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FERTILIZING THINNED AND UNTHINNED DOUGLAS FIR STANDS
(PROJECT B.C. 001)

by

Y. (Jim) Lee

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VICTORIA, BRITISH COLUMBIA

INTERNAL REPORT BC-21

DEPARTMENT OF FISHERIES AND FORESTRY

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TABLE OF CONTENTS

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INTRODUCTION

Although interest in fertilizer application to forest stands has greatly increased in British Columbia, Lee (1968a) found a lack of information on the development of forest fertilization within this province. A survey by Armson (1967) showed that of the 90 research projects under way across Canada, 25 were being conducted in British Columbia. Of these only 4 were concerned with the growth response of established stands.

In 1968, a project was initiated to study (a) the growth response of trees in stands of different ages to nitrogen fertilizer applied at different rates and seasons; (b) the interaction of fertilizer application with thinning, and (c) the combined effect of these treatments.

This project was undertaken to provide more information on nitrogen fertilization of Douglas fir on southern Vancouver Island.

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OBJECTIVES

The primary objective was to assess the feasibility of using urea fertilizer to increase volume growth of Douglas-fir stands by testing four levels of nitrogen fertilizer per acre (0, 100, 200 and 300 lb), and fertilizer effect in relation to time of application and thinning. A further objective was to provide basic information for assessment of potential economic returns from forest fertilization.

STUDY PLAN

Design and Treatments

The study comprised three installations in the three age classes: 0 to 20, 21 to 40 and 41 to 60, in uniform stands of site index 110 to 140, in the Greater Victoria Water District. One installation was established each year commencing in 1968. Each installation was designed to test four levels of nitrogen (0, 100, 200 and 300 lb of N per acre) in the form of urea (46% nitrogen) applied to thinned and unthinned Douglas-fir stands. Each age class was sampled by two blocks (replicates) of 16 plots each. A block covered four acres. Plots were 1/20 acre for age class 0 to 20, and 1/10 acre for the other two age classes, surrounded by buffer zones 20 feet wide. Fertilizer was applied to 12 of the 32 plots of an installation in the fall following plot establishment, and to a further 12 plots in the spring of the ensuing year.

Table 1 shows the treatment arrangements. Treatments were randomly located within each block, and fertilizers were applied to both plot and buffer zones.

Table 1. Treatment arrangements for each block

Time of N application	Unthinned lb. of N per acre 0	100	200	300	Thinned lb. of N per acre 0	100	200	300	Total No. of plots
Fall	1	1	1	1	1	1	1	1	8
Spring	1	1	1	1	1	1	1	1	8
Total No. of plots	2	2	2	2	2	2	2	2	16

Measurements

All trees above 0.05 inch dbh were numbered and marked at breast height with paint (yellow for control, red for 100 lb. of N per acre, white for 200 lb. and blue for 300 lb.). Diameters were measured at breast height with a diameter tape. The total heights of 15, 40 and all trees within each plot for age classes 41 to 60, 21 to 48 and 0 to 20 respectively were determined using a telescopic height pole or Haga clinometer.

Dbh remeasurements are to be made annually during the first 5 years after fertilization.

Prescriptions for further measurements, including stem analysis, will be determined by the end of the fifth year.

Soil

Soil classification and profile descriptions were based on pits dug in each study area. Two composite samples (one of litter, the other of mineral soil to one-foot depth), each comprising nine subsamples, were taken from each plot in the first installation in September before and after fertilization, and were analyzed for nitrogen content. Soil sampling was not repeated in the other installations because no variations in soil nitrogen content were found in the first installation.

Foliage

For the determination of foliage nutrient status, four dominant trees (one on each of the 4 buffer strips) on each plot were marked as sample trees. From these trees, current-year needles were collected in the fall, according to the procedure of Lavender (1968), i.e., needle samples were taken from a branch from the third whorl as shown in Fig. 1.

Growth Response

Growth response of individual trees and plots will be assessed on the basis of basal area, volume (total and merchantable) and height growth. Stem analysis will be undertaken 5 or 6 years after fertilization to provide a more comprehensive study of growth response.

