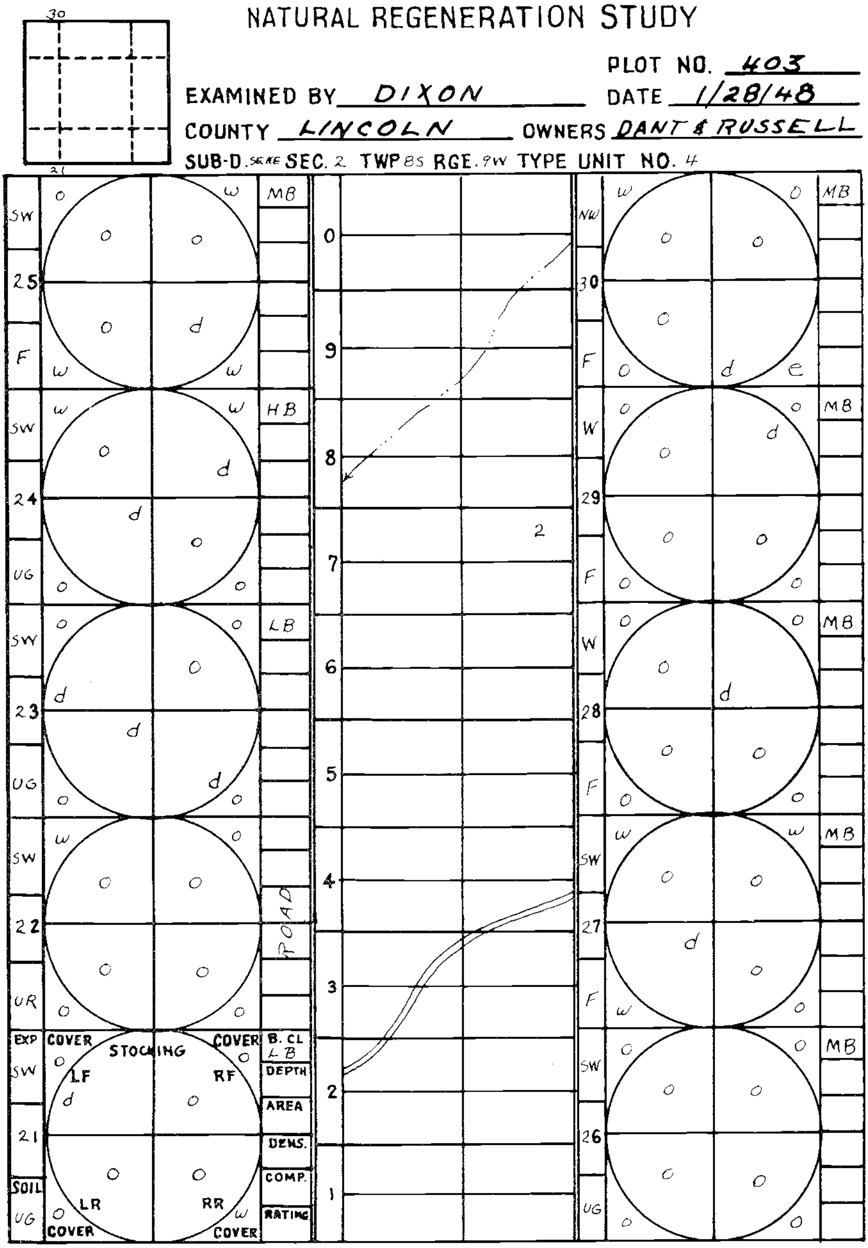

NATURAL REGENERATION STUDY
PLOT NO. 403
EXAMINED BY DIXON
DATE 1/28/48
COUNTY LINCOLN
OWNERS DANT & RUSSELL
SUB-D. SE NE SEC. 2 TWP 8S RGE. 9W TYPE UNIT NO. 4
COVER
STOCKING
B. CL
DEPTH
AREA
DENS.
COMP.
RATING
SOIL
EXP
LF
RF
LR
RR
ROAD

FIGURE 6.

Classification of Variables:

Exposures were listed by the four cardinal and four intercardinal directions as follows:

N—North
NE—Northeast
E—East
SE—Southeast
S—South
SW—Southwest
W—West
NW—Northwest

Soil was listed as F (favorable) or U (unfavorable). If unfavorable the further breakdown was used of:

UG (Very rocky)
UR (Solid rock)
UW (Excessive rotten wood)
UM (Excessive moisture—swamp, bog, marsh, etc.)

