AN INVESTIGATION OF THE EFFECTS OF PARTIAL CUTTING OF DOUGLAS FIR ON A FARM WOODLOT IN THE WILLAMETTE VALLEY

By

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INTRODUCTION

Is partial cutting a constructive or destructive plan for the management of farm woodlots of second growth Douglas fir? Many arguments have been advanced in support of both sides of this controversial question. The objective of this thesis is to investigate the effects of such cutting as done in the past and to supply factual information as to results, based on past cutting, specifically applicable to the area in which the investigation was conducted and generally pertinent to all similar areas in the Willamette Valley.

DESCRIPTION OF THE AREA STUDIED

The area selected for this study consisted of approximately forty acres of farm woodland located near the town of Yamhill, in Yamhill County, Oregon. Twelve acres of the tract were cut over in 1937. The intensity of cut varied with the size and quality of the timber and ranged from 58 percent to 100 percent of the volume merchantable under present standards of utilization. The comparatively light cutover portions of the area is attributable to the depressed condition of the lumber market in 1937 and consequent reluctance of mill operators to accept logs cut from excessively limby and fast growing trees and the logger's inability to handle the smaller trees on a profitable basis.

No conscious effort was made to improve or protect the remaining stand, but the use of light equipment prevented excessive mechanical damage to those trees which remained uncut. Slash was not burned, and no fires have occurred in the area since the time of cutting.

In addition to use as a woodlot, this area has been grazed by varying numbers of livestock -- cattle, sheep and horses -- since the time of cutting. This use has, however, been largely confined to the meadowland and hardwood types along the stream bisecting the area.

ITEMS TO BE CONSIDERED

Since this study is concerned with the total effect of partial cutting on the stand, it is necessary to give some consideration to the following factors: (1) Effect of cutting upon growth rate of the residual stand; (2) Relation of intensity of cut, grazing, and ground cover to presence of reproduction less than ten years of age; (3) Amount, severity and healing of logging injuries; (4) Evidence of insect infestation directly or indirectly attributable to cutting; (5) Relation of cutting to losses by windfall in residual stands.

The greatest emphasis will be placed on the investigation of growth rates prior and subsequent to cutting, losses from windfall and mechanical damage to the stand resulting from cutting. All other phases will be considered briefly in relation to their effect in bringing about the present condition of the stand.

FIELD INVESTIGATION

The field examination included an inventory consisting of a 20 percent line-plot cruise of the area, increment borings taken from trees representative of specified degrees of cutting and crown classes, and studies of logging injuries, windthrow, reproduction, and insect infestation.

The inventory, as previously stated, consisted of a 20 percent line-plot cruise of the area, with cruise lines spaced at five chain

intervals and running in a North-South direction so as to cross the principal drainage of the tract. One quarter acre circular plots were measured at two and one-half chain intervals along the cruise lines. All trees down to the twelve inch DBH class and containing at least two sixteen foot logs were considered to be merchantable, with the exception of those showing sporophores of Fomes pini. Trees in the diameter classes between twelve inches and six inches were tallied as poles.

The type map compiled in conjunction with the inventory is designed to indicate the percentages of original volume removed from the cutover areas as well as to show the type and age of timber remaining on uncut portions of the tract.

Since no figures were available on the exact volume of timber removed from the tract, it was necessary to make an approximation from the stumps and the average heights of adjacent standing trees. All stumps included in the one quarter acre cruise plots were recorded by diameter and these diameters were later used in computing the percentage of cut for each of the cutover types.

Information pertaining to loss from windfall and insect attack was obtained by a 100 percent coverage of the area. All windfalls and insect killed trees of merchantable size were tallied by DBH and merchantable height.

Grazing damage was estimated by general observation throughout the course of the field work.

The information on reproduction following cutting was obtained by counting the seedlings on four milacre plots with a common corner located at the center of each of the cruise plots. Ground cover was noted at each of these plots as it soon became apparent that there existed a definite relationship between ground cover and reproduction,

other things being equal.

Since one of the major objectives of this investigation is to obtain specific information on growth rates of individual trees in cutover and uncut stands of similar age classes, it was necessary to take a number of increment borings. The measured diameter at breast height, estimated total height, injuries, and crown class were recorded for each tree bored, along with measured diameter growth during the past twenty years.