WORK ACCOMPLISHED TO DATE

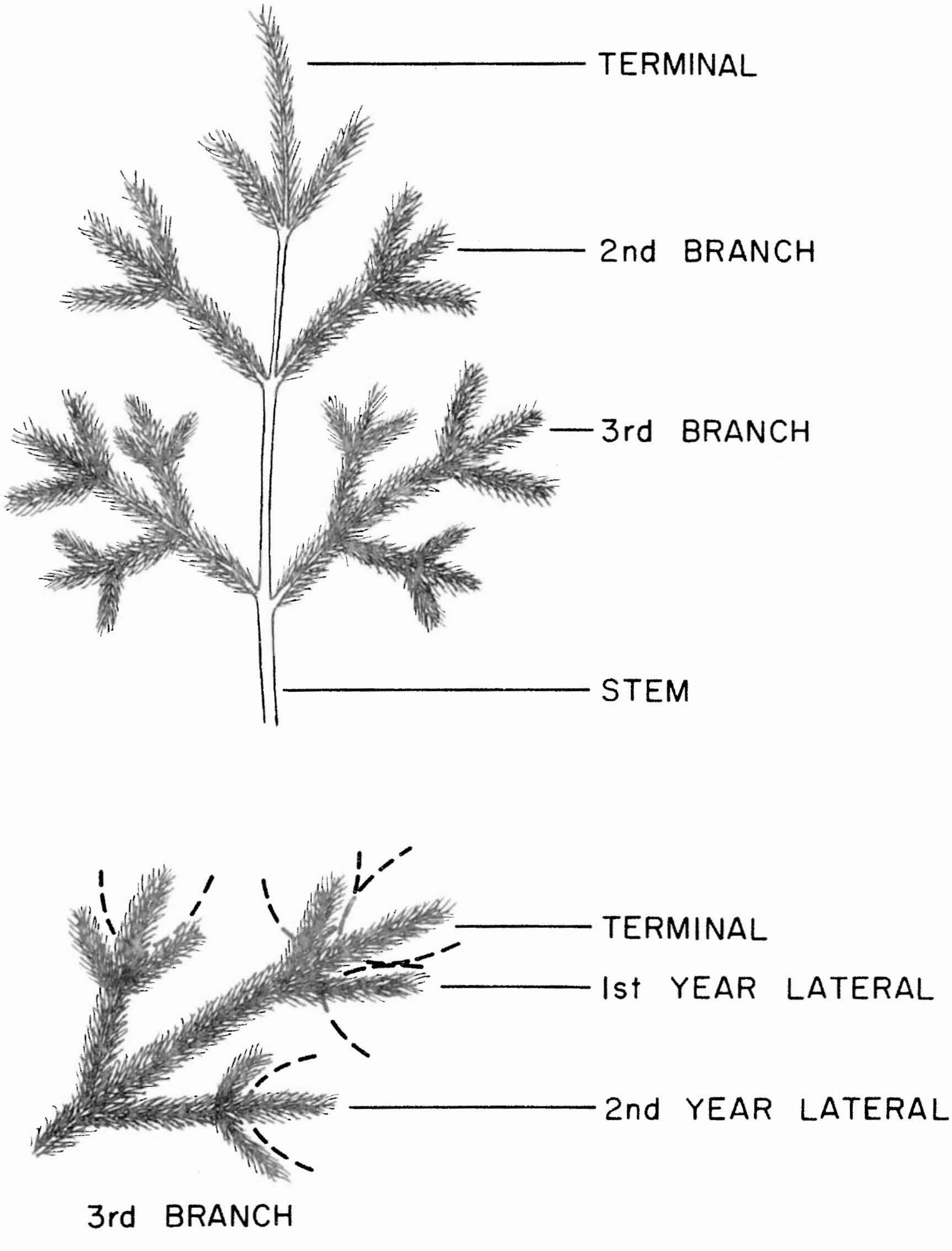
General description of the study areas

The first 2 installations (age classes 21 to 40 and 41 to 60) were located near "Branch 20G" and "Branch 30G" in the Goldstream Watershed, 15 miles west of the Forest Research Laboratory (Fig. 2). Elevation is about 1000 feet above sea level, and the terrain slopes gently toward the southwest.

The stands were fully-stocked, naturally regenerated, and even-aged. They comprise Douglas fir (*Pseudotsuga menziesii* (Mirb.) Franco) with a few western hemlock (*Tsuga heterophylla* (Raf.) Sarg.) and other coastal tree species. Ground vegetation is predominantly salal (*Gaulteria shallon*), with lesser amounts of Oregon grape (*Mahonia aquifolium*) and swordfern

FIGURE 1

LOCATION OF SAMPLE BRANCH FOR FOLIAR ANALYSIS.



