AN ABSTRACT OF THE THESIS OF

Elizabeth C. Cole for the degree of Master of Science

in Forest Science presented on April 23, 1984.

Title: Fifth-Year Growth Responses of Douglas-fir to Crowding and Other Competition

Abstract approved: Signature redacted for privacy.
Dr. Michael Newton

This thesis examines the competitive aspects of Douglas-fir trees growing with two commonly associated competitors--red alder and grass--at varying densities. Two Nelder plots in three different environments in the Oregon Coast Range were studied. The sites represented the warm, dry climate of the Willamette Valley; the warm, moist climate of the valleys of the mid-range; and the cool, moist climate found along the fog belt a few miles from the Pacific Ocean. Plots ranged in spacing from 300 to 15250 cm^2/tree and consisted of six "pie-shaped" treatments. The plots had been previously planted in the spring of 1978 with 2-0 bare root Douglas-fir nursery stock. Two sections were interplanted with red alder, and two sections

were broadcast seeded with grass the following year.

Measurements indicate that Douglas-fir growth is inhibited by red alder and grass competition as well as competition from other Douglas-fir. Grass competition is severe only during the initial years of the plantation, while red alder competition becomes more pronounced with time. Growth is a function of density, competitor type, and site, and significant interactions occur among the three.

Leaf area per tree of Douglas-fir under competition can be predicted by leaf weight, stand density, and competitor type. The formation of shade needles in response to density and competitor type increases the leaf area:leaf weight ratio. Growth efficiency (stemwood volume production/unit of leaf area) is not highest for the most vigorous trees. On a per hectare basis, high productivity is correlated with high leaf area index, but the relation is reversed on a per tree basis.

Fifth-Year Growth Responses of Douglas-fir to Crowding and Other Competition

by

Elizabeth C. Cole

A THESIS

submitted to

Oregon State University

in partial fulfillment of
the requirements for the
degree of

Master of Science

Completed April 23, 1984

Commencement June 1984

APPROVED:

Signature redacted for privacy.

Professor of Forest Science in charge of major

Signature redacted for privacy.

Head of Department of Forest Science

Signature redacted for privacy.

Dean of Graduate School

Date thesis is presented April 23, 1984

Thesis typed by Elizabeth C. Cole

ACKNOWLEDGEMENTS

Writing this thesis has been a sometimes exhilarating, sometimes depressing task. The experience has brought frustrations as well as rewards. Fortunately, I've not had to bear them alone.

First, I'd like to thank those who provided assistance and/or financial support. Starker Forests, Publishers Paper, and OSU Foundation have graciously provided the land for the research. Weyerhauser Corporation and the Bureau of Land Management have supplied money for portions of the research. Dr. Kermit Cromack, Jr., Oregon State University, provided funds for the soil analyses. The Plant Analysis Lab, OSU, gave assistance with the foliage digestions for the nutrient analyses. Although most of the field work was completed by myself, Dan Binkley provided help with the soil sampling and also with the anaerobic incubations. Jeff Sawyer operated the chain saw efficiently during the "great tree harvest," and he quickly learned to balance trees on the scale, even during wind storms.

The members of my committee, Drs. David Hibbs, Scott Overton, Jim Boyle, and Mike Newton, and Dr. John Tappeiner undertook the monumental task of reviewing my thesis, and I'd like to thank them for their comments and suggestions. A special thanks goes to my major professor, Mike Newton, who offered inputs, insights, and support throughout this project and who was always more concerned with keeping my body and soul intact than with meeting deadlines. Both he and his wife Jane took me into their family and made me feel at home.

Along with financial support and editorial comments comes moral support. I'd like to express my gratitude to my "long-distance" friends and to my friends at Sunflower House who put up with endless accounts of revengeful computers, long days, obnoxious trees, Oregon weather, etc. Their support and friendship have been invaluable.

Finally, I'd like to express my appreciation, gratitude, and undying love for my parents for their love and support through the years. I also thank them for not protesting when their city-raised daughter decided to move West and become a forester. No words can express my feelings of love for them.

TABLE OF CONTENTS

LIST OF FIGURES IN TEXT

LIST OF TABLES IN THE TEXT

LIST OF FIGURES IN THE APPENDICES

LIST OF TABLES IN THE APPENDICES

FIFTH-YEAR GROWTH RESPONSES OF DOUGLAS-FIR TO CROWDING AND OTHER COMPETITION

INTRODUCTION

In the Pacific Northwest, Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) is the primary timber species. Most Douglas-fir plantations are large-scale silvicultural operations which incorporate the concepts of competition into management principles. The lack of specific information about how Douglas-fir responds to various aspects of competition has led to improper prescriptions, plantation failures, and expensive litigations. This work postulates that Douglas-fir responds in certain ways to inter- and intra-specific competitive stresses. Further, an understanding of these growth responses will aid in managing competing vegetation to meet management objectives.

This study is an autecological study of Douglas-fir in relation to competitor type and density. Fifth-year growth responses of Douglas-fir are examined in association with two competitors--red alder (*Alnus rubra* Bong.) and grass--to reveal differences among competitor types and densities. Descriptive models are developed to illustrate growth and competitive trends. Although analyses of yearly trends of Douglas-fir growth and the growth and development of the red alder trees would help gain insight into the growth responses, these concepts are beyond the scope of this study and will be the subject of future studies and publications.

Primary production is based on the supply of photosynthates. In this regard, the ability of trees to maintain effective leaf areas for photosynthesis is essential for high growth rates. This study emphasizes the role of foliage development, with respect to light penetration, on tree growth. The effects of competitor type and density in determining the leaf area of trees is examined.

BACKGROUND AND REVIEW

Plant Competition

In any environment, there are lower and perhaps upper limits on factors that an organism can withstand. By being present in the environment, an organism modifies it (Harper, 1977). As a plant increases in size, it changes a greater portion of the environment. The plant's survival and growth depend upon the resource availability in the surrounding environment. Availability is determined by both the gross supplies of resources and their allocation among the plant populations.

Grime (1979) described competition among plants as "the tendency of neighboring plants to utilize the same quantum of light, ion of mineral nutrient, molecule of water, or volume of space." The plant which has the greater capacity to utilize the resources would have the competitive advantage over the other plants (Grime, 1977). Since competition occurs when some resource is limiting (Lidicker, 1979), the plants which have not capitalized on the resource in necessary amounts are deleteriously affected. Differences in competitive ability may occur when environmental conditions or growth habits give one organism the competitive edge (Grime, 1979).

Since plants have the ability to modify the environment (Harper, 1977), the success of a plant depends upon its ability to maintain "control" of the site and the necessary resources for its survival and growth. This capacity has been classified as the "dominance potential" (Newton, 1973). A species with high dominance potential can control the composition of the community by pre-empting resources, thus insuring its survival. Other species have to adapt to these conditions or be eliminated from the community.

Both inter- and intra-specific competition occur within plant communities. Since two plants of the same species (and same relative size) will need resources that are more closely aligned than two plants of different species, intra-specific competition can be more severe than inter-specific competition. However, if another species is capable of making a resource unavailable or extremely limited, then inter-specific competition may be more important. Factors, such as the size of individuals, locations of competitors, stocking level, environmental conditions, and the limiting resource, determine the relative importance of inter- and intra-specific competition.

Competition is not easily quantified. Many complicating factors can alter experimental results. For instance, variations in sites can give different species the competitive advantage. The effects of inter- and intra-specific competition are difficult to isolate. Environmental conditions may be so severe that competition is not the major determinant of survival and growth. Plants are also actively growing in two spheres--the aboveground and below-ground systems. Interactions between systems are difficult to quantify due to the inaccessibility of the root system. Another factor causing interpretive problems is the long-term effect of competition on perennials. The consequences of competition may not be apparent immediately nor distinguishable from other growth processes (Grime, 1979).

Growth and Density

Many experiments have compared the growth of trees at different densities (Bramble, Cope, and Chisman, 1949; Byrnes and Bramble, 1955; Eversole, 1955; Bennett, 1960; Bennett, 1963; Collins, 1967; Boyer, 1968; Curtis and Reukema, 1970; Reukema, 1970; van den Driessche, 1971; Harms and Langdon, 1976; Belanger and Pepper, 1978; Reukema, 1979;

Zedaker, 1981; Harrington and Reukema, 1983). These studies have examined a variety of species for different time intervals. From them, several conclusions can be reached. Summaries of the findings of some of the studies are shown in Table 1.

(1) Initial spacing strongly affects height growth, diameter, and biomass of trees (Bramble, Cope, and Chisman, 1949; Collins, 1967; Curtis and Reukema, 1970; Reukema, 1970; Harms and Langdon, 1976; Reukema, 1979; Harrington and Reukema, 1983). The intensity of effects varies with species and site. Bennett (1963) reports that Eastern white pine cordwood yields were not influenced by density as much as slash, red, loblolly, and longleaf pine yields were. He also found that significant site-density interactions occurred.

(2) Basal area per hectare (per acre) and volume per hectare (per acre) are highest at the closest spacings during the early years (Reukema, 1970; Harms and Langdon, 1976; Harrington and Reukema, 1983). After 25 years, basal area/acre and volume/acre of red pine were no longer highest at the closest spacings (Bramble, Cope, and Chisman, 1949). By 30 years, the cord production/acre was greatest at the lowest spacings (Byrnes and Bramble, 1955).

TABLE 1. SUMMARY OF PAST RESULTS FROM SELECTED DENSITY STUDIES.

SPECIES	TIME INTERVAL	DENSITY	EFFECT				SOURCE
Pinus resinosa Ait.	11 years		aver. DBH (in.)	aver. Hgt. (ft.)	basal /acre (ft^2)	vol./ acre (ft^3)	Bramble, Cope, and Chisman,
		5'X5'	2.25	12.8	7.2	521.5	1949;
		6'X6'	2.59	13.2	6.5	514.6	Byrnes and
		6'X8'	2.49	12.5	4.4	396.6	Bramble,
		10'X10'	3.01	13.7	4.0	246.6	1955
	30 years		aver. DBH (in.)	aver. Hgt. (ft.)	total vol./ acre (ft^3)	vol./ acre (ft^3) trees 7"+ DBH	
		5'X5'	5.08	36.9	3628	467	
		6'X6'	5.66	37.7	3899	646	
		6'X8'	6.40	40.9	3691	1445	
		10'X10'	8.10	42.3	3357	3128	

(TABLE 1 continued)

SPECIES	TIME INTERVAL	DENSITY	EFFECT		SOURCE
Pinus palustris L.	45- to 60-year old trees	trees/acre	annual growth/1000 lbs. foliage		Boyer, 1968
			Basal area (ft^2)	stemwood vol. (ft^3)	
		9	0.49	14.6	
		18	0.48	14.4	
		26	0.43	12.5	
		36	0.43	12.7	
		47	0.40	11.7	
Pinus taeda L.	14 years	trees/hectare	stand diameter (cm)		Harms and Langdon, 1976
		2500	11.4		
		4000	6.6		

(TABLE 1 continued)

SPECIES	TIME INTERVAL	DENSITY	EFFECT			SOURCE
Pinus strobus L.	20 years		volume (ft^3)			Bennett, 1963
		6'X6'	3094			
		12'X12'	2831			
Pinus elliottii Engelm.	7 years		annual diameter growth (in.)	average height (ft.)	average diameter (in.)	Bennett, 1960
		6'X6'	0.42	20.6	3.39	
		8'X8'	0.58	21.0	4.07	
		15'X15'	0.78	20.4	4.74	
	14 years		cord production/acre			Collins, 1967
		10'X10'	16.8			
		6'X8' clusters	9.9			
		10'X10' unthinned	1.5			

(TABLE 1 continued)

SPECIES	TIME INTERVAL	DENSITY	EFFECT			SOURCE
Pinus	25 years	trees/	cords	periodic annual growth at 25 years		Bennett,
elliottii		acre		cords		1963
Engelm.		200	33.9	1.52		
(cont.)		600	51.3	1.84		
		1000	55.1	1.81		
Pseudotsuga	40 years		merch.	diam. 100	hgt. 100	Reukema,
menziesii			vol.	largest	largest	1970
(Mirb.)			(ft^3)	(in.)	(ft.)	
Franco		4'X4'	1500	7.3	57	
		12'X12'	4350	12.1	79	
				site index		Curtis and
		4'X4'		82		Reukema,
		5'X5'		77		1970
		6'X6'		86		
		8'X8'		98		
		10'X10'		119		
		12'X12'		120		

(TABLE 1 continued)

SPECIES	TIME INTERVAL	DENSITY	EFFECT			SOURCE
Pseudotsuga menziesii (cont.)	51 years		diam. 100 largest (in.)	hgt. 100 largest (ft.)	vol. 100 largest (ft^3)	Reukema, 1979
		4'X4'	7.8	59	850	
		12'X12'	13.6	95	3840	
			gross volume production (ft^3) over 24 years			
		4'X4'	2370			
		10'X10'	5130			
	3 years	cm^2/tree	height(cm)	diameter (cm)		Zedaker, 1981
		300	107	1.08		
		390	107	1.18		
		506	112	1.24		
		658	116	1.35		
		854	115	1.41		
		1110	116	1.50		

(TABLE 1 continued)

SPECIES	TIME INTERVAL	DENSITY	EFFECT		SOURCE
Pseudotsuga		cm^2/tree	height (cm)	diameter (cm)	
menziesii		1441	113	1.57	
(cont.)		1827	112	1.70	
		2432	108	1.69	
		3159	112	1.73	

(3) The yield of large products is greatest at the lowest densities. In a study at Wind River, Washington, Eversole (1955) found that Douglas-fir trees at wide spacings produced the greatest volume of large products. Bennett (1963) determined that only the wide spacings produced sawtimber at early ages for the six species he reviewed.

(4) Since density can affect height growth, site index curves need to be adjusted for density (Reukema, 1979). In 1967, Collins, based on his work with slash pine, suggested that site index curves should incorporate density. Curtis and Reukema (1970) showed that estimates of site index varied from 80 to 120, depending upon density. In their study of red pine, Bramble, Cope, and Chisman (1949) noticed that the average diameter and height of the trees at low densities exceeded those given by yield tables.

(5) Density effects become more pronounced with age. Bramble, Cope, and Chisman (1949) found that differences in height among densities did not occur until after sixteen years. In their studies of Douglas-fir, Reukema and his associates (Reukema, 1970; Curtis and Reukema, 1970; Reukema, 1979; Harrington and Reukema, 1983) state that differences

among all measurement parameters increase as the age of the trees increases. The higher growth rate of the trees at wide spacings compensates for low stocking, so that with time, the low densities are producing more growth/tree and growth/hectare than the higher densities.

Mohler, Marks, and Spreugel (1978) speculated that all stands start with a normal distribution of weight/tree. As time progresses, the exponential juvenile growth of trees skews the distribution to the left. They postulate that the maximum skewness occurs just prior to natural thinning. Competition, expressed through density, accelerates the development of the skewed distribution.

Leaf Area Relations

The ability of a tree to produce photosynthates is based upon several factors which operate through time--temperature, moisture, nutrients, light intensity, and the leaf area relations of the tree. The leaf area of a tree is influenced by the surrounding environment of both abiotic and biotic factors. The capacity of a tree to maintain or build up its crown is an expression of its potential for growth. For instance, van den Driessche (1968) found that although Douglas-fir seedlings had a higher net assimilation rate than Sitka spruce (*Picea sitchensis* (Bong.) Carr.) seedlings, the low leaf area of Douglas-fir and high leaf area of Sitka spruce enabled Sitka spruce to have a higher relative growth rate.

When examining leaf area relations in stands, maximum leaf area index may not coincide with maximum growth. With an increase in leaf area, growth efficiency (grams of wood produced/projected leaf area) and rate of biomass accumulation decrease (Newman, 1979; Waring, 1980; Schroeder, *et al*., 1982). Waring, Newman, and Bell (1981) found that increments of basal area and volume, and growth efficiency of Douglas-fir declined 88, 92, and 72 percent, respectively, as leaf area index increased from 3.6 to 12. Stand growth increased until leaf area index was approximately half the projected maximum, after which, stand growth leveled before decreasing. In young plantations, Douglas-fir stemwood production (Waring, 1980) and dry weight of *Populus* (Larson and Isebrands, 1972) continue to rise with stand leaf area.

Stand leaf area development is related to environmental conditions. Maximum accumulation of foliage has been recorded in cool, moist sites with high levels of standing biomass (Waring, *et al.*, 1978). Gholz, Fitz, and Waring (1976) postulated that high leaf area is supported by a temperature regime that allows for moderate respiration rates and net photosynthesis even during the dormant season.

Growth (leaf) efficiency has been defined as grams of wood produced/projected leaf area (Waring, 1983). This relationship varies by tree position within the stand and by site quality (Satoo, 1962; Makela, Kellomaki, and Hari, 1980). Waring (1983) reports that plants under less competition for light show higher values for growth efficiency. He postulated that shading decreases efficiency since photosynthetic efficiency declines and since stemwood production has a lower priority for photosynthate than growth of other tissues. Other studies have indicated that suppressed trees are generally more efficient than dominant trees in terms of photosynthate produced/unit of leaf area (Weetman and Harland, 1964; Kellomaki and Hari, 1980). The higher efficiency of suppressed trees may be due to proportionally increased respiration losses in stems and branches of dominant trees (Satoo, *et al.*, 1956). Suppressed trees tend to increase the component of current needles by losing older, less efficient needles (Kellomaki and Hari, 1980).

Both dry matter production and photosynthesis (on a tree basis) increase as light intensity increases (Brix, 1967). In order to capitalize on low light intensities, trees form "shade leaves" (Anderson, 1955). These leaves have lower compensation and saturation points for light than "sun leaves," thus enabling more efficient utilization of low light levels (Krueger and Ruth, 1969; Kellomaki and Hari, 1980).

The differences in morphology of shade and sun leaves (especially the development of a greater palisade layer in sun leaves) result in different leaf area/leaf weight ratios, with shade leaves having the higher ratio (Brix, 1967; Kira, Shinozaki, and Hozumi, 1969; Westoby, 1977; Del Rio and Berg, 1979; Kellomaki and Oker-blom, 1981; Smith, Waring, and Perry, 1981). The increase in leaf area ratio under low light conditions delays the mortality of suppressed trees (Kellomaki and Oker-blom, 1981). Kellomaki and Kanninen (1980) found that dry matter production/leaf area accelerated under shaded conditions. When light intensity decreased, height growth was favored at the expense of radial growth. The importance of crown maintenance may result in a greater allocation of resources for height growth (Makela, Kellomaki, and Hari, 1980).

Crown growth varies greatly within stands (Hall, 1965). The history of crown development is more important than crown size (Reukema, 1961). Generally, trees have a high percentage of young foliage. In Douglas-fir trees in British Colombia, Silver (1962) reported that 90 percent of the foliage was less than five years old, with current foliage being 28 percent of the total. Mitchell (1974) stated that new needles accounted for over 50 percent of the total needle population in open-grown Douglas-fir trees. In terms of photosynthate, younger needles account for a greater share of the production. Hamilton (1969) found that current-year needles produced 50 percent of the assimilates, and needles from the last two years produced 80 percent.

With the importance of leaf area to tree growth, different methods of estimating leaf area have been developed. One method incorporates the leaf area/leaf weight ratio. Leaf weight is estimated, then an appropriate leaf area/leaf weight ratio is determined by either the glass-bead technique or by optical planimetry (Drew and Running, 1975). Even though the optical planimeter is best suited for hardwood species, coniferous species can be measured if a curvature correction factor is utilized (Barker, 1968; Krueger and Ruth, 1969; Drew and Running, 1975). Leaf weight can be measured directly in young trees by treating trees in cacodylic acid to remove the foliage (Emmingham, 1974).

Another method for estimating leaf area utilizes the relationship between leaf area and sapwood basal area (Grier and Waring, 1974; Waring, *et al.*, 1977). This method is based upon the hypothesis that a given unit of leaf area is served by a continuation of conducting tissue of cross-sectional area (pipe model theory) (Waring, Schroeder, and Oren, 1982). However, this relationship varies with age, density, and at different times of the year (Whitehead, 1978), so that individual correlations have to be determined.

EXPERIMENTAL PROCEDURES

Objectives

This study is part of an on-going research project that examines the resource factors that limit conifer growth in forests of the Oregon Coast Range. The overall objectives for the study include--

1. To describe in quantitative terms the ability of young Douglas-fir trees to utilize unoccupied site resources;
2. To determine the effects of density-induced stress on Douglas-fir growth and morphology;
3. To describe the specific effects of competing vegetation on the functional environment and subsequently the growth and development of young Douglas-fir;
4. To evaluate the specific importance of moisture and light competition in the growth of Douglas-fir over a range of conditions characteristic of planting sites in the Oregon Coast Range (Zedaker, 1981).

The specific objectives of this portion of the study include--

1. To determine the effects of inter- and intra-specific competition on the growth of

Douglas-fir at varying densities;

2. To determine the leaf area relations of young Douglas-fir plantations as affected by competitor type and density;
3. To determine the interaction between density of Douglas-fir stands and responses to understory herbaceous and dominant woody competitors;
4. To develop preliminary regression models describing the relationships and interactions among competitor types and densities.

Sites

Three sites (Figure 1) were selected for the study to represent a variety of conditions found in the Oregon Coast Range. The first site represents the warm, dry summer climate of the Willamette Valley. The mid-range site is indicative of the warm, moist summer climate found in the valleys of the mid-range. The third site is characteristic of the cool, moist climate found within the fog belt a few miles from the Pacific Ocean. All sites are below 200 meters in elevation. The study sites are located on Oregon State University Foundation, Starker Forests, and Publishers Paper land, respectively. Complete site

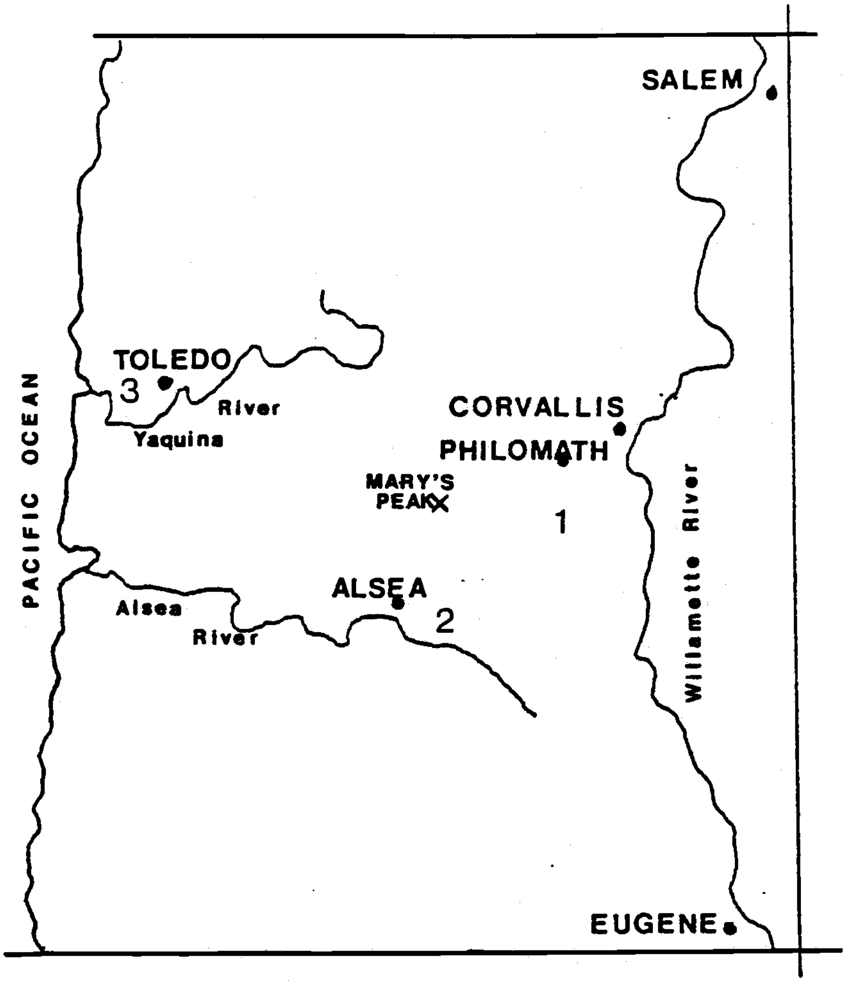

FIGURE 1. MAP OF CENTRAL WESTERN OREGON SHOWING LOCATION OF STUDY SITES.
1=Valley Site
2=Mid-Range Site
3=Coast Site
(from Zedaker, 1981)

descriptions can be found in Zedaker (1981).

Plot Layout and Treatments

Four Nelder (type 1a) plots (Nelder, 1962) were established on each site, for a total of twelve plots. To study the various densities, areas per tree ranged from 300 cm^2 to 15250 cm^2, representing a 30 percent increase in space per tree per arc. (See Figure 2.) Rectangularity of spacing was maintained at one. Plots consisted of 48 spokes and 18 arcs, for a total of 864 planting spots per plot. To reduce edge effect, the inner and outer arcs were not included in the measurements.

Each plot was divided into six "pie-shaped slices" and assigned one of three treatments. The treatments include--

1. Douglas-fir trees were planted in all spokes, and understory weeds were controlled throughout the experiment (Douglas-fir Only);
2. Douglas-fir trees were planted in all spokes, and grass was seeded in after one year of complete weed control (Douglas-fir/ Grass);
3. Douglas-fir and red alder trees were interplanted in alternating spokes, and understory

NELDER DESIGN

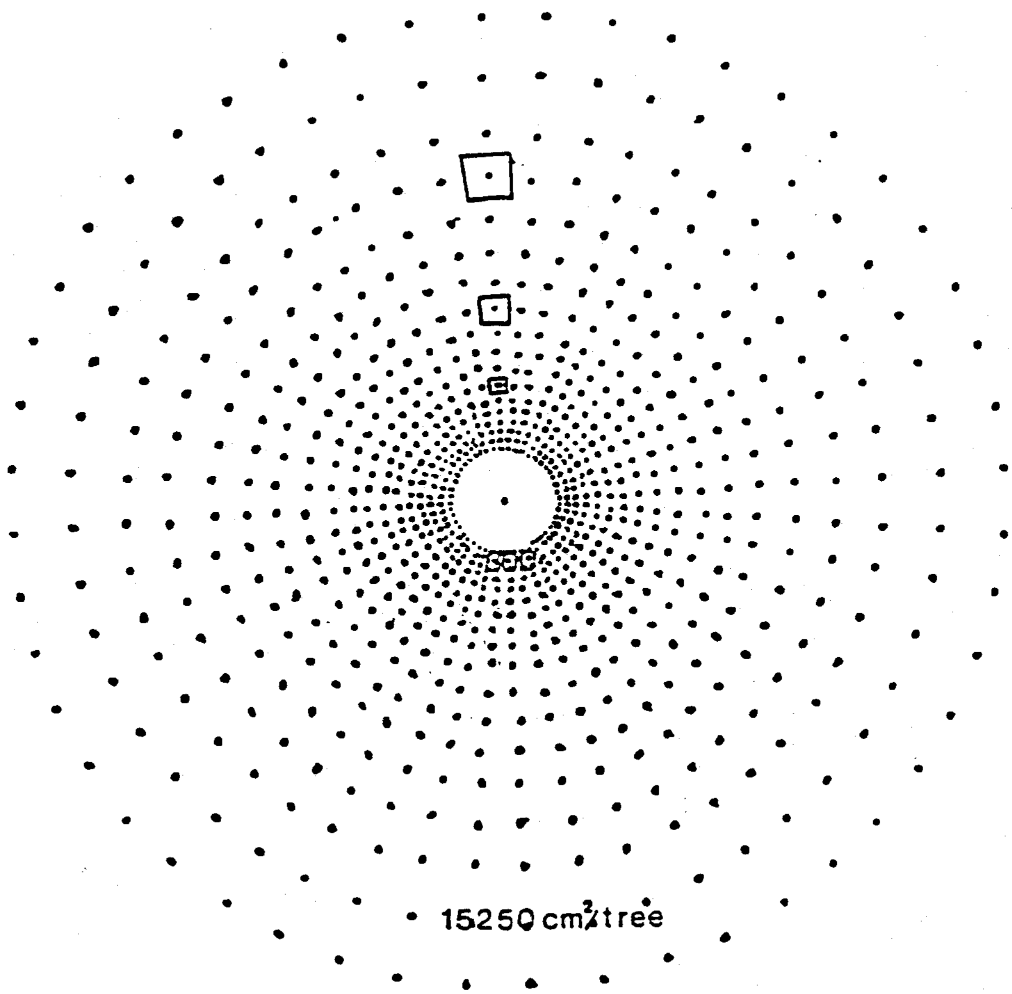

FIGURE 2. DIAGRAM OF NELDER DESIGN, consisting of 48 spokes and 18 arcs with a rectangularity of one. Densities from arcs 2 to 17 range from 300 to 15250 cm^2/tree (from Zedaker, 1981).

weed control occurred throughout the experiment (Douglas-fir/Red Alder). (See Figure 3.) The treatments were randomly assigned so that no two adjacent "pie slices" would have the same treatment.

In March 1978, the plots were planted with 2-0 bare root Douglas-fir nursery seedlings. Wild, one-year-old red alder seedlings were transplanted from local areas to the study sites. The grass seeded was a mixture of perennial ryegrass (Elymus spp.) and bentgrass (Agrostis tenuis L.).

Understory weed control was maintained by applications of glyphosate (1.5% Roundup© by volume) mixed with either simazine (1 cup simazine 90% dry flowable/4 gallons water) or 2,4-D (1% by volume) in early spring and summer. Weeds were spot sprayed so that no injury was sustained by the conifers or red alder.

Density was maintained by replacing mortality in the spring of the first two years of the experiment. Mortality was replaced by trees growing at approximately the same densities on each site. Douglas-fir mortality in the first year was 3.0 percent at the valley site, 1.0 percent at the mid-range site, and 0.3 percent at the coast site

EXAMPLE OF 'TREATMENT' LAYOUT

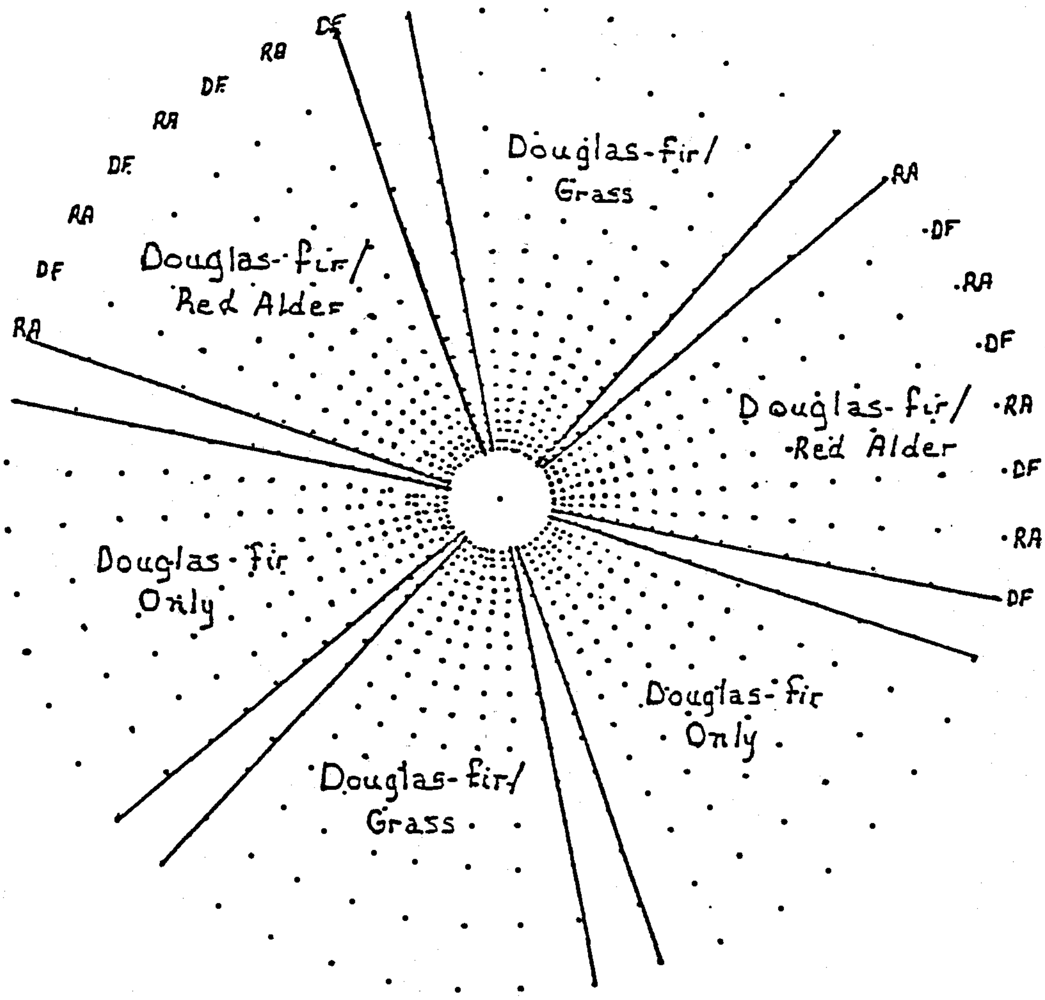

FIGURE 3. EXAMPLE OF TREATMENT LAYOUT FOR NELDER DESIGN. Each "pie slice" consists of 8 spokes, with 2 being border spokes. Treatments are repeated twice within each plot.

(Zedaker, 1981). First-year mortality of red alder was approximately 10 percent for all sites. However, a late frost topkilled most of the alder at the mid-range site, and these were replaced. Subsequently, the alder at the mid-range site are one growing season behind the Douglas-fir. Mortality of both species was less than 0.5 percent in year two. Mortality that was replaced after the 1979 growing season was not included in the measurements. After 1980, mortality was no longer replaced.

Small mammals were trapped where tunneling was observed the first year. Protection against damage by deer and elk was maintained by a single-wire electric fence surrounding and penetrating the plots.

Two problems occurred with maintenance of the plots, and these influence the results. First, grass establishment at the coast site was slow, requiring reseeding in the spring and fall of 1979. Therefore, the Douglas-fir/Grass trees were without the presence of grass for one extra growing season. Second, a problem arose from deer and elk browsing. Although the electric fencing was maintained for the first few years, deer and elk browsed and girdled the alder trees along the outer edges of the plots at both the valley and mid-range sites. Most of the browsed trees were subjected to repeated browsings or rubbing by antlers, and these trees died. The results of this are that the Douglas-fir/Red Alder trees at the outer edges are growing at lower densities than their analogues in the Douglas-fir Only and Douglas-fir/Grass treatments and with less than the intended influence of red alder.

Experimental Design

The original design was a split-strip plot with nested replications within sites and within plots. However, sections of the plots were destructively sampled in 1980, so that replications are no longer repeated within plots. Due to limitations of manpower and funding, only two of the four remaining "half-plots" were used for the fifth-year results.

The data were analyzed by analysis of variance and multiple regression techniques. The percentage increase of spacing by arc constrains the regression analysis. The "best-fit" models are generally logarithmic when density is the independent variable. With the ANOVA's, the assumption of homogeneity of variance was not met (Bartlett's test), but this was not determined to be a problem. The ANOVA procedure is not invalidated with heterogeneity of variance (Snedecor and Cochran, 1980).

When these plots were established by Zedaker and Newton in 1978, they decided to alternate spokes of Douglas-fir with red alder. This leads to a change in geometry in the Douglas-fir plantation which is necessary to provide for a test of inter-specific competition among trees. The rectangularity of all trees (Douglas-fir and red alder) is 1 X 1, but that of the Douglas-fir trees is 1 X 2. To maintain the Douglas-fir trees on a 1 X 1 spacing as in the other treaments, red alder would have to have been planted in extra spokes, leading to a double total population of trees. This difficulty in interpretation of results will be discussed in the Results and the Discussion sections as to the utility and limitations of the findings, particularly on stand-level interpretations.

More complete descriptions of the design and the ensuing problems can be found in Nelder (1962) and Zedaker (1981), who described this particular study.

Data Collection

Two types of data were collected during the fifth year of the experiment:

1. nonintensive sampling of environmental parameters and
2. intensive sampling of growth parameters.

The nonintensive sampling consisted of measurements in four areas (1) foliage and soil nutrients, (2) predawn moisture stress, (3) foliage moisture diffusion, and (4) light levels within the canopy. Foliage and soil samples were collected in March prior to the fifth growing season. Branches from the upper crown of Douglas-fir trees were cut in each treatment at both high and low densities. Two samples, representing three trees each, were collected, for a total of four samples from each treatment. Samples were analyzed for nitrogen and phosphorus by micro-kjedahl techniques (Lavender, 1970). Soil was collected from the upper 15 cm of soil on each plot. Two samples were taken in the Douglas-fir Only and Douglas-fir/Grass treatments, and four, two each at high and low densities, in the Douglas-fir/Red Alder treatment. Analyses were performed for bulk density, pH, available nitrogen (by anaerobic incubation), and total nitrogen (by micro-kjedahl) (Keeney and Bremner, 1966; Allen, et al., 1974).

Throughout July, August, and the first part of September, predawn moisture stress, stomatal resistance, and light measurements were collected. Each treatment was divided into three density categories:

1. High density (ranging from 300 cm^2/tree to 1110 cm^2/tree);
2. Medium density (from 1441 cm^2/tree to 4107 cm^2/tree); and
3. Low density (from 5339 cm^2/tree to 15250 cm^2/tree).

Three trees in each of the three densities were selected at random for predawn moisture stress and porometry measurements. Predawn samples were collected from the upper crown of Douglas-fir trees, and the stress was measured by a Scholander-type pressure bomb (Waring and Cleary, 1967; Ritchie and Hinckley, 1975). Porometry samples were also from the upper crowns and were measured by a null-balance diffusion porometer (Beardsell, Jarvis, and Davidson, 1972). Due to lack of precision in the porometry measurements, the data collected have been disregarded for this paper.

Light measurements within the canopy were collected using ozalid photosensitive paper placed in petri dishes (Friend, 1961). These ozalid stacks were placed at two locations within each of the three density categories and at four canopy levels--0 cm, 75 cm, and 150 cm above the ground and at the top of the fifth whorl on dominant Douglas-fir trees. Samples were placed in the field before dawn and collected after dark. The samples were kept in the dark until they were developed in ammonia fumes (Friend, 1961) the following day. Calibrations to relate light penetration through the ozalid stacks to langleys were made twice during the season. Each time, ozalid stacks were set out at different time intervals and correlated with readings from a solar net radiometer (Fritschen, 1963; 1965). Since the curves developed did not differ significantly for the two runs, the data were pooled, and a single calibration curve developed (Figure 4).

At the end of the fifth growing season, each Douglas-fir sample tree was measured for diameter at 15 cm above ground, total height, and height at each node since planting. Trees were cut at the ground and weighed at the site. To determine dry weights, a subsample (one spoke per treatment per plot) was collected and treated with cacodylic acid

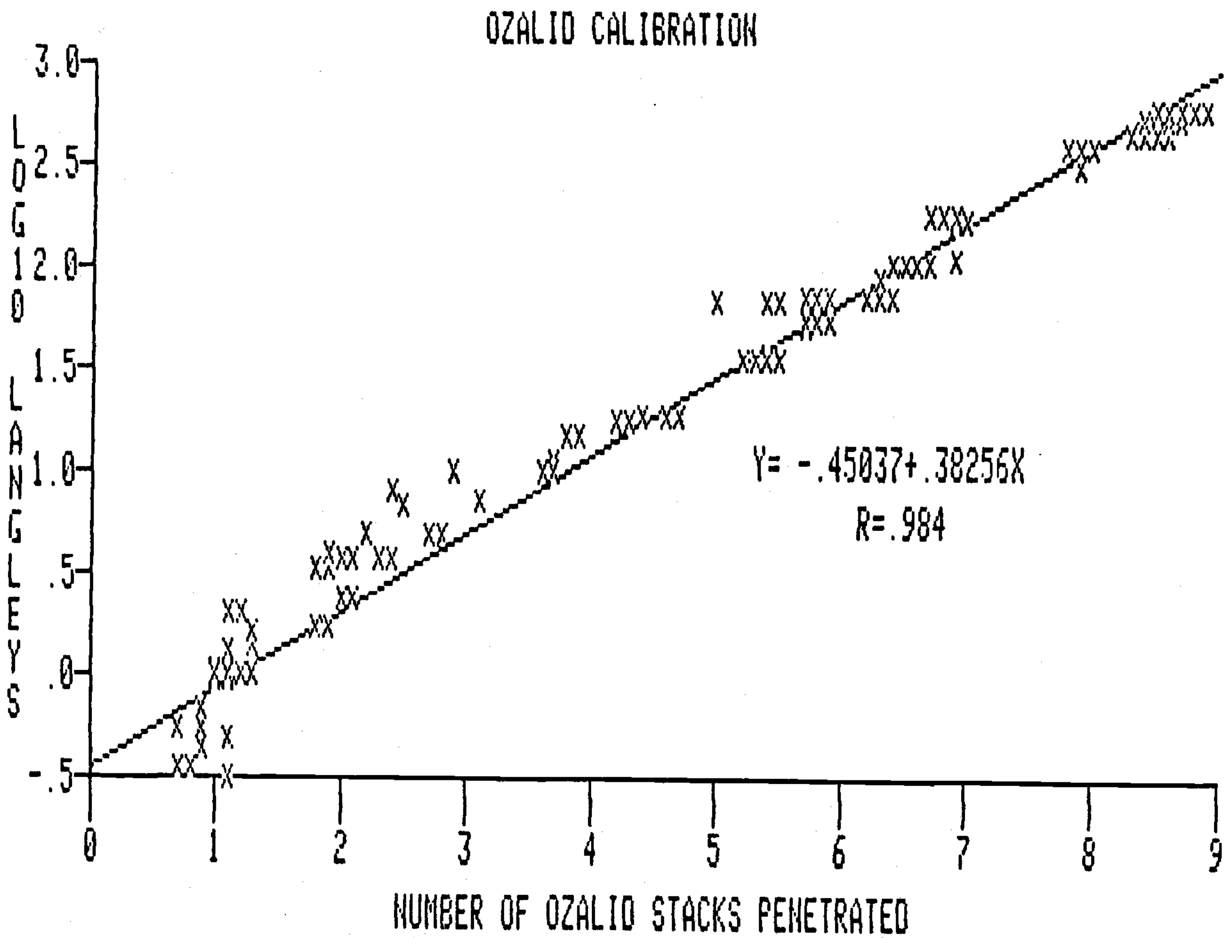

FIGURE 4. OZALID CALIBRATION CURVE RELATING NUMBER OF OZALID STACKS PENETRATED TO LANGLEYS.

to facilitate removal of foliage. These trees were taken to the Forest Research Lab, Oregon State University where they were separated into wood and foliage, dried in a 90°C oven, and re-weighed. Yearly diameter measurements were also made on these trees. Leaf area samples were collected from the trees used for the porometry sampling. These samples were kept in a cooler until leaf area could be determined by a Li-Cor optical planimeter (Drew and Running, 1975). To adjust for the shape of conifer needles, a curvature correction factor of 1.16 (Drew and Running, 1975) was used. After measuring, the samples were dried in a 90°C oven and weighed.

Curve-Fitting

From the subsamples, several equations were derived for estimation of growth parameters. Dry weight for all sample trees was estimated from the dry weight/fresh weight correlations developed from the subsample trees by utilizing linear regression. Wood weight equations were also derived from the subsample trees, using dry weight as the independent variable. Leaf weight was obtained by subtraction. From the leaf samples, a leaf area:leaf weight ratio was established. This ratio varies by stand density as well as competitor type. Competitor types were analyzed separately, and density was included as an independent variable as leaf weight*natural logarithm of spacing interaction. The "best fit" models were determined by multiple regression techniques. Leaf area per tree was estimated by using the leaf area equations and the estimates of leaf weight obtained by subtraction. Equations and error analyses can be found in Appendix A.

To determine basal area growth and stemwood volume production, fourth-year basal diameter measurements were taken from the subsample trees. Equations were derived relating 1981 basal diameter to 1982 basal diameter. Since field measurements for all sample trees were taken at 15 cm above ground, basal diameter was adjusted for taper to diameter at 15 cm. This ratio was used for both 1981 and 1982 measurements. Basal area growth was determined by subtraction. Equations are given in Appendix A.