Ground cover was given general classification as to type and density. The classes entered in the field sheet were as follows:

Light weed	(w)—light growth of fire weed, bracken fern or similar minor annual vegetation.
Heavy weed	(W)—heavy growth of fire weeds, bracken fern or similar minor annual vegetation.
Light decidous	(h)—light cover of alder, willow, vine maple, salmonberry, thimbleberry and similar deciduous growth.
Heavy deciduous	(H)—heavy cover of alder, willow, vine maple, salmonberry, thimbleberry and similar deciduous growth.
Light evergreen	(e)—light cover of salal, Oregon grape, ceanothus coniferous reproduction and similar evergreen growth.
Heavy evergreen	(E)—heavy cover of salal, Oregon grape, ceanothus, coniferous reproduction and similar evergreen growth.

The cover was considered to be light if 50 percent or more of the ground was discernible through the cover.

Stocking was listed by species and broken down into three classes. The classes used were:

Advanced —stocking which was established at time of logging was designated with capital letters.

Established—stocking which had become established subsequent to logging or slash burning was designated with lower case letters.

First Year —seedlings which were in their first year of growth were designated by circled lower case letters. The following abbreviations were used for species:

D, d—Douglas fir
H, h—West coast hemlock
S, s—Sitka spruce
C, c—Western red cedar
PO, po—Port Orford cedar
I, i—Incense cedar
NF, nf—Noble fir
GF, gf—Grand fir
WF, wf—White fir

Seed trees were platted in their respective locations. All trees of seed-bearing size (determined by evidence of cone bearing) were classified as follows:

Class		
1	18″ or larger	At least 1/3 crown, dense and wide.
2	18″ or larger	1/3 to 1/6 crown, dense and wide.
3	18″ or larger	1/6 to 1/8 crown, dense and wide.
4	No limit	All other trees of seed-bearing size between advanced reproduction and class three seed tree.

Seed trees were platted at each four milacre plot either on the east-west lines or the north-south lines. The platting space on the field sheet represented one chain forward, one chain to the rear and one tally right and left. This procedure provided 100 percent coverage of the entire 160-acre tract. The same abbreviations used for seedlings designated the species of seed trees.

Such other data as locations of roads, streams, ridges, seed blocks and uncut settings were also recorded in the same portion of the field sheet.

Burns were classified in the following manner:

HB (hard burn)

Duff and humus completely gone.

Twigs and small limbs were completely consumed.

Soil might appear reddish in color.

Clinkers were often present.

On burns older than one year, moss was often growing profusely in shaded spots.

Few higher type plants appeared.

MB (medium burn)

Mineral soil may have been visible but humus not completely destroyed.

Some charred small branches found but no needles or twigs remained.

Moss was sparse and some higher type plant life appeared on recent burns.

LB (light burn)

The humus not destroyed and the duff not appreciably damaged.

Some small twigs not completely consumed.

No moss apparent and some small evergreens found.

Slash was rated by a system which combined into figures and letters the factors of depth of slash, area covered by slash, density of slash, and the composition of the slash. The formula used for determining the slash rating was DA + S + C where D is the depth of slash, A is the area covered, S is the slash density and C is the composition. The determination of the numbers of letters to substitute in the formula was as follows:

D (depth of slash)

The deepest point in slash was measured (Measurements were not to include lone sticks or limbs from felled tops which would have unduly exaggerated depth).

0″ - 3″	= 0
4″ - 9″	= ½
10″ - 18″	= 1
19″ - 30″	= 2
31″ - 42″	= 3
43″ and over	= 4

A (area covered)

½ or less of plot covered (2 or less quadrants)	= 1
more than ½ plot covered	= 3

B (slash density)

¾ ground visible (sparse)	= –1
¾ to ½ ground visible (moderate)	= 0
less than ½ ground visible (dense)	= +1

C (composition)

Fine—sticks, twigs and logs under 6″	= A
Medium—sticks, twigs and logs 7″ to 18″	= B
Coarse—mostly sticks and logs 7″ to 18″	= C
Heavy—nearly all logs 19″ and over	= D

The use of these numbers and letters in the formula provided a slash rating that was converted in Table XXVI into general descriptive terms.