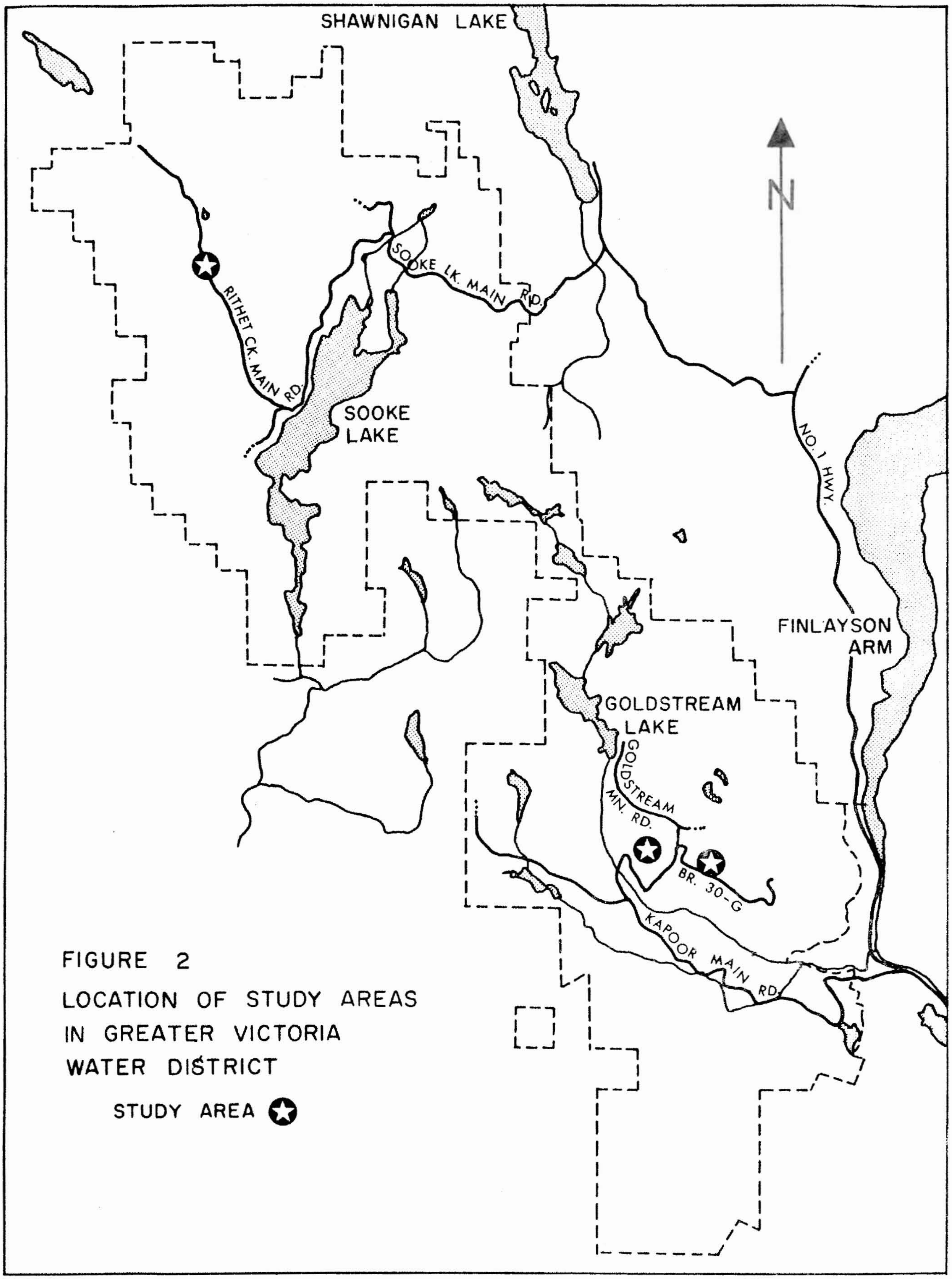


FIGURE 2
LOCATION OF STUDY AREAS IN GREATER VICTORIA WATER DISTRICT

(*Polystichum munitum*).