Stemwood volume production was derived by projecting a cone with total height and diameter as the height and base. Growth was determined by subtracting the conical values for 1981 from those for 1982.

For most other equations involving growth parameters, the natural logarithm of spacing, spacing, and spacing-squared are the independent variables. The Nelder design suggests the use of a logarithmic relationship due to the constant percentage increase in space per arc. The log transformation can stabilize the variance if the true effects of the dependent variable vary proportionally to the independent variable (Snedecor and Cochran, 1980).

The quadratic (spacing-squared) and the spacing terms are needed to express the asymptotic relations found in most curves. They also allow for modifications of the relationship based on density-driven functions for which the logarithmic transformation is not entirely responsive. However, significant "lack of fit" may result if values are highly variable with density. Significant deviations from the model may occur where responses are highly variable at the high densities, but asymptotic at the low densities.

Curves were based on means at each spacing rather than all of the sample values. For analysis of growth trends, the means give a better indication of trajectories than the individual tree values, since the problem of unequal variances is eliminated. Each mean was calculated from one to twelve sample values. The number varied due to mortality and previous sampling in the plots. If the intercepts in the equations did not significantly differ from zero, the equations were forced through zero for the calculations. This increases the R-squared values, so coefficients of variation are included in the error analyses.

The "best-fit" equations were selected by examining the different runs of the equations. Those runs having small mean square errors, high R-squared values, small residuals, and a random distribution of residuals were chosen. To simplify the curve-fitting, only spacing, spacing-squared, and natural logarithm of spacing were used as independent variables. This results in significant "lack of fit" among certain growth parameters, since these variables are not always adequate to express the relationships.

Several of the growth parameters were examined on a per hectare basis. These values were adjusted for mortality by including both the number of trees and the total area available to the trees for growth in the calculations. The Douglas-fir/Red Alder trees were considered to be growing on the same space as allocated for the Douglas-fir Only and Douglas-fir/Grass trees. Since the red alder trees occupied half the spokes, this calculation doubles the per hectare values for the Douglas-fir/Red Alder trees.

The equations developed are not designed to be predictive in terms of estimating growth parameters. Instead, these curves illustrate differences and similarities in growth among competitor types and growth trends related to density. From these, the effects of inter- and intra-specific competition may be characterized.

RESULTS

Environmental Parameters

No significant differences in percent nitrogen in Douglas-fir foliage were found among competitor types (Table 2), but the Douglas-fir/Grass trees had significantly higher phosphorus concentrations (Table 3). The valley and mid-range sites had comparable nutrient values, while the coast site was significantly higher in nitrogen and lower in phosphorus, regardless of treatment. Nutrient concentrations in foliage at the high densities were significantly lower than those at the low densities, but total nutrient content of foliage per hectare was greater at the high densities. No values were in the range considered deficient for Douglas-fir foliage (Krueger, 1967; Lavender, 1970).

Soil nitrogen was not significantly different among competitor types (Table 4). Differences were significant among sites, with the highest values for total nitrogen and lowest values for available nitrogen occurring at the coast. Although levels of available nitrogen were comparable at the valley and mid-range sites, total nitrogen was significantly higher at the valley site. Bulk density of the

TABLE 2. NITROGEN LEVELS IN DOUGLAS-FIR FOLIAGE PRIOR TO THE FIFTH GROWING SEASON.

TREATMENT AND DENSITY	VALLEY		MID-RANGE		COAST	
	%N	SD	%N	SD	%N	SD[1]
Douglas-fir Only						
High	1.68	0.16	1.46	0.18	1.87	0.13
Low	1.77	0.21	1.73	0.15	2.19	0.26
Douglas-fir/Grass						
High	1.58	0.07	1.60	0.09	1.90	0.19
Low	1.77	0.17	1.76	0.12	2.05	0.26
Douglas-fir/Red Alder						
High	1.69	0.16	1.50	0.09	1.85	0.13
Low	1.90	0.10	1.73	0.08	2.21	0.29

[1] %N=percent nitrogen, SD=standard deviation

TABLE 3. PHOSPHORUS LEVELS IN DOUGLAS-FIR FOLIAGE PRIOR TO THE FIFTH GROWING SEASON.

TREATMENT AND DENSITY	VALLEY %P	VALLEY SD	MID-RANGE %P	MID-RANGE SD	COAST %P	COAST SD[1]
Douglas-fir Only						
High	0.160	0.019	0.163	0.012	0.129	0.010
Low	0.170	0.013	0.178	0.012	0.137	0.007
Douglas-fir/Grass						
High	0.170	0.013	0.175	0.018	0.137	0.016
Low	0.220	0.029	0.218	0.026	0.149	0.009
Douglas-fir/Red Alder						
High	0.149	0.010	0.159	0.018	0.128	0.010
Low	0.178	0.012	0.188	0.016	0.137	0.009

[1] %P=percent phosphorus, SD=standard deviation

TABLE 4. TOTAL AND AVAILABLE NITROGEN LEVELS IN SOILS PRIOR TO THE FIFTH GROWING SEASON
Values have been adjusted for bulk density.

	Total Nitrogen		Available Nitrogen	
	g/l	SD	mg/l	SD[1]
VALLEY SITE				
Douglas-fir Only	2.19	0.18	35.1	6.4
Douglas-fir/Grass	2.11	0.25	38.8	12.2
Douglas-fir/Red Alder				
High Density	2.12	0.20	38.8	15.4
Low Density	2.16	0.23	32.1	12.8
MID-RANGE SITE				
Douglas-fir Only	1.68	0.24	38.2	5.6
Douglas-fir/Grass	1.58	0.16	46.5	16.5
Douglas-fir/Red Alder				
High Density	1.64	0.22	41.2	6.3
Low Density	1.63	0.17	34.8	9.1
COAST SITE				
Douglas-fir Only	2.83	0.59	16.0	3.9
Douglas-fir/Grass	2.90	0.53	18.5	5.3
Douglas-fir/Red Alder				
High Density	3.13	0.61	21.4	7.8
Low Density	3.48	1.03	19.9	8.7

[1] g/l=grams/liter, mg/l=milligrams/liter, SD=standard deviation

soils was significantly different among sites. The mid-range site had the highest values, while the coast site had the lowest (Table 5). No differences in pH levels were found among sites or competitor types (Table 5).

Predawn moisture stress measurements indicate that moisture stresses were similar among competitor types and densities on each site at the beginning of the season. These later deviated based upon density and competitor type (Figures 5a, 5b, and 5c). Higher densities had higher moisture stress values, with the highest readings in the Douglas-fir/Red Alder high densities. The lowest values were in the Douglas-fir Only low densities. On the coast, stress levels were much lower than at the other sites, and moisture did not appear to be a limiting factor for growth until late in the season. At the valley and mid-range sites, stress readings were high enough to cause limitations on photosynthesis (Unterscheutz, et al., 1974).

Light measurements indicate a decrease in available light through the canopy. Readings in the upper portion of the conifer canopy were lower in the Douglas-fir/Red Alder sections than in other treatments. As the season progressed, higher light

TABLE 5. BULK DENSITY AND pH OF SOILS PRIOR TO FIFTH GROWING SEASON.

	Bulk Density		pH	
	kg/l	SD		SD[1]
VALLEY SITE				
Douglas-fir Only	0.825	0.054	4.1	0.45
Douglas-fir/Grass	0.777	0.094	4.4	0.26
Douglas-fir/Red Alder				
High Density	0.758	0.054	4.0	0.37
Low Density	0.807	0.061	4.1	0.35
MID-RANGE SITE				
Douglas-fir Only	0.866	0.047	4.2	0.37
Douglas-fir/Grass	0.920	0.084	4.2	0.29
Douglas-fir/Red Alder				
High Density	0.851	0.101	4.3	0.39
Low Density	0.889	0.084	4.2	0.28
COAST SITE				
Douglas-fir Only	0.721	0.083	3.8	0.30
Douglas-fir/Grass	0.658	0.098	3.8	0.17
Douglas-fir/Red Alder				
High Density	0.586	0.100	3.9	0.33
Low Density	0.754	0.060	3.9	0.21

[1] kg/l=kilograms/liter, SD=standard deviation

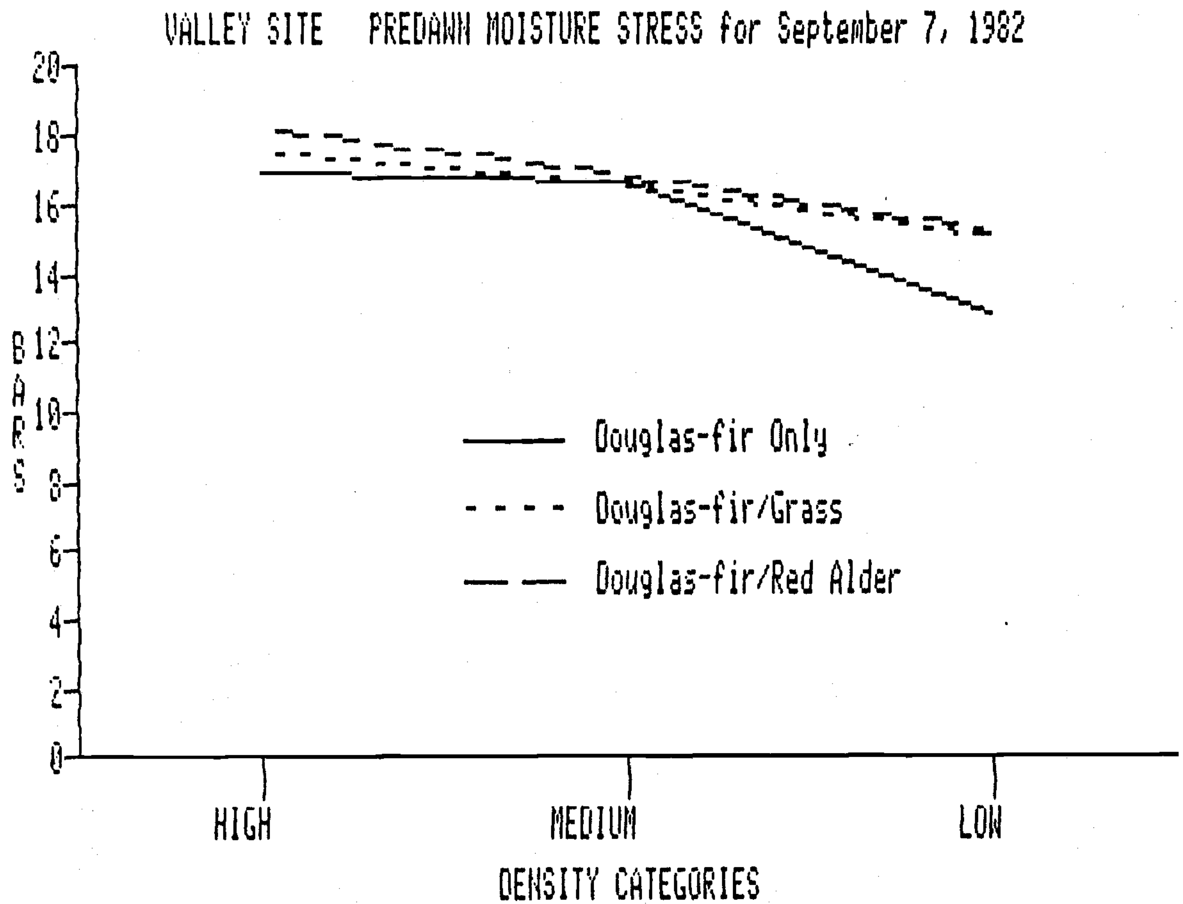

FIGURE 5a. PREDAWN MOISTURE STRESS READINGS FOR THE VALLEY SITE ON SEPTEMBER 7, 1982. Density categories are High (from 300 to 1110 cm^2/tree), Medium (from 1441 to 4107 cm^2/tree), and Low (5339 to 15250 cm^2/tree).

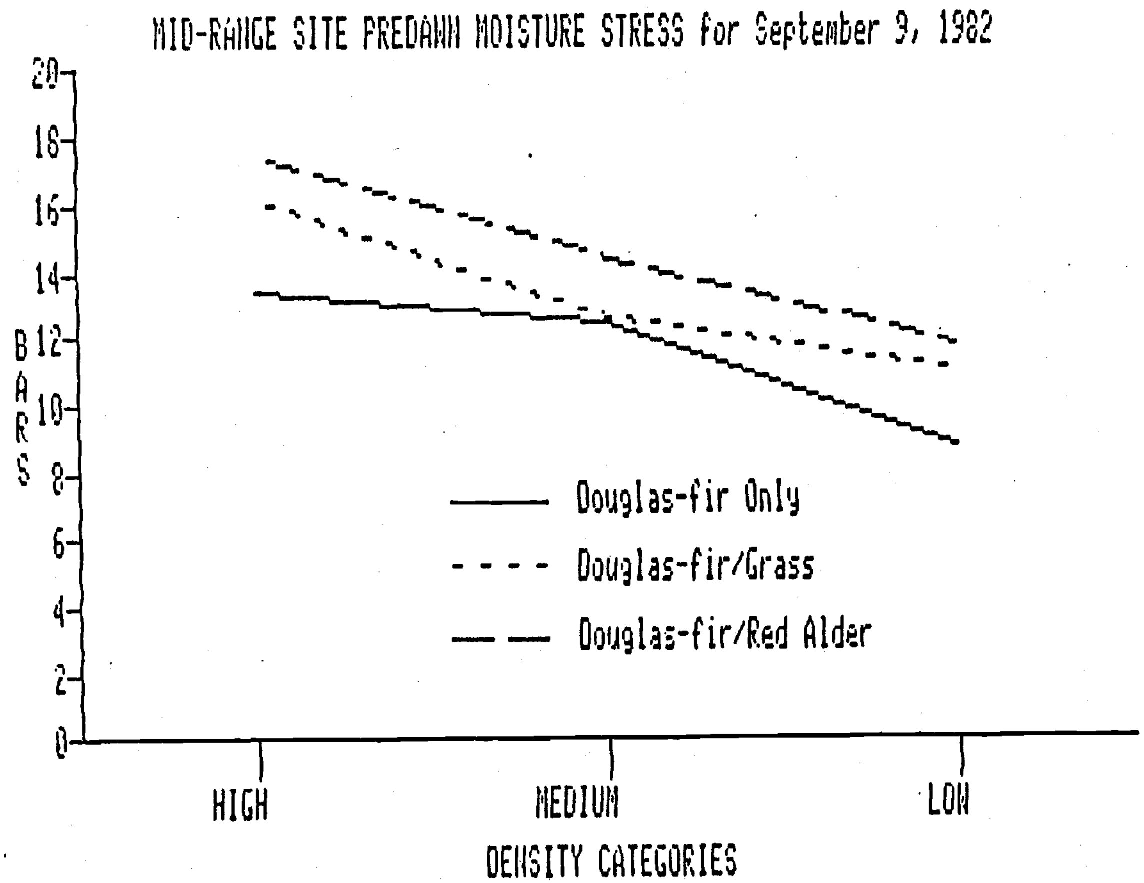

FIGURE 5b. PREDAWN MOISTURE STRESS READINGS FOR THE MID-RANGE SITE ON SEPTEMBER 9, 1982. Density categories are High (from 300 to 1110 cm^2/tree), Medium (from 1441 to 4107 cm^2/tree), and Low (from 5339 to 15250 cm^2/tree).

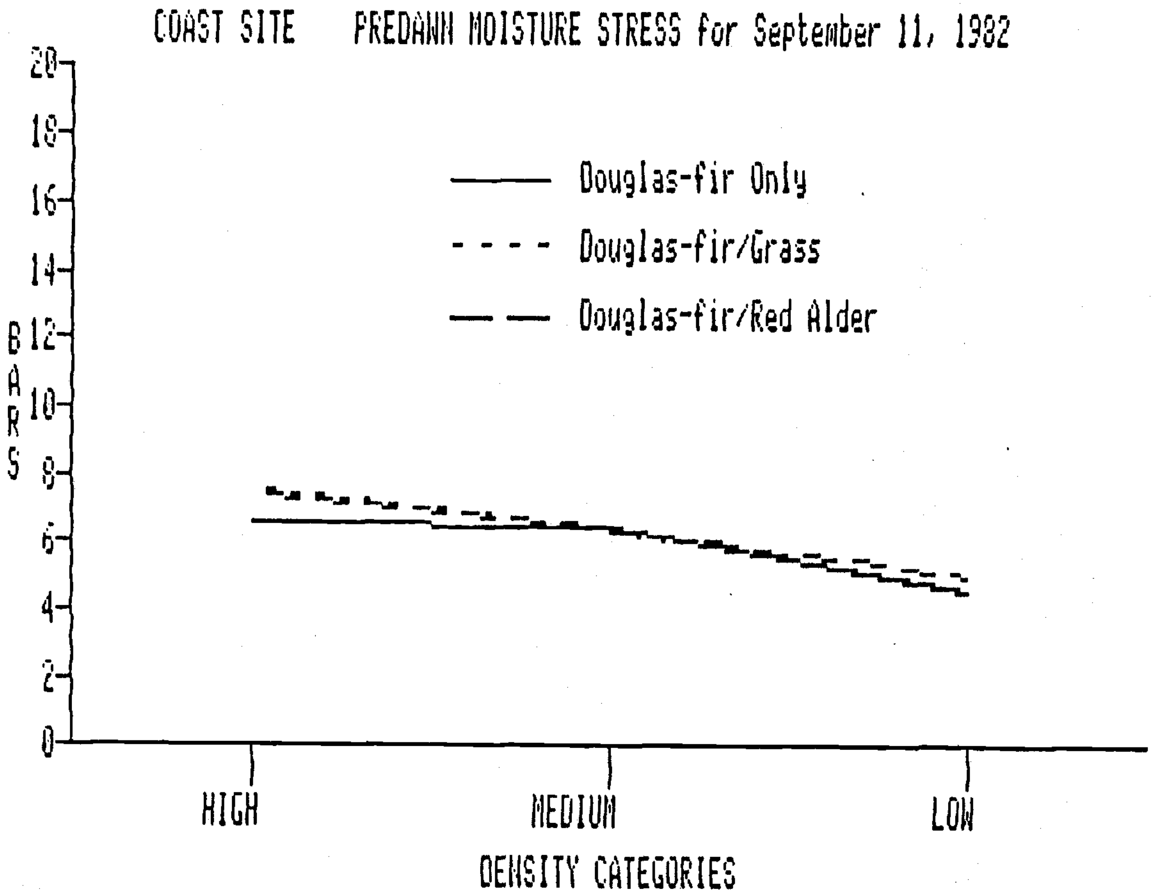

FIGURE 5c. PREDAWN MOISTURE STRESS READINGS FOR THE COAST SITE ON SEPTEMBER 11, 1982. Densities are High (from 300 to 1110 cm^2/tree), Medium (from 1441 to 4107 cm^2/tree), and Low (from 5339 to 15250 cm^2/tree).

readings (percent of light in the open) were found in the Douglas-fir/Red Alder section, due to the loss of inner canopy red alder leaves. Except at the coast site where values were similar, these levels were not higher than the readings in the Douglas-fir Only and Douglas-fir/Grass sections. Absolute values of light decreased in all treatments and at all sites through the season. The lowest light levels were generally found at 0 cm in the Douglas-fir Only sections. Comparisons among sites are not valid since measurements occurred on days when weather conditions varied. Examples of light measurements at the valley site are presented in Figures 6a, 6b, and 6c. Examples from the mid-range and coast sites are in Appendix D, Figures D1 to D5.

In Appendix D, average values for the first and last sample dates are presented. Light values from the other sample dates fall within the range of these values, progressively decreasing from the beginning to the end of the season. Results will be presented more completely in a future publication.

Results of the environmental measurements are presented more completely in Appendices B, C, and D.

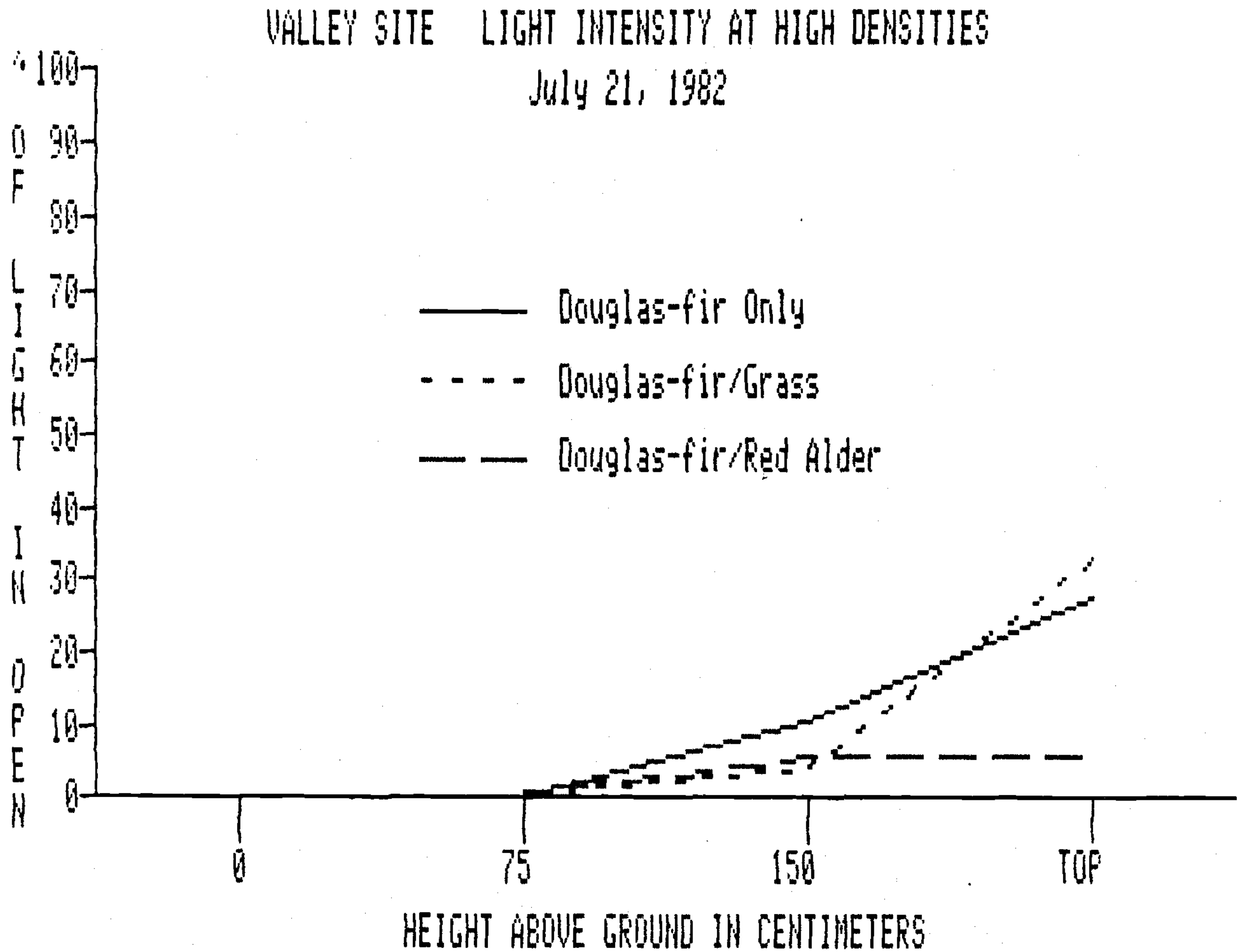

FIGURE 6a. PERCENT OF LIGHT IN THE OPEN FROM OZALID STACKS AT HIGH DENSITIES AT THE VALLEY SITE ON JULY 21, 1982.

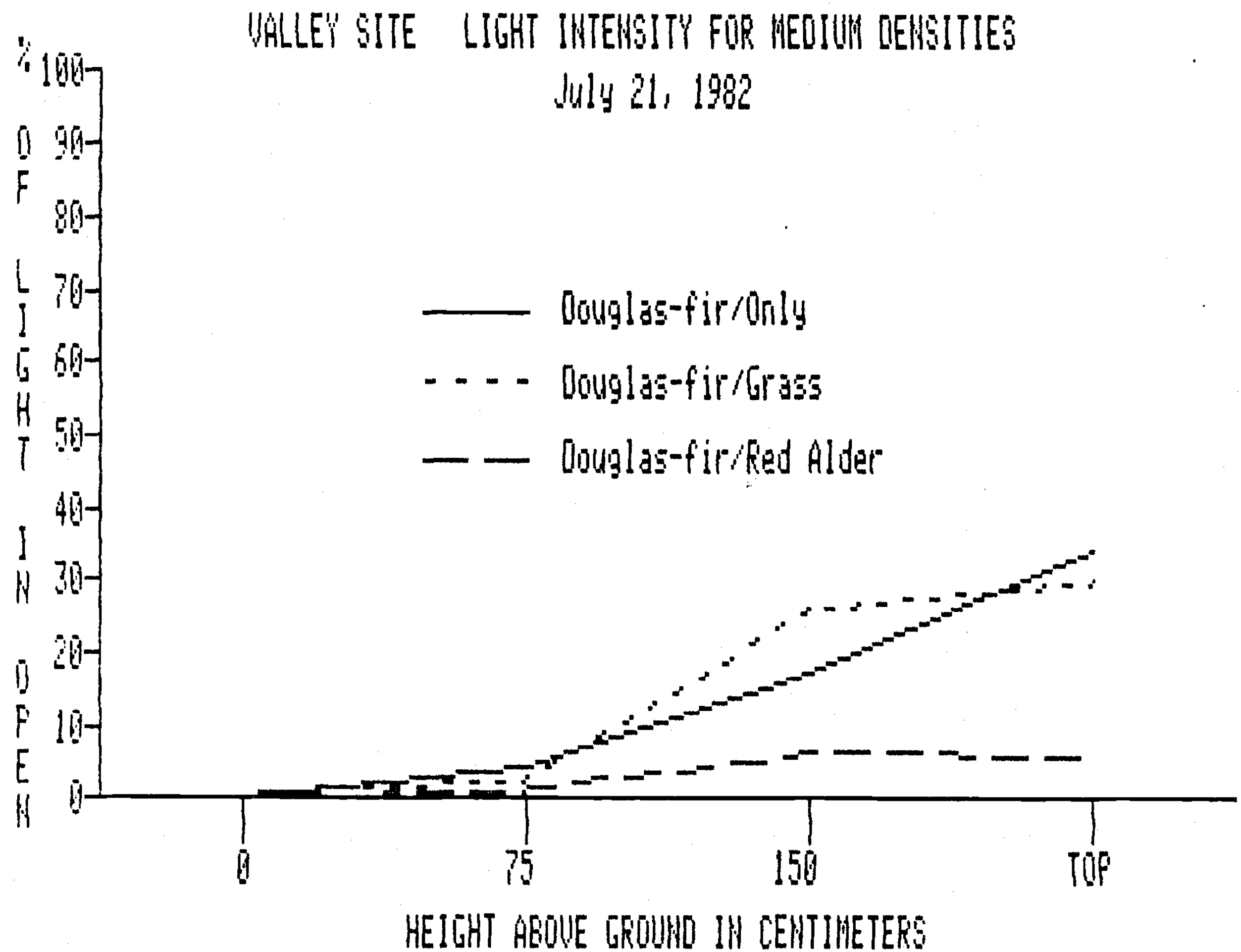

FIGURE 6b. PERCENT OF LIGHT IN THE OPEN FROM OZALID STACKS AT MEDIUM DENSITIES AT THE VALLEY SITE ON JULY 21, 1982.

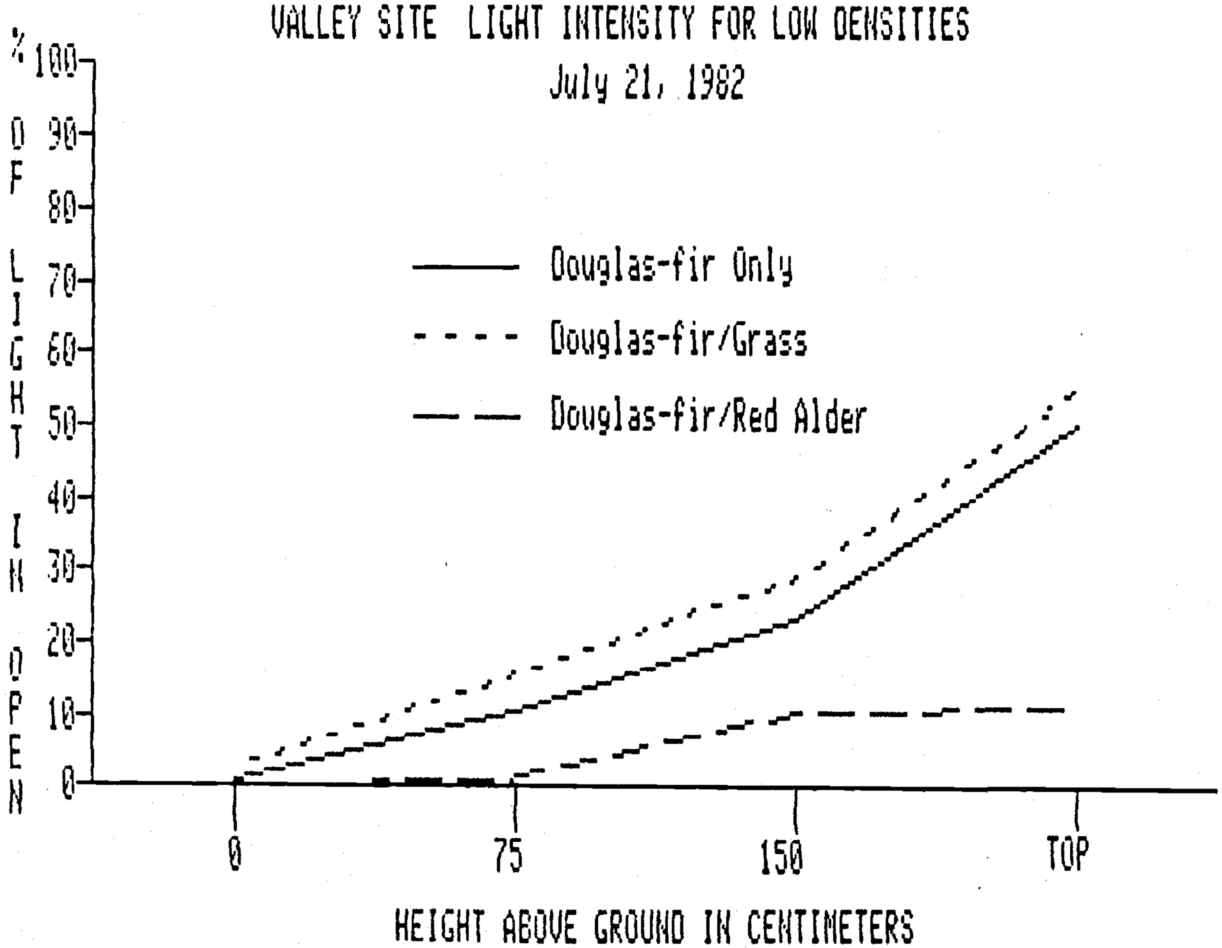

FIGURE 6c. PERCENT OF LIGHT IN THE OPEN FROM OZALID STACKS AT LOW DENSITIES AT THE VALLEY SITE ON JULY 21, 1982.

Growth Parameters

In this section, the growth trend results are discussed. For simplification, the coefficients and error analyses of the equations are presented in Appendix E. Mean values and the analyses of variance are in Appendix F.

When references are made to "significant" differences among the curves, the differences are based on comparisons among the means (F test) at the densities involved rather than tests among the curves. Since significance levels varied among the densities, significant differences refer to an alpha level of at least 0.05.

The figures presented in this section illustrate the growth of the Douglas-fir/Red Alder trees as if each red alder tree replaces a Douglas-fir tree in alternate spokes. This action doubles the area per Douglas-fir tree, if only Douglas-fir trees are considered in density calculations. Yields of Douglas-fir on a per hectare basis are overstated by a factor of two. The individual tree parameters are placed at half the actual density of Douglas-fir trees, but at the appropriate densities if the red alder trees are counted when estimating density. More mention of this will be made in the Discussion (Competitive Effects) section.

Total Height

At all sites, height varies with density, but the tallest trees do not occur at the lowest densities (Figures 7a, 7b, and 7c). Significant differences are found among competitors and densities, as well as competitor*density and site*competitor*density interactions. At the valley site, the Douglas-fir/Red Alder trees are shorter than the Douglas-fir Only trees except at the two lowest densities. Although there is little difference between the Douglas-fir/Grass and Douglas-fir Only curves at the high densities, the Douglas-fir/Grass trees are much shorter from the mid-densities to the lowest densities. The mid-range site has similar curves to the valley site, although the differences among the curves are not as pronounced. At the coast site, the Douglas-fir Only and Douglas-fir/Grass curves are almost identical. The Douglas-fir/Red Alder curve falls below both of those curves except at the highest densities, where there is suppression and mortality among the red alder trees.

Diameter at 15 cm

Diameter varies with density and competitor

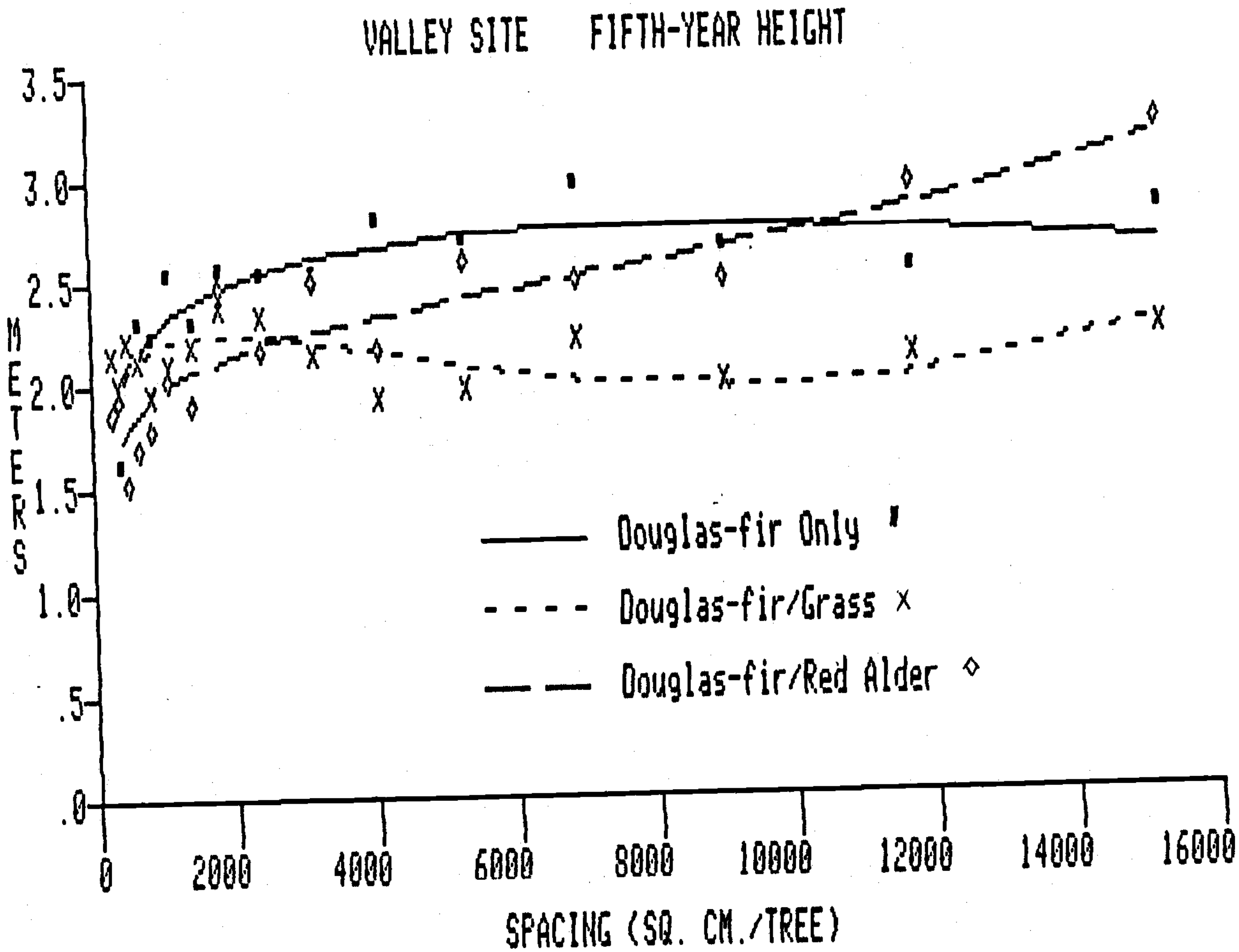

FIGURE 7a. FIFTH-YEAR TOTAL HEIGHT BY SPACING FOR THE VALLEY SITE. Symbols represent means at each spacing.

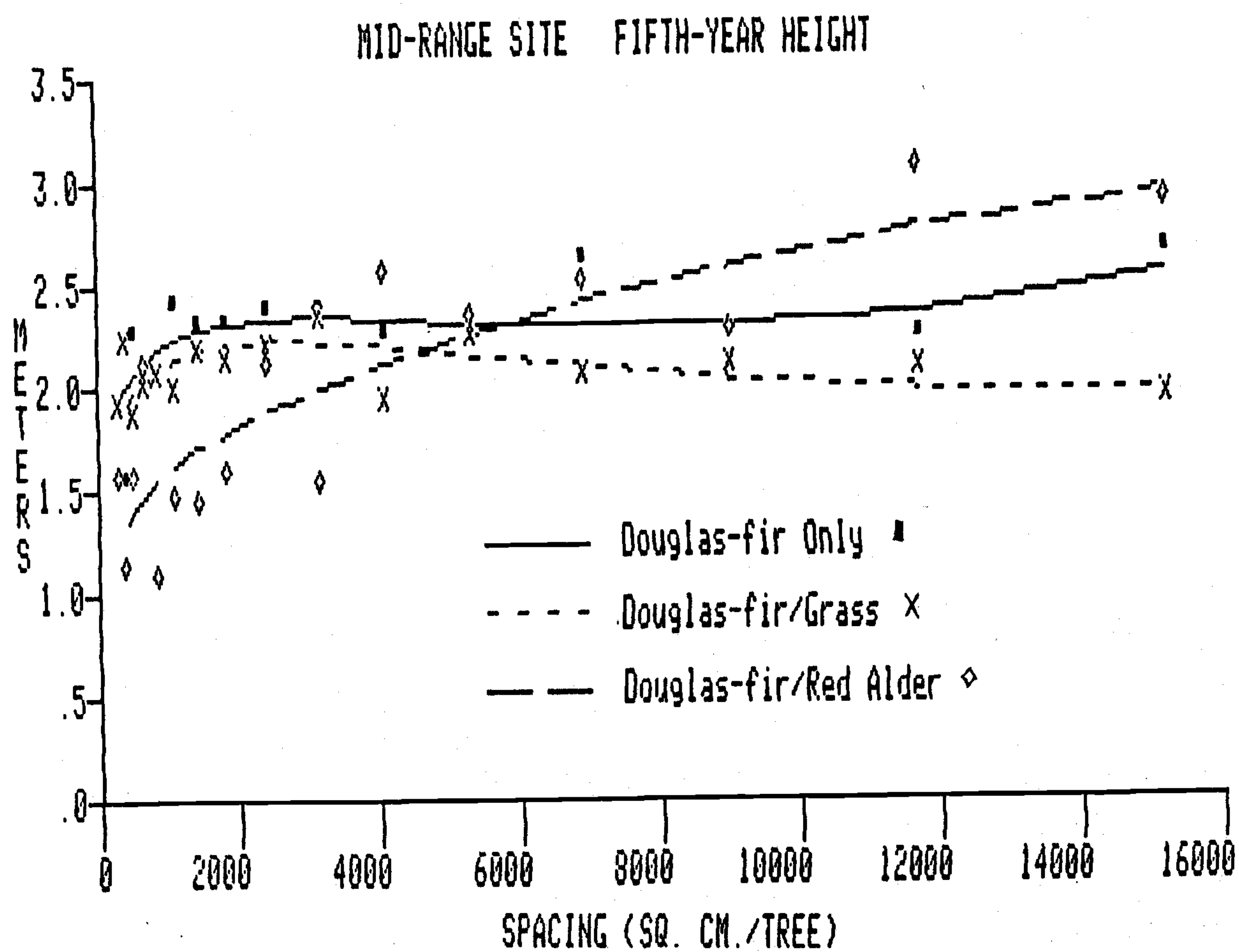

FIGURE 7b. FIFTH-YEAR TOTAL HEIGHT BY SPACING AT THE MID-RANGE SITE. Symbols represent means at each spacing.

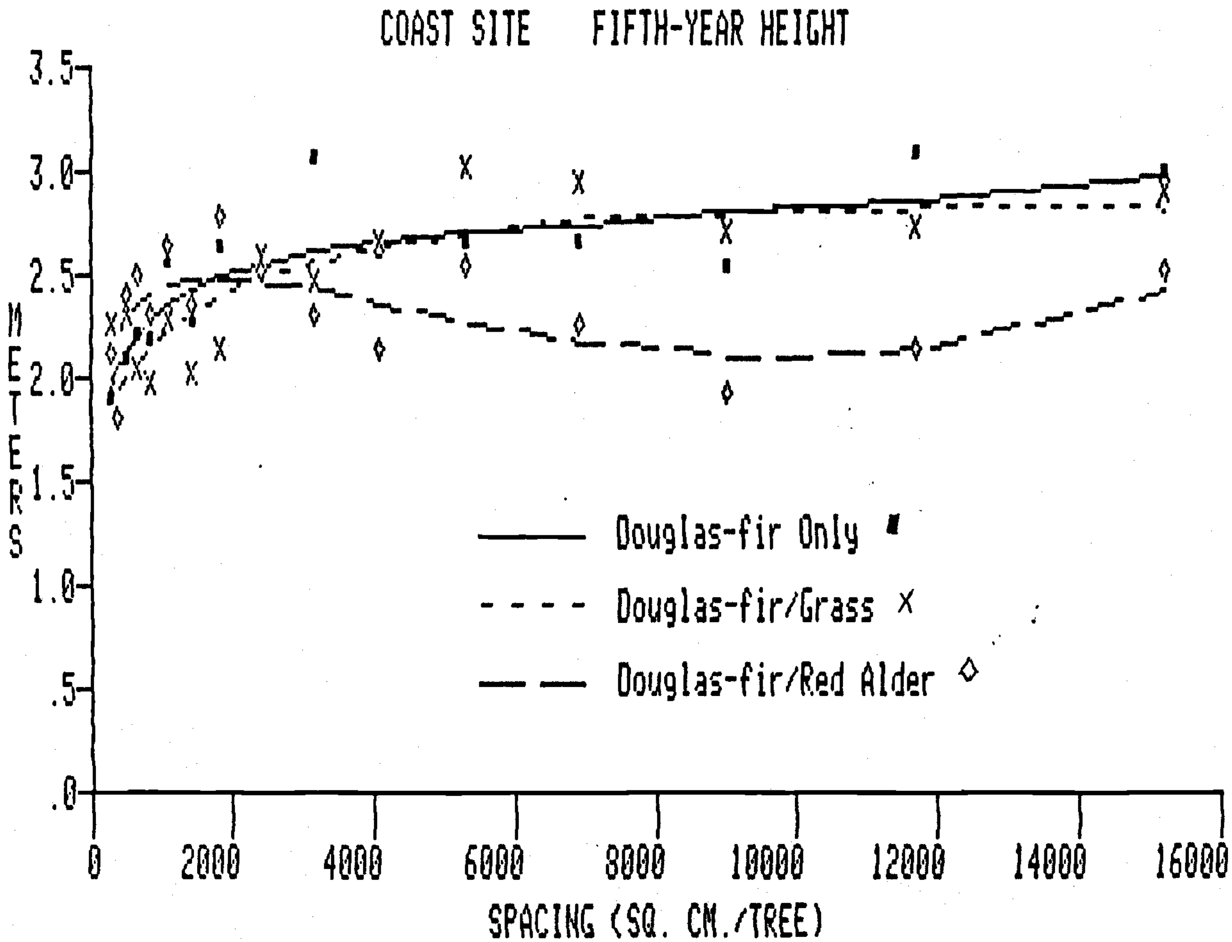

FIGURE 7c. FIFTH-YEAR TOTAL HEIGHT BY SPACING FOR THE COAST SITE. Symbols represent means at each spacing.

and is also affected by competitor*density and site* competitor*density interactions (Figures 8a, 8b, and 8c). The largest trees occur at the lowest densities. At the valley and mid-range sites, the Douglas-fir/Grass trees are substantially smaller than the Douglas-fir Only and Douglas-fir/Red Alder trees, except at the highest densities. The Douglas-fir/Red Alder trees are slightly smaller than the Douglas-fir Only trees except at the two lowest densities, where they are larger. At the coast site, the Douglas-fir Only and Douglas-fir/ Grass curves are similar until the lower densities; then the Douglas-fir/Grass curve falls below the Douglas-fir Only curve. Except at the high densities, the Douglas-fir/Red Alder trees are significantly smaller than the other trees. Corrected for absolute space of Douglas-fir trees, the Douglas-fir/ Red Alder trees are substantially smaller than indicated at all sites.