In addition to the study of relation of injuries to growth rate, a careful study was made on several basal and trunk injuries to ascertain the rate of healing and the rate of occurrence of infection by fungus diseases. The increment borer was used in testing the depth of wood discoloration and possible fungus attack adjacent to the actual scar. Additional information was obtained by chopping into the wood immediately inside the scarred surfaces.

COMPILATION AND ANALYSIS OF INFORMATION

Upon completion of the field work, it was necessary to compute the volume of the timber included in each of the several categories to be considered, and to arrange and tabulate all data secured from the field investigation in such a manner that it be readily available for comparison and analysis prior to drawing conclusions or making recommendations based on the results of field examination.

The volumes of the merchantable trees in each of the plots were computed, using Table 9 in Forest Mensuration by Mason and Nettleton. The volumes thus obtained were then segregated into groupings corresponding to their respective timber types as indicated on the type map constructed in conjunction with the cruise. A converting factor based

on the relationship of the area actually measured in each type to the total area of the type was applied to the measured volume as computed for the type. This procedure was repeated for each of the forest cover types indicated on the type map, and the results summarized. Non-merchantable volume was then computed by the same process. The number of pole sized trees was computed for each type by multiplying the number actually tallied for that type by the converting factor previously computed.

All volumes and areas determined in the preceding steps were then tabulated, giving a detailed inventory of the entire tract.

Since type differentiations considered age, species, degree of stocking prior to cut, and relative degree of cutting, this summary will later serve as a source of factual information to substantiate conclusions and recommendations.

DBH measurements for computing the volume of timber removed from each of the types were obtained by subtracting one inch from the diameter outside bark of each of the stumps tallied on the cruise plots of that type. Using those measurements as DBH and the average height of trees of similar size on the areas immediately adjacent to the location of the stumps, the corresponding volumes were determined from Table 9 of Forest Mensuration by Mason and Nettleton. The volumes of the individual trees tallied in each cutover type were then totaled and the proper converting factor applied to obtain the volume cut from each of the cutover types.

Windfall was measured in the field by a 100 percent coverage of the area, windthrown trees being tallied by DBH and merchantable height, so total volume of windfall for each type was determined by finding the volume of each of the recorded trees in the volume table and totaling

the volumes in each type.

Approximation of relative growth rates in uncut and partially cut areas of the same age class required a number of calculations. It was originally intended that growth rates be obtained for several degrees of cutting, but insufficient data were obtained to approximate growth on any but the uncut and lightly cut areas. In determining growth during the past decade in uncut areas it was first necessary to obtain the degree of stocking. This was accomplished by dividing the volume per acre as determined in the cruise by the volume on an acre of fully stocked stand of the same age and site index as obtained from Table 15 in Forest Mensuration by Mason and Nettleton. The volume per acre one decade prior to the time of examination was computed by multiplying the volume given in the yield table by the percent of stocking. Growth per acre during the past decade was then obtained by subtraction.

Since the yield table used in computing growth was compiled from studies in uncut forests, it was obvious that it was not applicable to cutover stands and that some other method must be devised for the approximation of growth in the partially cut areas. The number of trees per acre and dimensions of the merchantable portion of each tree tallied were readily obtainable from the tally sheets. These dimensions were averaged to give the diameter breast high and merchantable height in sixteen foot logs of the average tree. Growth during the past decade was measured on increment borings taken from a number of trees of all crown classes in the cutover area. Average diameter growth per tree during the past decade was obtained by averaging the increments previously measured. Present volume per acre was computed by multiplying average volume per tree by the number of trees per acre. The volume thus obtained was then checked against the cruise data and found to agree within

three percent -- close enough for the purpose of this study. Volume per tree as of ten years ago was, of course, obtained by subtracting averaged diameter growth from the present dimensions of the average tree as previously computed for the type, and determining the corresponding value in the volume table. Conversion to volume per acre was then completed by multiplying by the number of trees per acre. Growth per acre during the decade was then obtained by subtracting past volume from present. Increase in volume due to growth in height was assumed to be negligible.