The soil is well-drained, sandy-loam textured colluvium overlying till; it is classified according to Day *et al*. (1959) as acid-brown wooded.

For the third (0 - 20-year age class) installation, a Douglas-fir plantation was selected near "Branch 20R" on the Rithet Creek Main Road of the Greater Victoria Water District.

Plot establishment

Two of the installations were completed in the summers of 1968 and 1969.

(1) Age class 21 to 40

This installation was established in the summer of 1968, in a 25-year-old stand. Fig. 3 shows the layout. All plot trees were numbered, marked and measured, and the heights of the tallest 40 trees in each plot were measured. Eight plots in each block were thinned to a relatively constant basal area (90 square-feet per acre). The basal area removed ranged from 20 to 95 square-feet per acre, with an average of 42 square feet.

Five pits were dug for soil classification and profile description (Fig. 4). Soil and foliage samples were collected before fertilization in September, 1968 and post fertilization in September, 1969. (Analysis of soil and foliage for N content has been completed.)

Urea was broadcast by hand as scheduled in September, 1968 and April, 1969.

(2) Age class 41 to 60

The second installation was established in the summer of 1969, in a 55-year-old stand (Fig. 5). Establishment details were similar to those for the first installation except that height measurements were made only on 15 trees per plot. Eight plots in each block were thinned to

FIGURE 3

Fertilization plot layout for age class 21 to 40.