Dry Weight/Tree

Dry weight/tree results reflect aboveground measurements only. Since dry weight correlates well with diameter, it is understandable that the dry

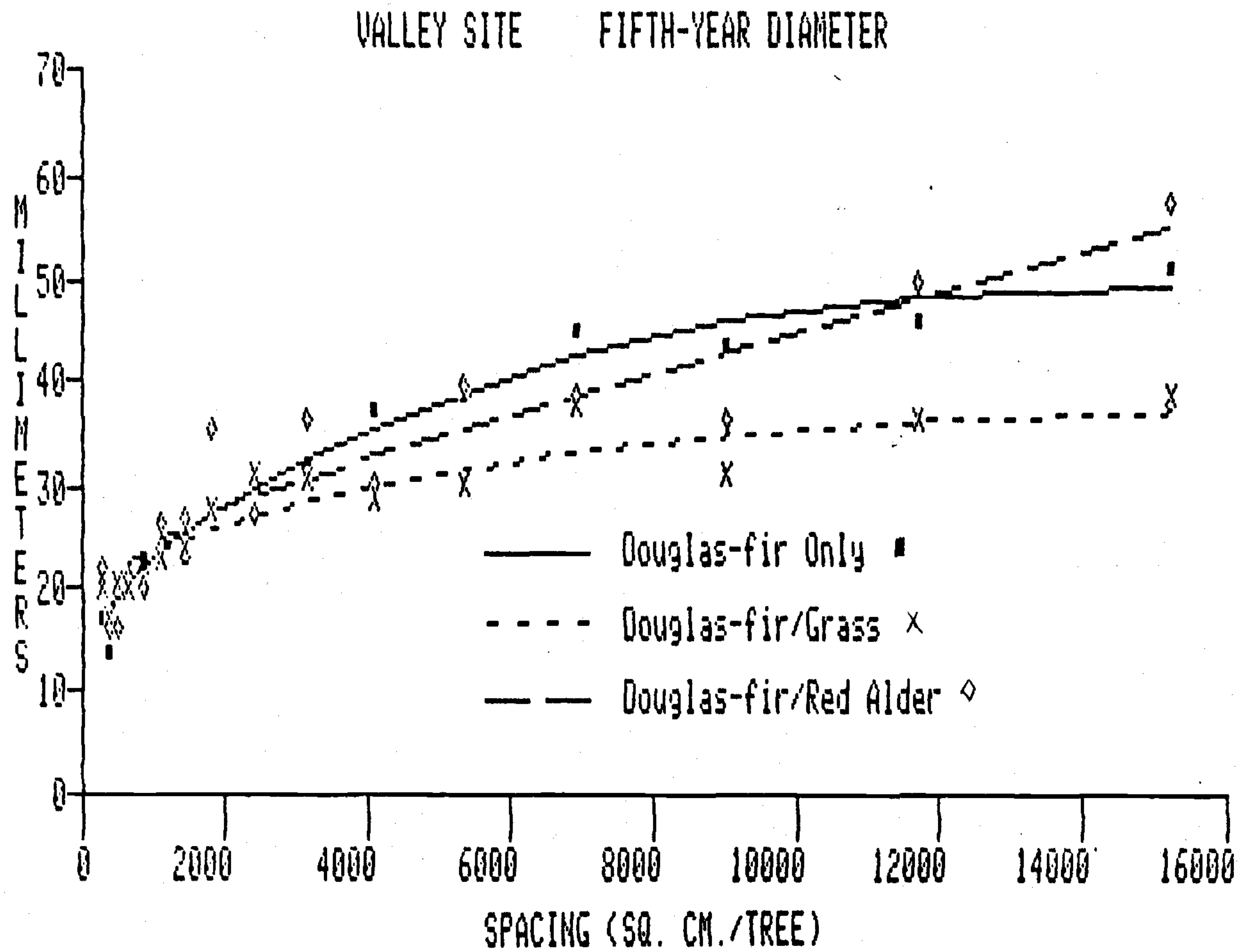

FIGURE 8a. FIFTH-YEAR DIAMETER AT 15 CM VS. SPACING FOR THE VALLEY SITE. Symbols represent means at each spacing.

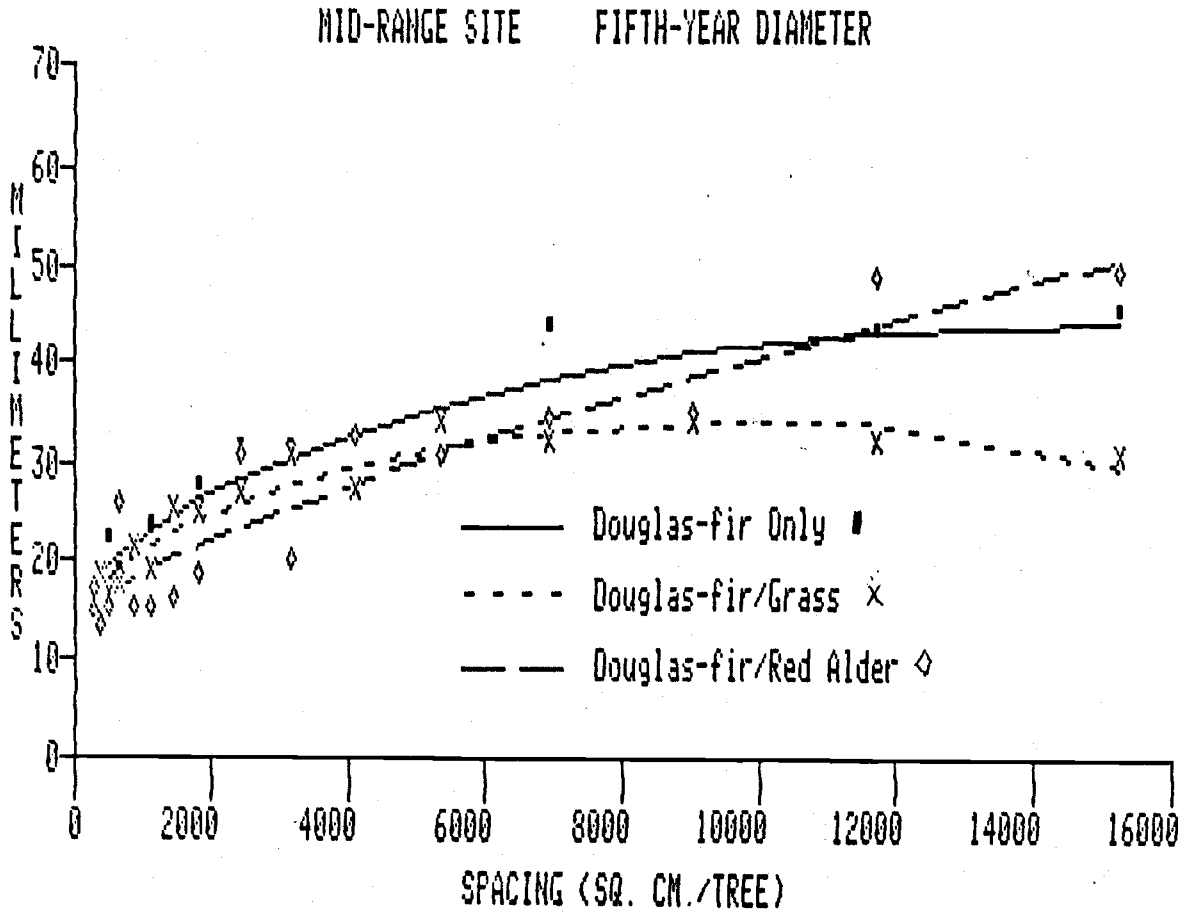

FIGURE 8b. FIFTH-YEAR DIAMETER AT 15 CM VS. SPACING FOR THE MID-RANGE SITE. Symbols represent means at each spacing.

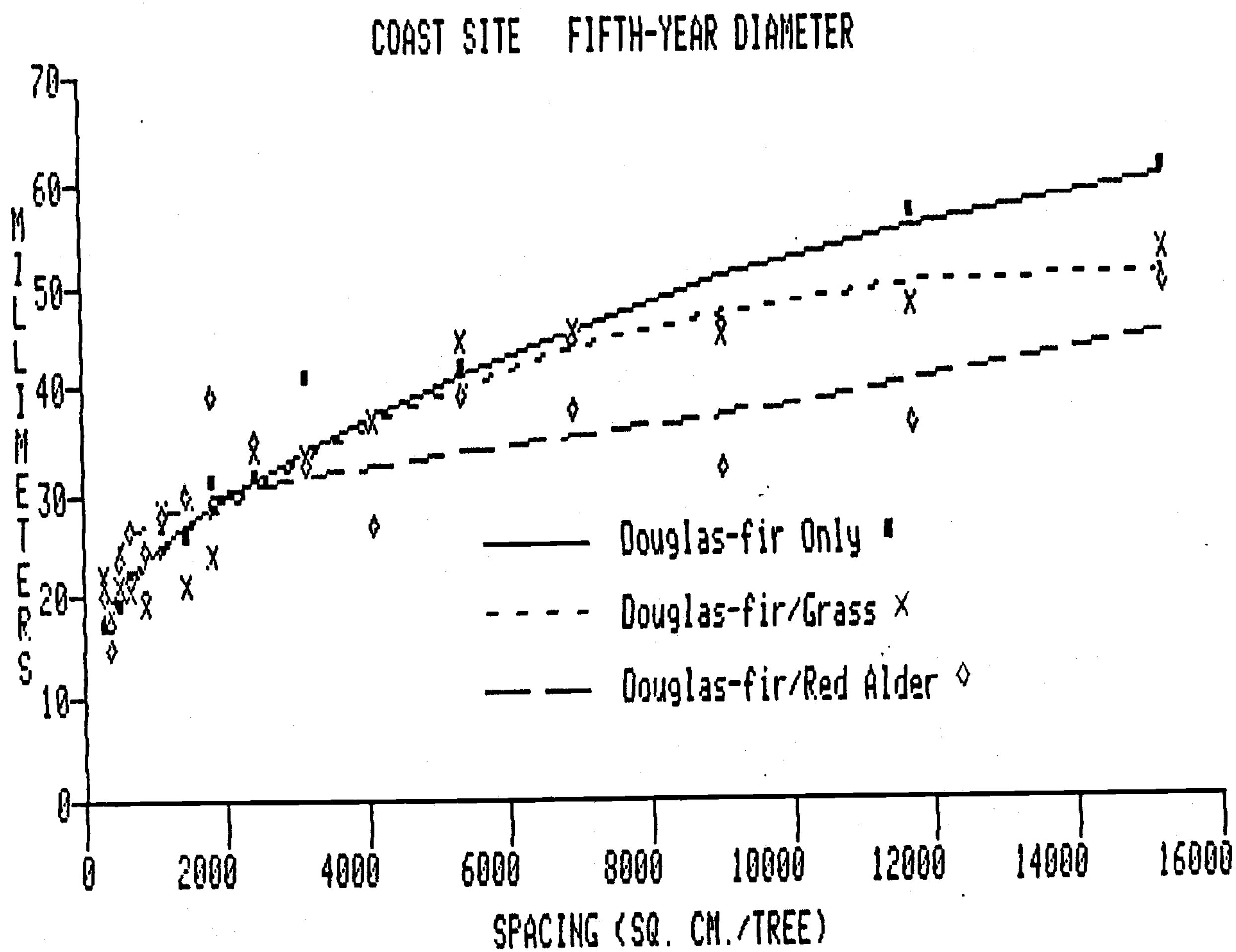

FIGURE 8c. FIFTH-YEAR DIAMETER AT 15 CM VS. SPACING FOR THE COAST SITE.
Symbols represent means at each spacing.

weight curves are similar in form to the diameter curves (Figures 9a, 9b, and 9c). However, dry weight also varies significantly with site and site*density interaction. The trees at the coast at the low densities have the most biomass/tree. Differences at the valley site between the Douglas-fir Only and Douglas-fir/Red Alder curves are slight if the density of the Douglas-fir/Red Alder trees is considered for total population of trees (red alder and Douglas-fir). The Douglas-fir/Red alder trees at the two lowest densities average greater weights than those in the Douglas-fir Only section, with have half the area per Douglas-fir tree. The Douglas-fir/Grass curve indicates that the trees have significantly less biomass/tree than those in the Douglas-fir Only section.

At the mid-range site, the Douglas-fir/Red Alder curve is much lower than the Douglas-fir Only curve at the high densities, but becomes higher at the two lowest densities, which again are actually less than the densities of the Douglas-fir Only trees. The Douglas-fir/Grass trees weigh less than the Douglas-fir Only trees at all but the high densities, where values are similar and the grass has been gone for several years due to canopy closure.

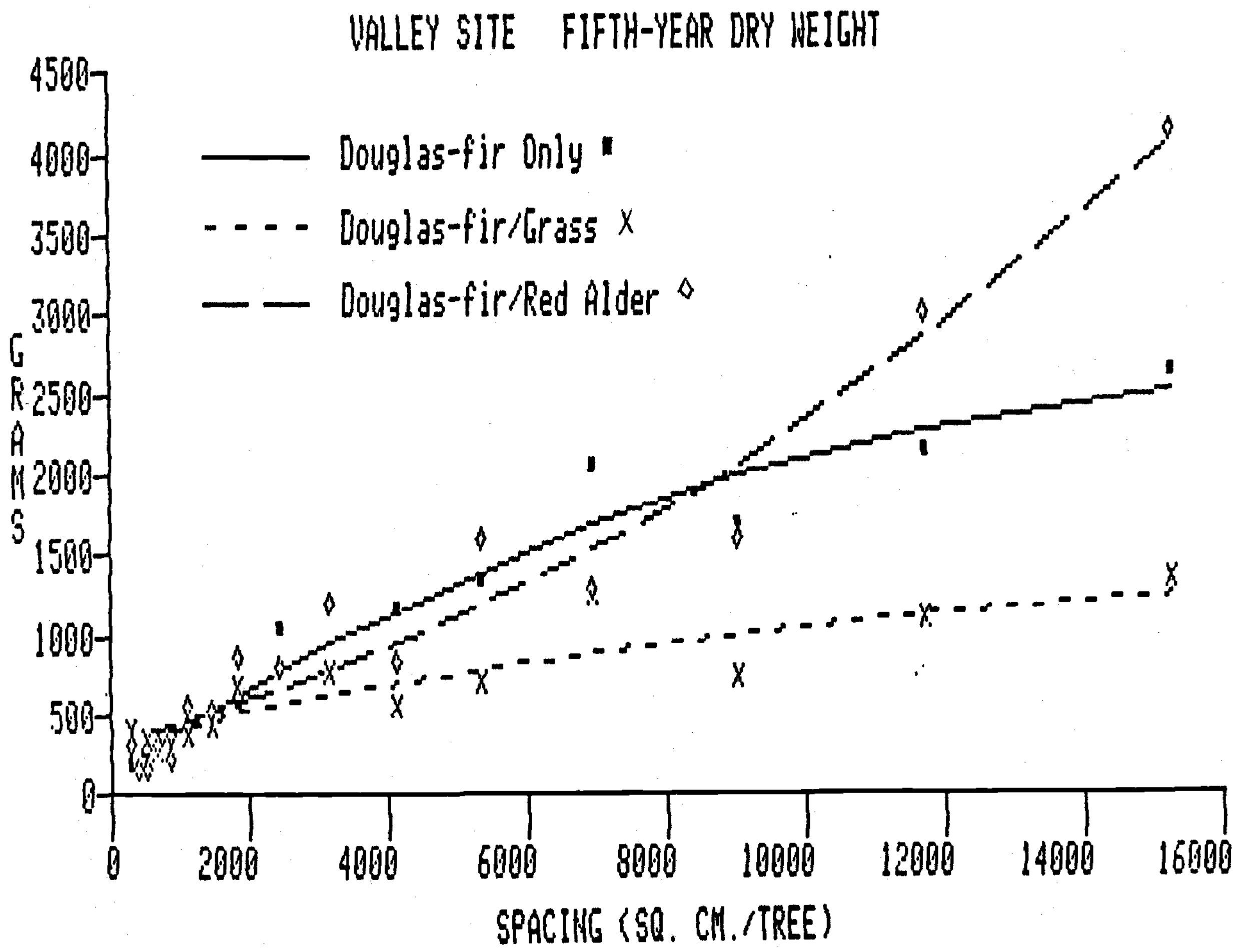

FIGURE 9a. FIFTH-YEAR DRY WEIGHT/TREE VS. SPACING FOR THE VALLEY SITE. Symbols represent means at each spacing.

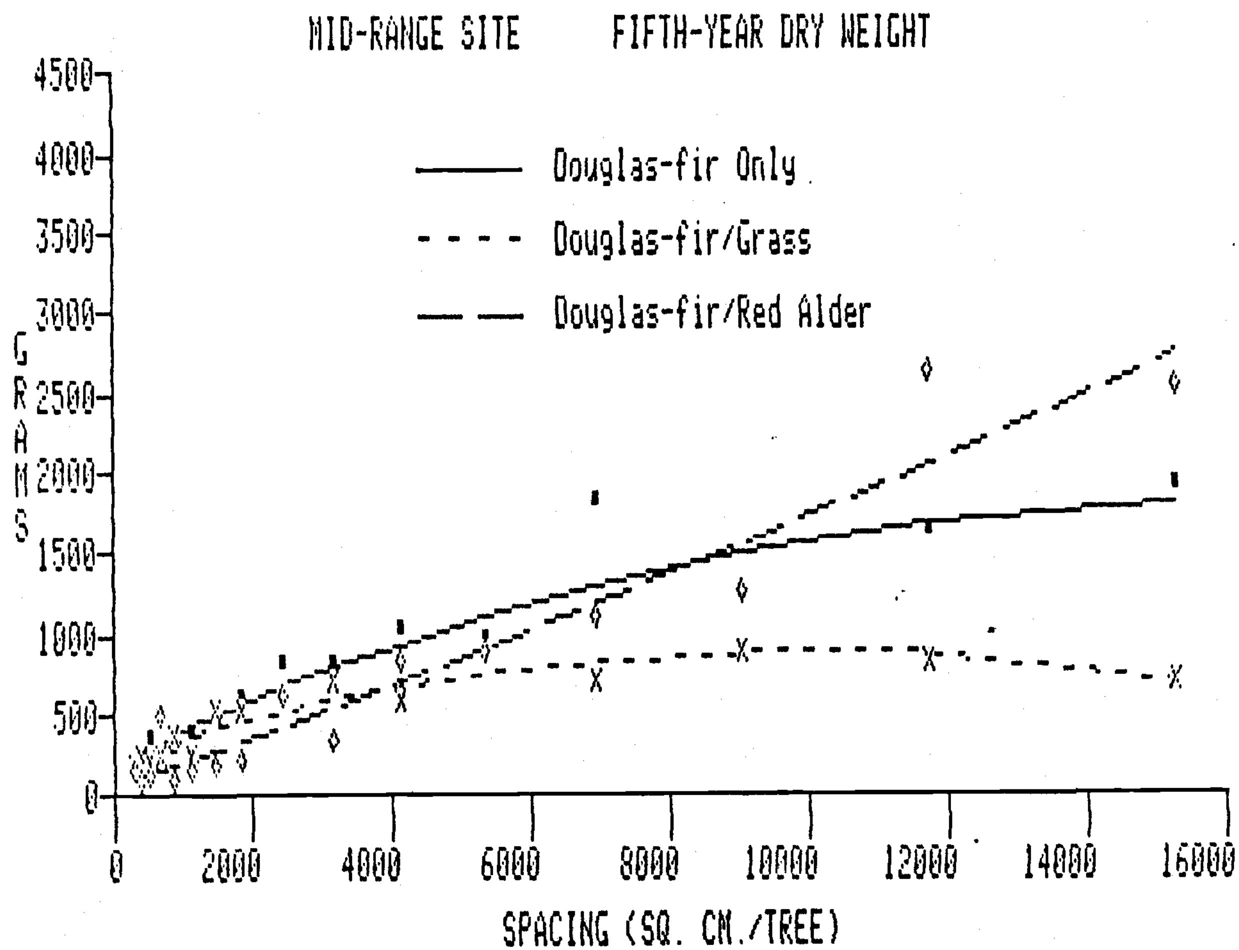

FIGURE 9b. FIFTH-YEAR DRY WEIGHT/TREE VS. SPACING FOR THE MID-RANGE SITE. Symbols represent means at each spacing.

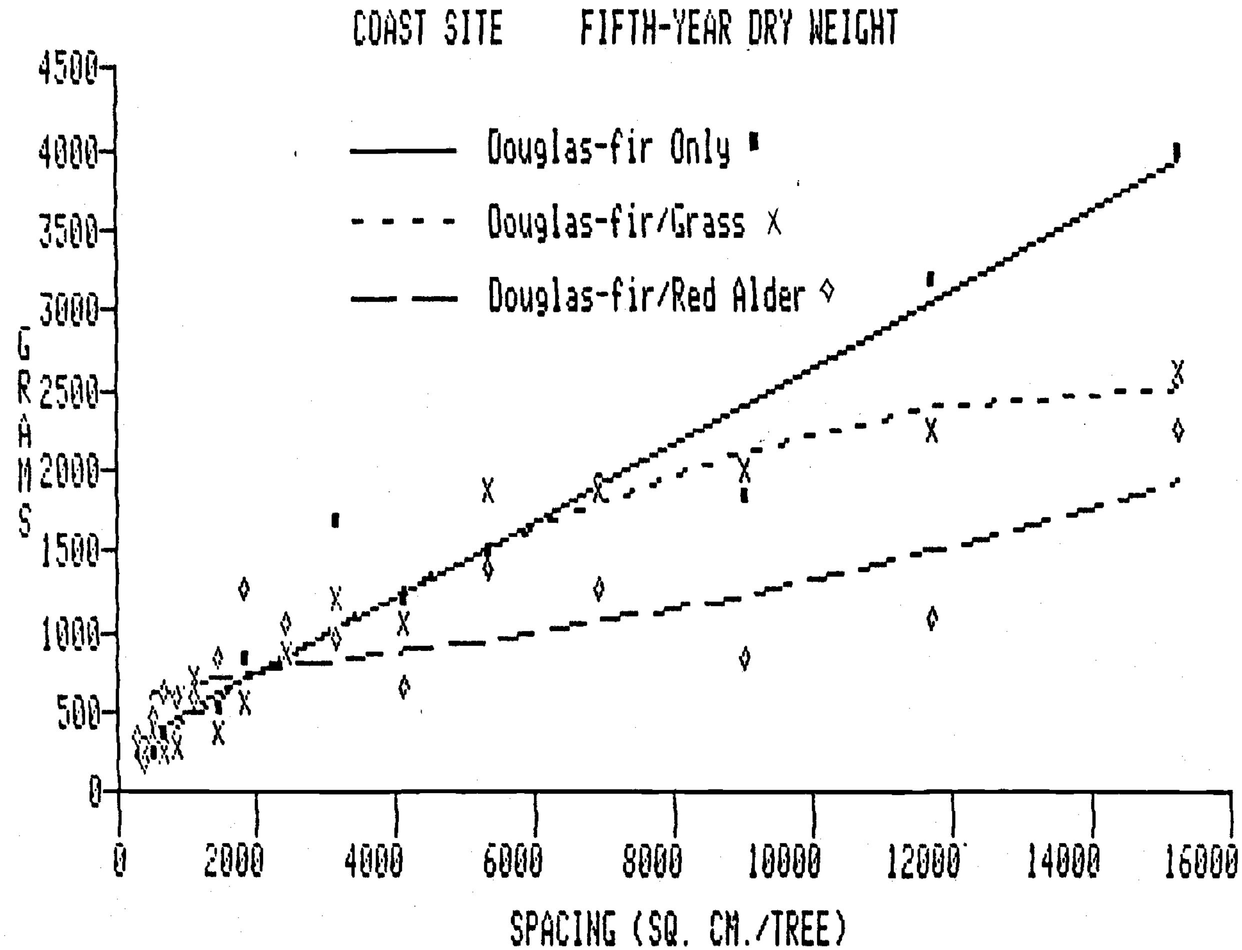

FIGURE 9c. FIFTH-YEAR DRY WEIGHT/TREE VS. SPACING FOR THE COAST SITE. Symbols represent means at each spacing.

At the coast site, the Douglas-fir Only curve is almost a straight line, increasing continually with increasing space/tree. The Douglas-fir/Grass curve falls below that curve for the last three densities. The Douglas-fir/Red Alder trees weigh less than trees in the other sections, except at the high densities, where space/tree is greater than indicated due to the mortality of the red alder trees.

Dry Weight/Hectare

Dry weight/hectare consistently shows the highest values at the highest densities (Figures 10a, 10b, and 10c). At the valley site, the Douglas-fir/Red Alder and Douglas-fir Only curves are not significantly different, but the Douglas-fir/Grass curve is significantly lower then the other curves. The Douglas-fir/Red Alder curve is lower at the high densities and higher at the low densities than both the Douglas-fir/Grass and Douglas-fir Only curves at the mid-range site. Differences are significant only at the high densities. At the coast, the Douglas-fir/Red Alder curve is higher at the high densities, but lower at the low densities than the other curves. Differences are significant at most densities. It should be noted that values for the Douglas-fir/Red Alder trees were

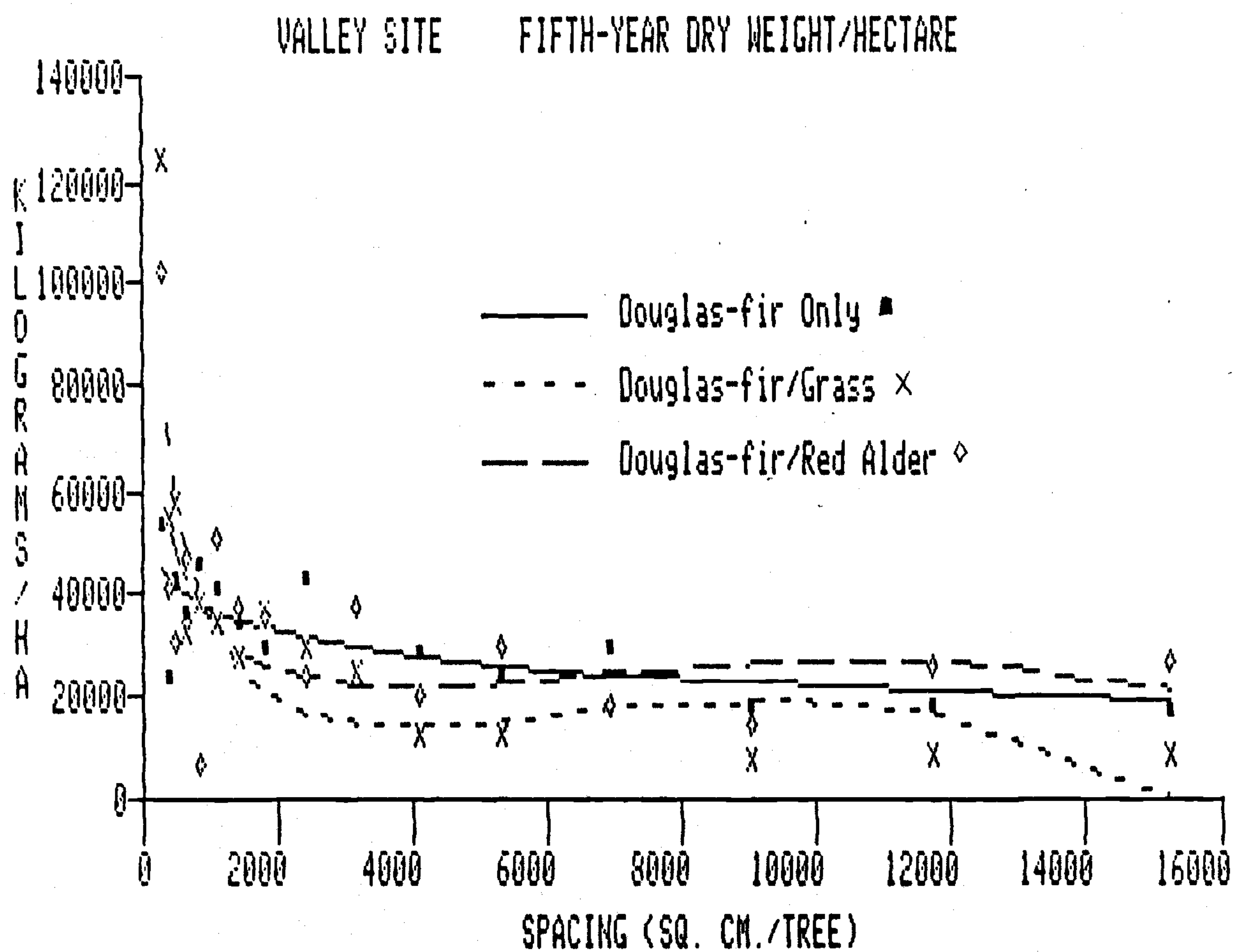

FIGURE 10a. FIFTH-YEAR DRY WEIGHT/HECTARE VS. SPACING FOR THE VALLEY SITE. Symbols represent means at each spacing.

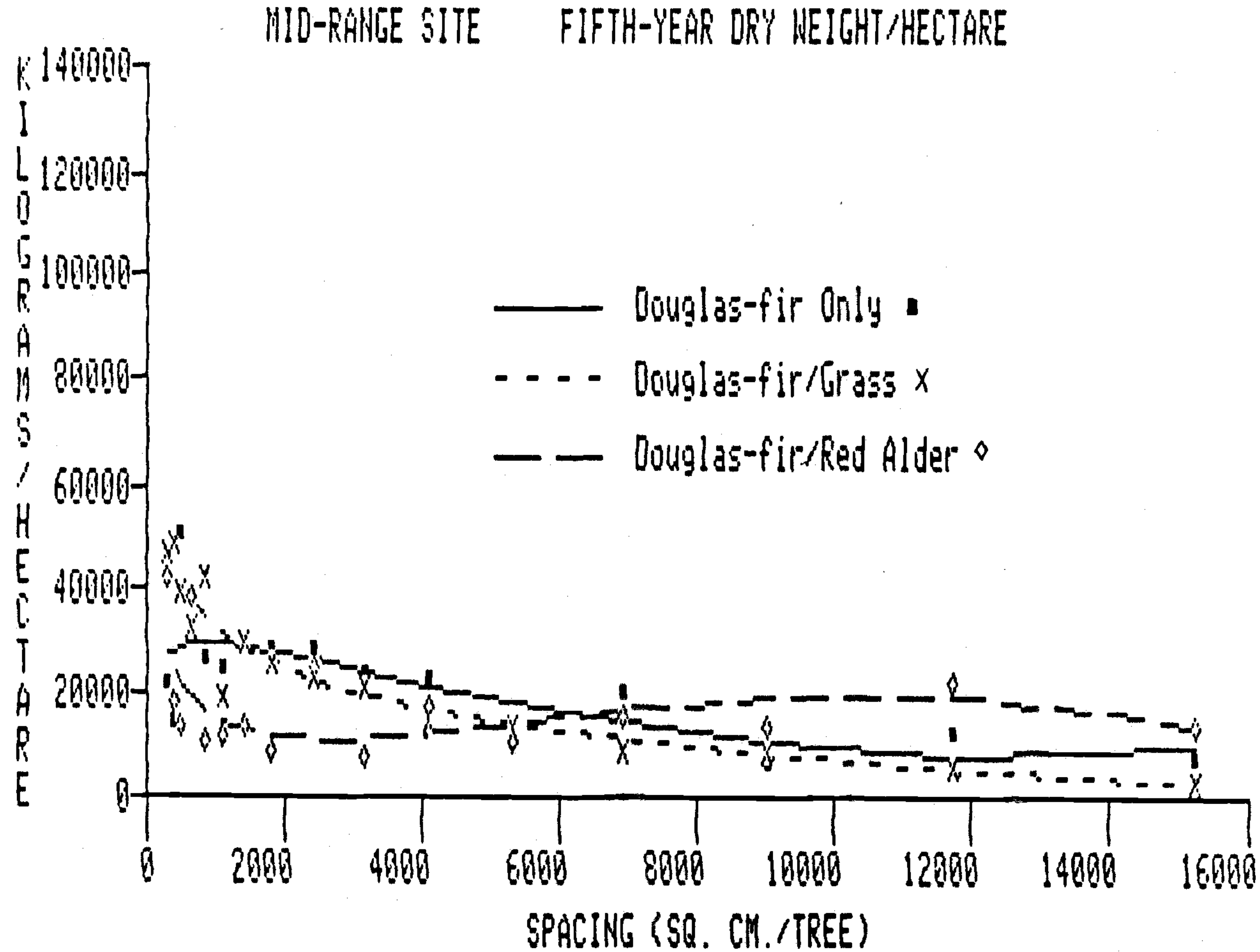

FIGURE 10b. FIFTH-YEAR DRY WEIGHT/HECTARE VS. SPACING FOR THE MID-RANGE SITE. Symbols represent means at each spacing.

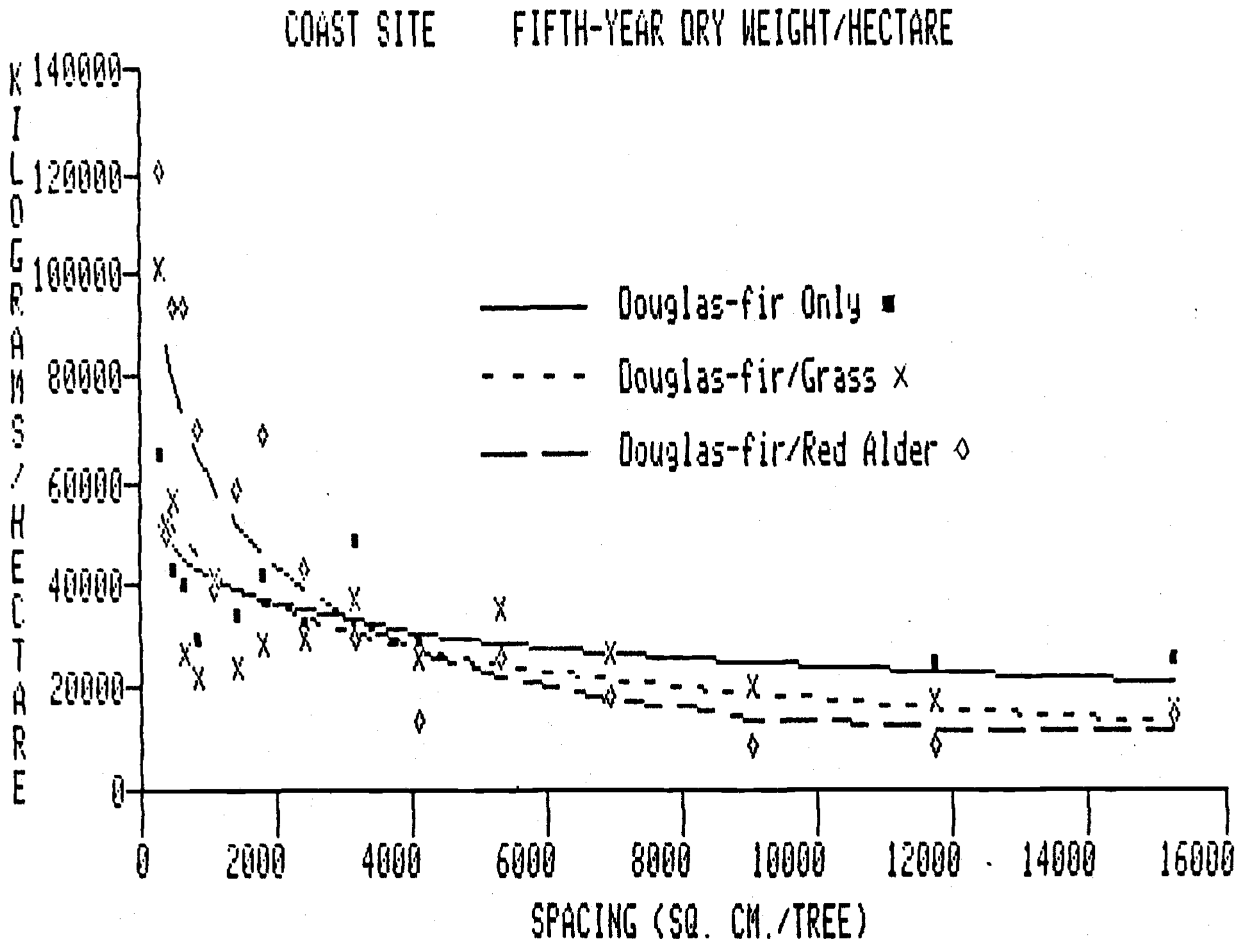

FIGURE 10c. FIFTH-YEAR DRY WEIGHT/HECTARE VS. SPACING FOR THE COAST SITE. Symbols represent means at eacn spacing.

doubled to compensate for the half-density of the Douglas-fir trees in that section.

Fifth-Year Height Growth

As with total height, height growth varies with competitor and density and is affected by the competitor*density and site*competitor*density interactions (Figures 11a, 11b, and 11c)... At all sites, the greatest height growth by the Douglas-fir/ Red Alder trees occurs at the lowest densities. The Douglas-fir/Grass trees at the valley site have the greatest growth at the lowest density, but the peaks occur at higher densities at the other sites.

At the valley site, height growth by the Douglas-fir/Grass trees appears almost constant from the mid-densities to the outer edge. The Douglas-fir/ Red Alder trees have significantly lower growth than the Douglas-fir Only trees at all but the lowest densities. The Douglas-fir/Red Alder trees exhibit even lower growth at the mid-range site, except for the trees at the lowest densities. At this site, the grass appears to be having less effect than at the valley site. The Douglas-fir/Red Alder trees at the coast site have greater height growth at the high densities, but less at the mid- and low densities

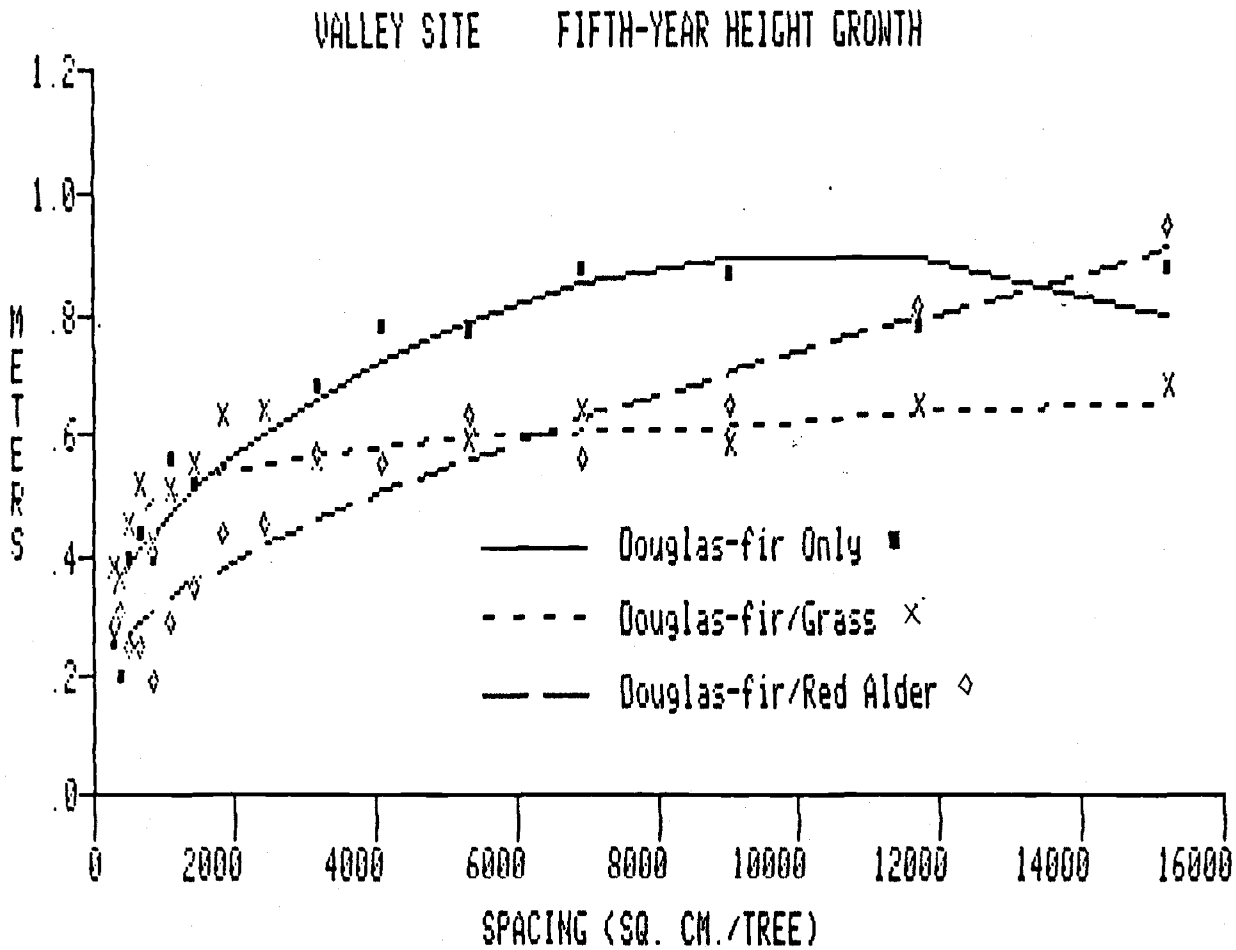

FIGURE 11a. FIFTH-YEAR HEIGHT GROWTH/TREE VS. SPACING FOR THE VALLEY SITE. Symbols represent means for each spacing.

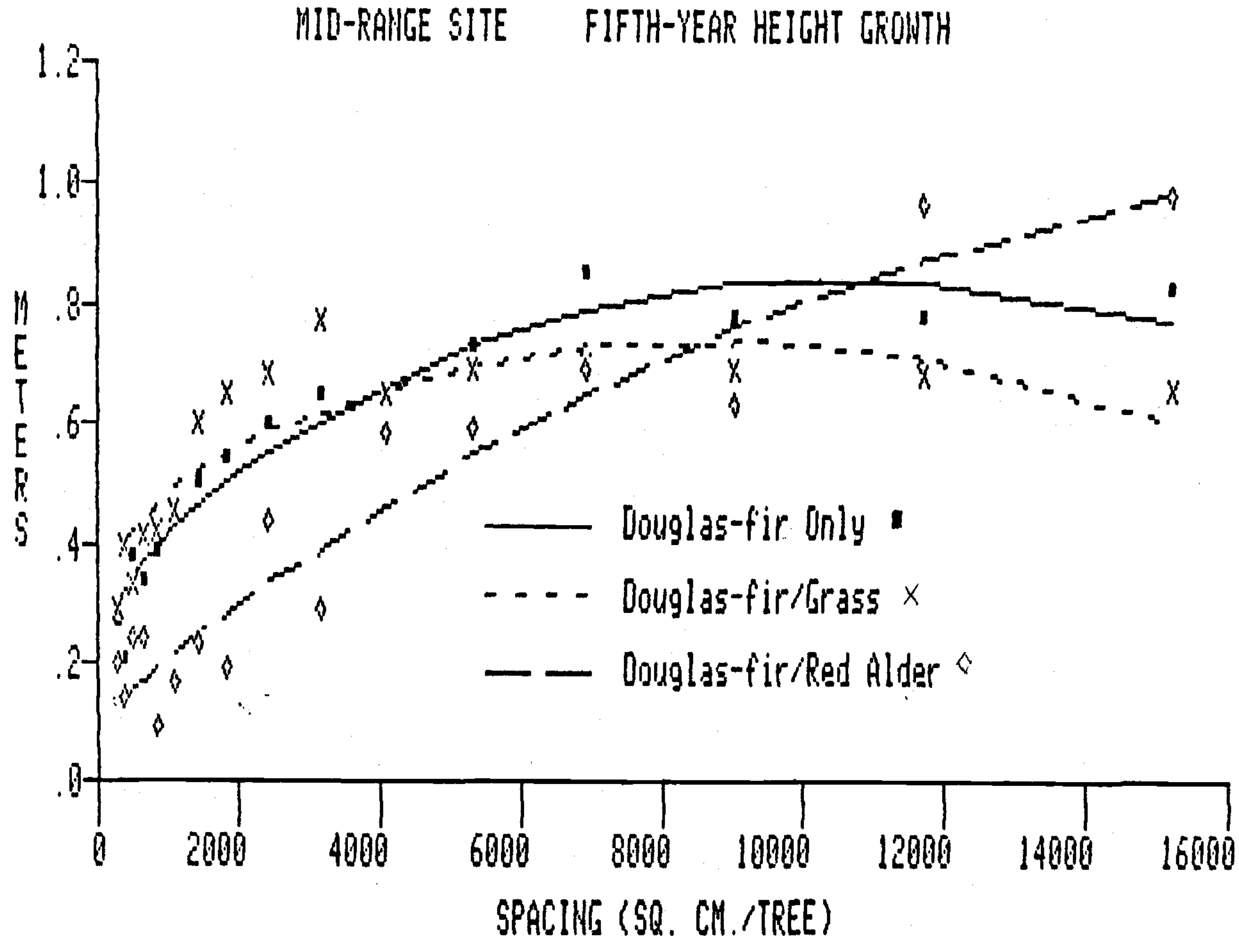

FIGURE 11b. FIFTH-YEAR HEIGHT GROWTH/TREE VS. SPACING FOR THE MID-RANGE SITE. Symbols represent means for each spacing.