TABLE XXVI

Table for Conversion of Numerical and Letter Slash Concentration-Designations Into Descriptive Terms

Very Light	*Light*	*Medium*	*Heavy*	*Extreme*
0 A, B, C or D	1 A, B, C or D	2.5 A, B, C or D	6 A, B, C or D	9 A, B, C or D
.5 A, B, C or D	1.5 A, B, C or D	3 A, B, C or D	7 A, B, C or D	10 A, B, C or D
	2 A, B, C or D	4 A, B, C or D	8 A, B, C or D	11 A, B, C or D
		5 A, B, C or D		12 A, B, C or D
				13 A, B, C or D

Office Procedures

Field notes were summarized and totaled on summary sheets designed for the purpose.

Logging and burn history were compiled from the records of the various logging companies concerned and from the records of the Oregon State Board of Forestry.

In order to make comparisons among the various types and amounts of seed source an arbitrary system of assigning numercial values to the seed sources was established. The system provided a figure for relative comparisons among plots.

The system of assigning numerical values to seed sources was based on the following assumptions:

1. Seed trees are of value in proportion to their number and class.

2. Uncut timber (including seed blocks, long corners, etc.) is of value in proportion to the amount of timber edge and the distance of this edge from the area to be seeded.

3. The following amounts of seed source were assigned comparative equality in computing the original seed source values:

a. Two seed trees per acre (forty-acre sub-tract).

b. Two-acre seed block centrally located (forty-acre sub-tract).

c. A front of uncut timber 1320 feet long within one-fourth mile of the center of the forty-acre sub-tract.

d. A front of uncut timber 3960 feet long between ¼ and ½ mile of the center of the forty-acre sub-tract.

Two seed trees per acre were given a value of 100. All other seed tree values were a direct ratio of this amount.

The value for seed blocks (not to exceed 24 acres in size) was taken from a curve which was constructed for this purpose (see Figure 8). This curve is essentially an area-circumference ratio for a circle. Seed blocks which were not centrally located within the forty in question were handled the same as adjacent timber.

The seed source value for adjacent timber depended upon the number of feet of the uncut timber within one-quarter or one-half mile of the center of the forty (sub-tract) in question. The determination of the number of feet of uncut timber edge was accomplished by having the seed source platted on cross section paper (see Figure 10) and using a transparent overlay, on which circles were superimposed with scaled one-quarter and one-half mile radii (see Figure 9). The number of squares of timber edge within the ¼ and ½ mile circles were counted. Once the number of squares were counted the seed source values were taken from a straight line curve prepared for this purpose (see Figure 11).

The seed source values for seed trees, seed blocks and adjacent timber, when added together, constituted the total seed source value for the forty-acre sub-tract.