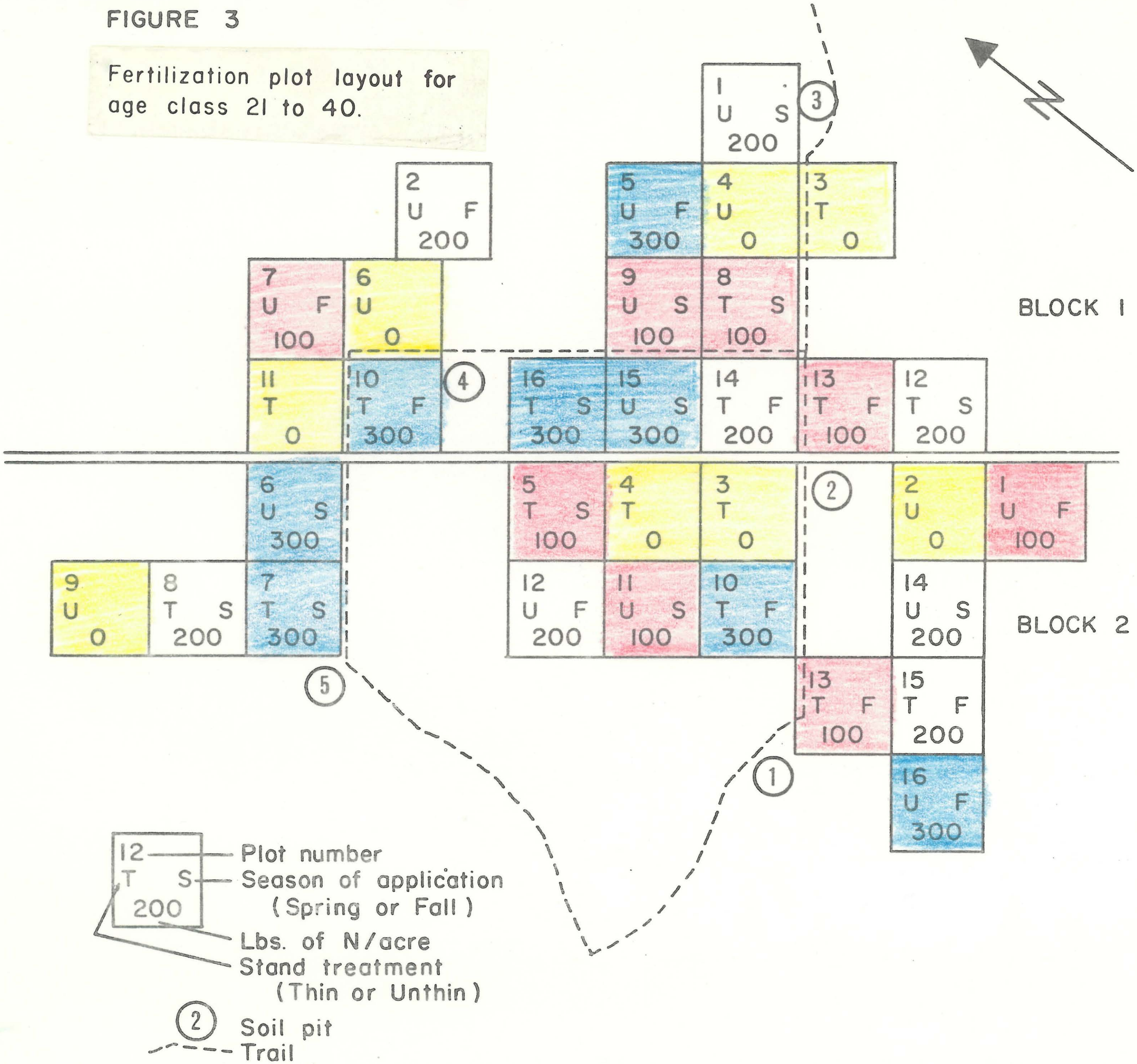


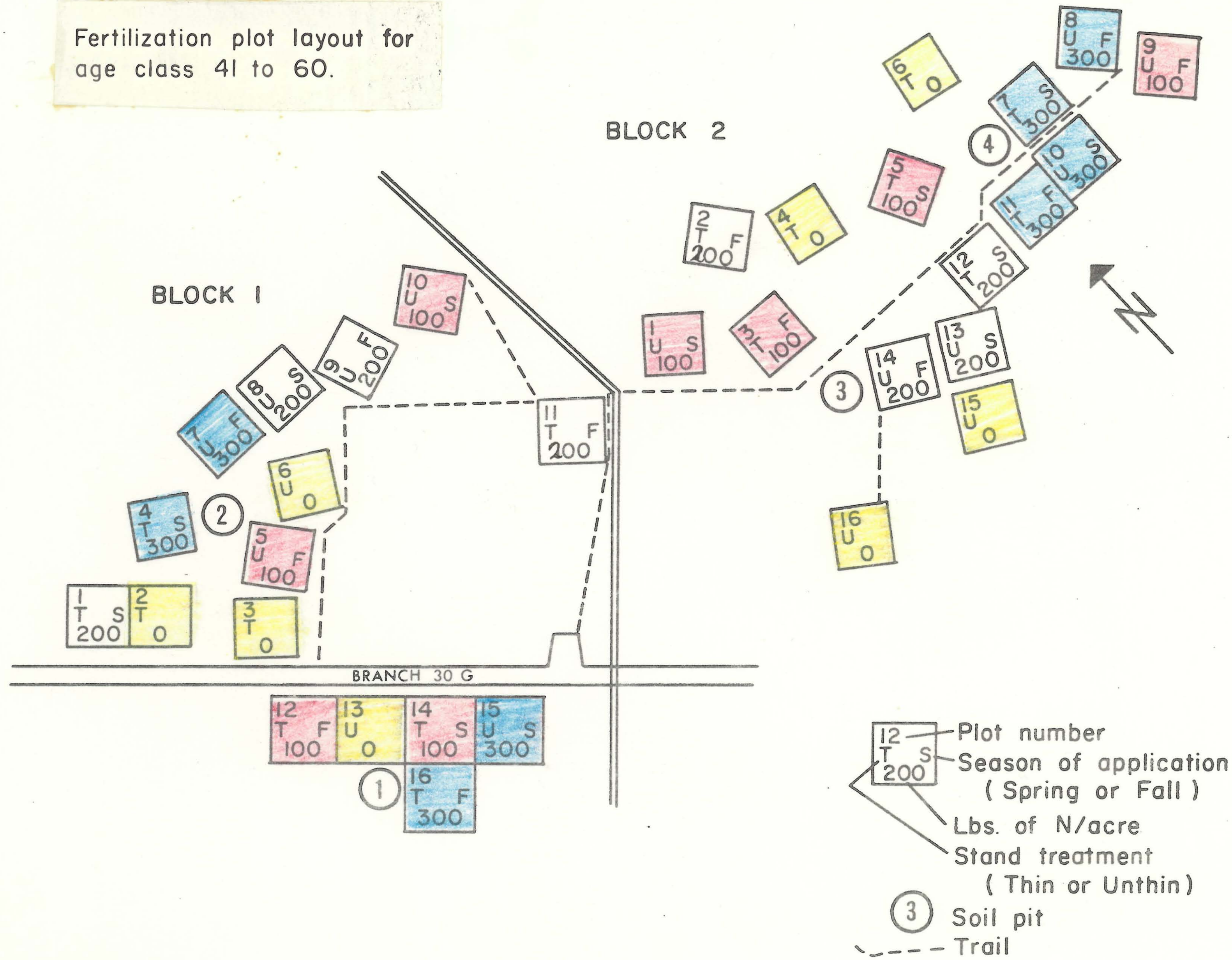
FIGURE 4. Soil profile descriptions for age class 21 to 40.
Mini humo-ferric (Podzol)