The next phase of investigation was devoted to the determination of the percentage of the total merchantable volume removed from each of the types. This procedure was complicated by the necessity of considering the factors of growth and windfall occurring since the time of cutting. The present merchantable volume was readily available from the summary of the timber inventory. Growth subsequent to the time of cutting was calculated for each type in the manner outlined in the preceding paragraph. The windfall loss and volume cut on each type had been determined in previous steps so it was then possible to determine the total volume per acre just prior to cutting by totaling the present volume, windfall loss and volume cut and subtracting increment in the residual stand. Percentage of cut was then obtained for each type by dividing the volume cut by the total volume at the time of cutting.

Loss attributable to insect attack was determined by totaling the losses noted during the course of the field inventory.

Degree of restocking was computed for each type by counting the number of stocked quadrats and dividing by the number of quadrats counted in that type.

Comparative growth rates by crown classes and rates of growth

prior and subsequent to logging, were obtained simply by averaging the results of field measurements and tabulating the averaged data under the appropriate headings.

RESULTS

Detailed results of the several phases of this investigation are shown in tabular form so only the more general aspects will be discussed in this section.

Site was determined by height measurements and increment borings of several dominant and codominant trees and was found to be a low Site III and quite typical of second growth stands of Douglas fir in the Willamette Valley.

Results of the inventory of growing stock remaining on the tract indicate that approximately 52,400 board feet of merchantable Douglas fir timber and 24,400 board feet of defective timber remain on the cutover portion of the area. The majority of the remaining merchantable volume (42,700 board feet) was found in the cutover type from which 5% of the merchantable volume was removed at the time of cutting. Degree of stocking prior to cutting was found to vary from 30 to 40 percent of normal. Volumes for other types and species are listed in Table I.

Percentage of the merchantable volume removed from each of the cutover types was found to vary from 100 percent in type "C", to 57 percent in type "E". Complete results of computations of cut per acre and percentage of total volume cut for each type are indicated in Table II.

Windfall was found to vary from 175 to 875 board feet per acre in the cutover types, and from zero to 3,260 board feet per acre in the uncut types. Much of the loss in type "F" where the heaviest wind damage occurred was directly attributable to butt rot

(Polyporus schwienitzii) in the mature and frequently fire scarred timber of that type. No windfall was noted in uncut second growth stands. Complete results of the study of windfall loss are included in Table III.

Losses due to insect infestation were found to be negligible, as a careful examination of the entire tract revealed only two trees of pole size that had succumbed to insect attack.

Growth per acre for the partially cut types was found to range from 12.5 board feet per acre per year in the lightest residual stands of type "A" to 80 board feet per acre per year in type "E", which carried a residual stand of 6,000 board feet per acre immediately following the cutting. Uncut types showed a variation from no appreciable growth in the mature timber of type "F" to 222 board feet per acre per year in the densely stocked young second growth of type "Y". Net growth (total growth minus measurable losses) in the cutover types varied from the loss of 23.5 board feet per acre per year to a net gain of 62.5 board feet per acre per year. Complete results of this growth study are included in Table III.

Studies of the diameter growth of individual trees in uncut and cutover areas revealed a number of interesting facts. Dominants and codominants showed response to release from competition after an average of 1.5 years, while trees of intermediate and suppressed crown classes required average periods of 2.0 and 3.6 years, respectively, before annual growth rings indicated any response to the release from competition.

Dominant and codominant crown classes showed an average diameter growth of 0.234 inches per year for the ten-year period subsequent to cutting, as compared with an average growth of 0.128 inches per year for the decade prior to the year of cutting. Trees of intermediate

crown class showed an even greater comparative acceleration of growth with an average growth of 0.176 inches per year since the time of cutting, and 0.058 inches per year during the next preceding decade. Suppressed trees more than doubled their rate of growth during the ten years between 1937 and 1947.

A true picture of growth conditions must consider the elapsed time between cutting and response to release from competition and the growth rate since that time. A glance at the summary of results of this phase of the study (Table IV) shows that growth per year since time of response to release is considerably in excess of the average for the entire period. This acceleration is consistently true for all crown classes.

Increment borings in an adjacent area of uncut timber of identical age and site class show dominant and codominant trees to have an average diameter growth of 0.038 inches per year for the ten-year period since 1937, and 0.074 per year for the preceding decade -- a complete reversal of the trend on the adjacent area from which 57 percent of the merchantable timber had been removed. Trees of suppressed crown types in the uncut sample showed no significant variation in the growth rate during the 20 year period considered.