SEED SOURCE VALUE FOR SEED BLOCKS

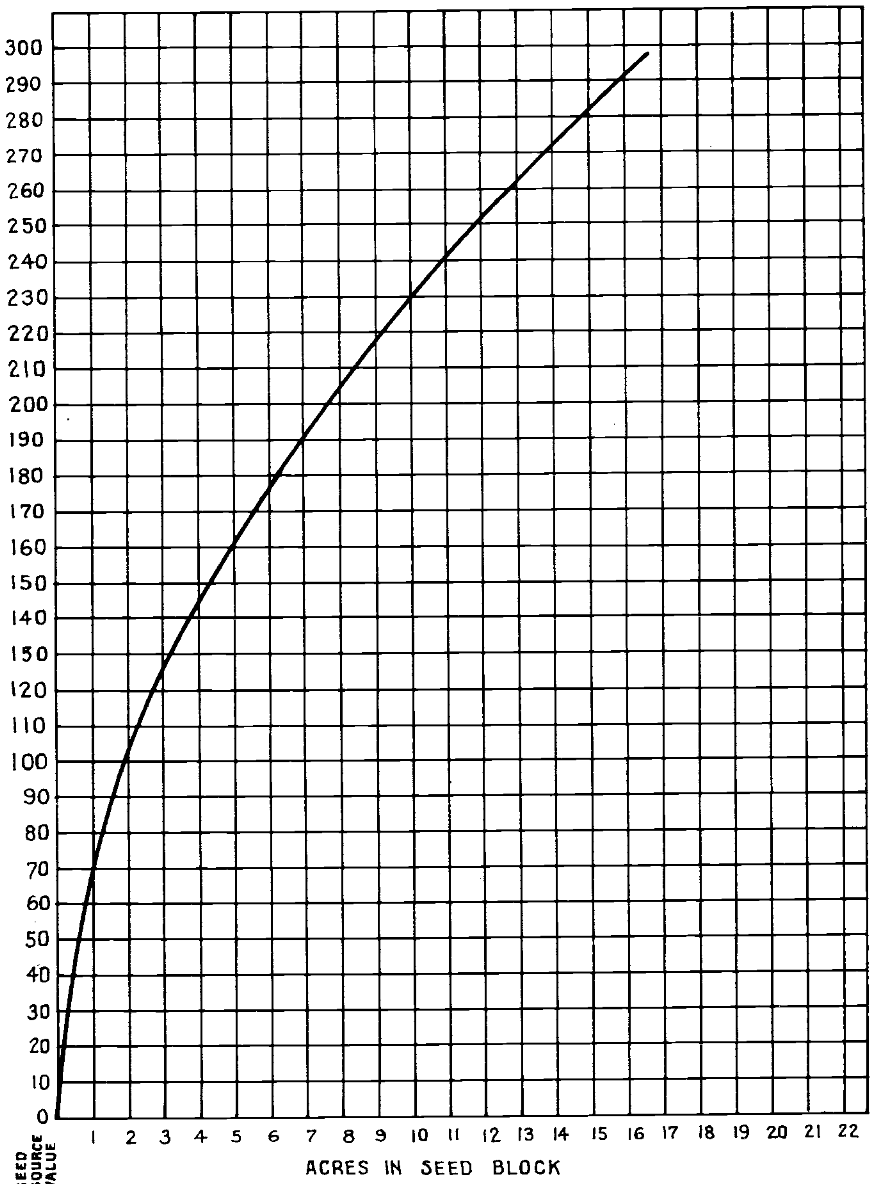


FIGURE 8

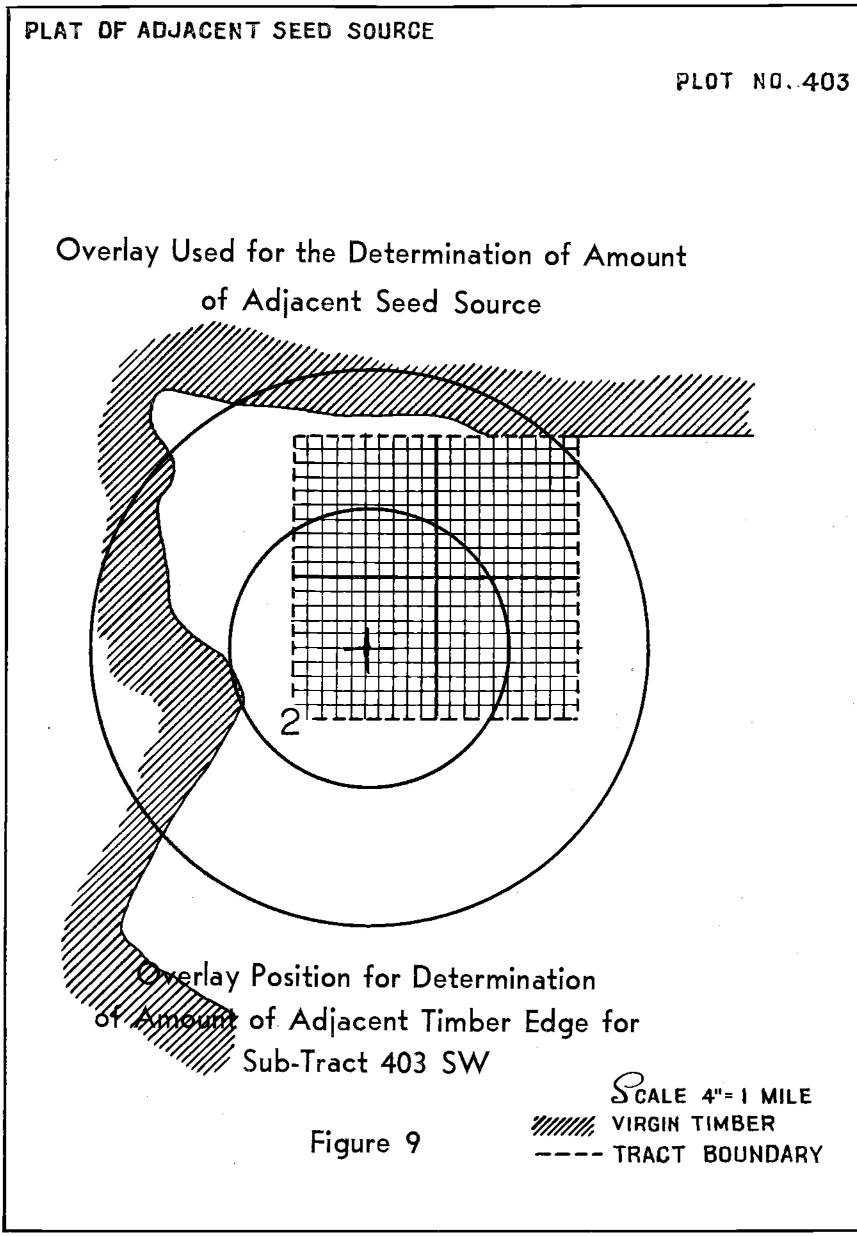

PLAT OF ADJACENT SEED SOURCE
PLOT NO. 403
Overlay Used for the Determination of Amount of Adjacent Seed Source
2