Soil depth (inches): 0, 10, 20, 30, 40

Horizon	Texture	Root concentration %	pH	Pit No.
L-H			5.90	1
Bfh	Sandy loam	40	6.35	1
Bf1				1
Bf2	Loam	50	6.30	1
BC	Loam	10	6.00	1
C	Loam			1
L-H			5.55	2
Bf1	Loam to sandy loam	60	6.20	2
Bf2	Loam	30	6.35	2
BC	Loam	10	6.10	2
C	Loam			2
L-H			5.45	3
Bf	Loam	80	6.00	3
BC	Loam	20	6.30	3
C				3
L-H			5.59	4
Bf	Sandy loam to loam	80	6.20	4
BC	Loam	20	6.05	4
C	Loam			4
L-H			5.80	5
Bfh				5
Bf1	Sandy loam	45	6.25	5
Bf2	Loam	30	6.35	5
BC	Loam	25	6.15	5
C				5

FIGURE 5

Fertilization plot layout for age class 41 to 60.



release severe crown competition. The basal area removed ranged from 34 to 82 square feet per acre, with an average of 63 square feet. The remaining basal area ranged from 121.4 to 203.3 square feet per acre, with an average of 167.3 square feet. The fall application of urea was undertaken in September, 1969 and the spring application in April, 1970.

Four pits were dug for soil classification and profile description (Fig. 6). Soil and foliar samples were not collected.

TREATMENT EFFECTS TO DATE (AGE CLASS 21 TO 40)

Initial measurements of dbh and height, made in the summer of 1968, were punched onto IBM cards, and plot statistics were summarized. Subsequently, in September 1969, diameters at breast height were remeasured for all plots on the first installation (age class 21 to 40). The basal area growth was analyzed (Tables 2 and 3).

(1) Thinned versus unthinned

Thinning without fertilization resulted in a greater percentage basal area growth (2.6%) in the first year (Table 3), but the actual basal area increase per acre per year was approximately the same for the unfertilized thinned and unthinned control plots (Table 2). Thinning also yielded a greater percentage basal area growth in the fall application of 100 and 300 lb. of N per acre with little difference at the 200 lb. level. Percentage basal area growth in the thinned plots, was higher than that in the unthinned plots at all rates of spring fertilization. However, with two exceptions, the actual basal area increases (per acre per year) in these instances were less for thinned than for unthinned plots (Table 2); the exceptions were the plots treated with 300 lb. of N in the fall and

FIGURE 6. Soil profile descriptions for age class 41 to 60.
Mini humo-ferric (Podzol)

Soil depth (inches)	Horizon	Texture	Root concentration %	pH	Pit No.
0–30	L-H			5.55	1
	Bf	Sandy loam	80	6.15	
	BC	Sandy loam-loam	10	6.05	
	C	Sandy loam	10	6.15	
0–30	L-H			6.15	2
	Bf	Sandy loam-loam	100	5.95	
	ROCK				
0–30	L-H			6.15	3
	Bf	Sandy loam	70	6.55	
	BC	Sandy loam-loam	30	6.35	
	C				
	WEATHERED SHALES	Sandy loam-loam		6.30	
0–30	L-H			5.40	4
	Bf	Sandy loam	50	6.10	
	BC	Sandy loam loam	40	6.00	
	C	Loam	10	6.00	

Table 2. Basal area growth per acre in 1969 for various thinning and fertilizing treatments, age class 21 to 40.