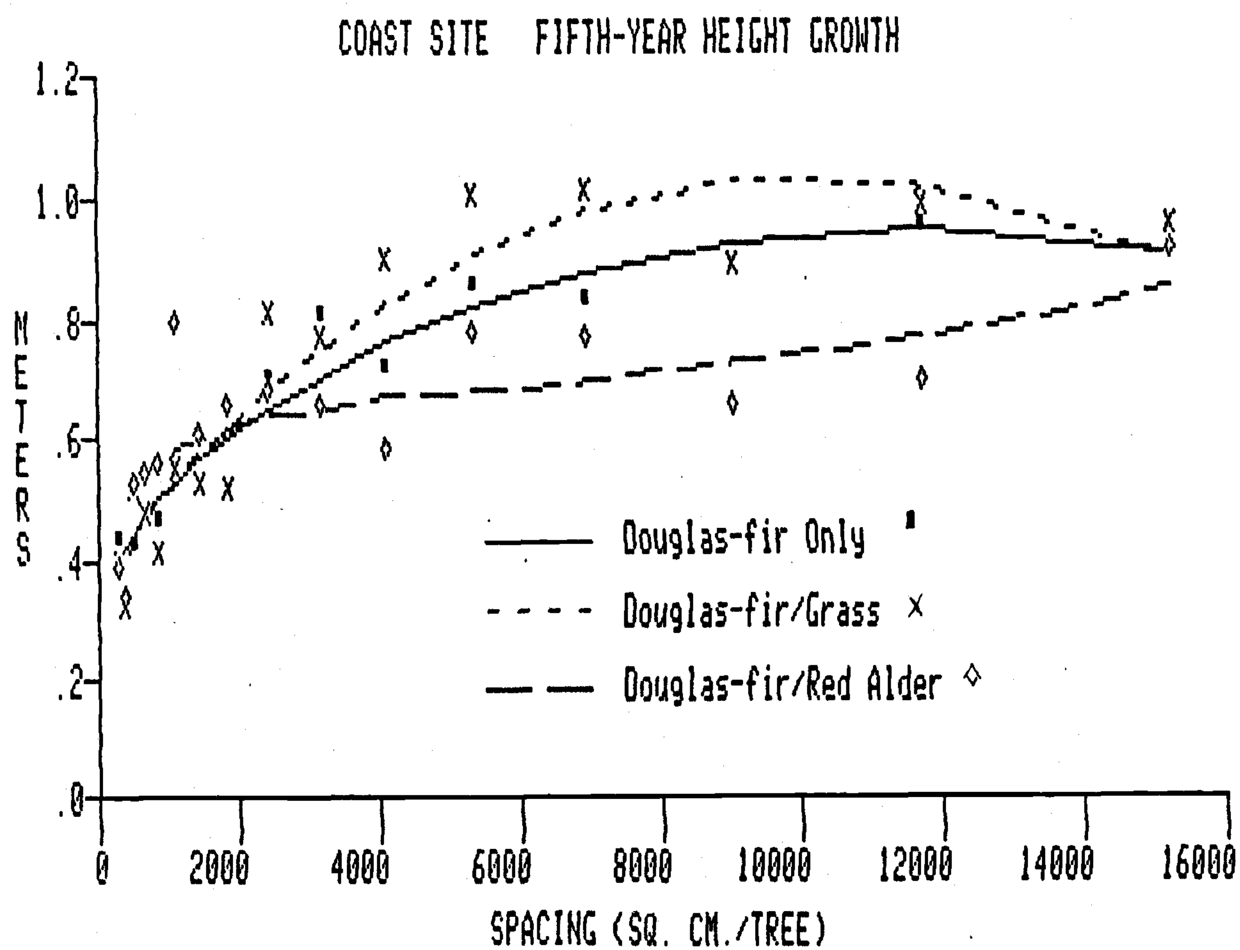

FIGURE 11c. FIFTH-YEAR HEIGHT GROWTH/TREE VS. SPACING FOR THE COAST SITE. Symbols represent means for each spacing.

than the other trees. The Douglas-fir Only and Douglas-fir/Grass trees have similar growth patterns, with the Douglas-fir/Grass trees exhibiting slightly greater growth through the mid-densities.

Basal Area/Hectare

At all sites, basal area/hectare is highest at the high densities (Figures 12a, 12b, and 12c). No differences among competitors are apparent when the density of all trees is considered. If the Douglas-fir/Red Alder values are calculated based on density of only the Douglas-fir trees, then the amounts would be half those shown, and the curves would fall below those of the Douglas-fir Only and Douglas-fir/Grass trees.

Basal Area Growth/Tree

Basal area growth/tree is affected by density, competitor*density, and site*competitor*density (Figures 13a, 13b, and 13c). Except for the mid-range Douglas-fir/Grass trees, the greatest growth occurs at the lowest densities. For these trees, the basal area growth peaks at the mid-densities and then declines. The valley site curves are

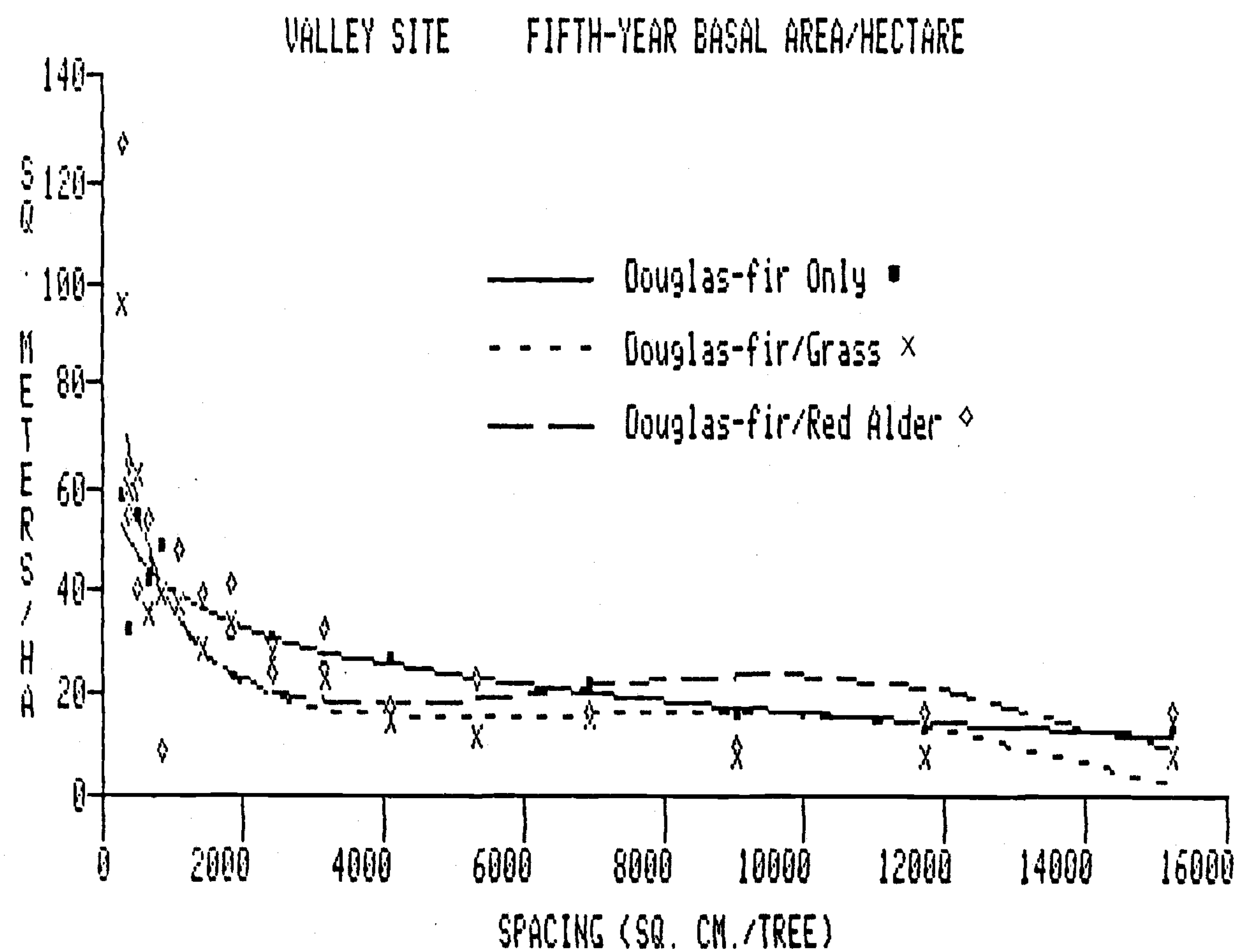

FIGURE 12a. FIFTH-YEAR BASAL AREA/HECTARE VS. SPACING FOR THE VALLEY SITE. Symbols represent means at each spacing.

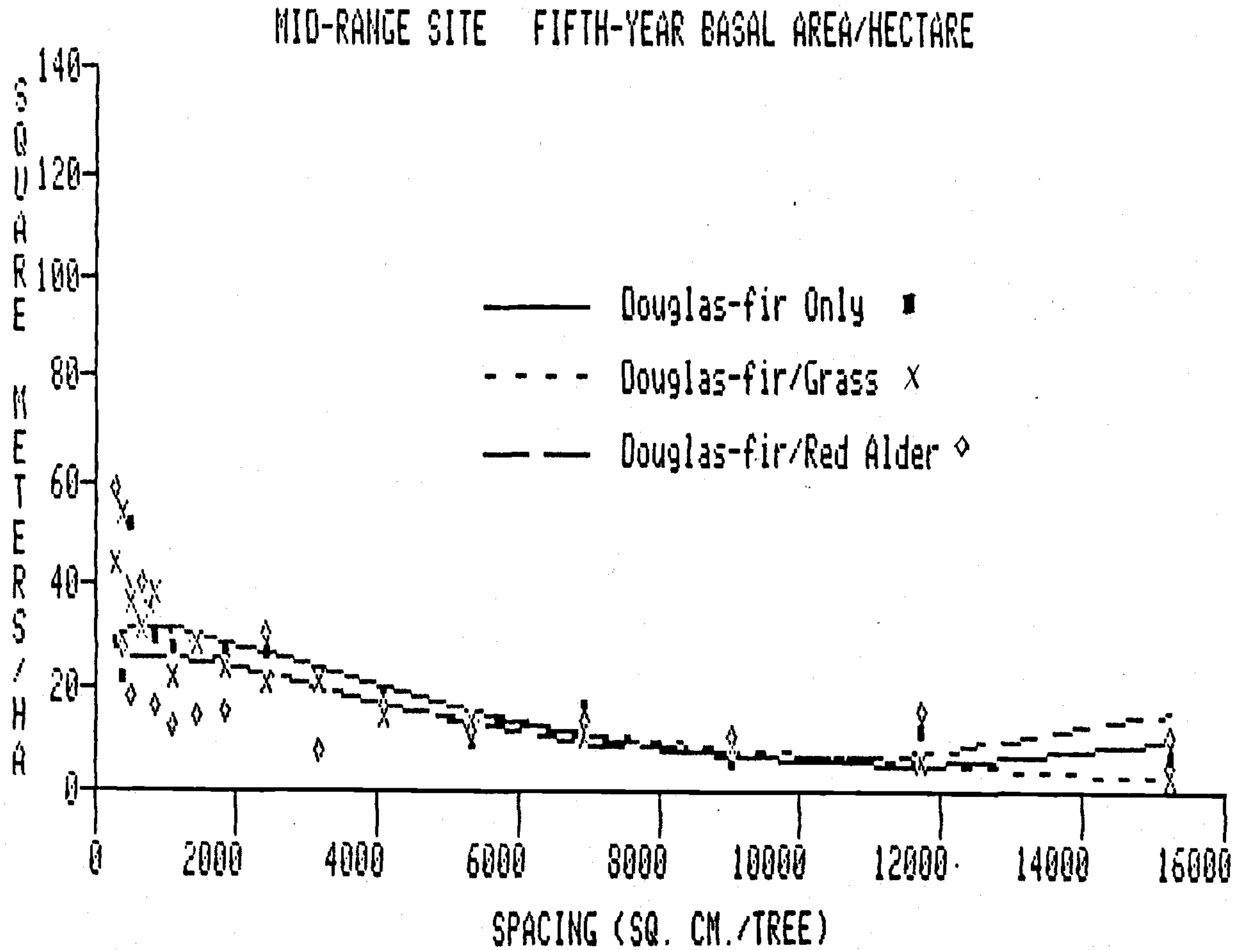

FIGURE 12b. FIFTH-YEAR BASAL AREA/HECTARE VS. SPACING FOR THE MID-RANGE SITE. Symbols represent means at each spacing.

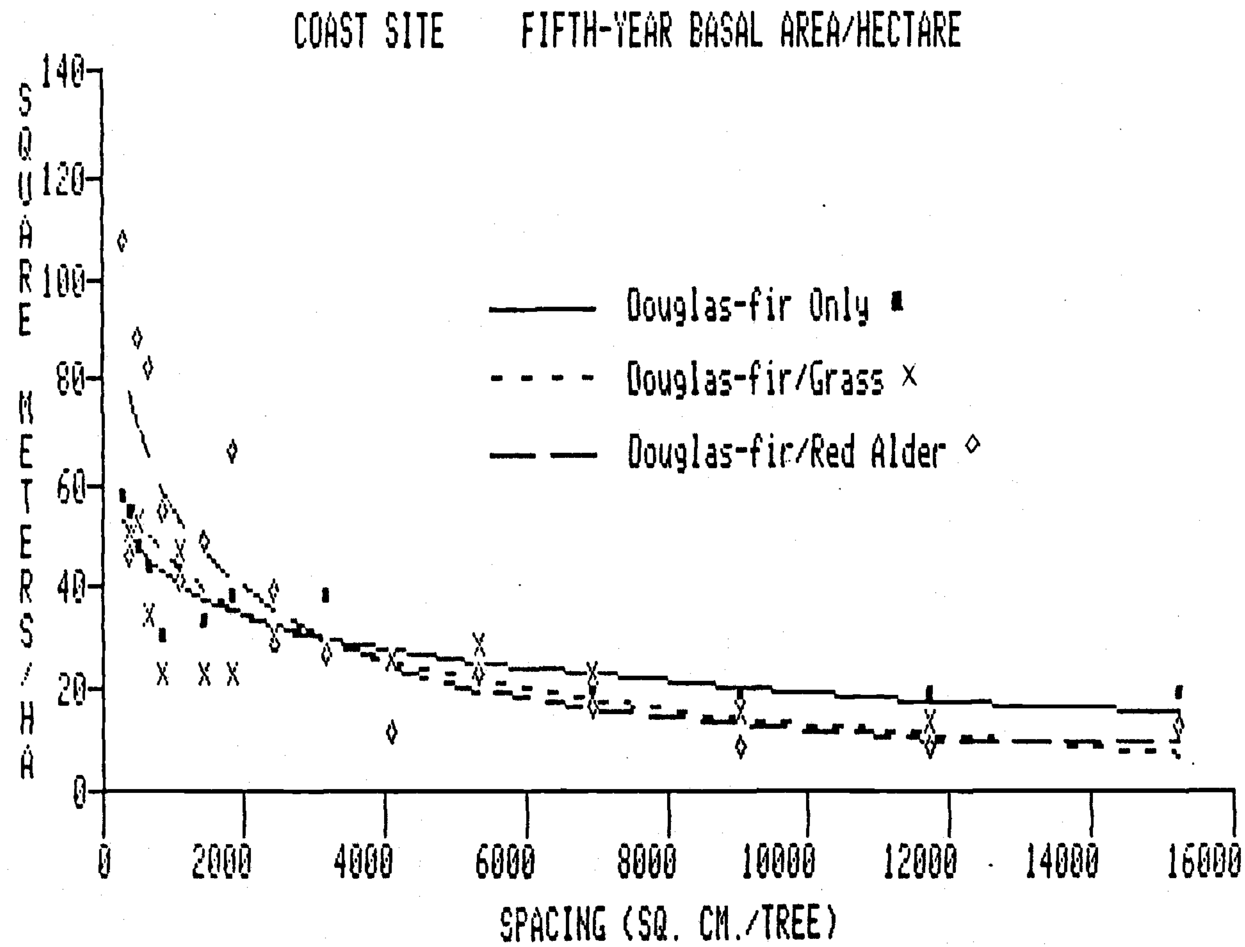

FIGURE 12c. FIFTH-YEAR BASAL AREA/HECTARE VS. SPACING FOR THE COAST SITE. Symbols represent means at each spacing.

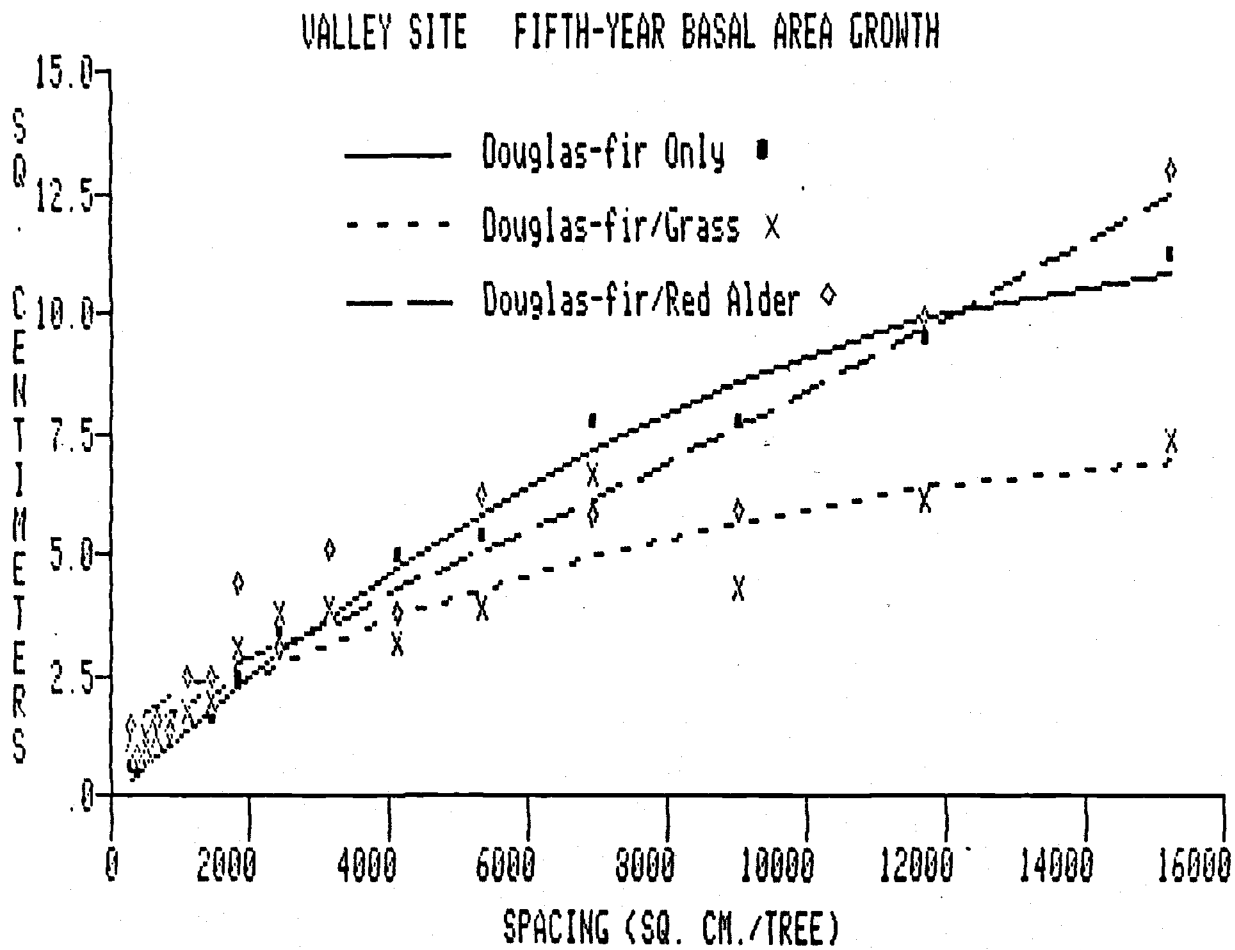

FIGURE 13a. FIFTH-YEAR BASAL AREA GROWTH/TREE VS. SPACING FOR THE VALLEY SITE. Symbols represent means at each spacing.

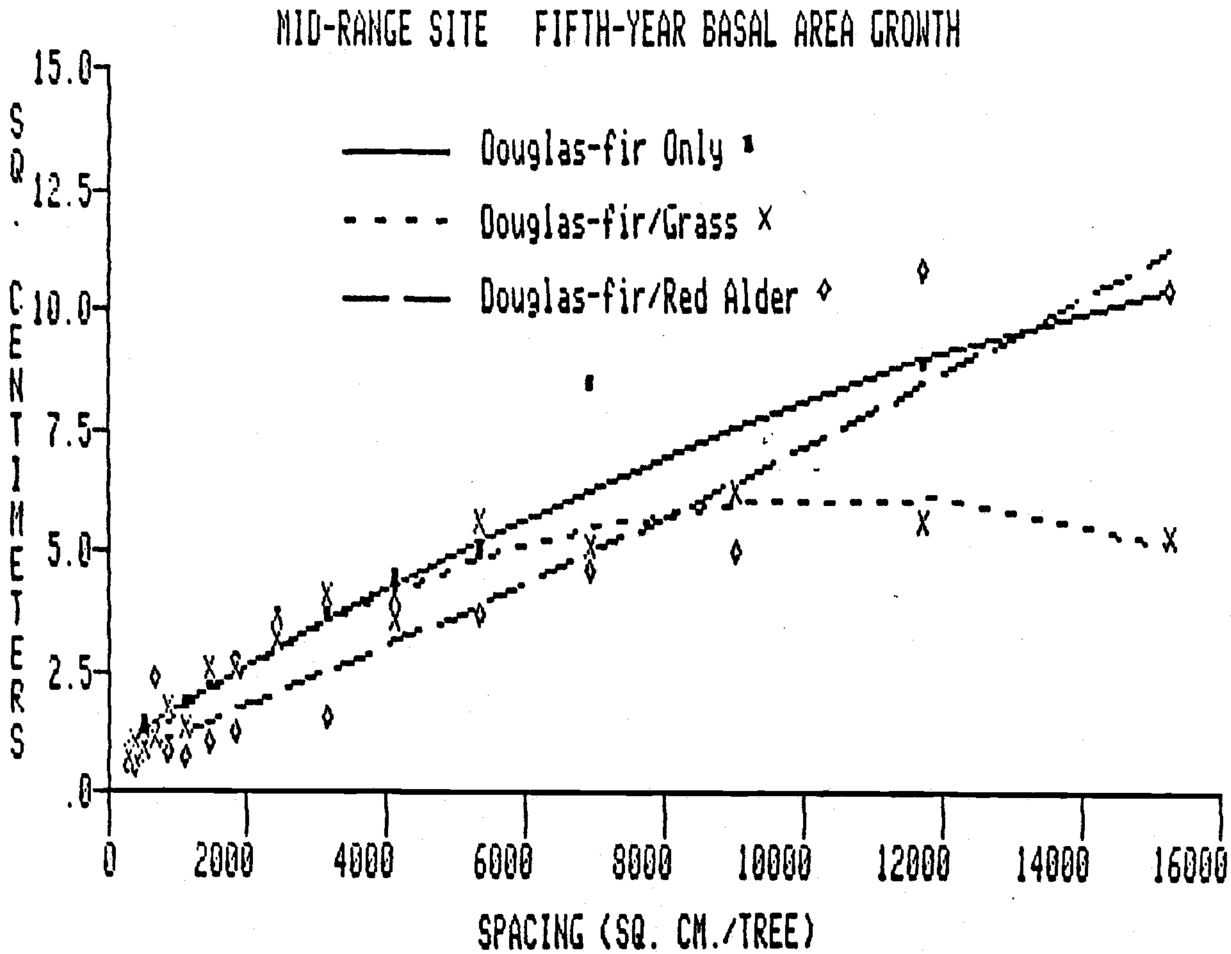

FIGURE 13b. FIFTH-YEAR BASAL AREA GROWTH/TREE VS. SPACING FOR THE MID-RANGE SITE. Symbols represent means at each spacing.

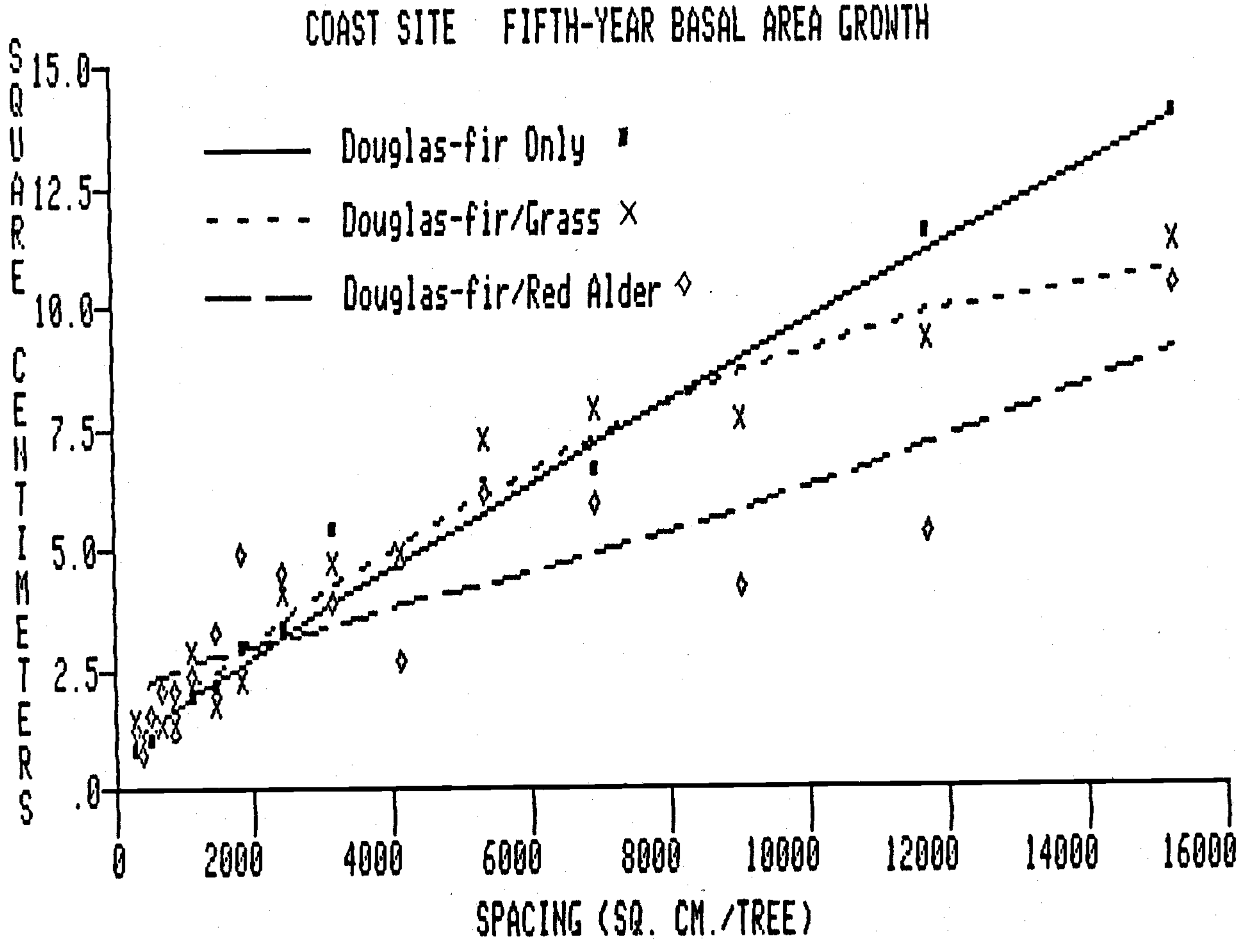

FIGURE 13c. FIFTH-YEAR BASAL AREA GROWTH/TREE VS. SPACING FOR THE COAST SITE. Symbols represent means at each spacing.

similar in form to the diameter curves. The Douglas-fir/Grass trees grew less than the Douglas-fir Only and Douglas-fir/Red Alder trees, which had similar growth. At the mid-range site, the Douglas-fir/Red Alder trees grew less than the Douglas-fir Only trees except at the two lowest densities. The Douglas-fir/Grass trees exhibit similar growth to the Douglas-fir Only trees at high densities, then basal area growth declines at wider spacings. As with the diameter curve at the coast, the Douglas-fir Only trees continually increase in basal area growth as density decreases. Except for the three lowest densities where basal area growth decreases, the Douglas-fir/Grass curve is similar. The Douglas-fir/Red Alder trees grew less at all but the highest densities.

Fifth-Year Basal Area Growth/Hectare

As with basal area/hectare, all curves are highest at the highest densities (Figures 14a, 14b, and 14c). At the valley and coast sites, both the Douglas-fir/Grass and the Douglas-fir/Red Alder curves are above the Douglas-fir curve at the high densities. However, at the low densities the Douglas-fir Only curve is above the other curves. The differences

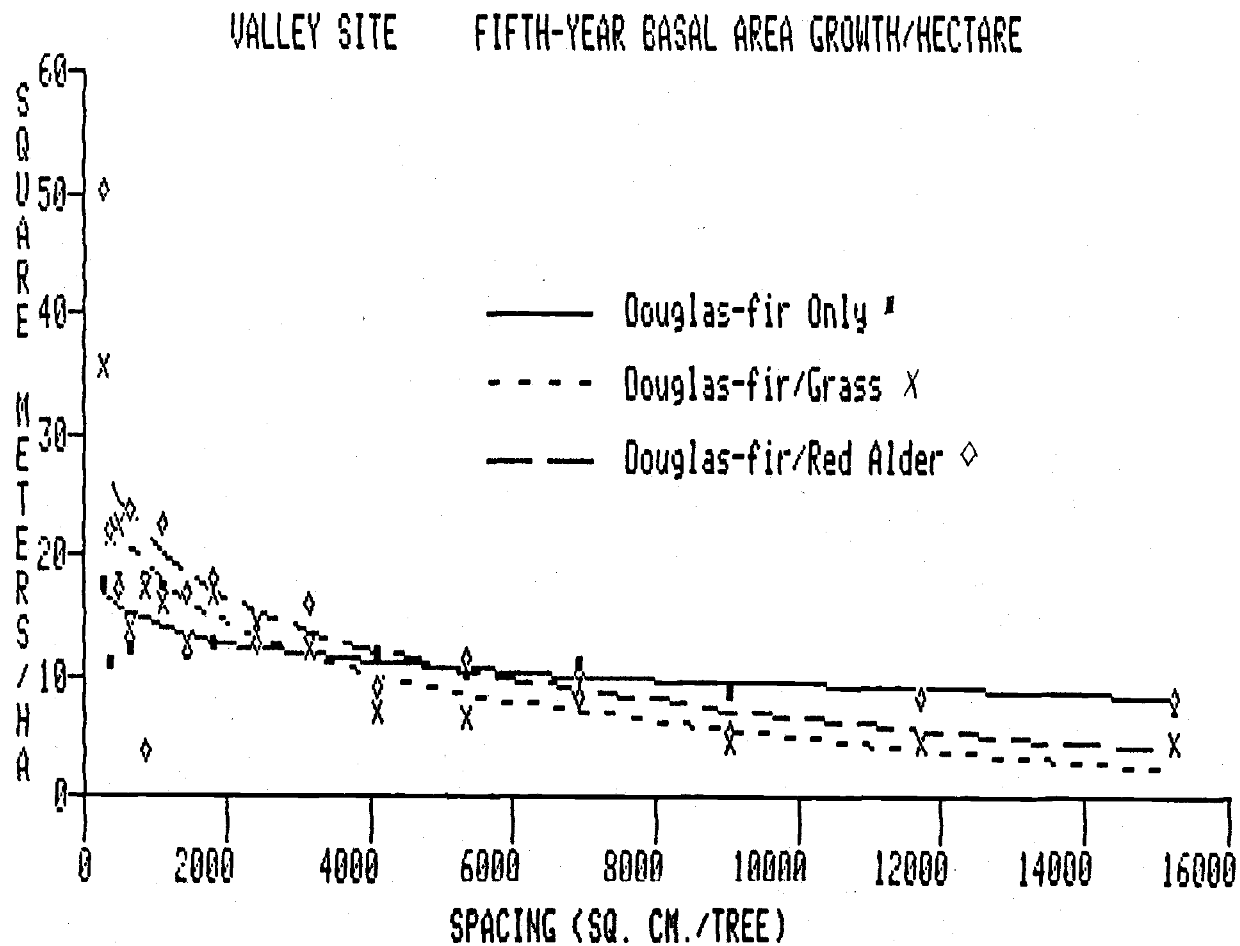

FIGURE 14a. FIFTH-YEAR BASAL AREA GROWTH/HECTARE VS. SPACING FOR THE VALLEY SITE. Symbols represent means at each spacing.

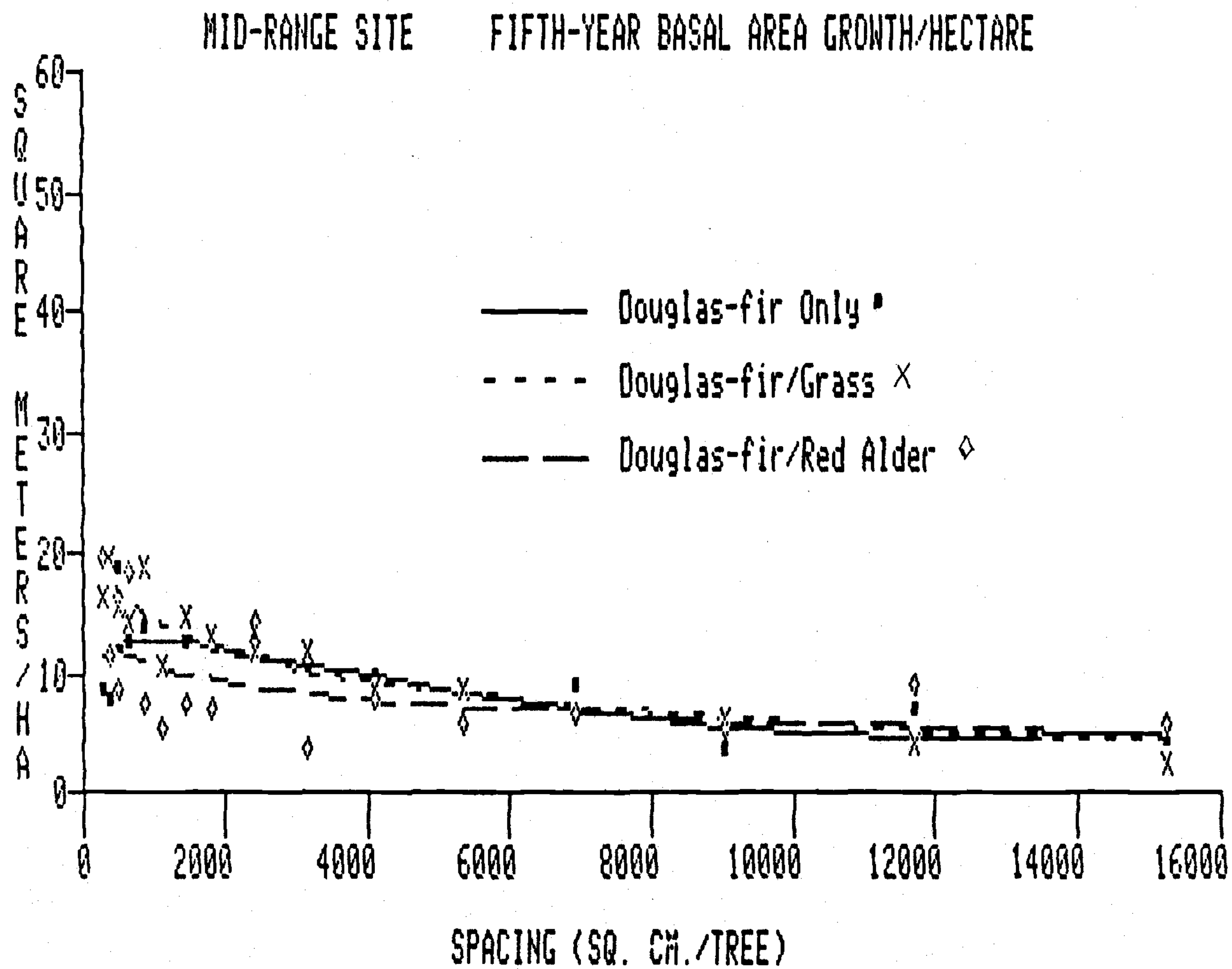

FIGURE 14b. FIFTH-YEAR BASAL AREA GROWTH/HECTARE VS. SPACING FOR THE MID-RANGE SITE. Symbols represent means at each spacing.

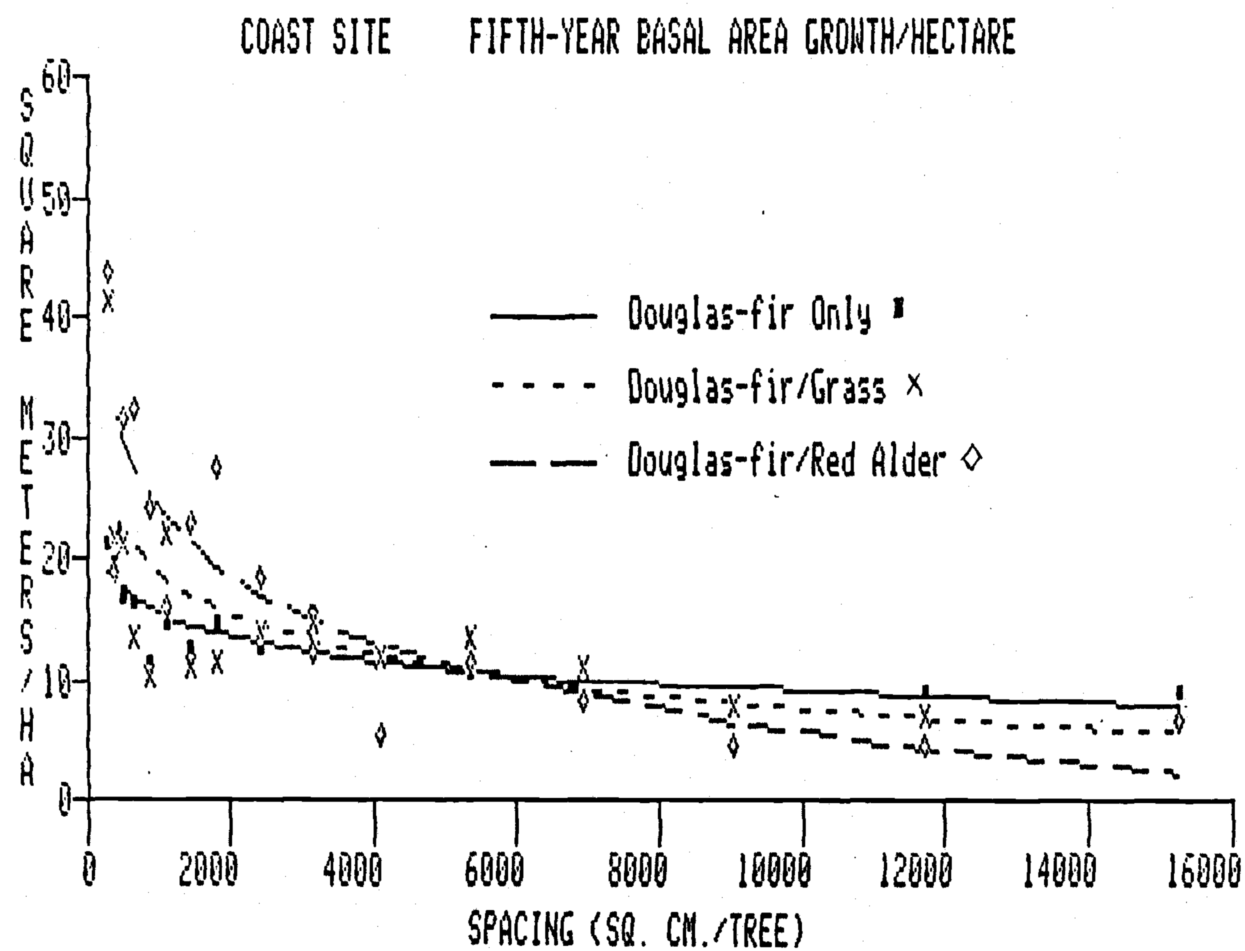

FIGURE 14c. FIFTH-YEAR BASAL AREA GROWTH/HECTARE VS. SPACING FOR THE COAST SITE. Symbols represent means at each spacing.

are not significant. There are no differences among the curves at the mid-range site. Again, if the Douglas-fir/Red Alder values are calculated based on the density of Douglas-fir trees alone, the values illustrated would be halved.

Fifth-Year Stemwood Volume Production/Tree

Stemwood volume production/tree follows the same trends as basal area growth, plus significant differences among sites (Figure 15a, 15b, and 15c). The coast site shows the greatest growth. The curves reflect almost identical patterns to those of basal area growth.