The extensive sampling of reproduction showed satisfactory restocking (75 percent or more) on those portions of the more heavily cut types which were free from dense ground cover or accumulations of unreduced slash. The less heavily cut area (type "E") shows a restocking of 65 percent, but the reproduction was poorly spaced with a tendency to be concentrated in old skidroads. Over 90 percent of the reproduction was found to be Douglas fir, with the remainder consisting of Pacific Yew and Lowland White Fir. Abundant seed source was present, both in

well distributed individual seed trees and blocks of uncut timber on at least three sides of all cutting areas. Reproduction varied directly with the density of ground cover.

No apparent grazing damage was noted in the coniferous forest cover types. A complete absence of reproduction or trees under 30 years of age in the hardwood type is undoubtedly traceable to grazing use. This elimination of hardwood reproduction is not considered undesirable since the hardwoods are poorly formed and not especially valuable, and the pasture from the area is important to the economy of this farm unit.

Exact measurement of logging damage to the residual stand was obviously impossible since damage by wood destroying fungi cannot be determined by examination of the exterior of the tree. Mechanical damage as compiled from the tally sheets of the timber inventory show that in type "A", 10 percent of the residual trees lost up to one-half their live crowns through damage incurred in felling; 30 percent of the trees suffered broken tops, and 10 percent showed basal scars. In type "B", 20 percent of the trees had lost both the top and one-half their live crown. Type "E" showed less damage to crowns and a greater amount of injury through basal and trunk injuries; 12 percent of the residual trees showing damage of the former type and 15 percent displaying the latter type of injury.

None of the trees exhibiting injury to the crown showed any sporophores of the wood rotting fungi, but this does not necessarily indicate that no fungal infection has occurred in these wounds, since sporophores are not ordinarily produced until a number of years after the initial infection.

Infection and healing of basal wounds was much more easily determined due to their more accessible location on the tree. Most

of the basal injuries were either completely healed over or were protected by a layer of pitch outside the face of the wound and pitch impregnated wood for an average distance of slightly more than one inch immediately inside the wood surface exposed at the time of injury. No attempt was made to secure exact figures on the rate of occurrence of decay related to injuries, but a limited number of samples (10 trees) seems to indicate that approximately 50 percent of the basal injuries have been infected with Polyporus schweinitzii. All occurrence of fungal infection was noted in scars which had healed over rapidly and showed little or no pitch exudation, while none of the scars with heavy exudations of pitch showed evidence of the presence of wood rotting fungi.

DISCUSSION AND RECOMMENDATIONS

The most readily apparent and indisputable fact revealed by this study is that heavy partial cuts, as exemplified by types "A" and "B", are not suitable for the harvesting of second growth Douglas fir, since increment of the residual trees fails to equal the loss by windfall. The variation shown in net growth between types "A" and "B", from which approximately equal percentages of the timber had been removed, is due to two factors. Type "A" showed a lesser degree of stocking prior to cutting and type "B" was located on the crest of a small ridge and therefore more exposed to the wind.

Cutting 57 percent of the merchantable volume produced an appreciable acceleration in the rate of diameter growth of individual trees, but left a relatively small growing stock. Windfall was much less than noted in the more heavily cut types. Lack of field data from less heavily cut areas limits the conclusions that may be drawn from this trend of relationship between degree of cut and rate of

growth and windfall. It is, however, obvious that a cut of 57 percent of the total volume was much more satisfactory than the heavier cuts on the basis of resultant net growth.

Satisfactory Douglas fir reproduction was obtained in slash free portions of the area from which 57 percent of the volume had been removed. However, much of this reproduction was found in old skidroads and would be highly susceptible to damage during future cutting of the residual timber, since these skidroads followed the natural routes for yarding logs from the area.

Occurrence of reproduction varied directly with the ground cover, since an abundance of seed was available to all portions of the tract. Reproduction was most abundant on areas which were relatively free from slash and dense growths of brush, indicating that some form of partial slash disposal would have increased the degree of restocking.

Injuries to uncut trees were naturally most frequent in the denser stands but were surprisingly small in their total effect. Some such damage is, of course, inevitable, but it can be minimized through care in felling and yarding. These injuries seemed to have little effect on growth rates. Some loss is to be expected through decay admitted by wounds incurred during logging, but it is probable that another cut would be made before the fungus attack had spread to destroy more than a very minor portion of the tree.