Overlay Position for Determination of Amount of Adjacent Timber Edge for Sub-Tract 403 SW
SCALE 4"= 1 MILE
VIRGIN TIMBER
TRACT BOUNDARY
Figure 9

FIGURE 10

CURVE FOR DETERMINING
SEED SOURCE VALUE FOR ADJACENT TIMBER

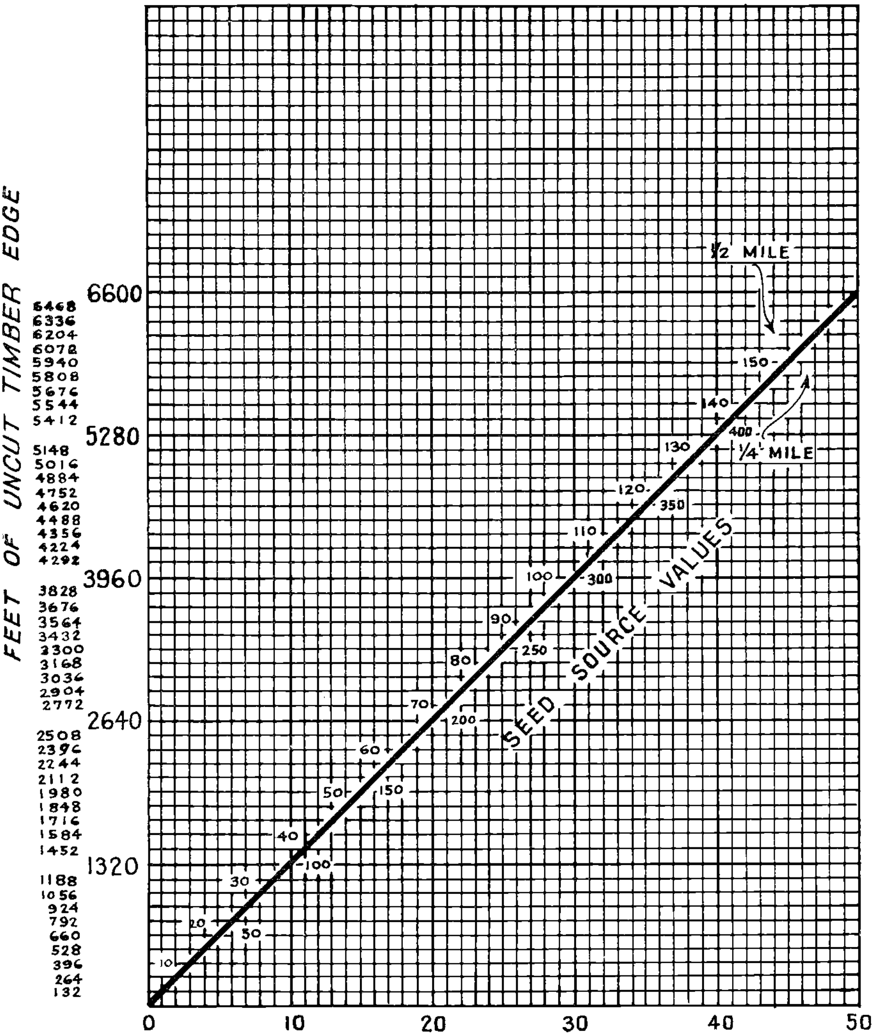


FIGURE 11