Fifth-Year Stemwood Volume Production/Hectare

At the valley site, stemwood volume production/hectare is highest at the high densities. Throughout the mid-densities, the Douglas-fir Only curve is significantly higher than the Douglas-fir/Red Alder curve, but no differences exist at the lowest densities (Figure 16a). At the mid-range site (Figure 16b), the Douglas-fir/Grass and Douglas-fir Only means are not statistically different. Both have the highest production/hectare at the highest

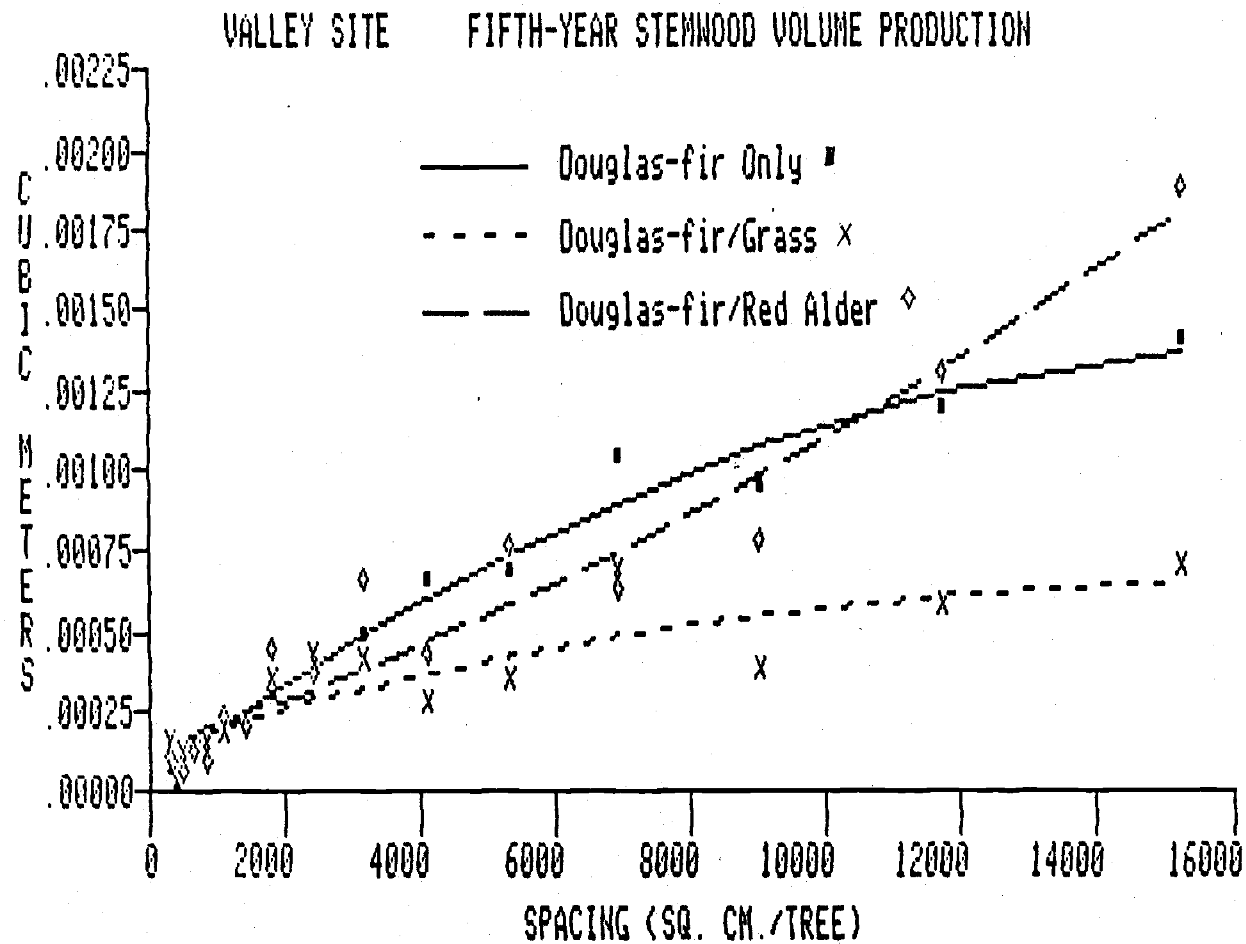

FIGURE 15a. FIFTH-YEAR STEMWOOD VOLUME PRODUCTION/TREE VS. SPACING FOR THE VALLEY SITE. Symbols represent means at each spacing.

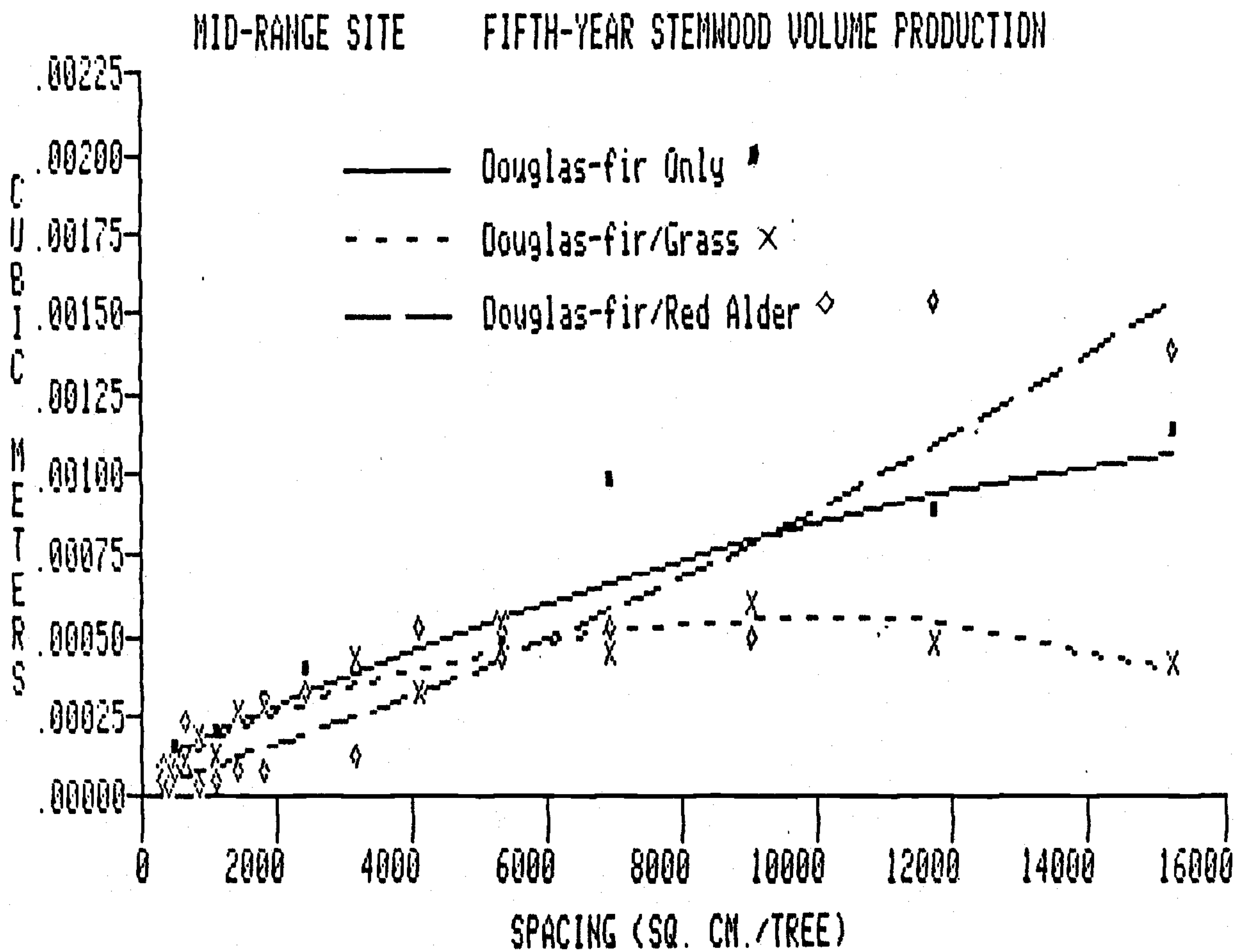

FIGURE 15b. FIFTH-YEAR STEMWOOD VOLUME PRODUCTION/TREE VS. SPACING FOR THE MID-RANGE SITE. Symbols represent means at each spacing.

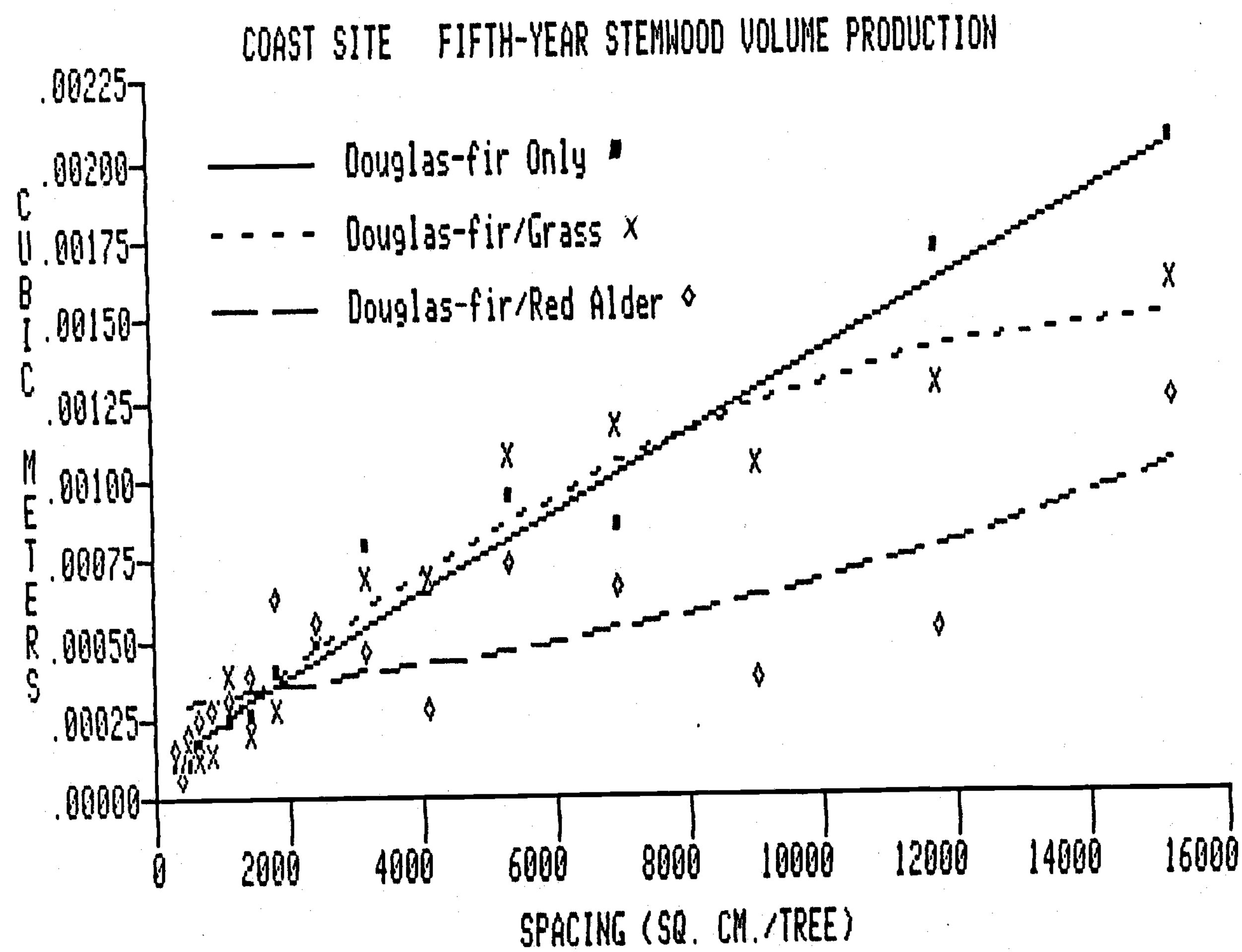

FIGURE 15c. FIFTH-YEAR STEMWOOD VOLUME PRODUCTION/TREE VS. SPACING FOR THE COAST SITE. Symbols represent means at each spacing.

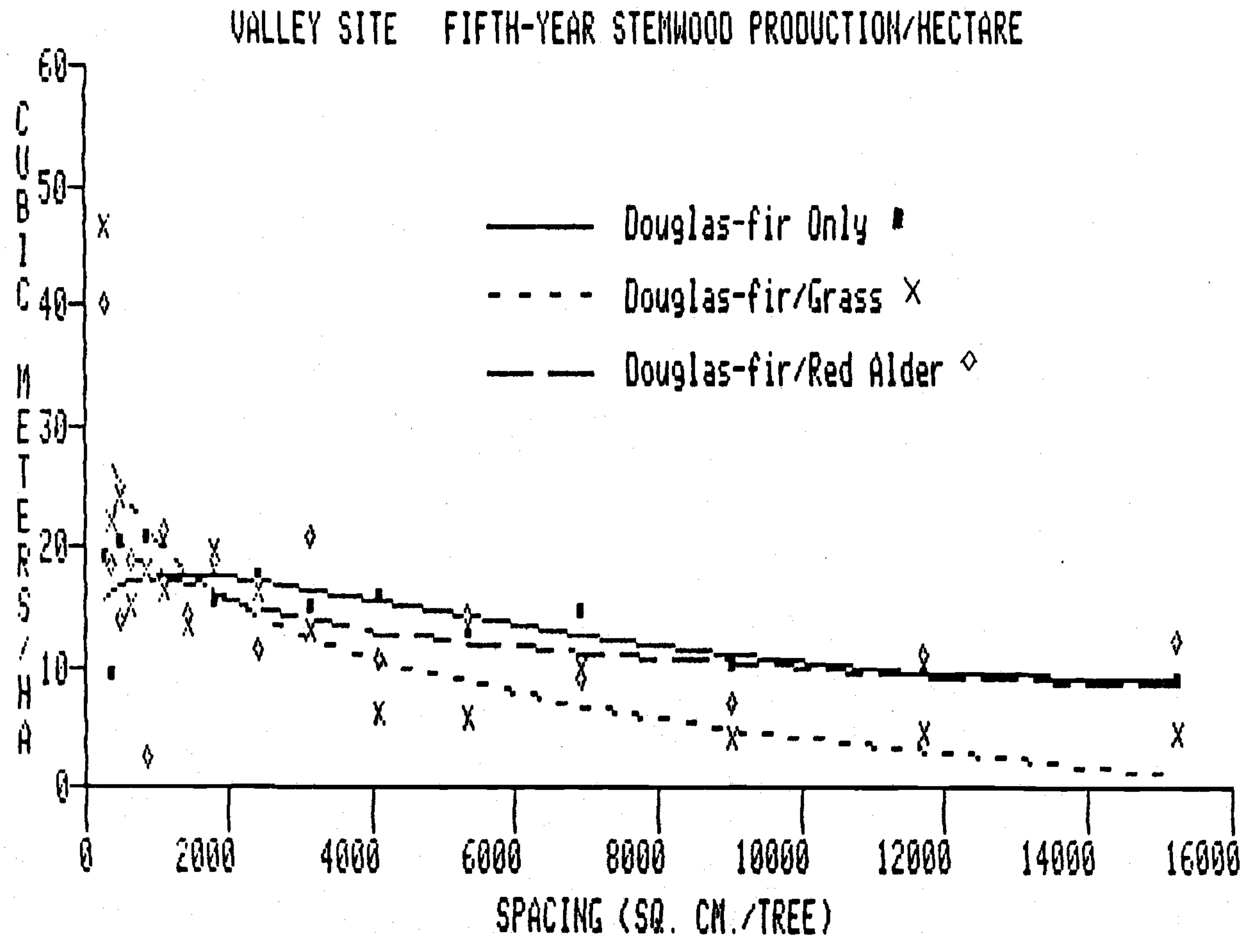

FIGURE 16a. FIFTH-YEAR STEMWOOD VOLUME PRODUCTION/HECTARE VS. SPACING FOR THE VALLEY SITE. Symbols represent means at each spacing.

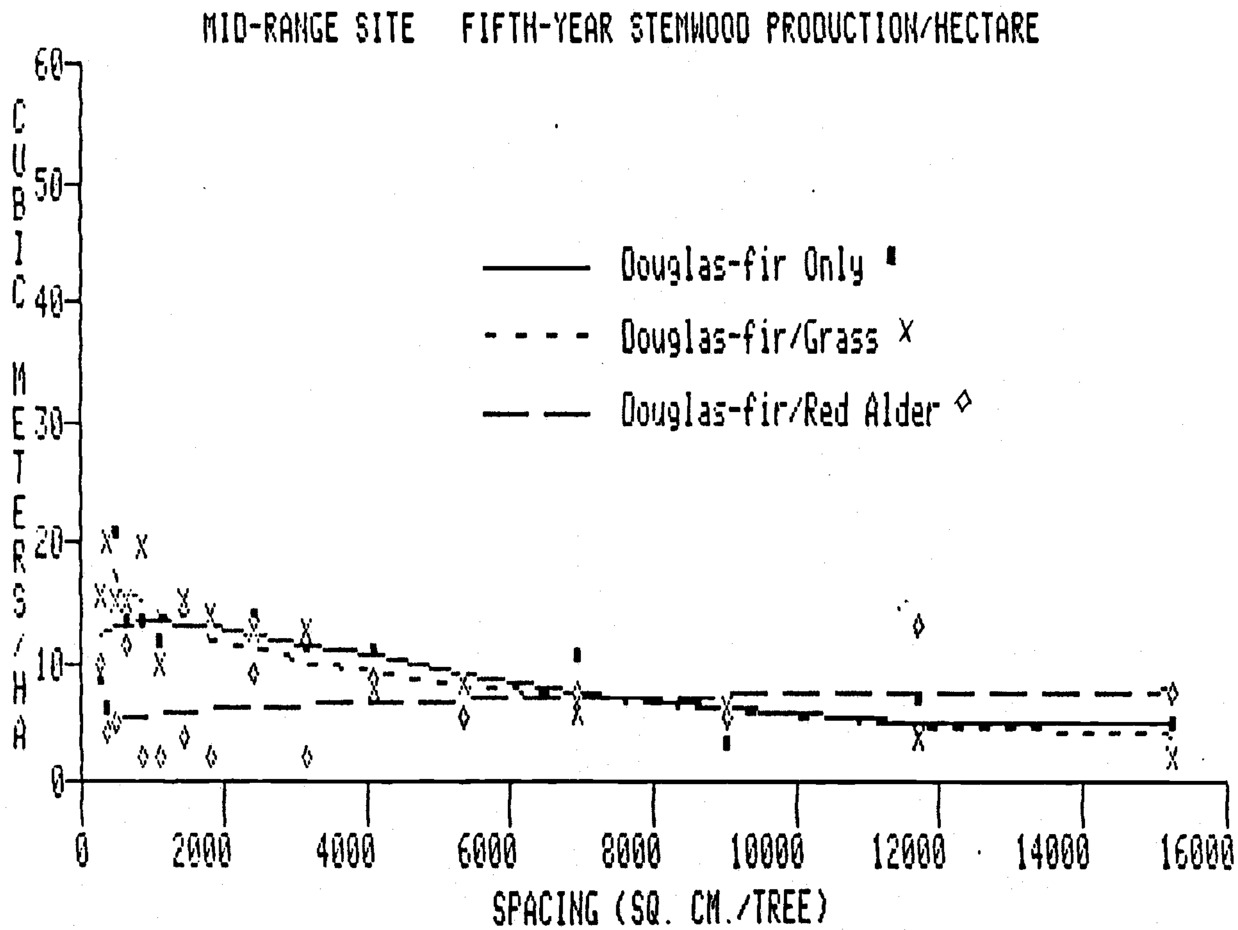

FIGURE 16b. FIFTH-YEAR STEMWOOD VOLUME PRODUCTION/HECTARE VS. SPACING FOR THE MID-RANGE SITE. Symbols represent means at each spacing.

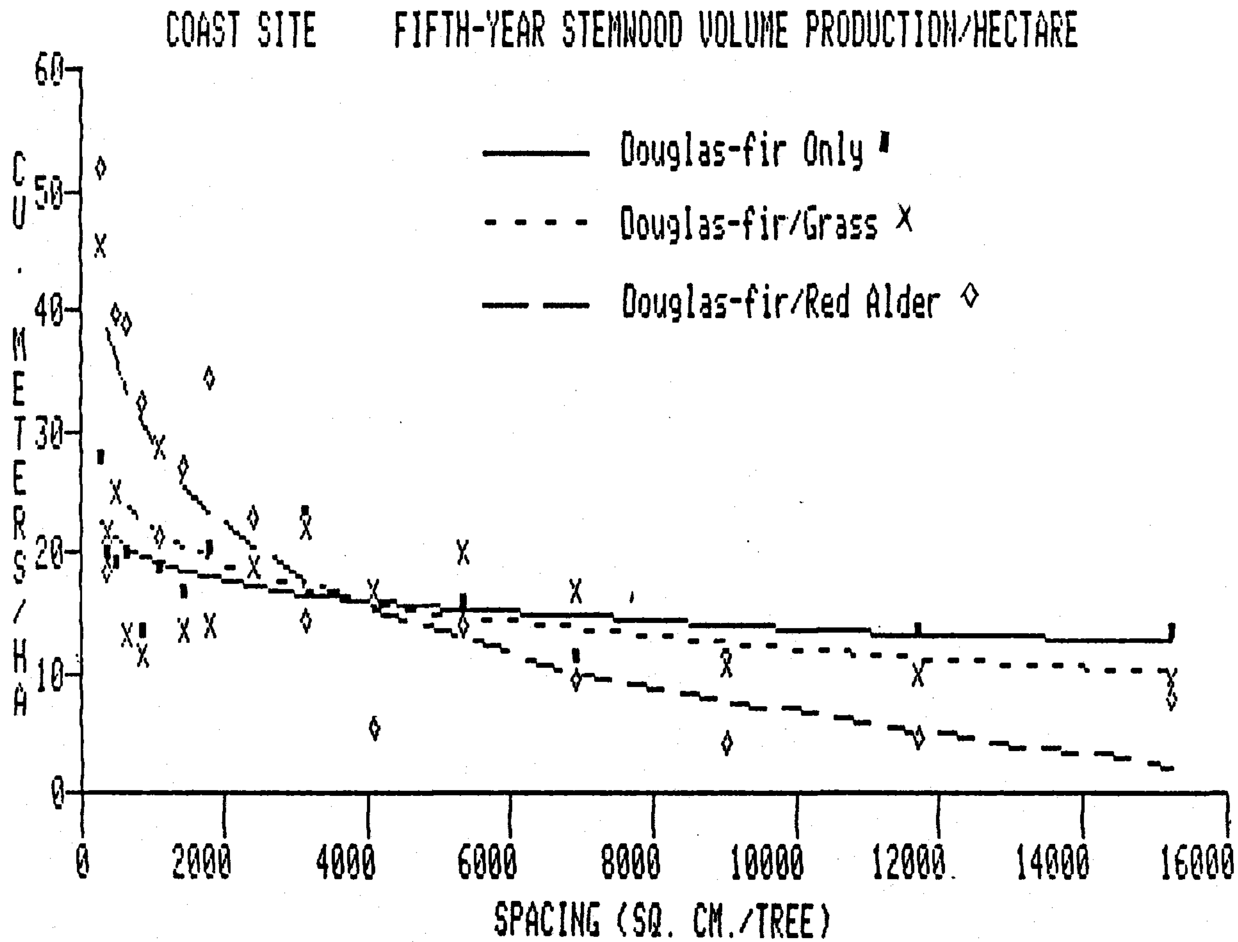

FIGURE 16c. FIFTH-YEAR STEMWOOD VOLUME PRODUCTION/HECTARE VS. SPACING FOR THE COAST SITE. Symbols represent means at each spacing.

densities at the coast site (Figure 16c). The Douglas-fir/Red Alder curve is higher at the high densities and significantly lower at the low densities than both the other curves.

Height/Diameter

The height/diameter ratio reflects the proportion of resources allocated to height and diameter. If the ratio is large, more resources are allocated toward height growth at the expense of diameter growth. This ratio was found to vary with competitor and density and the site*density and competitor* density interactions. All curves show similar forms, with the highest ratios being at the highest densities, despite the trees having the shortest stature (Figures 17a, 17b, and 17c). At the valley and mid-range sites, the ratios are lower at the high densities for the Douglas-fir/Red Alder trees. The mid-range site shows a difference among the curves at low densities which is not found at the other sites. The Douglas-fir/Red Alder trees have the highest ratio, then the Douglas-fir/Grass trees, followed by the Douglas-fir Only trees. At the coast site, all curves are similar.

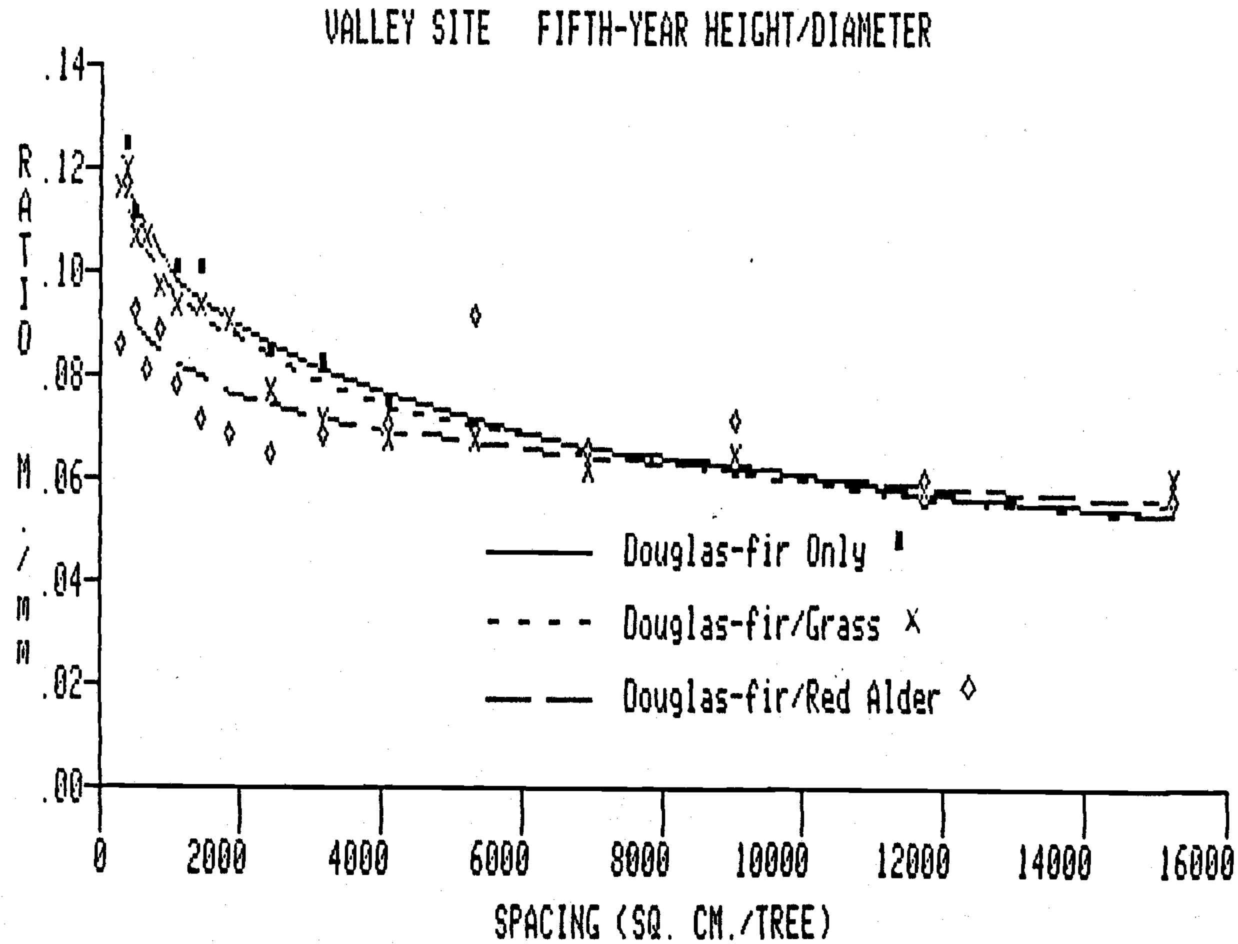

FIGURE 17a. FIFTH-YEAR HEIGHT/DIAMETER RATIOS VS. SPACING FOR THE VALLEY SITE. Symbols represent means at each spacing.

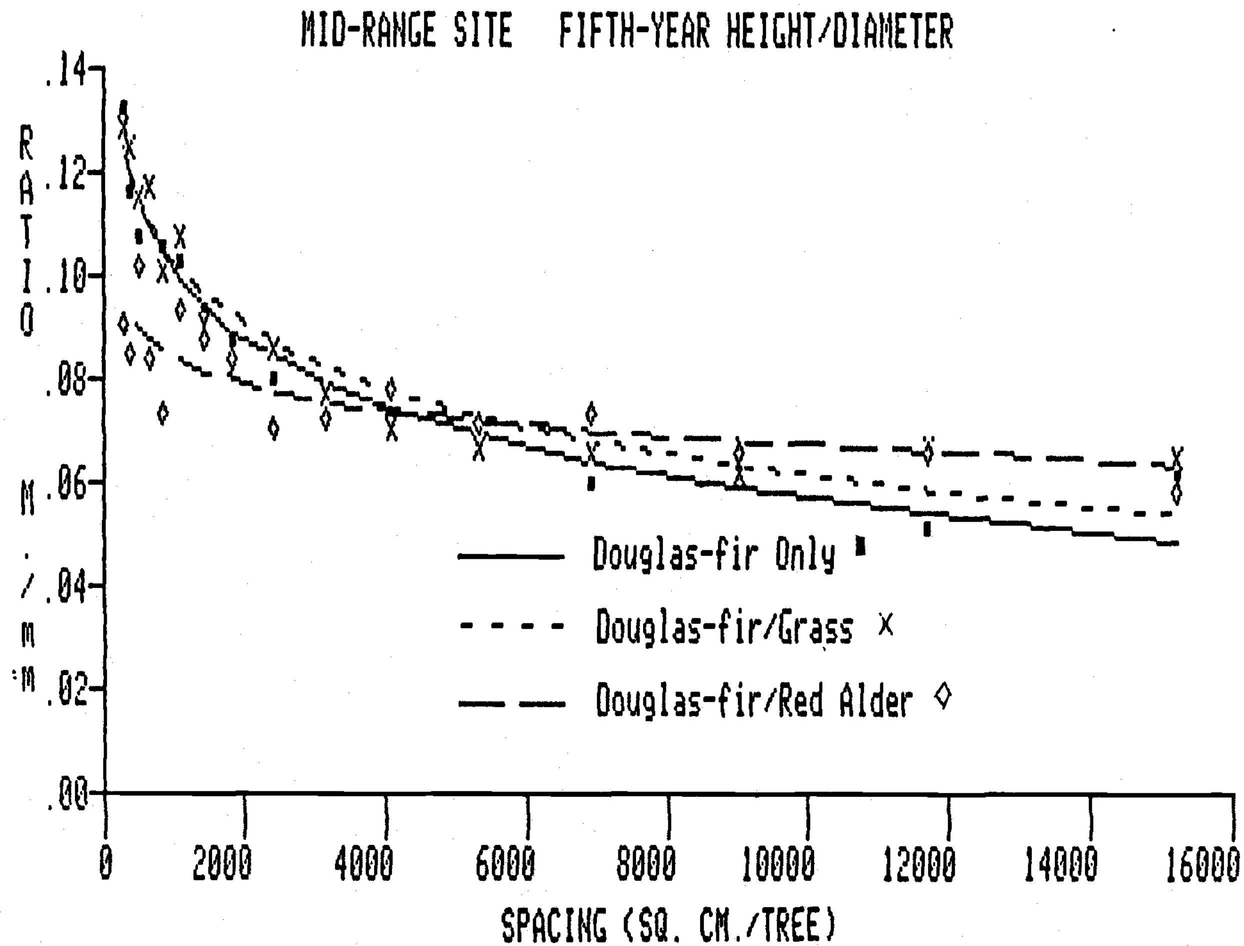

FIGURE 17b. FIFTH-YEAR HEIGHT/DIAMETER RATIOS VS. SPACING FOR THE MID-RANGE SITE. Symbols represent means at each spacing.

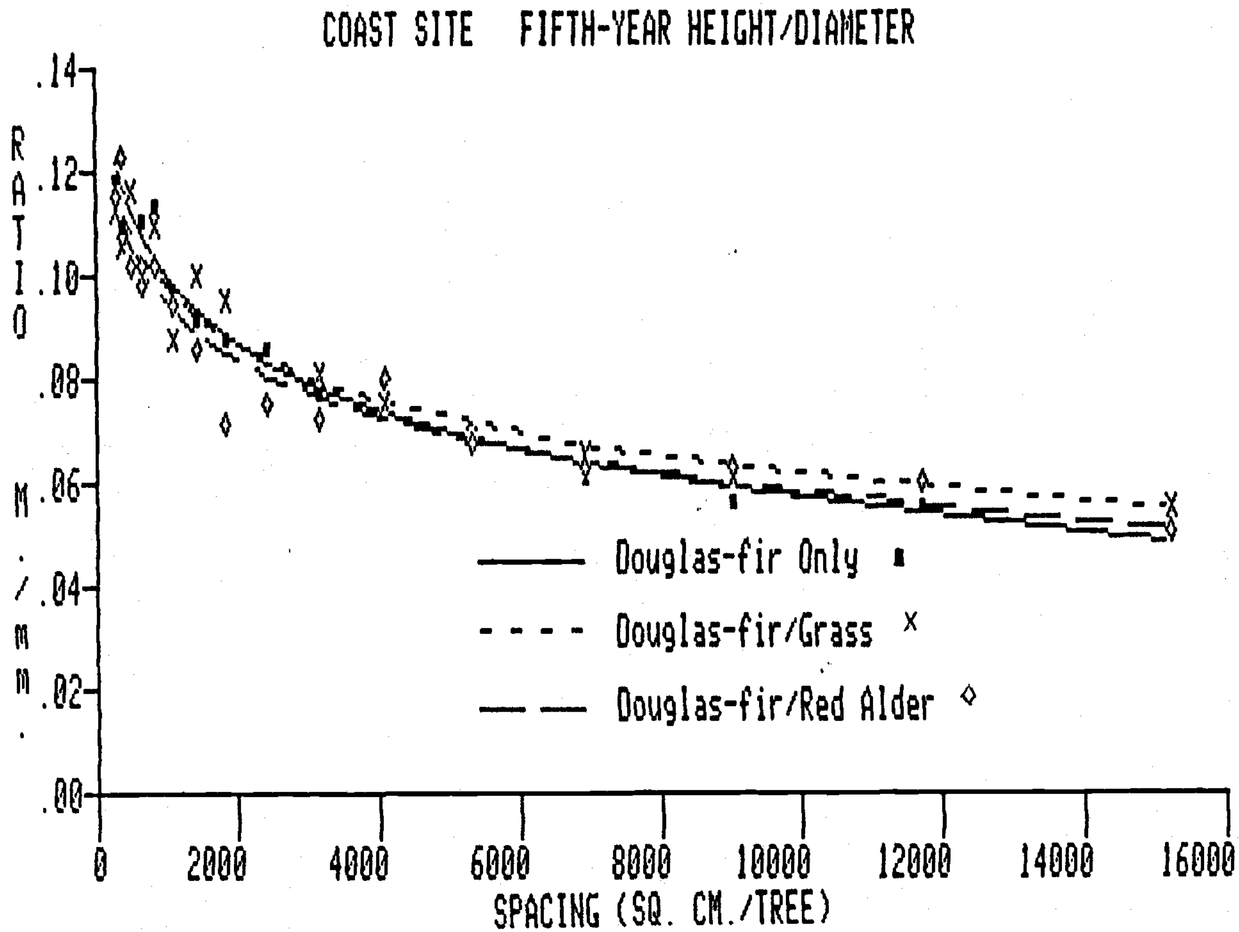

FIGURE 17c. FIFTH-YEAR HEIGHT/DIAMETER RATIOS VS. SPACING FOR THE COAST SITE. Symbols represent means at each spacing.

Leaf Area/Tree

The leaf area/tree varies significantly with density and competitor and by three interactions--site*competitor, competitor*density, and site*competitor*density. Leaf area/tree increases with decreasing density, except for the mid-range Douglas-fir/Grass trees which peak before the lowest density. At the valley site, the Douglas-fir/Grass trees have the lowest leaf area/tree. The Douglas-fir/Red Alder and Douglas-fir Only trees show similar values until the mid- and low densities where the leaf area/tree increases dramatically in the Douglas-fir/Red Alder trees. The mid-range results differ from the valley results only at the high densities. There the Douglas-fir/Red Alder trees have lower values than the Douglas-fir/Grass trees. At the coast site, the Douglas-fir Only curve reflects the increase in leaf biomass with decreasing density. The Douglas-fir/Grass curve is consistently below that of the Douglas-fir Only. The Douglas-fir/Red Alder trees have the lowest rather than the highest values of leaf area/tree. Curves are illustrated in Figures 18a, 18b, and 18c.

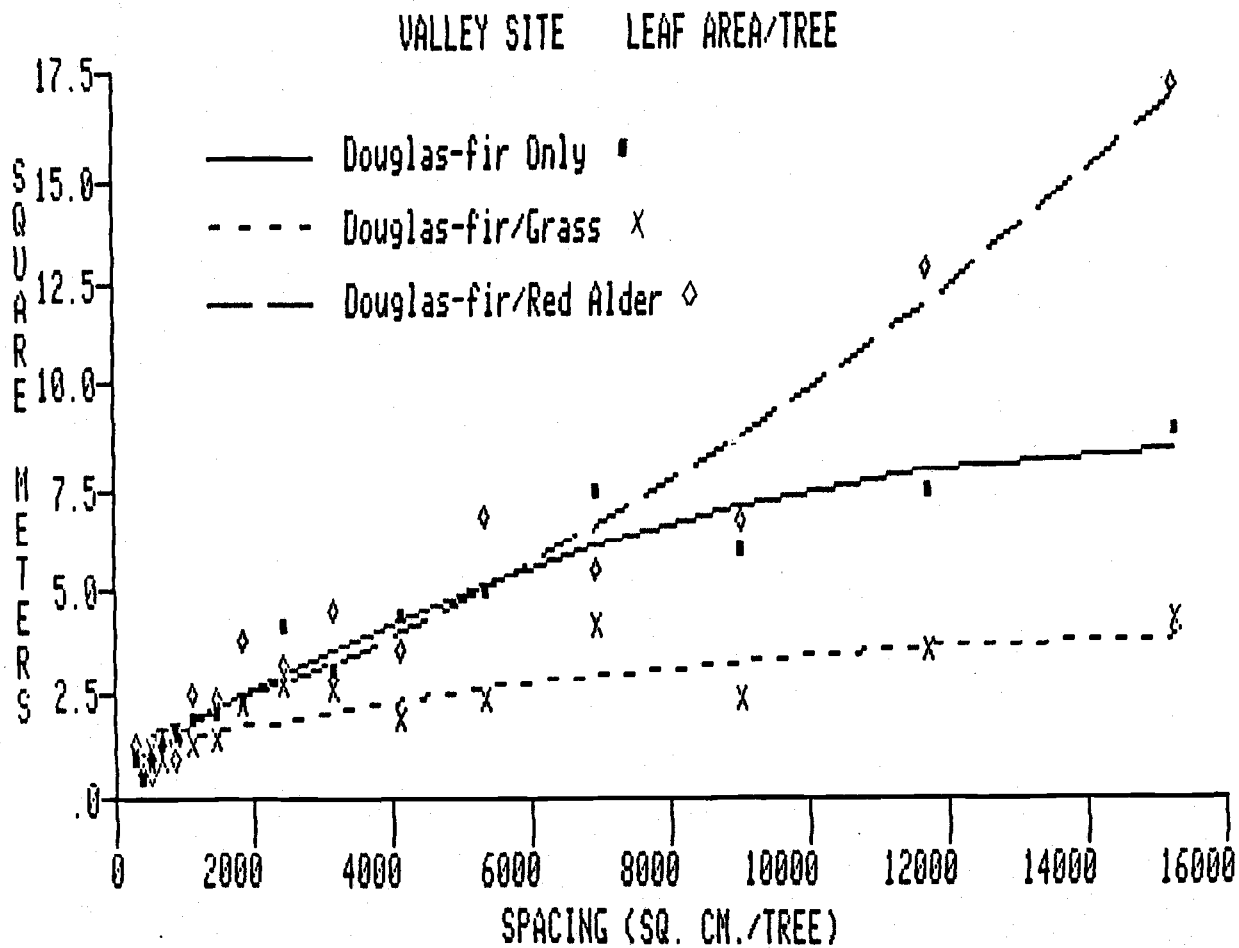

FIGURE 18a. FIFTH-YEAR LEAF AREA/TREE VS. SPACING FOR THE VALLEY SITE. Symbols represent means at each spacing.

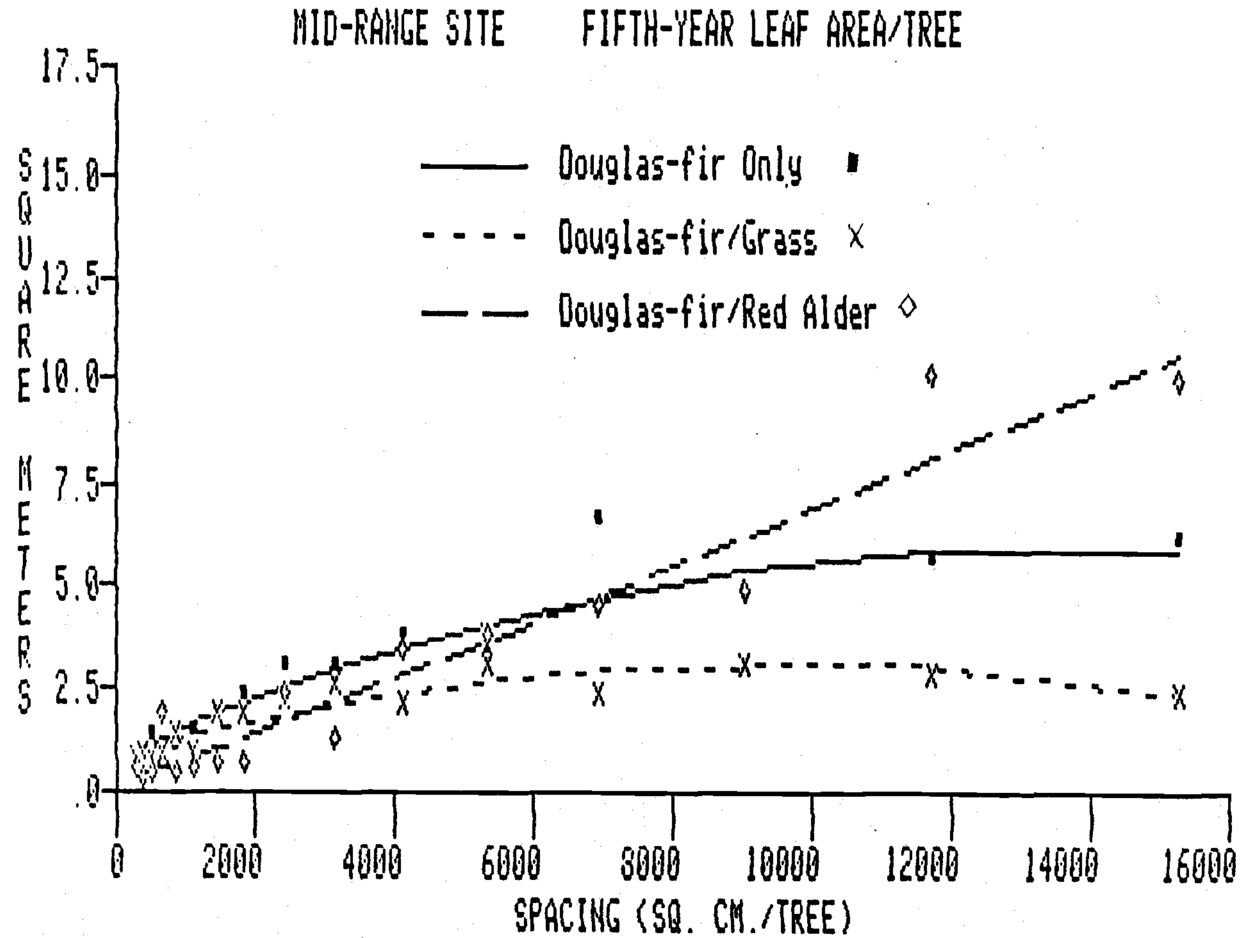

FIGURE 18b. FIFTH-YEAR LEAF AREA/TREE VS. SPACING FOR THE MID-RANGE SITE. Symbols represent means at each spacing.