Rate of application lb. of N/acre	Thinned Time of N application Fall	Thinned Time of N application Spring	Unthinned Time of N application Fall	Unthinned Time of N application Spring
	Square feet per acre			
0	6.15	6.15	6.22	6.22
100	6.90	6.50	10.00	6.95
200	8.05	8.40	12.00	5.80
300	12.60	7.70	11.40	8.20
	Multiples of control			
0	1.00	1.00	1.00	1.00
100	1.12	1.06	1.61	1.12
200	1.31	1.36	1.93	0.93
300	2.05	1.25	1.83	1.32

Table 3. Basal area growth in 1969 expressed as a percentage of the total basal area in 1968, for various thinning and fertilizing treatments, age class 21 to 40.

Rate of application lb. of N/acre	Thinned Time of N application		Unthinned Time of N application	
	Fall	Spring	Fall	Spring
	Percentage basal area growth			
0	6.69	6.69	4.05	4.05
100	7.64	7.94	6.21	4.86
200	8.80	8.97	9.02	3.71
300	13.68	8.36	7.18	5.02
	Multiples of control			
0	1.00	1.00	1.00	1.00
100	1.14	1.19	1.53	1.20
200	1.32	1.34	2.23	0.92
300	2.04	1.25	1.77	1.24

200 lb. of N in the spring.

(2) Fall versus spring application

For thinned stands, there was no difference in percentage or actual basal area growth response between fall and spring fertilization at the two lower rates (100 and 200 lb of N), but response to 300 lb. of N per acre was better with fall application (Tables 2 and 3).

For unthinned stands, the first-year percentage or actual basal area growth response was considerably greater with fall application at all rates (Tables 2 and 3).

(3) Rates of fertilizer application

Growth during the first year was generally increased with rate of N application (Tables 2 and 3) with the exception of the 200 and 300 lb. of N applied in the spring to thinned and unthinned plots, respectively. The greatest response in percentage basal area growth was from the unthinned stands treated with 200 lb. of N per acre in the fall of 1968, about 2.2 times that of the unthinned control. The next greatest response was from the thinned stands treated with 300 lb. of N per acre in the fall of 1968, about 2 times that of the thinned control, not only in percentage responses but also in actual basal area growth.

For the thinned and unthinned stands treated with 100 and 300 lb. of N per acre in the spring of 1969, the growth responses in terms of percentages or actual basal area increase were approximately the same (Tables 2 and 3, multiples of control).

(4) Mortality

During the first year after plot establishment, only 6 trees died in the 16 thinned plots. On the other hand, 198 trees died on the 16 unthinned plots. The dead trees were not evenly distributed among these plots.

Table 4. First-year mortality in the 16 unthinned plots.

Rate of application lb of N/acre	Number of trees per acre		Mortality %	
	Live trees in 1968	Mortality	Trees	Basal area
0	3065	168	5.5	2.0
100	3432	155	4.5	1.0
200	2922	68	2.3	0.7
300	3992	105	2.6	1.5
Average	3353	124	3.7	1.3

The average mortality of 124 trees per acre per year appeared to be higher than that indicated by the B.C.F.S. yield tables (70 trees per acre per year for site index 110). This high mortality may be due to (a) the large initial number of trees per acre (3353) in this stand compared with that of the B.C.F.S. yield tables (2500), and (b) a heavy snowfall in the Greater Victoria area in the winter of 1968.

As shown in Table 4, the rate of N application did not seem to have any effect on mortality in the first year after fertilization.

(5) Summary of results

Thinning without fertilization resulted in a greater percentage basal area growth (2.6%) in the first year, but the actual basal area growth per acre was the same for the unfertilized thinned and unthinned control plots. Thinning also resulted in an additional effect on the percentage basal area growth response to 100 and 300 lb. of N application in fall as well as to spring fertilization at all rates.

Fall application was more effective than spring at all rates of fertilization for unthinned stands. But in thinned stands, fall application was superior only in the 300 lb. of N treatment (the highest rate).

Growth during the first year increased with the rate of N application in most cases.

The average mortality of 124 trees per acre per year appeared to be higher than that indicated by the B.C.F.S. yield tables. Rate of N application did not have any effect on mortality in the first year after fertilization.

The above findings, based only on the first-year responses in one installation, will be verified when remeasurements are taken.

FUTURE WORK

After completion of the third installation in an 11-year-old Douglas-fir plantation in the summer of 1970, fall treatments will be applied, with remeasurements taken annually. The results of soil and foliar analysis data for the 1968 installation will be analyzed and a report prepared.

ACKNOWLEDGEMENT

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