Losses by insect attack subsequent to logging were found surprisingly small. Some past studies of cutover stands of second growth Douglas fir have indicated serious losses by insect attack on trees weakened by logging injuries or fire. Since it is known that many species of forest insects are strongly attracted to freshly burned timber, it seems probable that absence of slash burning may have been

the principal factor in eliminating losses by insect attack.

In general, the results of this study indicate the impracticability of employing very heavy partial cuts in the harvesting of second growth Douglas fir. If partial cutting on a tree selection basis is to be attempted, the cut must be as light as is economically feasible. The growth rate of individual trees was favorably influenced by reduction of competition. Insect loss was negligible in the absence of slash burning and loss by windfall and logging damage was not excessive in the area where cutting had been more moderate. Reproduction was greatly influenced by ground cover, but was found to be of the original species and in reasonably adequate amount following a 57 percent cut.

TABLE I

SUMMARY OF GROWING STOCK INVENTORY

Type	VOLUMES Bd. Ft. Merch. D.f.	Bd. Ft. Cull D.f.	D.f. Poles	Bd. Ft. D.f. Windfall	Cords Maple	Cords Ash
A	6,280	21,390	46	760	2.24	-
B	3,460	-	-	875	-	-
C	-	-	5	-	-	-
D	5,870	3,200	-	-	-	-
E	42,675	2,455	-	1,110	-	-
F	102,000	162,000	-	29,980	2.71	-
G	46,185	6,390	-	-	-	-
H	-	-	-	-	7.71	2.54
Y	9,660	480	144	-	-	-
M	-	-	-	-	-	-
Total	216,630	195,915	195	34,760	12.66	2.54

TABLE II

VOLUMES IN BOARD FEET PER ACRE
ON DOUGLAS FIR TYPES
BEFORE AND AFTER CUTTING

Type	Present Volume	Cut	Volume Prior To Cutting	Percent Cut
A	1,460	5,140	6,670	77
B	3,460	10,050	13,130	75
C	-	15,000	15,000	100
D	2,935	-	-	0
E	6,670	8,120	14,175	57
F	28,750	-	-	-
G	6,040	-	-	-
Y	3,220	-	-	-

TABLE III

SUMMARY, BY TYPES,
OF GROWTH AND LOSS IN BOARD FEET
DURING THE 10 YEAR PERIOD SINCE CUTTING

Type	Present Net Vol./Acre	Vol./Acre After Cut	Growth/A. Since Cut	Loss/A. Since Cut	Net Growth/A
A	1,460	1,510	125	175	-50
B	3,460	3,690	645	875	-235
C	-	-	-	-	-
D	2,935	2,405	530	-	530
E	6,670	6,045	800	175	625
F	11,140	14,400	-	3,260	-3,260
G	6,040	4,950	1,050	-	1,050
Y	3,220	1,000	2,220	-	2,220

Note: Volume per acre immediately after cutting includes the amount later lost as windfall.

TABLE IV

RELATIONSHIP BETWEEN CROWN CLASS AND
RATE OF DIAMETER GROWTH OF TREES
IN AREA OF 57 PERCENT CUT.
AREA CUT IN 1937 AND GROWTH MEASUREMENTS MADE IN 1947

Crown Class	Ave. D.B.H.	Ave. Diam. Growth 1937-'47	Ave. Diam. Growth 1927-'37
Dominant	24.9 in.	2.34 in.	1.28 in.
Intermediate	16.9	1.76	0.58
Suppressed	12.9	0.74	0.32

Ave. Time Req'd. to Respond to Release	Ave. Diam. Gr/Yr. Since 1937	Ave. Diam. Gr./Yr. 1927-1937
1.50 in.		
2.00		
3.60		