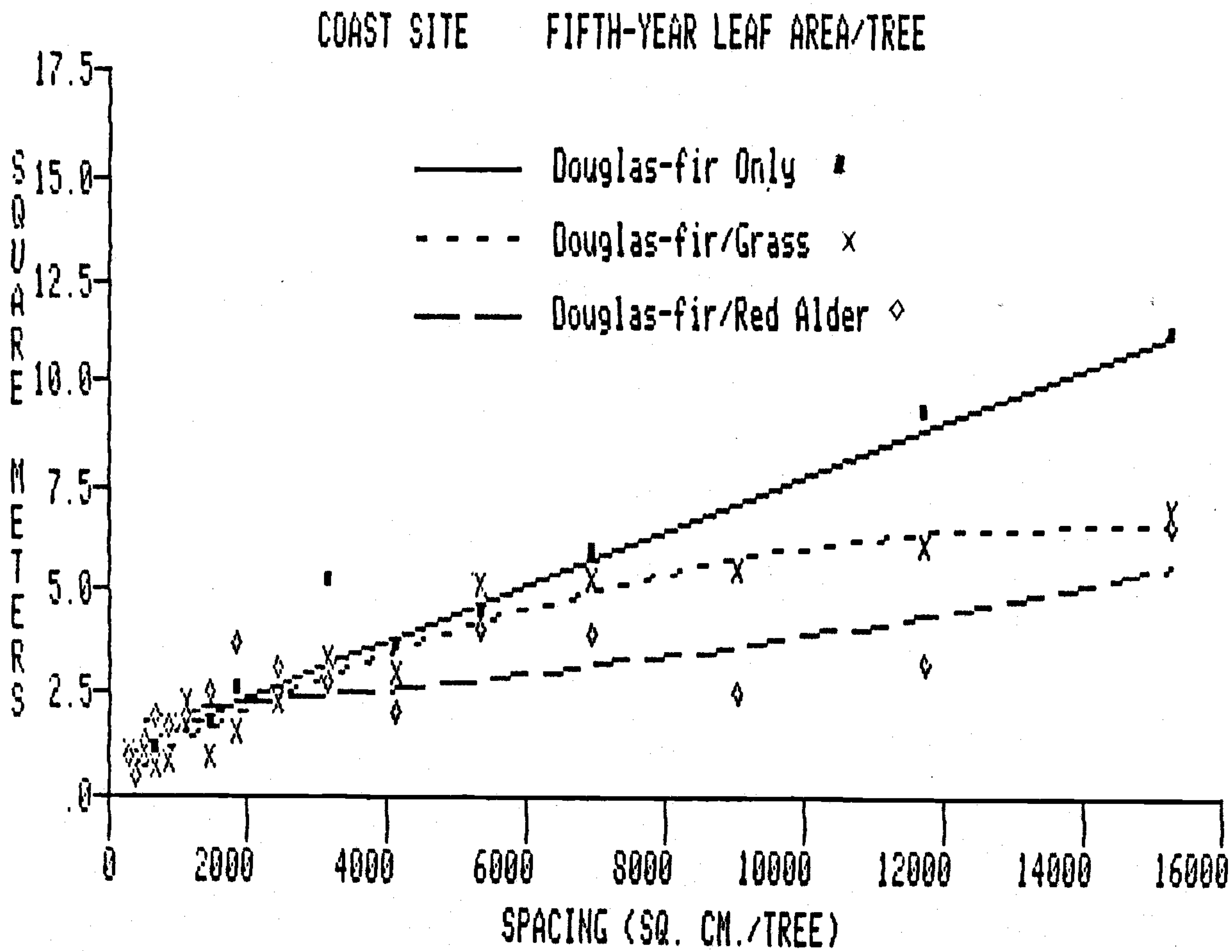

FIGURE 18c. FIFTH-YEAR LEAF AREA/TREE VS. SPACING FOR THE COAST SITE. Symbols represent means at each spacing.

Leaf Area Index (LAI)

Leaf area index values represent the LAI of the average tree projected over the sum of the densities at each arc. For instance, if the average tree at 300 cm^2/tree had a leaf area of 0.5 square meters, then the LAI would be 0.5 square meter /300 cm^2/tree or 16.7 square meters/square meter.

Unlike leaf area/tree, leaf area index varies significantly only with density, and it decreases with decreasing density (Figures 19a, 19b, and 19c). At all sites, the Douglas-fir/Grass section maintained the lowest LAI values. For the Douglas-fir Only section, LAI values were higher at the high densities and lower at the mid- and low densities than the Douglas-fir/Red Alder values at the valley and mid-range sites. The trend was reversed at the coast. At the coast, LAI's at the high densities were highly variable and demonstrated almost no correlation with density.

Stemwood Volume Production/Tree/Leaf Area Index

At all sites, stemwood production/leaf area index (growth efficiency) continually increases as density decreases (Figures 20a, 20b, and 20c).

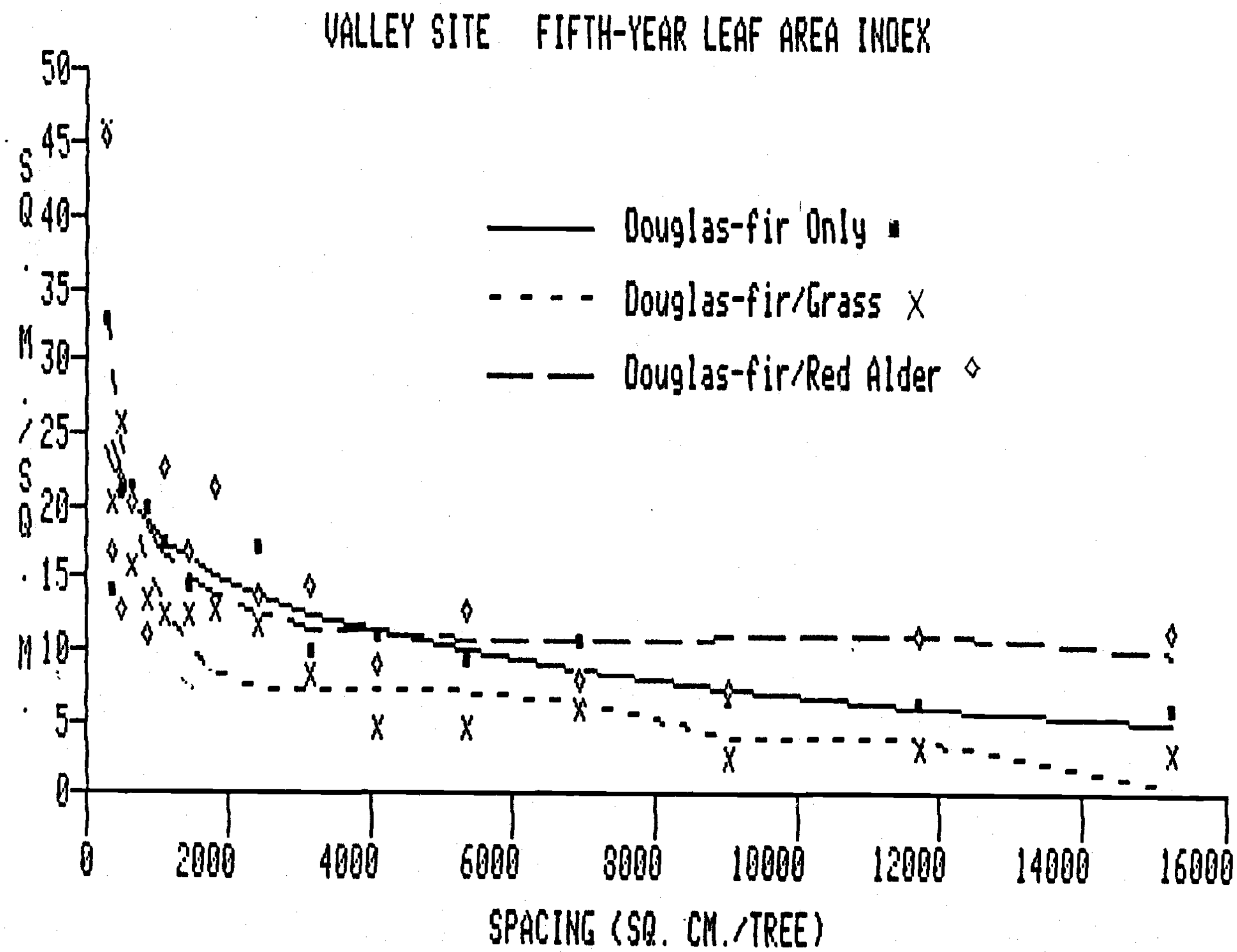

FIGURE 19a. FIFTH-YEAR LEAF AREA INDEX VS. SPACING FOR THE VALLEY SITE. Symbols represent means at each spacing.

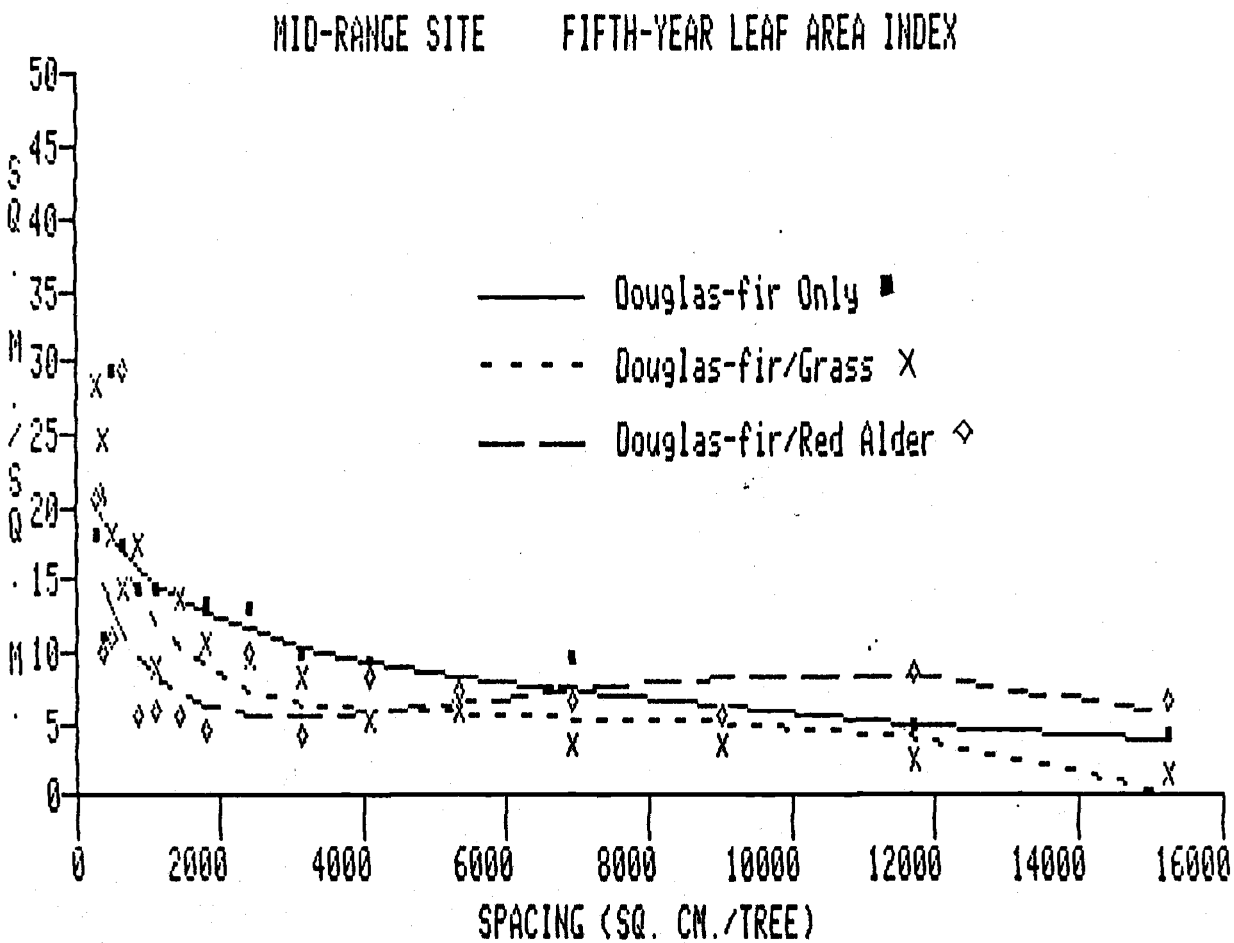

FIGURE 19b. FIFTH-YEAR LEAF AREA INDEX VS. SPACING FOR THE MID-RANGE SITE. Symbols represent means at each spacing.

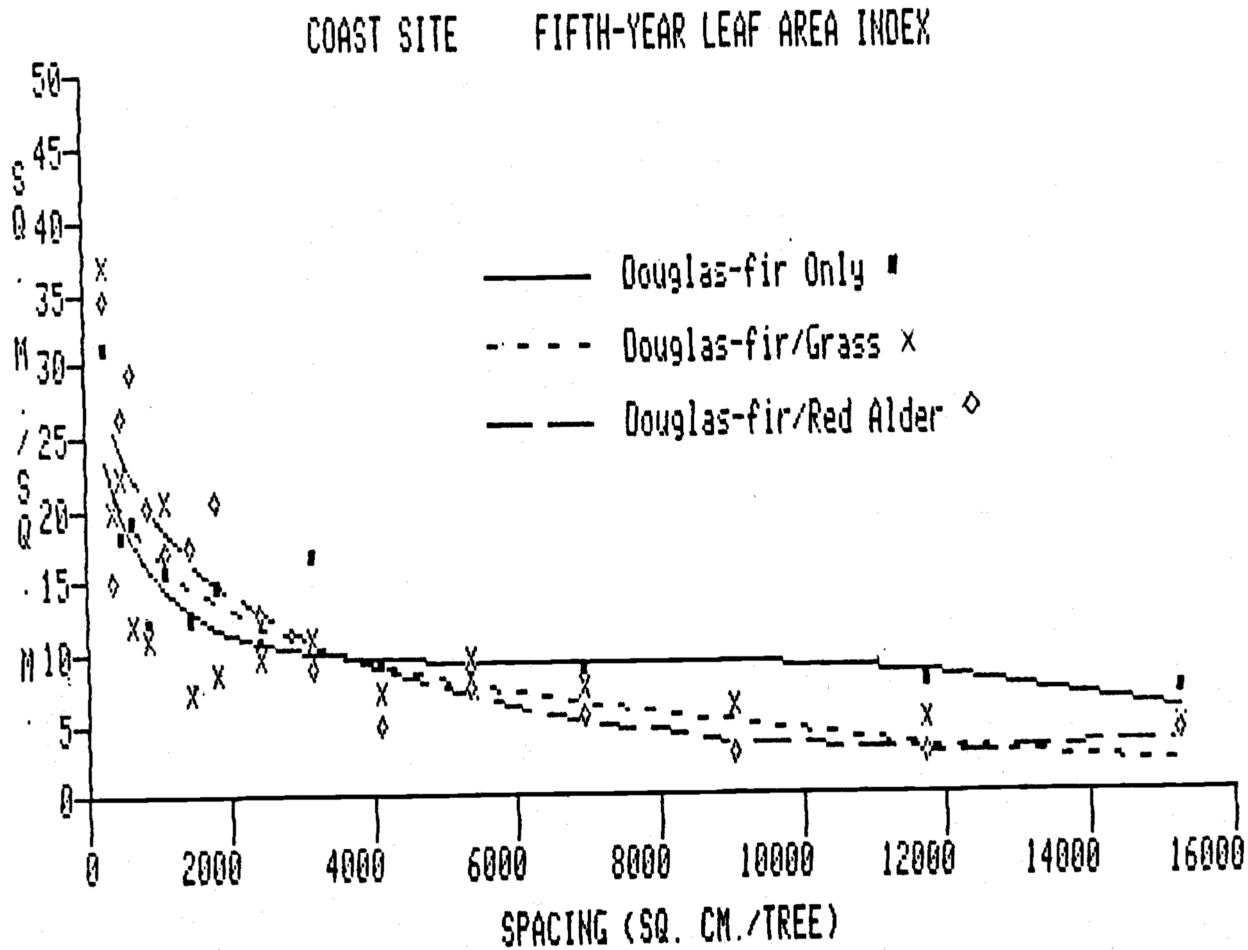

FIGURE 19c. FIFTH-YEAR LEAF AREA INDEX VS. SPACING FOR THE COAST SITE. Symbols represent means at each spacing.

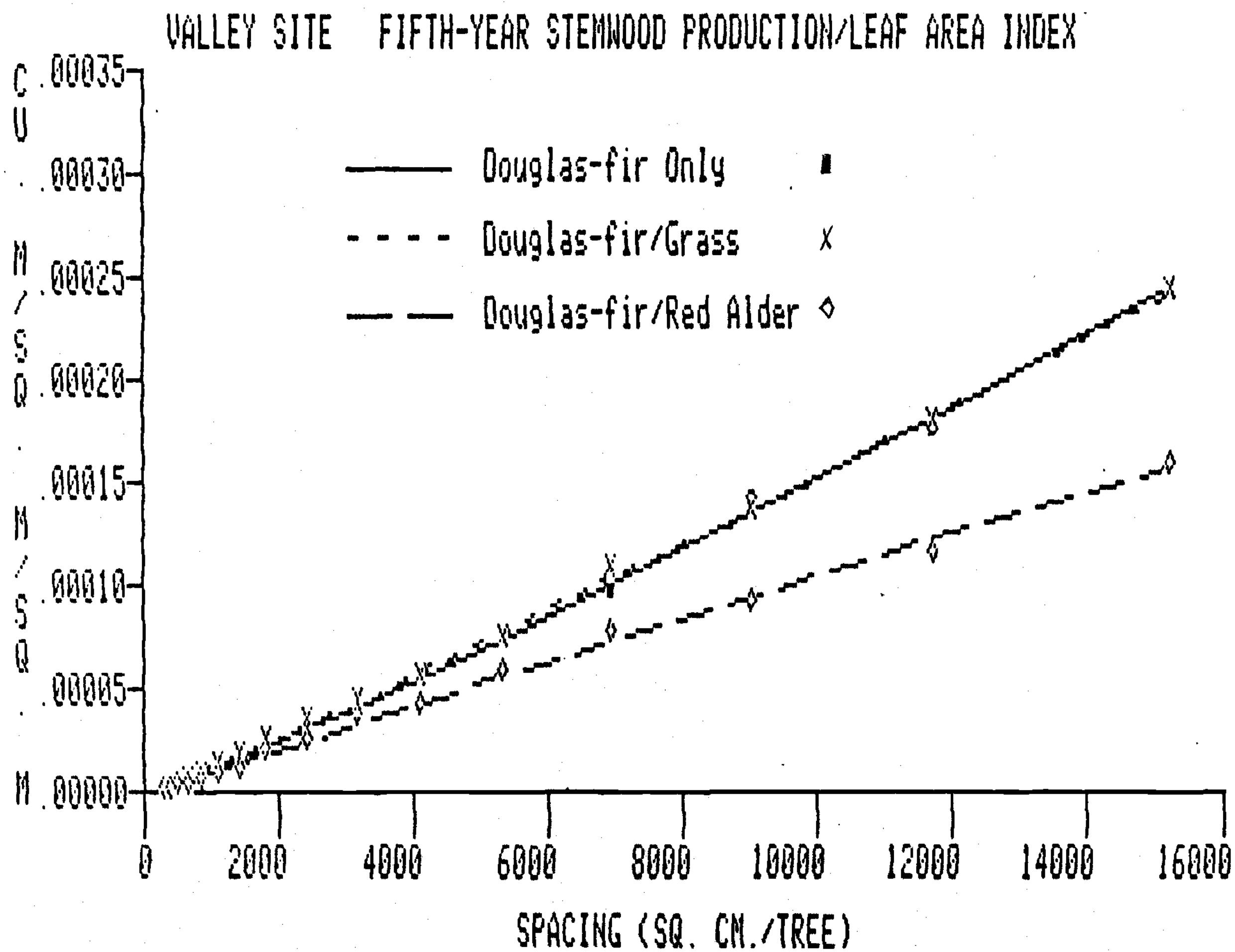

FIGURE 20a. FIFTH-YEAR STEMWOOD VOLUME PRODUCTION/TREE/LEAF AREA INDEX VS. SPACING FOR THE VALLEY SITE. Symbols represent means at each spacing.

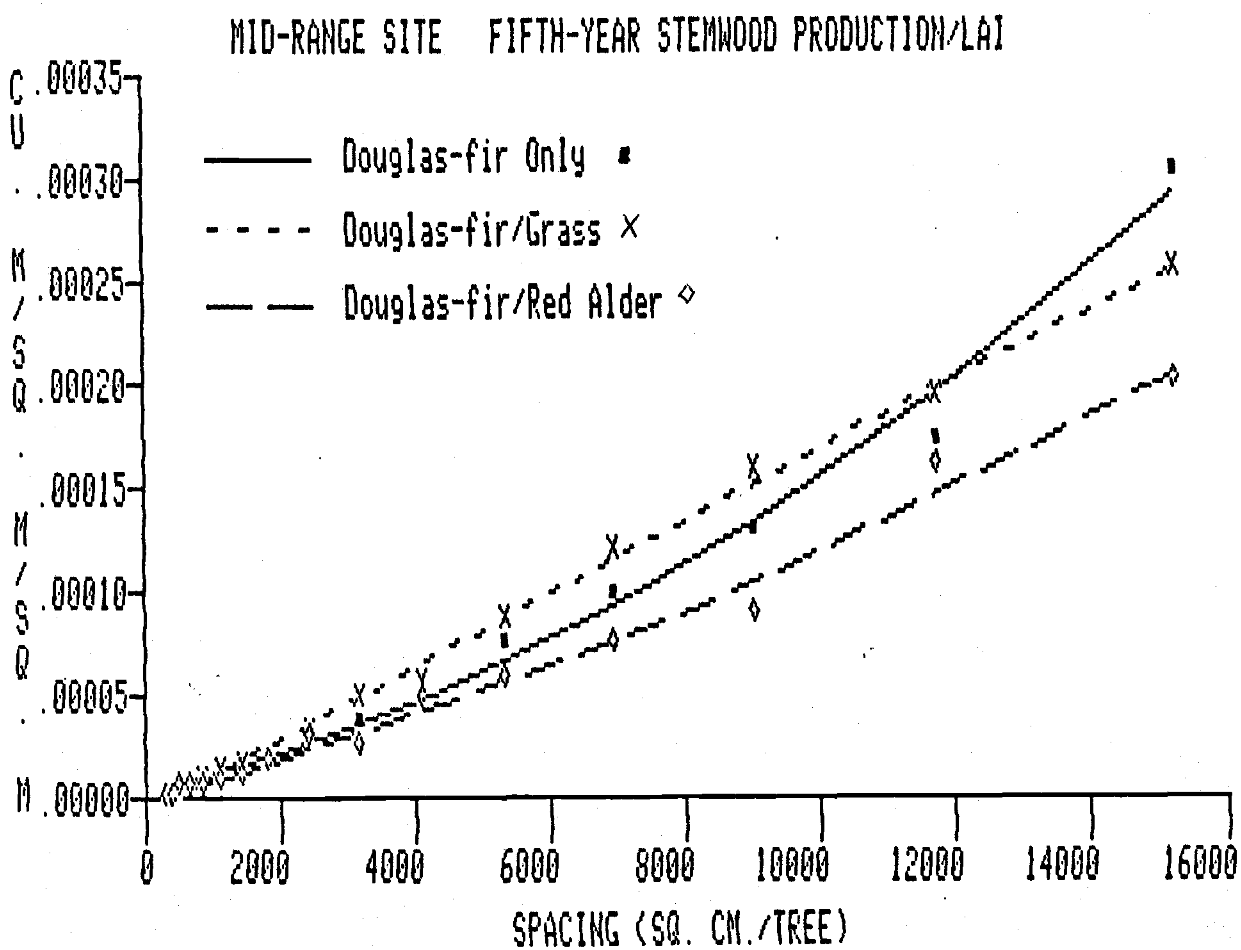

FIGURE 20b. FIFTH-YEAR STEMWOOD VOLUME PRODUCTION/TREE/LEAF AREA INDEX VS. SPACING FOR THE MID-RANGE SITE. Symbols represent means at each spacing.

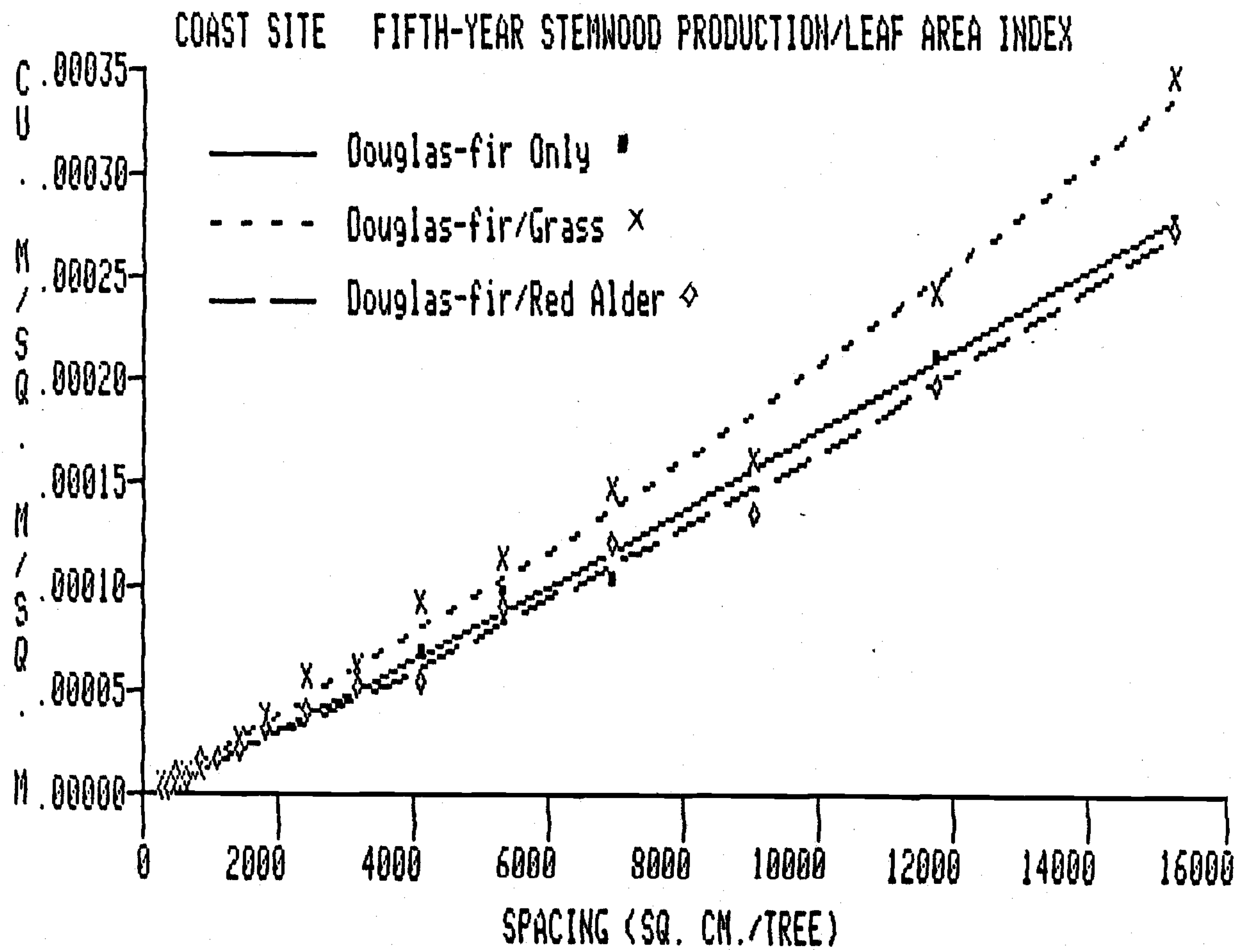

FIGURE 20c. FIFTH-YEAR STEMWOOD VOLUME PRODUCTION/TREE/LEAF AREA INDEX VS. SPACING FOR THE COAST SITE. Symbols represent means at each spacing.

Values vary with site, density, site*density, competitor*density, and site*competitor*density. The Douglas-fir/Grass and Douglas-fir Only trees exhibit almost no difference in values at the valley site. The Douglas-fir/Red Alder trees have lower values at all densities. The trend is similar at the mid-range site, except the Douglas-fir/ Grass and Douglas-fir Only curves show some differences, with the Douglas-fir/Grass curve being slightly higher. At the coast site, the Douglas-fir/Grass values are highest at all densities, followed by the Douglas-fir Only results, and then those of the Douglas-fir/Red Alder trees.

Stemwood Volume Production/Tree/Leaf Area/Tree

Site, competitor, density, and competitor* density affect stemwood production/tree/leaf area/tree (Figures 21a, 21b, and 21c). Generally, values increase rapidly as density decreases and then reach plateaus. At the valley and mid-range sites, the results of the Douglas-fir/Red Alder trees are much lower than the other treatments. The Douglas-fir/Grass and Douglas-fir Only curves at the valley site are similar at the lower densities,

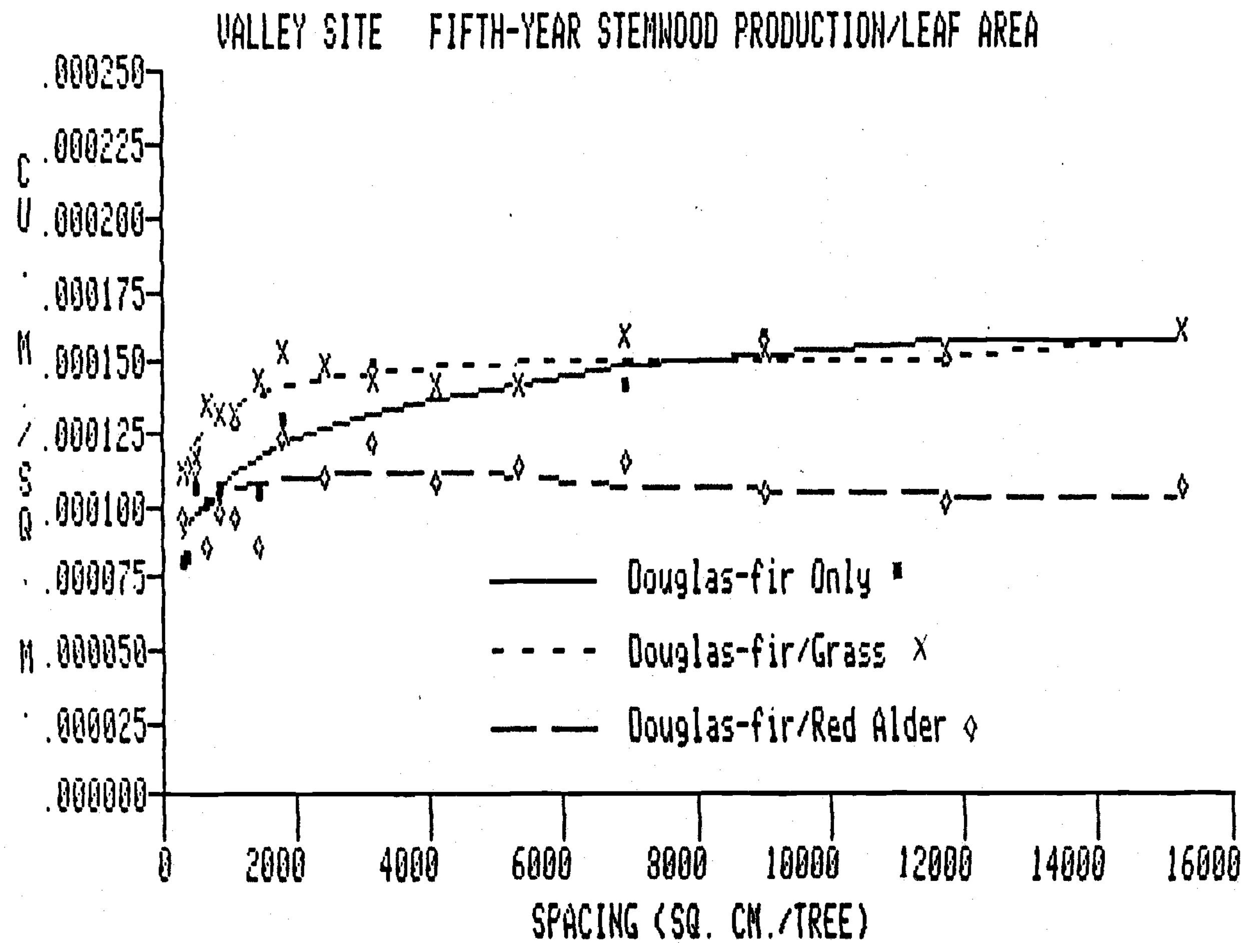

FIGURE 21a. FIFTH-YEAR STEMWOOD VOLUME PRODUCTION/TREE/LEAF AREA/ TREE VS. SPACING FOR THE VALLEY SITE. Symbols represent means at each spacing.

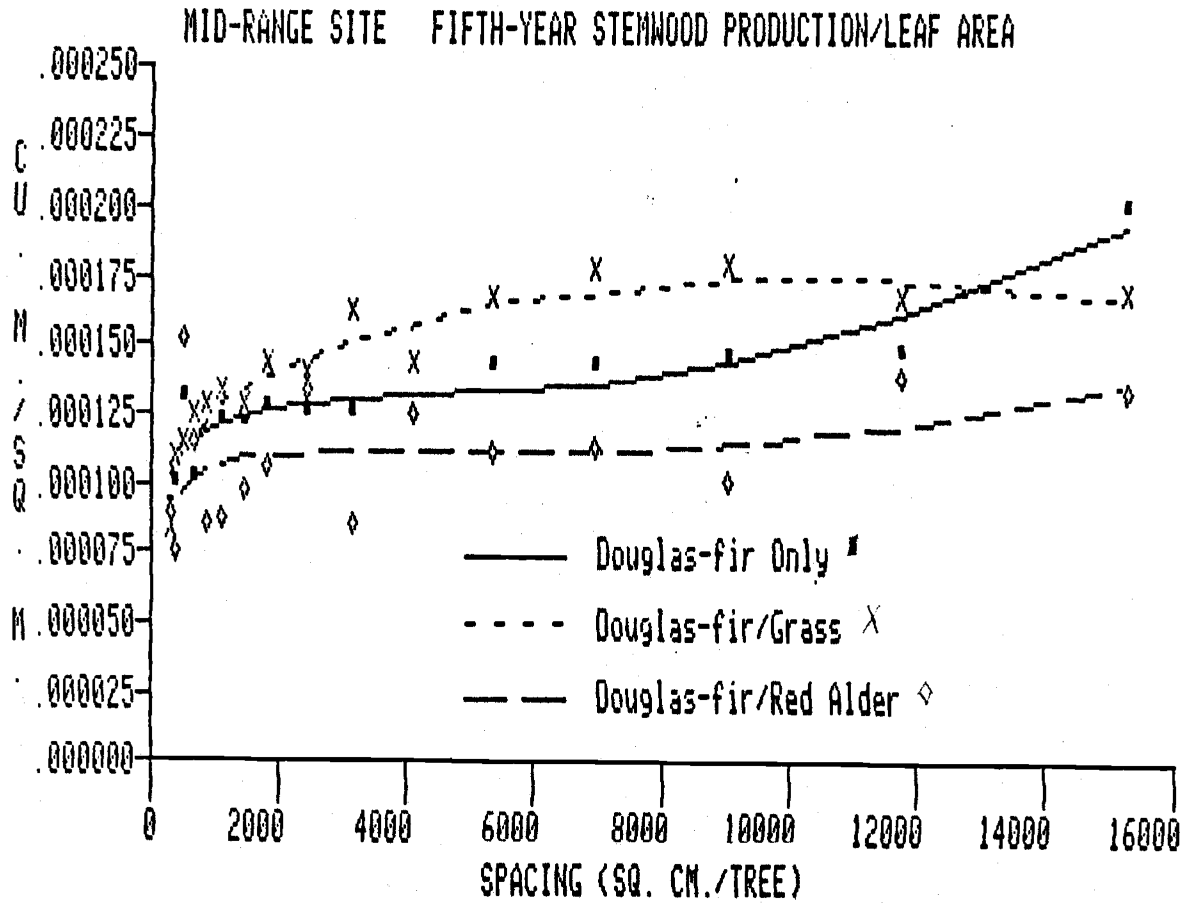

FIGURE 21b. FIFTH-YEAR STEMWOOD VOLUME PRODUCTION/TREE/LEAF AREA/TREE VS. SPACING FOR THE MID-RANGE SITE. Symbols represent means at each spacing.

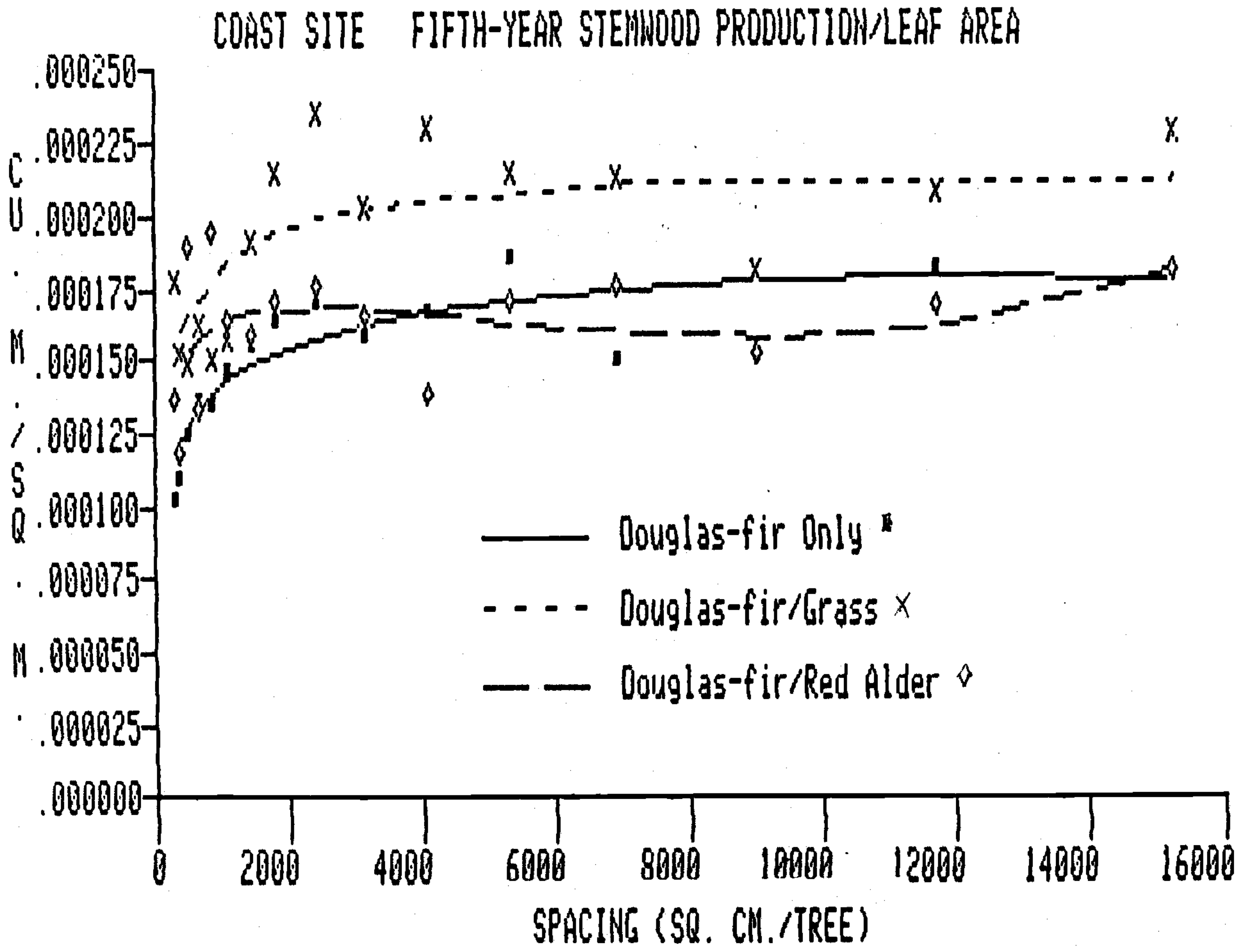

FIGURE 21c. FIFTH-YEAR STEMWOOD VOLUME PRODUCTION/TREE/LEAF AREA/TREE VS. SPACING FOR THE COAST SITE. Symbols represent means at each spacing.

but the Douglas-fir/Grass values are higher at the high densities. At the mid-range and coast sites, the Douglas-fir/Grass values are higher throughout the range of densities. The Douglas-fir Only curve at the coast is higher than the Douglas-fir/Red Alder curve at the low densities, but lower at the high densities.

Stemwood Volume Production/Hectare/Leaf Area Index

At the valley site, all curves are similar at the high densities (Figure 22a). The Douglas-fir/Red Alder curve is below both the Douglas-fir/Grass and the Douglas-fir Only curves at all lower densities, and the differences are significant. The Douglas-fir/Grass curve is above the Douglas-fir Only curve, but the differences are not significant. At the mid-range site, the Douglas-fir/Red Alder curve is significantly lower than the Douglas-fir Only curve at all densities (Figure 22b). Differences are significant only at the mid-densities. At the coast site, the Douglas-fir/Grass curve is significantly higher than the other curves at all but the high densities (Figure 22c). The Douglas-fir/Red Alder curve falls significantly below the Douglas-fir Only curve at the mid-densities.

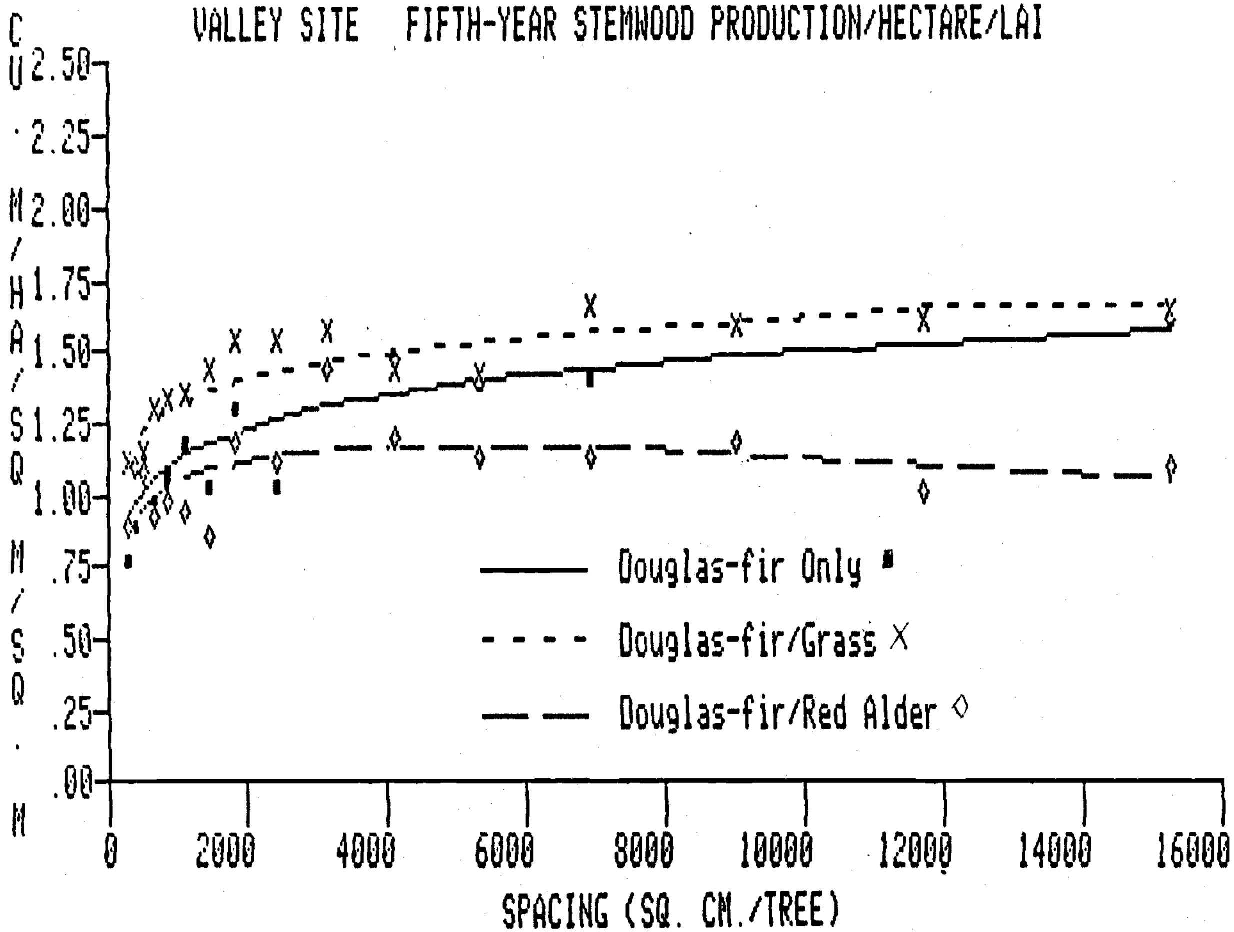

FIGURE 22a. FIFTH-YEAR STEMWOOD VOLUME PRODUCTION/HECTARE/LEAF AREA INDEX VS. SPACING FOR THE VALLEY SITE. Symbols represent means at each spacing.