Ave. Diam. Growth/Yr. Since Response to Release
0.264 in.
0.200
0.112

TABLE V

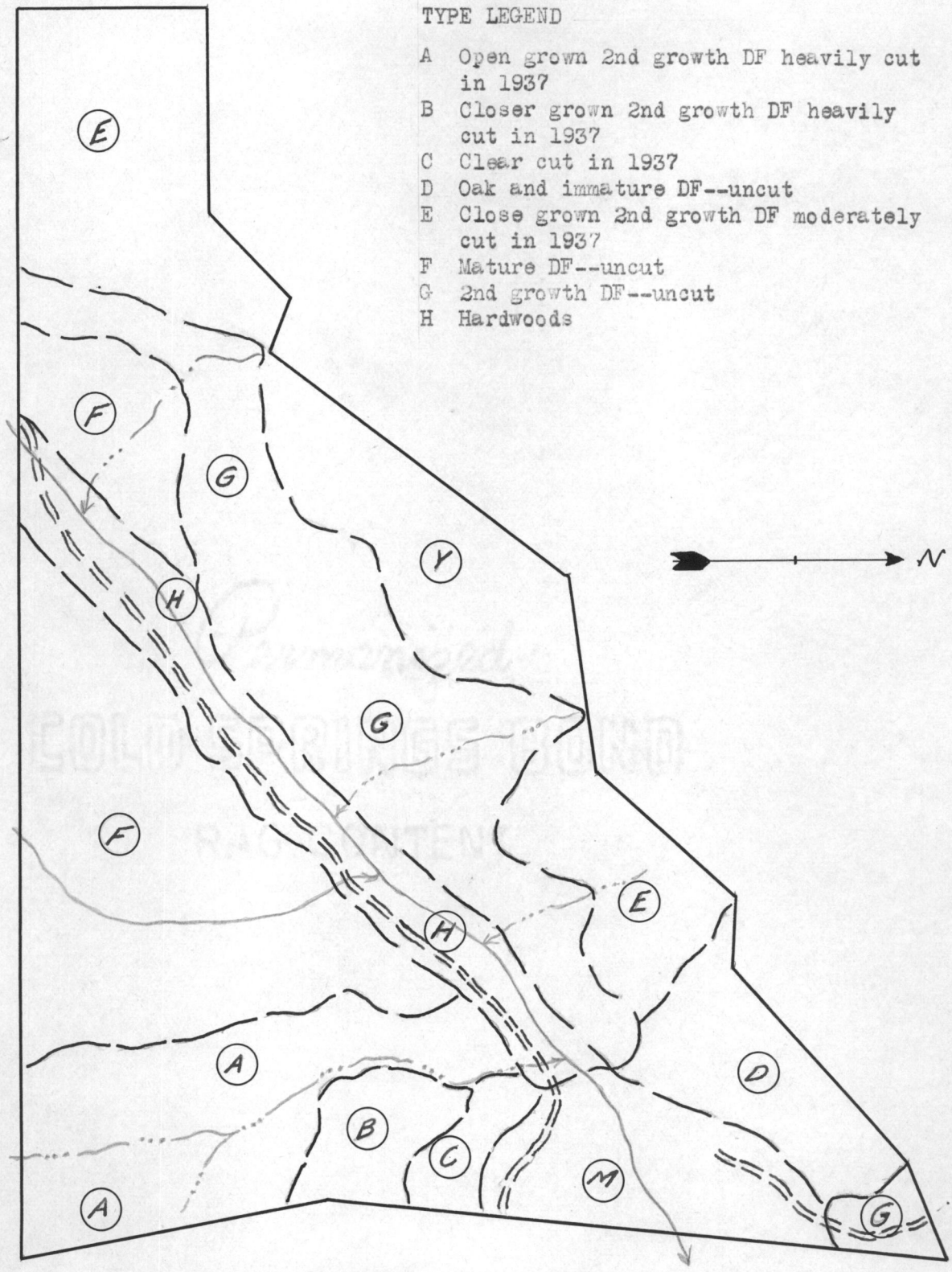
AVERAGE GROWTH PER YEAR IN UNCUT STAND
ADJACENT TO PARTIALLY CUT AREA

Crown Class	1937-1947	1927-1937
Dominant	0.038 in.	0.074
Intermediate	0.028	0.032
Suppressed	0.022	0.020

TYPE MAP OF AREA STUDIED

TYPE LEGEND

A Open grown 2nd growth DF heavily cut in 1937
B Closer grown 2nd growth DF heavily cut in 1937
C Clear cut in 1937
D Oak and immature DF--uncut
E Close grown 2nd growth DF moderately cut in 1937
F Mature DF--uncut
G 2nd growth DF--uncut
H Hardwoods



TOTAL AREA - 40.8 ACRES

SCALE - $\frac{1}{4}$ INCH = 1 CHAIN