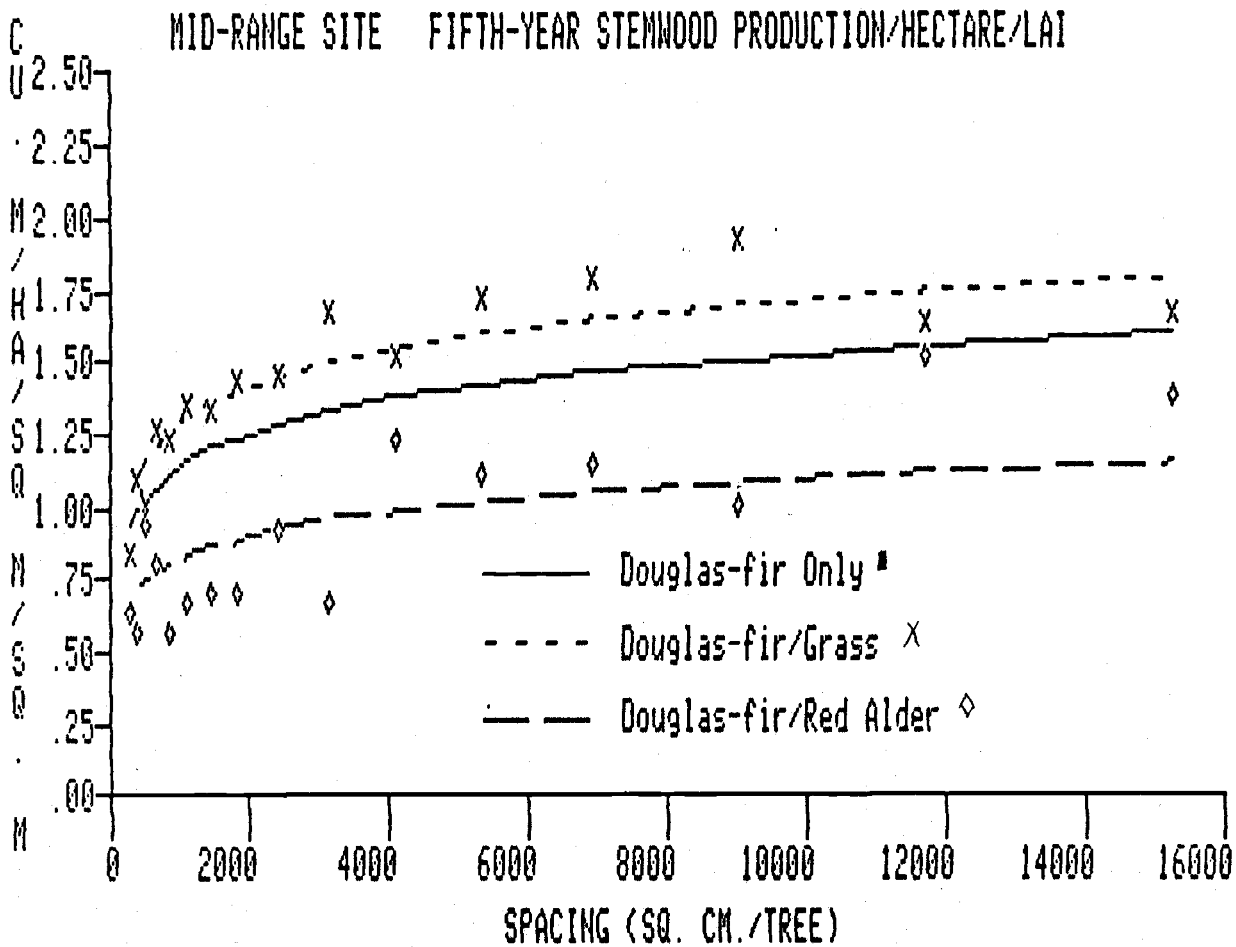

FIGURE 22b. FIFTH-YEAR STEMWOOD VOLUME PRODUCTION/HECTARE/LEAF AREA INDEX VS. SPACING FOR THE MID-RANGE SITE. Symbols represent means at each spacing.

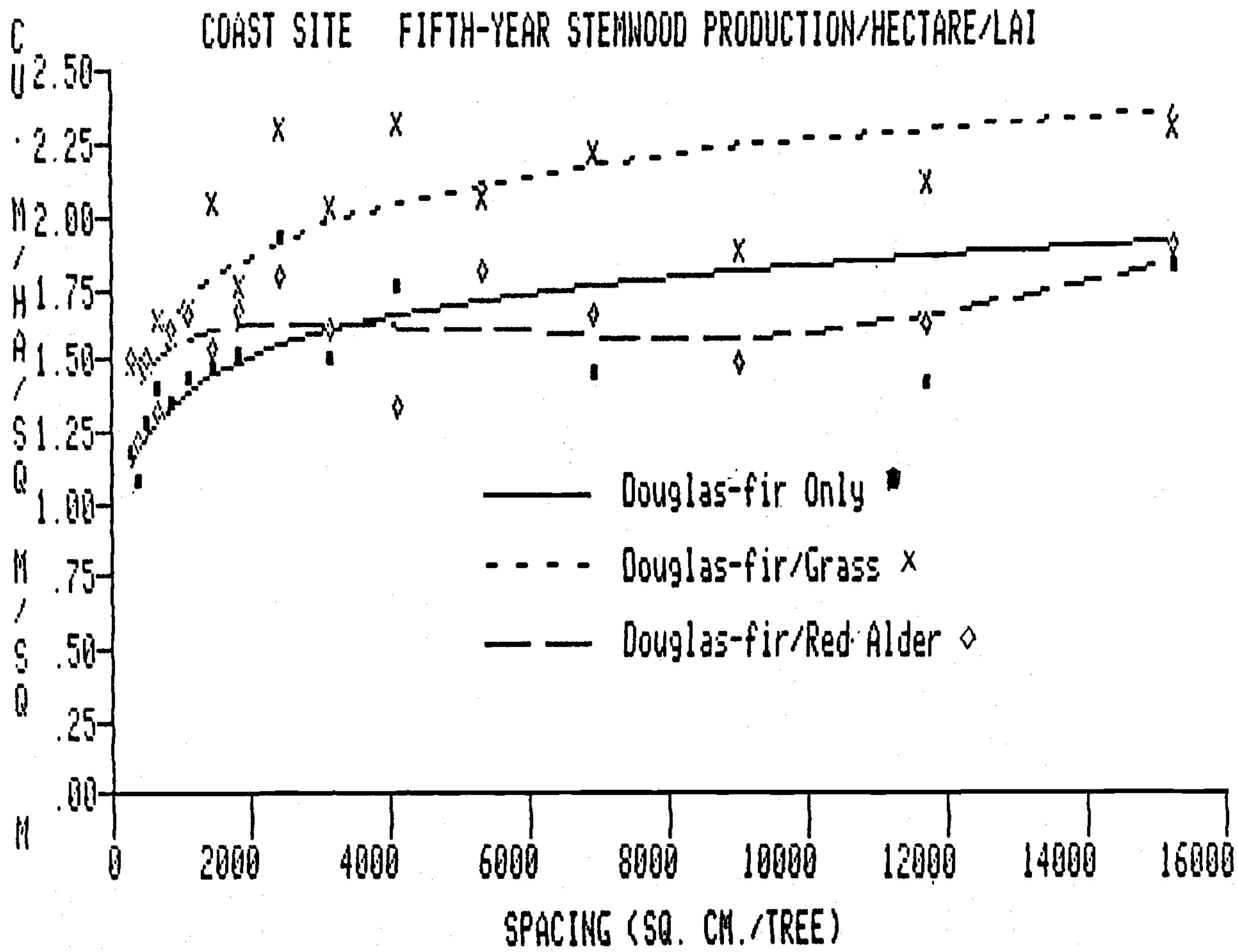

FIGURE 22c. FIFTH-YEAR STEMWOOD VOLUME PRODUCTION/HECTARE/LEAF AREA INDEX VS. SPACING FOR THE COAST SITE. Symbols represent means at each spacing.

Basal Area Growth/Tree/Leaf Area Index

Changes in basal area growth/tree/leaf area index are affected by competitor, density, site*competitor, site*density, competitor*density, and site*competitor*density (Figures 23a, 23b, and 23c). Values increase as density decreases. At the valley and mid-range sites, the Douglas-fir/Grass values are the highest, then the Douglas-fir Only values, followed by the Douglas-fir/Red Alder results. The coast site shows little difference between the Douglas-fir/Grass and Douglas-fir/Red Alder curves, both of which are above the Douglas-fir Only curve.

Basal Area Growth/Hectare/Leaf Area Index

When placed on a leaf area index basis, basal area growth/hectare shows the highest values at the lowest densities (Figures 24a, 24b, and 24c). At both the valley and mid-range sites, the Douglas-fir/Grass curve has the highest values. The Douglas-fir/Red Alder curve has similar values to the Douglas-fir/Grass curve at high densities, but it is significantly lower than both the Douglas-fir Only and Douglas-fir/Grass curves at the low densities. The Douglas-fir Only curve is

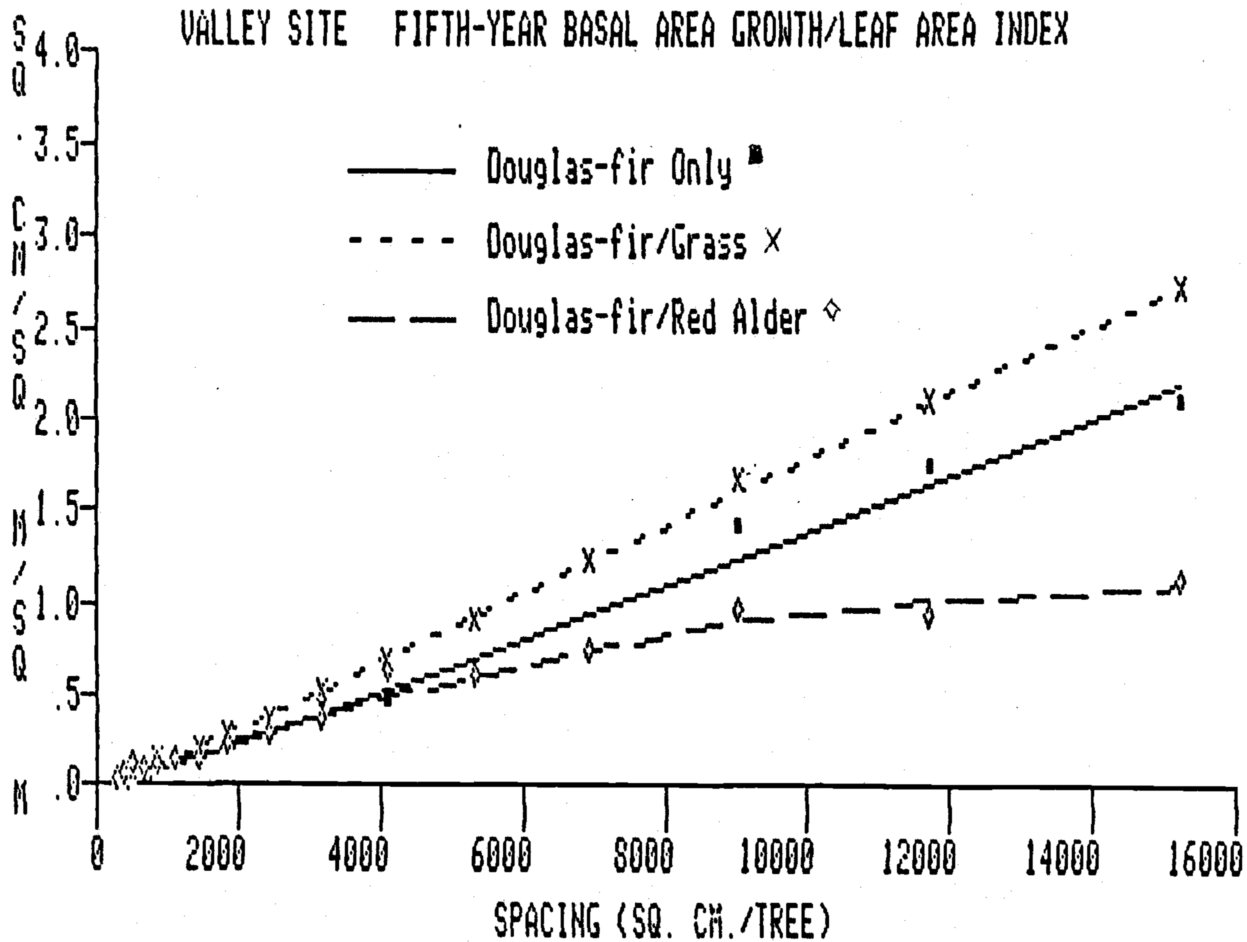

FIGURE 23a. FIFTH-YEAR BASAL AREA GROWTH/TREE/LEAF AREA INDEX VS. SPACING FOR THE VALLEY SITE. Symbols represent means at each spacing.

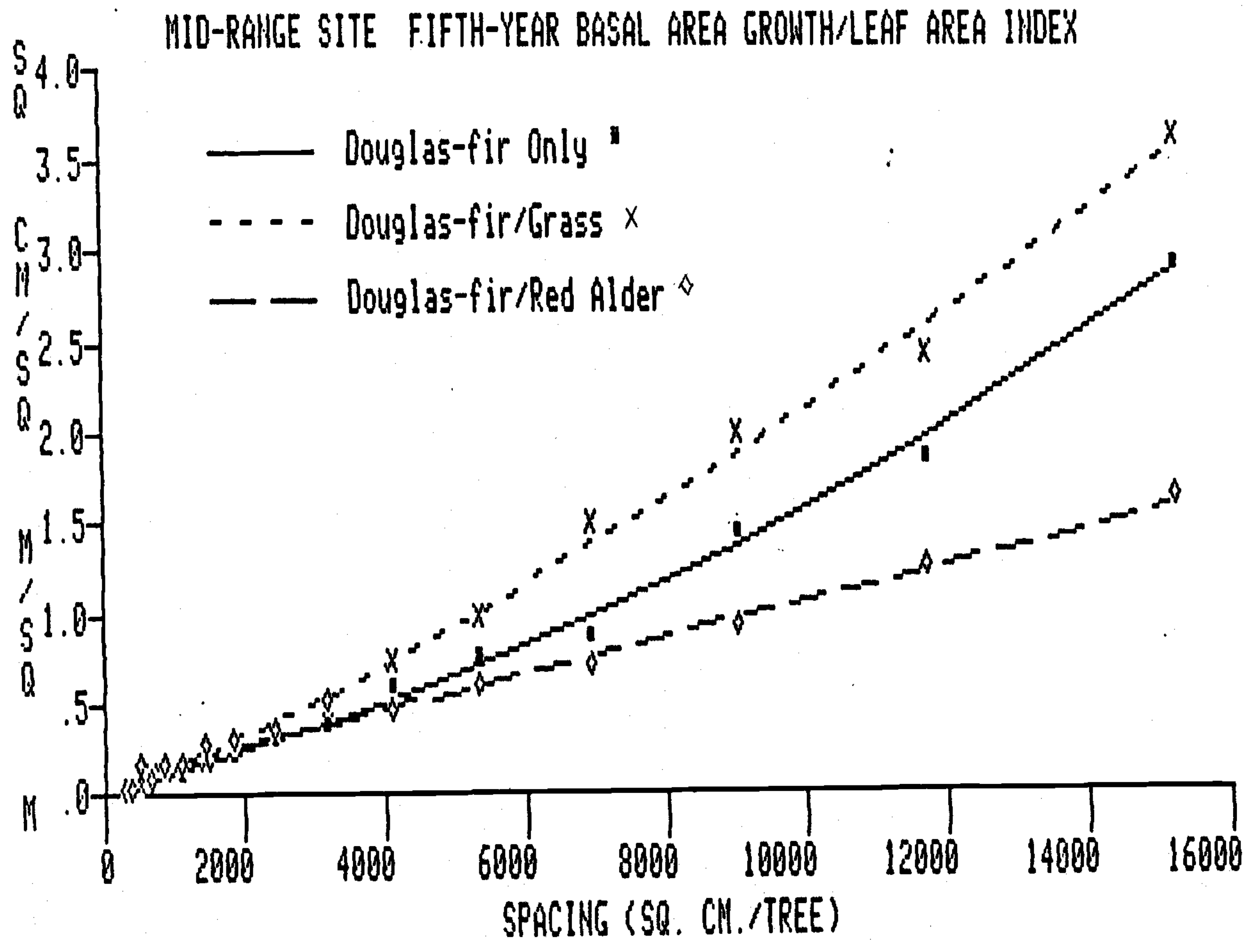

FIGURE 23b. FIFTH-YEAR BASAL AREA GROWTH/TREE/LEAF AREA INDEX VS. SPACING FOR THE MID-RANGE SITE. Symbols represent means at each spacing.

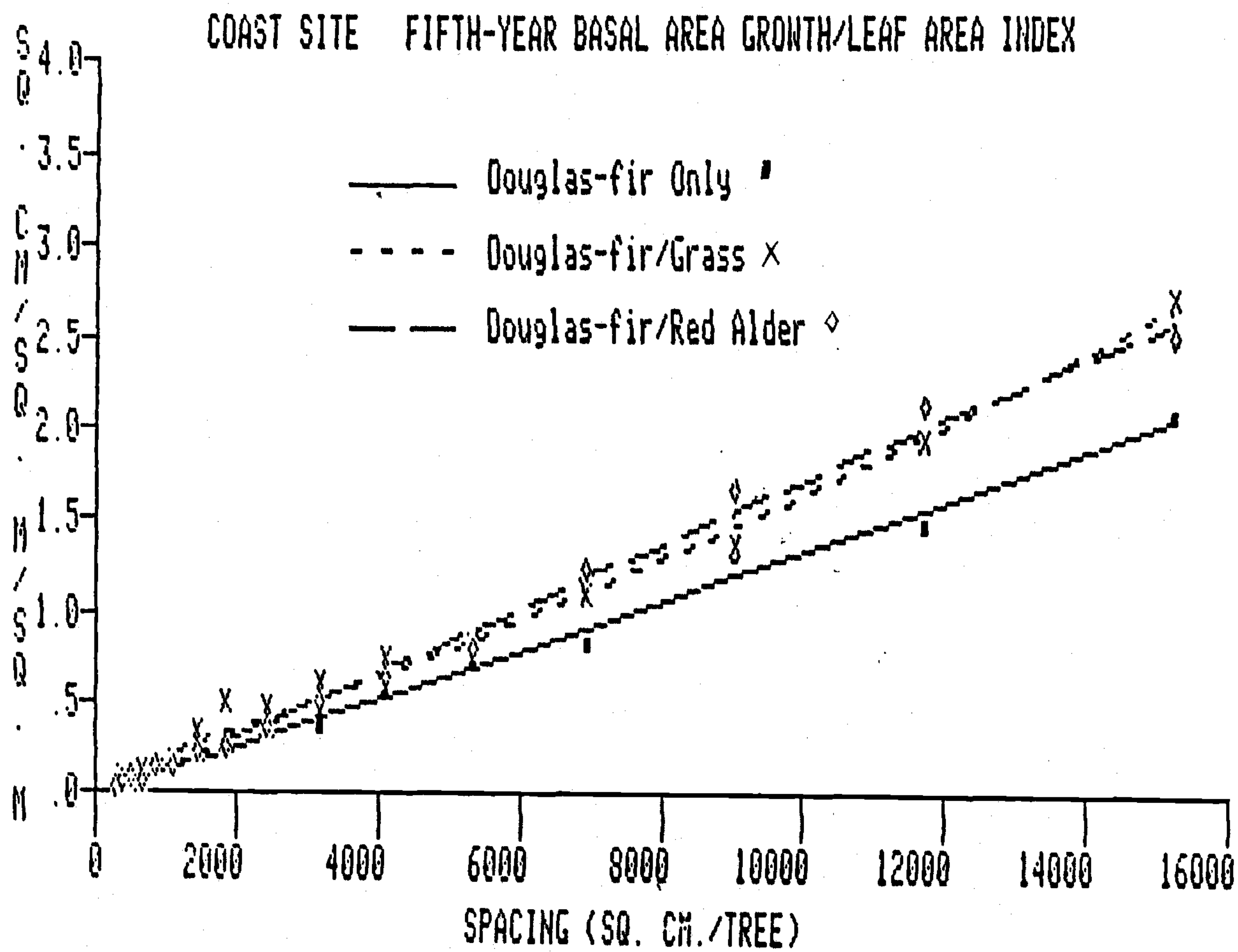

FIGURE 23c. FIFTH-YEAR BASAL AREA GROWTH/TREE/LEAF AREA INDEX VS. SPACING FOR THE COAST SITE. Symbols represent means at each spacing.

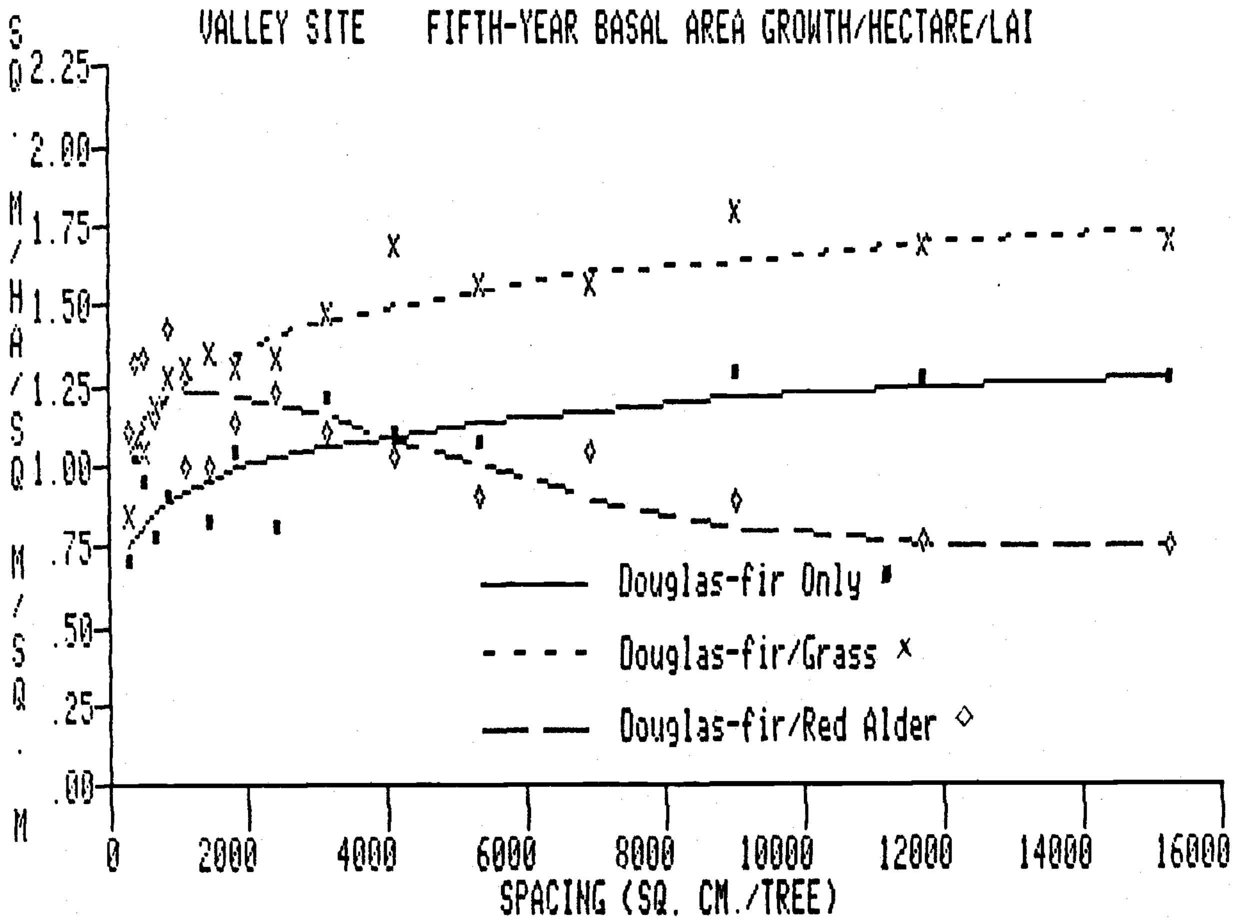

FIGURE 24a. FIFTH-YEAR BASAL AREA GROWTH/HECTARE/LEAF AREA INDEX VS. SPACING FOR THE VALLEY SITE. Symbols represent means at each spacing.

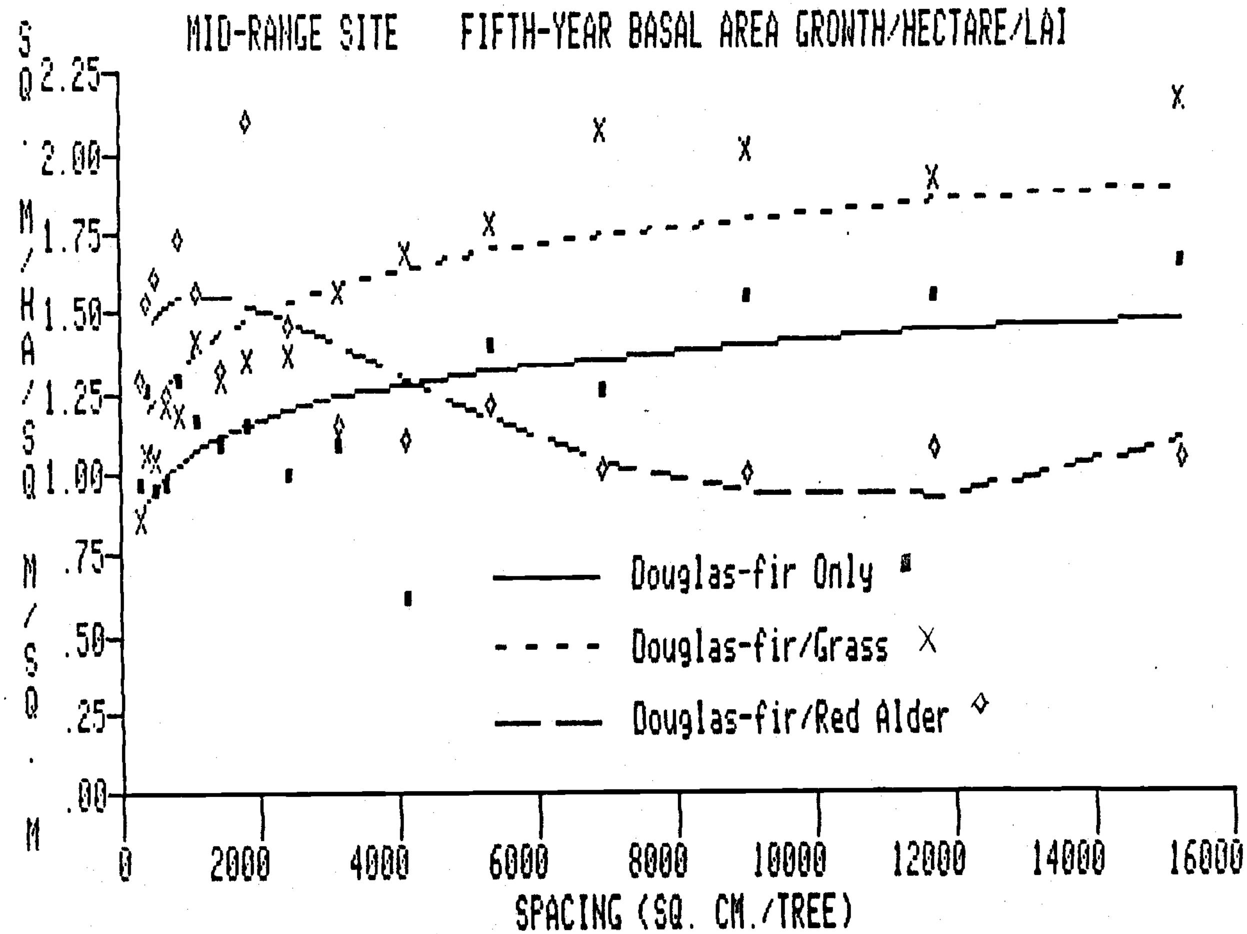

FIGURE 24b. FIFTH-YEAR BASAL AREA GROWTH/HECTARE/LEAF AREA INDEX VS. SPACING FOR THE MID-RANGE SITE. Symbols represent means at each spacing.

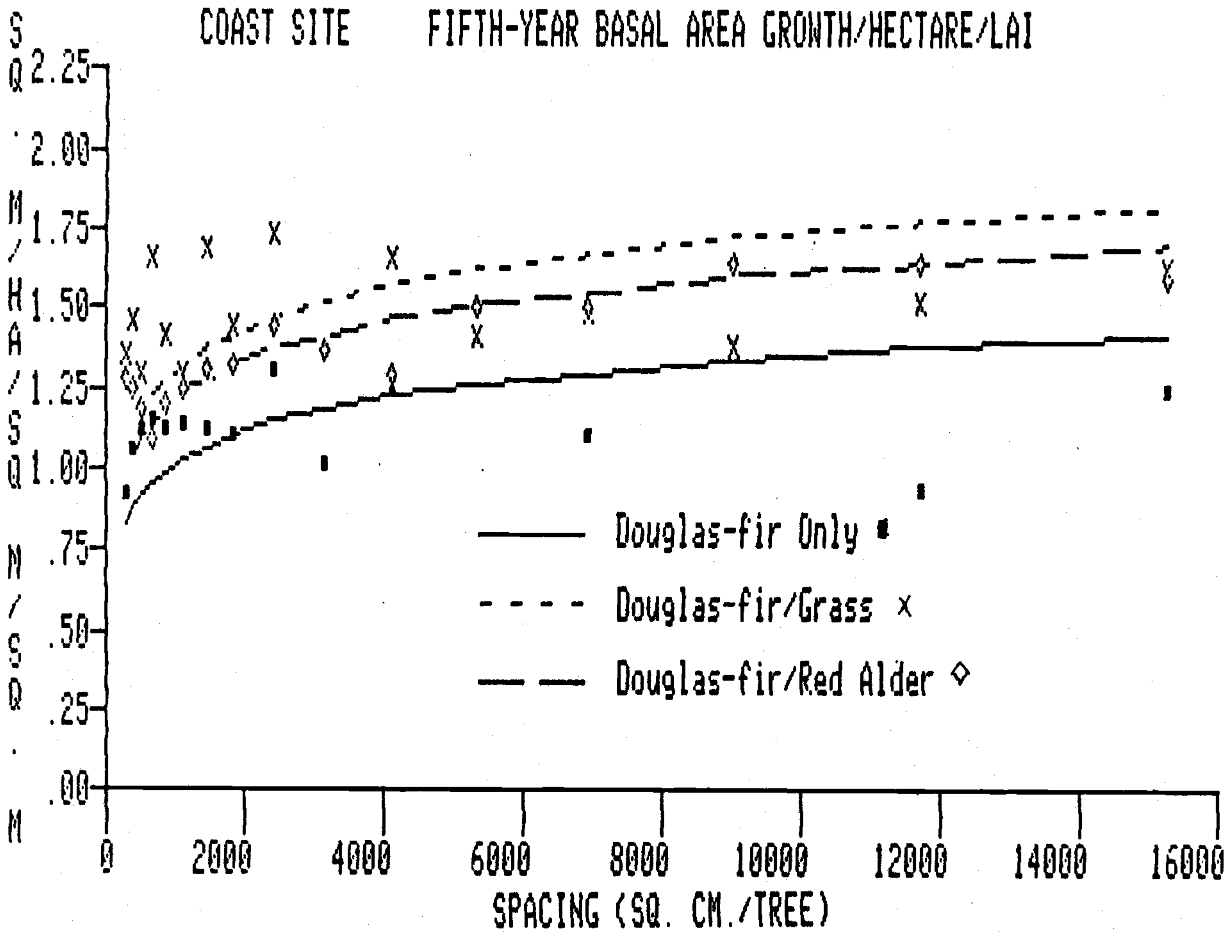

FIGURE 24c. FIFTH-YEAR BASAL AREA GROWTH/HECTARE/LEAF AREA INDEX VS. SPACING FOR THE COAST SITE. Symbols represent means at each spacing.

significantly lower than the Douglas-fir/Grass curve at almost all densities. At the coast site, the Douglas-fir Only curve is lower than both the Douglas-fir/Grass and Douglas-fir/Red Alder curves, which are not significantly different.

Dry Weight/Tree/Leaf Area

Dry weight/tree/leaf area increases at the high densities, then reaches plateaus at the mid- and low densities (Figures 25a, 25b, and 25c). Values vary with site, competitor, density, site* competitor and competitor*density. At the valley site, the Douglas-fir/Grass ratios are higher than the Douglas-fir Only values, which are higher than those of the Douglas-fir/Red Alder trees. The Douglas-fir/Grass and Douglas-fir Only curves are not significantly different at the mid-range site. Both curves are higher than the Douglas-fir/Red Alder curve, except at the highest densities. At the coast site, relationships vary with density. At the high densities, the Douglas-fir/Red Alder ratios are the highest, but this does not hold for the mid- and low densities. There the Douglas-fir/ Grass trees have the highest values and the Douglas-fir/Red Alder the lowest.

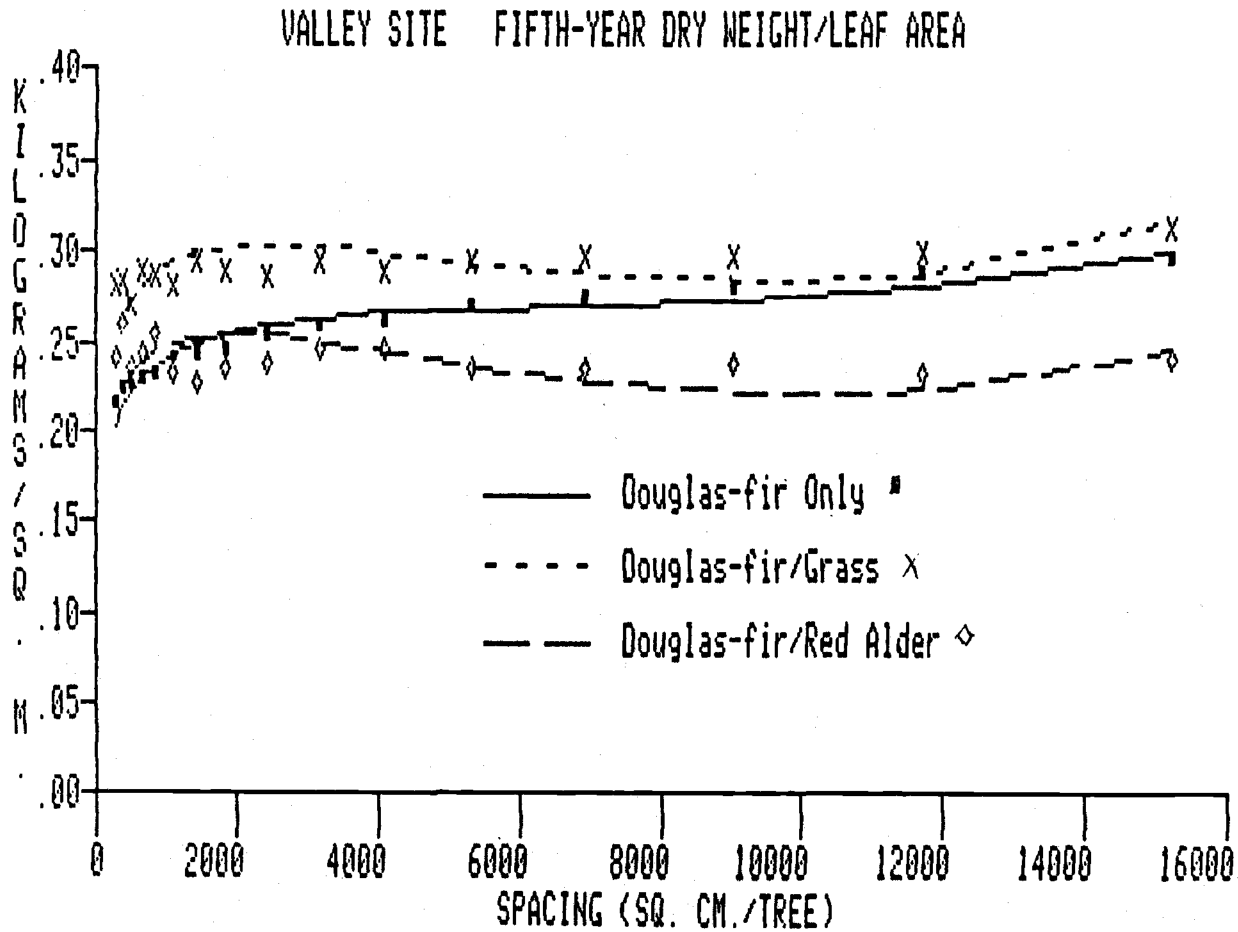

FIGURE 25a. FIFTH-YEAR DRY WEIGHT/TREE/LEAF AREA/TREE VS. SPACING FOR THE VALLEY SITE. Symbols represent means at each spacing.

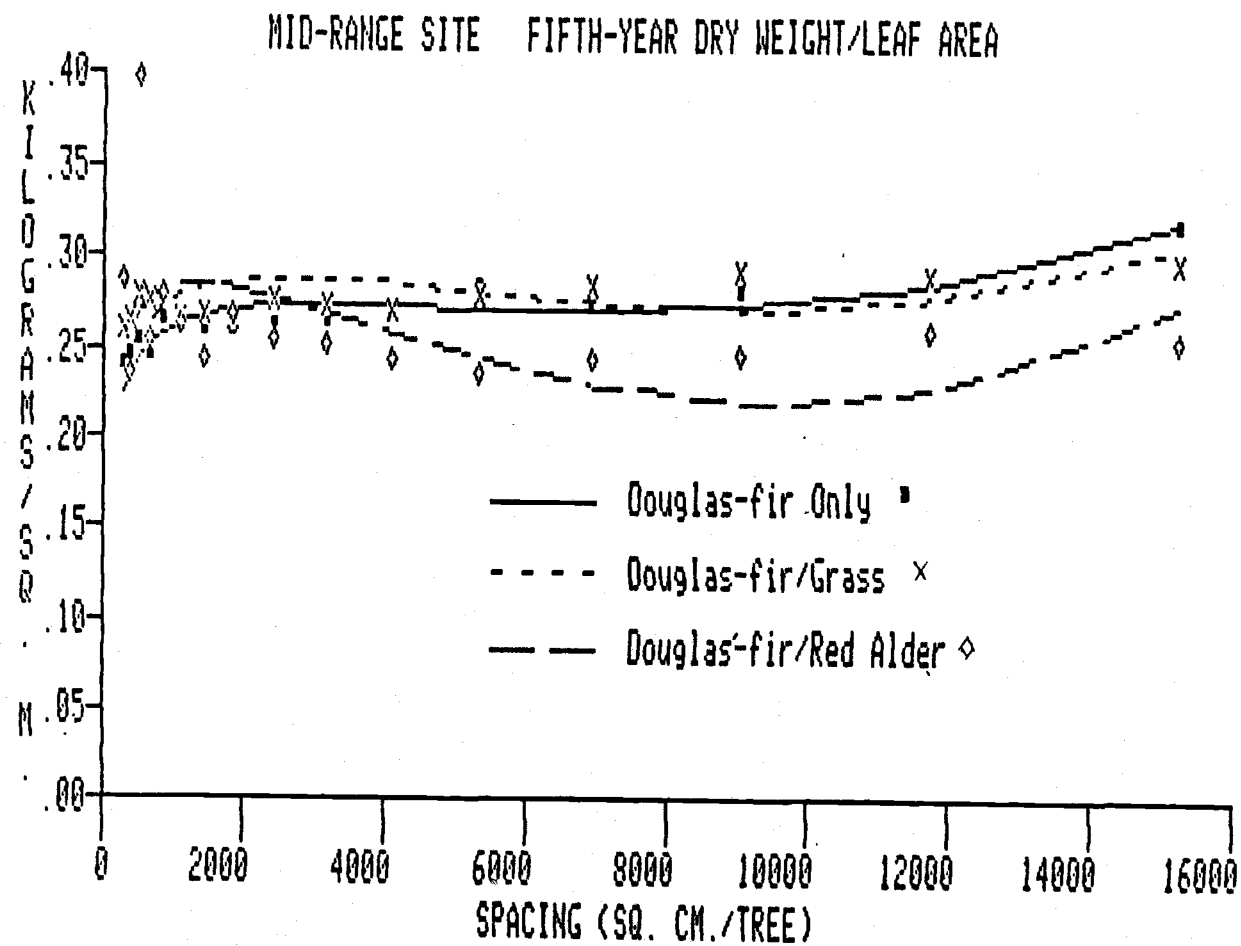

FIGURE 25b. FIFTH-YEAR DRY WEIGHT/TREE/LEAF AREA/TREE VS. SPACING FOR THE MID-RANGE SITE. Symbols represent means at each spacing.

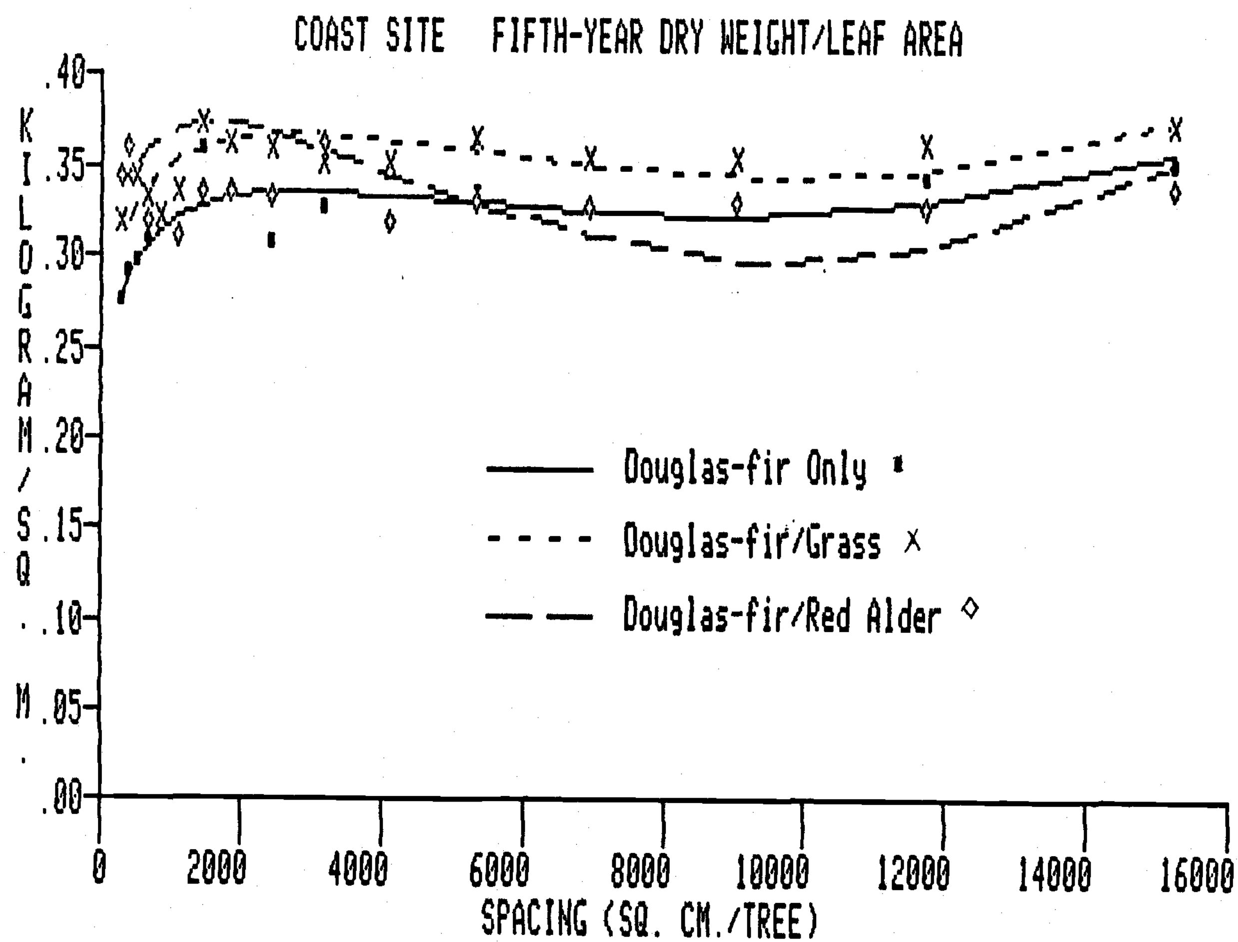

FIGURE 25c. FIFTH-YEAR DRY WEIGHT/TREE/LEAF AREA/TREE VS. SPACING FOR THE COAST SITE. Symbols represent means at each spacing.

Dry Weight/Hectare/Leaf Area Index

At the valley site, the Douglas-fir/Grass curve is almost a straight line, showing little difference with density (Figure 26a). The Douglas-fir Only curve has the highest values at the low densities. It is significantly different from the Douglas-fir/Grass curve only at the high densities. The Douglas-fir/Red Alder curve is not significantly different from the Douglas-fir Only curve at the high densities, but it is significantly lower at the mid- and low densities. The mid-range site shows no differences between the Douglas-fir/Grass and the Douglas-fir Only curves (Figure 26b). The Douglas-fir/Red Alder curve is similar to the other curves at the high densities, but significantly lower at most mid- and low densities. At the coast site, the Douglas-fir Only curve has the lowest values, the Douglas-fir/Grass the highest, with the Douglas-fir/Red Alder curve between the two (Figure 26c).

Leaf Area/Sapwood Basal Area

Leaf area/sapwood basal area curves are similar to the leaf area curves (Figures 27a, 27b,

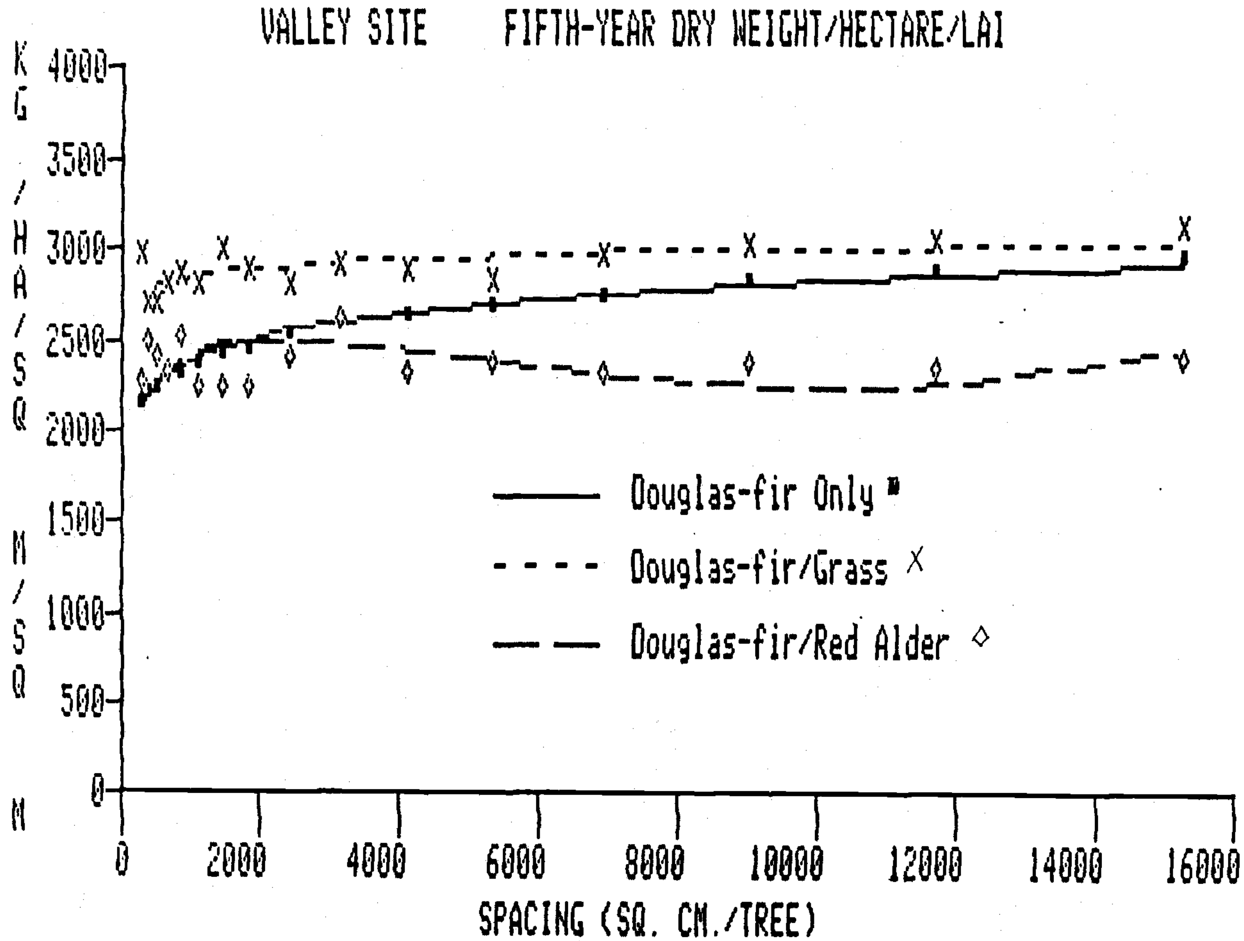

FIGURE 26a. FIFTH-YEAR DRY WEIGHT/HECTARE/LEAF AREA INDEX VS. SPACING FOR THE VALLEY SITE. Symbols represent means at each spacing.

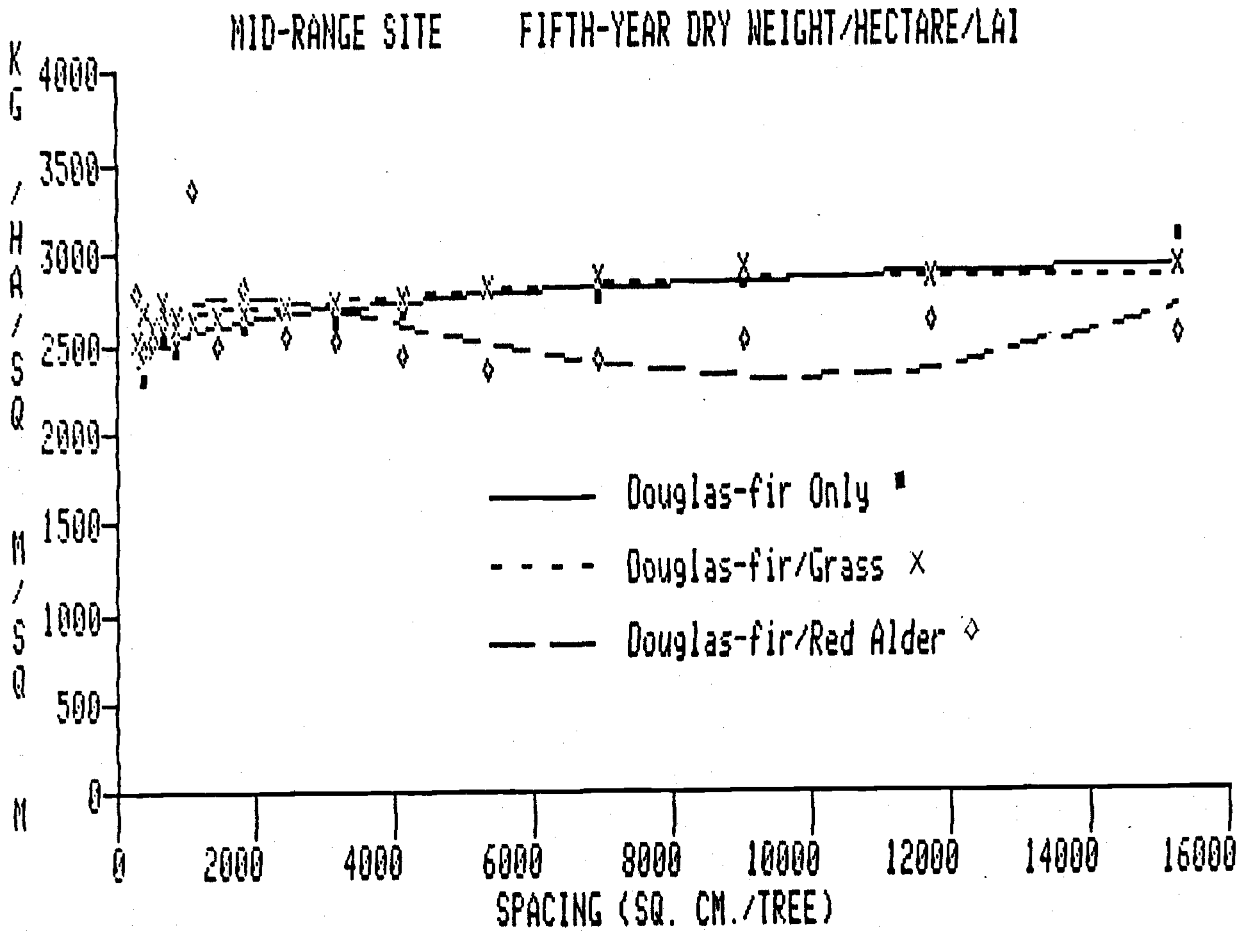

FIGURE 26b. FIFTH-YEAR DRY WEIGHT/HECTARE/LEAF AREA INDEX VS. SPACING FOR THE MID-RANGE SITE. Symbols represent means at each spacing.

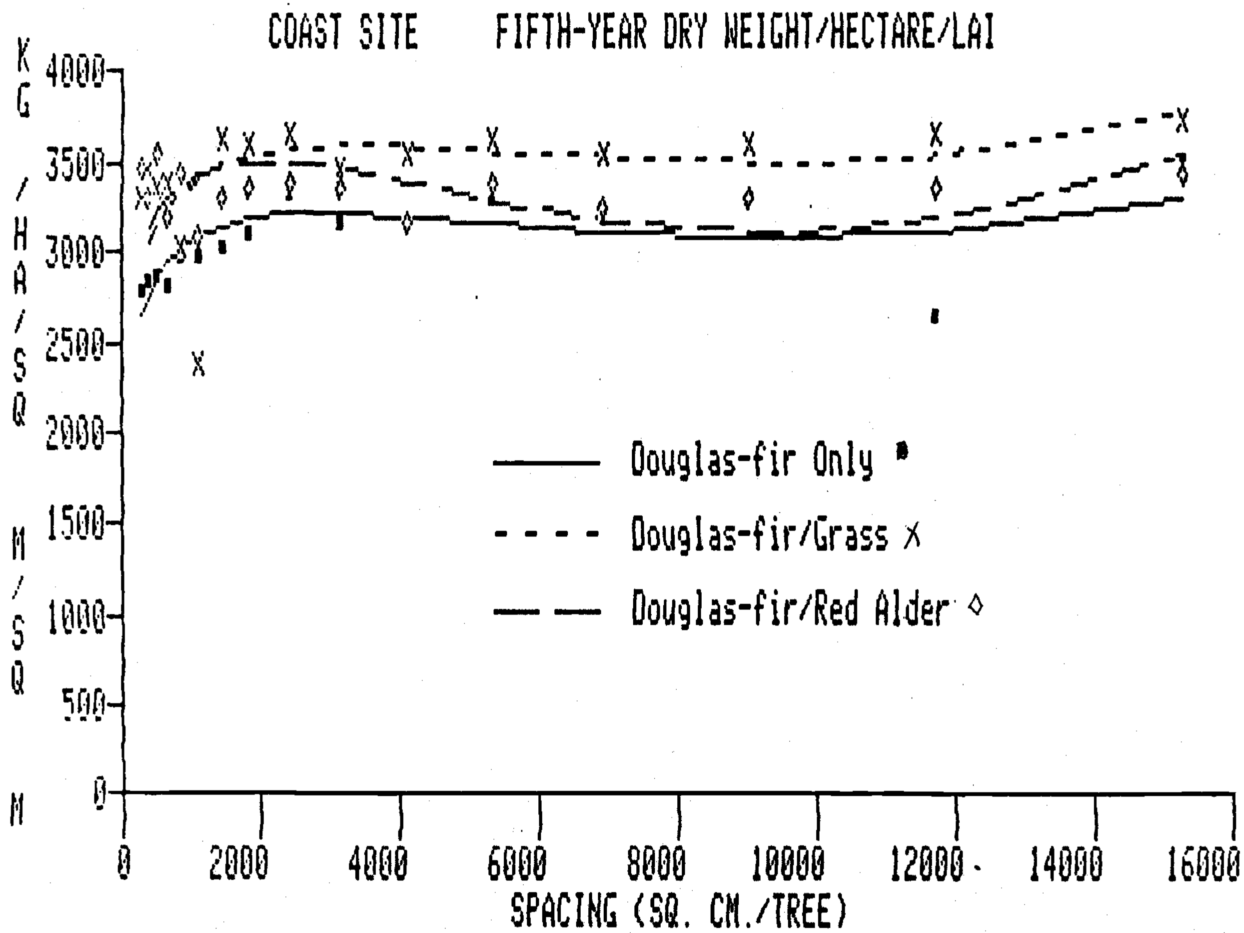

FIGURE 26c. FIFTH-YEAR DRY WEIGHT/HECTARE/LEAF AREA INDEX VS. SPACING FOR THE COAST SITE. Symbols represent means at each spacing.

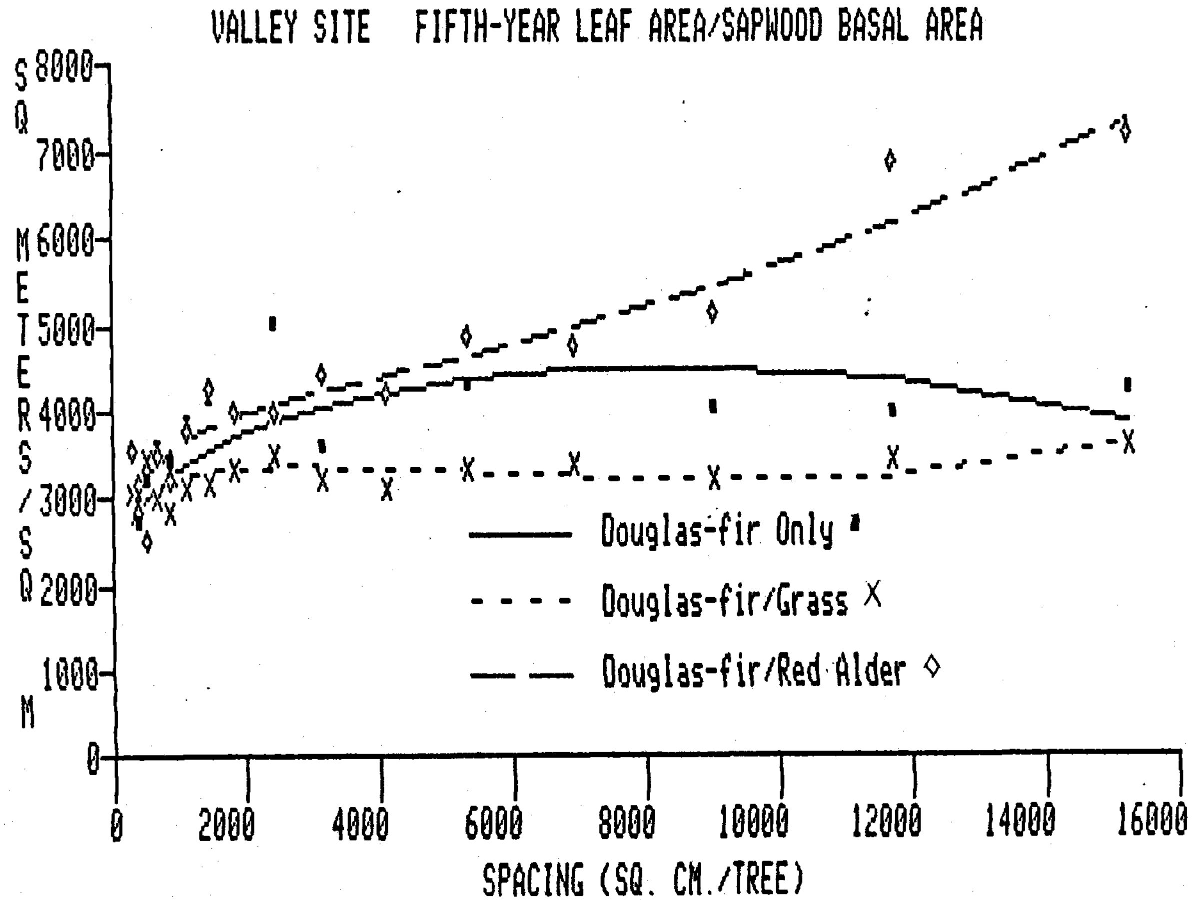

FIGURE 27a. FIFTH-YEAR LEAF AREA/TREE/SAPWOOD BASAL AREA/TREE VS. SPACING FOR THE VALLEY SITE. Symbols represent means at each spacing.

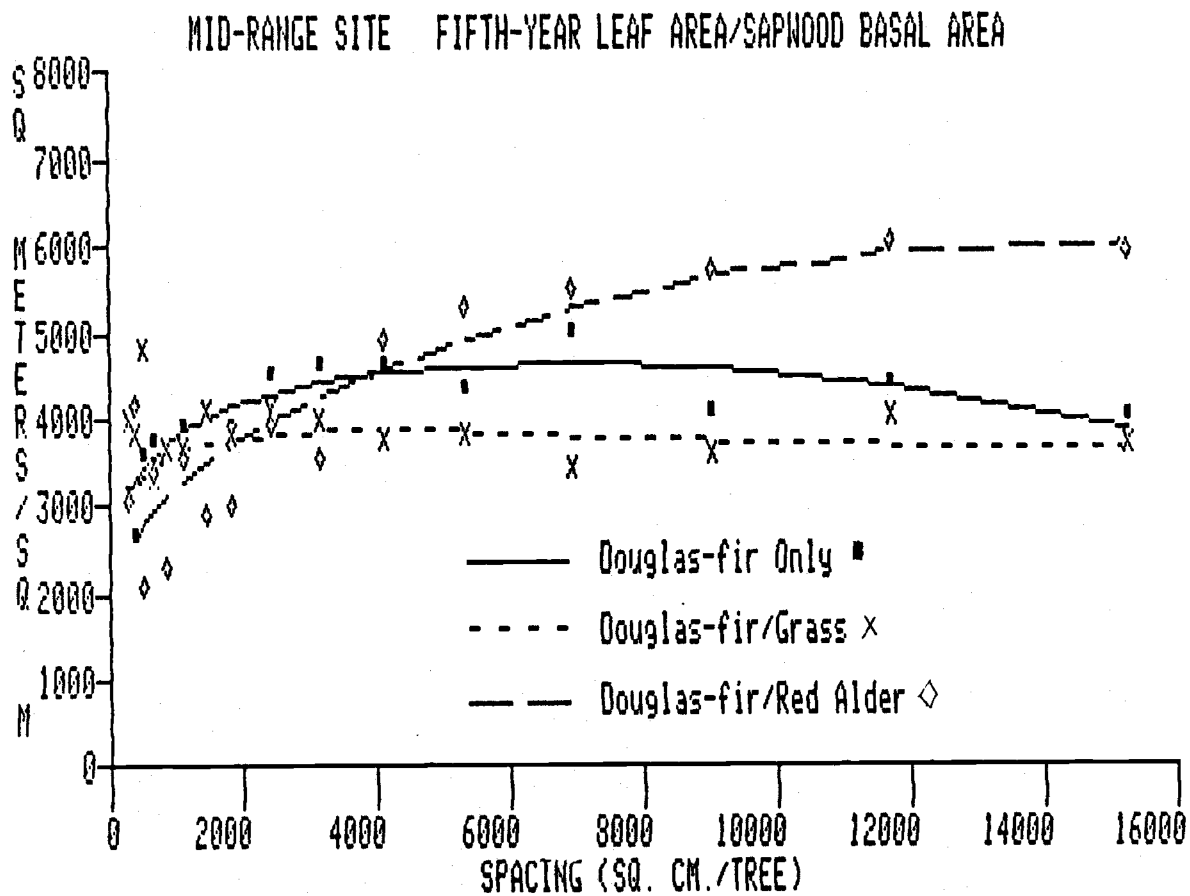

FIGURE 27b. FIFTH-YEAR LEAF AREA/TREE/SAPWOOD BASAL AREA/TREE VS. SPACING FOR THE MID-RANGE SITE. Symbols represent means at each spacing.

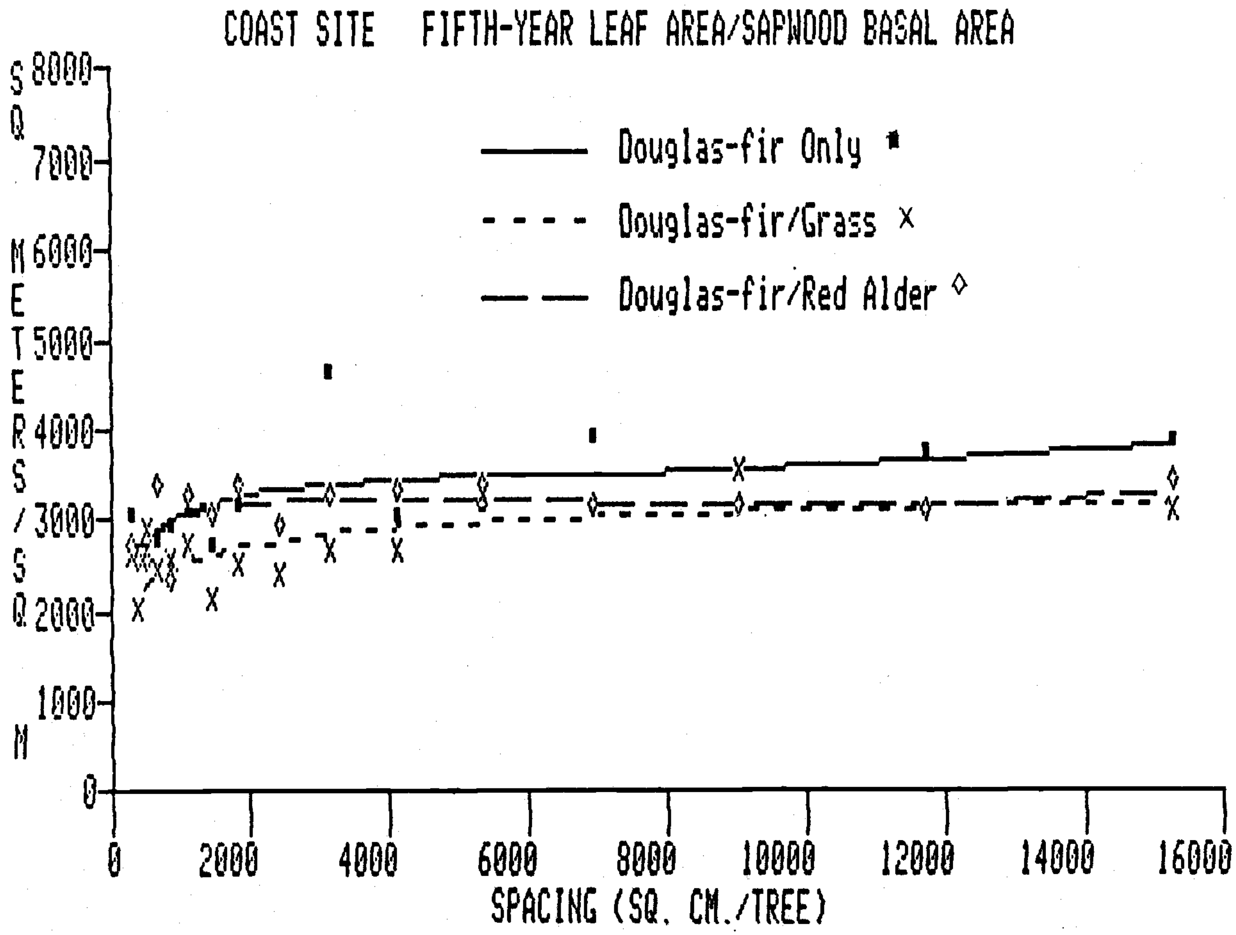

FIGURE 27c. FIFTH-YEAR LEAF AREA/TREE/SAPWOOD BASAL AREA/TREE VS. SPACING FOR THE COAST SITE. Symbols represent means at each spacing.

and 27c). Site, competitor, and density affect the ratios. At the valley and mid-range sites, the values of the Douglas-fir/Grass trees are almost constant and are also the lowest values. The Douglas-fir/Red Alder values increase sharply with decreasing density and exhibit the highest values. With the Douglas-fir Only curve, the values increase, reach a plateau, and then decrease as density decreases. On the coast, all curves respond to density at the high densities. The Douglas-fir Only values are the highest, while the Douglas-fir/ Grass ratios are the lowest.

DISCUSSION

The environmental measurements indicate that resources have become limiting on all sites; competition is occurring. Since the predawn moisture stresses at the valley and mid-range sites are high, lack of moisture may have caused limitations on growth, especially at the end of the growing season. Even though stresses are lower at the coast site, they increased during the season (except after rain). Depletion was occurring, and some competition for moisture may have been happening.

Although nitrogen levels are not considered deficient for Douglas-fir trees (Krueger, 1967), the lower percentages at the high densities may denote that the trees are competing for nutrients. The high leaf area indices at these densities would create high demands for nutrients.

The light measurements show that light levels vary with canopy height and competitors. Therefore, under most conditions, light is a limiting resource. Although these measurements were not intensive enough to evaluate levels of resource limitation, they do reveal that the trees are competing for site resources.

Site Effects

Although the third-year results indicated no differences among sites (Zedaker, 1981), the fifth-year results show differences in growth and growth trends among sites. Overall, the trees are taller, larger, and have more biomass at the coast. Both height and basal area growth rates are higher for the coast trees. Scarification (for site preparation) at the coast has not slowed the growth of the trees. This may change as the trees become larger and occupy more of the soil matrix, specifically the compacted subsoil.

At the coast site, the red alder trees are generally of poor vigor, with chlorotic leaves, and are unable to maintain an adequate leaf area for growth due to early leaf senescence. This is reflected in poor growth among the alder to such an extent that considerable mortality has occurred at the high densities. The cause of this problem is unknown. No disease organisms were found from the leaves during a pathological analysis by the Plant Disease Clinic, Oregon State University. Foliage analyses did not show deficient nutrient levels. Volunteer alder on the site did not display the same symptoms; hence, the "disease" is apparently associated with planting, or with use of a twenty-mile-distant seedling source.

Growth trends are different among the sites. The coast site appears to be more of an energy-limited system than the other sites. For all growth parameters, the Douglas-fir/Red Alder trees are smaller in size and have lower growth rates than the Douglas-fir Only and Douglas-fir/Grass trees at the mid- to low densities. Due to the high mortality of red alder, this trend is reversed at the high densities. The differences among the growth at the low densities indicate that even though the alder are exhibiting poor growth, the canopies are producing enough shade to cause reduced growth among the Douglas-fir trees. At the high densities, the Douglas-fir/Red Alder trees are growing faster than their analogues in both the Douglas-fir/Grass and Douglas-fir Only sections. The mortality of the alder has decreased the density of all trees. Each Douglas-fir tree has relatively more resources at its disposal and is no longer experiencing shading from the alder canopy.

At the mid-range site, the effect of the red alder is most pronounced at the high densities, while at the valley site the effects are most noticeable at the mid-densities. Both sites show increased growth at the low densities due to the absence of some of the red alder trees that were removed by animal damage. Grass competition appears to be more severe at the valley site than at the mid-range site.

Comparable studies among different sites were not found in the literature.

Density Effects

Generally, as trees have access to more resources, they are capable of greater growth. However, the trees may not be able to capitalize on these resources on a strictly proportional basis. Competitors may be more efficient at utilizing the available resources, or, limitations on size, crown expansion, or root extension may place the resources beyond the capacity of the trees. Trees which are not at maximum site occupancy show progressively less increased growth as density decreases to the point at which all further increases in space are beyond the reach of the trees.

In this experiment, the tallest trees now occur at low densities, but at age three, they did not. Even at age five, the tallest trees are not at the lowest density. This indicates that Douglas-fir trees require some degree of crowding to maintain maximum height growth. Belanger and Pepper (1978) found that sycamore trees required "moderate competition" for maximum height growth. Other studies (Bramble, Cope, and Chisman, 1949; Curtis and Reukema, 1970; Harms and Langdon, 1976) have indicated that differences in height among densities greater than 4' X 4' do not occur until the trees are at least ten years old. These studies had lower initial densities than this experiment, and crowding would not happen as quickly.

The point of maximum height growth appears to be prior to maximum site occupancy. Therefore, as the trees increase in size and occupy more of the site, the point at which maximum height and height growth occur will shift to the lower densities. This has been shown for Douglas-fir trees when old plantations have been re-measured (Reukema, 1979; Harrington and Reukema, 1983).

At the valley and mid-range sites, the slopes of the diameter and dry-weight curves are greater at high densities than at low densities and generally form asymptotes at the low densities. This indicates a lack of complete site occupancy at the low densities, or perhaps upper limits on the growth of juvenile Douglas-fir trees. The Douglas-fir Only dry weight curve at the coast has a constant slope, where dry weight continually increases with decreasing density. These trees, which are larger, are approaching full site occupancy faster than those at the other sites. Other parameters, such as basal area growth, stemwood volume production, and leaf area/tree, also exhibit asymptotic relations at the low densities, indicating either upper limits on growth or a lack of ability to capitalize proportionally on available resources.

When growth parameters are examined on a per hectare basis, the highest values are found at the highest densities. This concurs with findings by Reukema (1970), Harms and Langdon (1976), and Harrington and Reukema (1983). Bramble, Cope, and Chisman (1949) found that this relationship changed with time. After 25 years, red pine at the closest spacings (5 feet by 5 feet) did not have the maximum values of basal area/acre and volume/acre.

The increases in growth are not proportional to the increases in stocking on a per hectare basis. For a 50 fold increase in stocking (300 cm^2/tree compared to 15250 cm^2/tree), a maximum 14 fold and an average (over site and competitor) six fold increase in dry weight/hectare were observed. With basal area/hectare, increases ranged from three fold to 12.5 fold. Basal area growth/hectare increases with increased stocking had a narrower range, from 1.9 to 7.4 fold. Stemwood volume production/hectare increases ranged from 1.3 to 7.8 fold. Overall, the 50 fold increase in stocking did not account for a proportional increase in growth. This is especially significant since the growth increases are distributed among smaller trees at the high densities. When Zedaker (1981) examined these trees at age three, growth on a stand basis was more nearly a reflection of stocking than at age five. It is evident that as tree size increases, the increased growth/tree compensates for the reduced stocking level at the low densities, in terms of maximum stand growth.

Analyses of the growth data indicate that there is heterogeneity of variance among the densities. The highest densities generally have the highest variances. These trees vary in stand position from dominant to severely suppressed, covering a wide range of growth responses. Trees at the low densities are generally more uniform in size and growth. Those trees at the low densities which exhibit low growth responses have been damaged (usually by mouse-girdling). The greater growing space available for trees at the low densities enables trees which have otherwise become suppressed to succeed.

Competitor Effects

At high densities, intra-specific competition is more severe than inter-specific competition when comparing the Douglas-fir Only and Douglas-fir/Grass treatments. In the Douglas-fir/Red Alder treatment, inter-specific competition is more severe. The exception to this occurs in the Douglas-fir/Red Alder section at the coast site. As mentioned previously, the mortality of the alder at the coast site has decreased the density for the Douglas-fir/Red Alder trees, so that the trees, nominally at half stocking, exhibit greater growth than trees in the other treatments. At the mid-range site, suppression by the alder has been so severe that the Douglas-fir/Red Alder trees are exhibiting greatly reduced growth. For these trees, inter-specific competition has been severe. In the grass section, canopy closure is complete at the high densities. Grass has been eliminated and is no longer a competitor.

As space/tree increases, the distance to the nearest neighboring Douglas-fir tree increases. The effects of grass and red alder become more pronounced, since these competitors are closer in proximity than the other Douglas-fir trees. The effect of grass competition on Douglas-fir growth is apparent at the low densities. At the valley and mid-range sites, the Douglas-fir/Grass trees have approximately half the standing biomass that the Douglas-fir Only trees have. Curves of growth parameters fall below those of the Douglas-fir Only trees at the mid- and low densities, indicating reduced growth.

At the coast site, the late establishment of the grass makes it difficult to evaluate herbaceous competition. Although both the diameter and dry weight of the Douglas-fir/Grass trees at the lowest densities are below that of the Douglas-fir Only trees, this cannot be attributed to grass competition at this time. The differences are not statistically significant. If the trend continues for the next few years, the differences may become great enough to speculate that moisture competition from grass is occurring at the coast site as well as the other sites. At this time, predawn moisture stress levels are not different in the Douglas-fir/Grass and Douglas-fir Only treatments at the coast.

At all sites, canopy closure eliminates the grass, thereby decreasing grass competition. Grass competition is most critical during the establishment years of a plantation.

Unlike grass competition, red alder competition becomes more pronounced with time. Initially, the red alder and Douglas-fir are similar in size. After the first year, growth of the alder trees exceeds that of the Douglas-fir trees, so that differences in height, hence suppression, accentuate with time. If a system is limited primarily by light, competition with red alder will result in progressively greater growth reductions as density and age increase. This is apparent at the coast site, where even though the alder trees are of poor vigor, the Douglas-fir/Red Alder trees at the mid- and low densities exhibit less growth than the Douglas-fir Only and Douglas-fir/Grass trees.

At the valley and mid-range sites, the results are influenced by the removal (by deer and elk) of the red alder trees at the outer edges of the plots.

This has allowed greater growth among the Douglas-fir/Red Alder trees, which are growing at lower densities than their counterpart trees in the Douglas-fir Only and Douglas-fir/Grass sections. Greater growth would be expected and did occur. This distorts the growth parameter curves by causing an atypical upward trend at the low densities.

At high and mid-densities at the valley and mid-range sites, height growth of the Douglas-fir/Red Alder trees is less than that for the Douglas-fir Only trees. Yet, the trees have comparable total heights. This indicates that the Douglas-fir/Red Alder trees had greater height growth in past years, possibly due to hyperelongation in response to partial shading by the alder trees. Relatively, the height growth of the Douglas-fir/Red Alder trees is declining, while that of the Douglas-fir Only trees is increasing. The greater height growth of the Douglas-fir/Red Alder trees at the low densities may be due now to hyperelongation, resulting from recent shading by the red alder trees. If this is true, then these trees will probably exhibit less height growth in the future as the alder assume greater dominance.

Past studies have considered the effects of red alder competition on Douglas-fir growth. Results have indicated that red alder increased Douglas-fir growth on nitrogen-deficient sites, but had no effect or caused reduced growth on highly fertile sites (Miller and Murray, 1978; Binkley, 1982). Newton *et al*. (1968) stated that red alder was a serious competitor with Douglas-fir and that Douglas-fir needed three to eight years of free growth before red alder establishment to insure dominance by Douglas-fir. Third-year results from this experiment demonstrated that Douglas-fir growth was best where red alder development was the poorest (Zedaker, 1981).

Since the Douglas-fir/Red Alder trees are growing at half densities, interpretations of the competition data are complicated. At a nominal spacing of 9000 cm^2/tree, there is actually only one Douglas-fir tree per 18000 cm^2. The alder trees become superimposed upon a plantation of Douglas-fir trees growing at half the densities found in the Douglas-fir Only and Douglas-fir/Grass treatments. It would be quite reasonable to project the relation between Douglas-fir size and absolute space per Douglas-fir tree under the influence of red alder on a half-density scale. This was done for dry weight/tree, stemwood volume production/ tree, and stemwood volume production/hectare and is illustrated in Figures 28a to 30c for comparison. Although this clearly shows that Douglas-fir has considerably less growth per tree and per hectare under alder than without the alder, differences in radial position and rectangularity complicate statistical evaluation of the differences. The curves are interesting, however, since they do provide an approximation of the absolute offset in conifer growth induced by superimposing alder on Douglas-fir plantations of comparable densities.

Leaf Area Relations

Conifer foliage varied in abundance and form along both competitor and density gradients. At all sites, the degree of shading determined the leaf area/leaf weight ratio. The Douglas-fir/Red Alder trees have the highest ratios, hence the thinnest needles. These trees are almost totally shaded by the red alder trees. The Douglas-fir/ Grass trees have the lowest ratios. Since these trees have a smaller biomass than the Douglas-fir Only trees, crown overlap is not as extensive, and

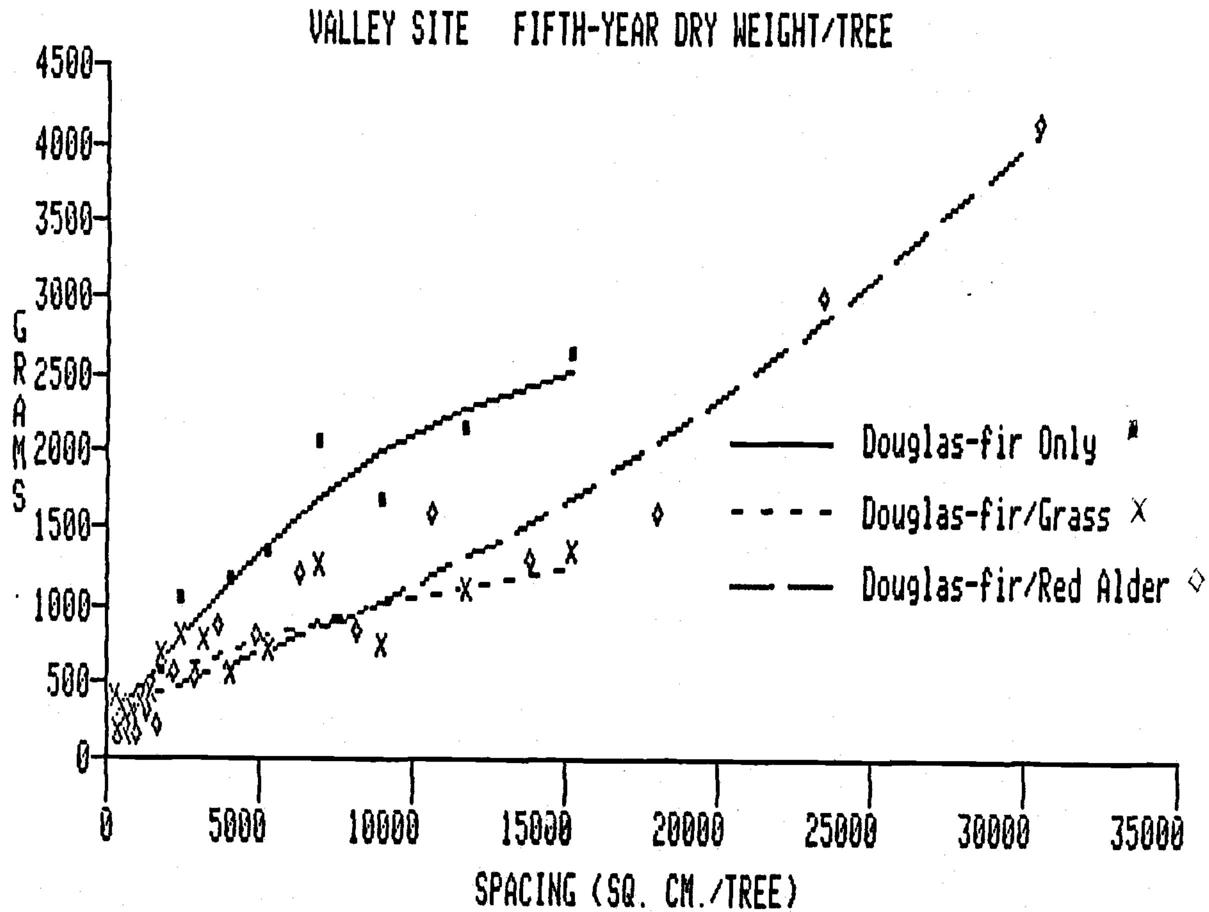

FIGURE 28a. FIFTH-YEAR DRY WEIGHT/TREE AT THE VALLEY SITE WITH THE DOUGLAS-FIR/RED ALDER TREES ADJUSTED FOR ABSOLUTE DENSITY OF DOUGLAS-FIR TREES.

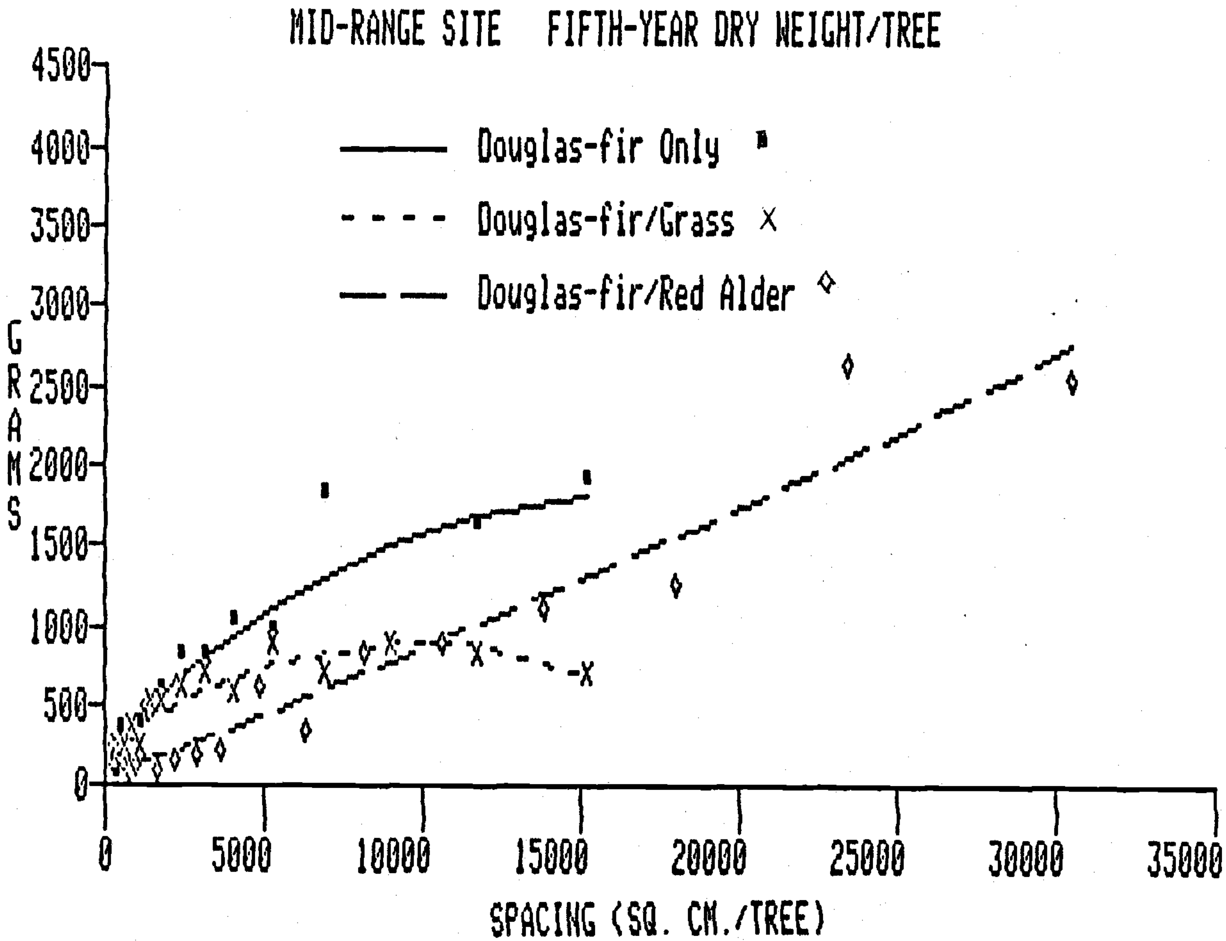

FIGURE 28b. FIFTH-YEAR DRY WEIGHT/TREE FOR THE MID-RANGE SITE WITH THE DOUGLAS-FIR/RED ALDER TREES ADJUSTED FOR ABSOLUTE DENSITY OF DOUGLAS-FIR TREES.

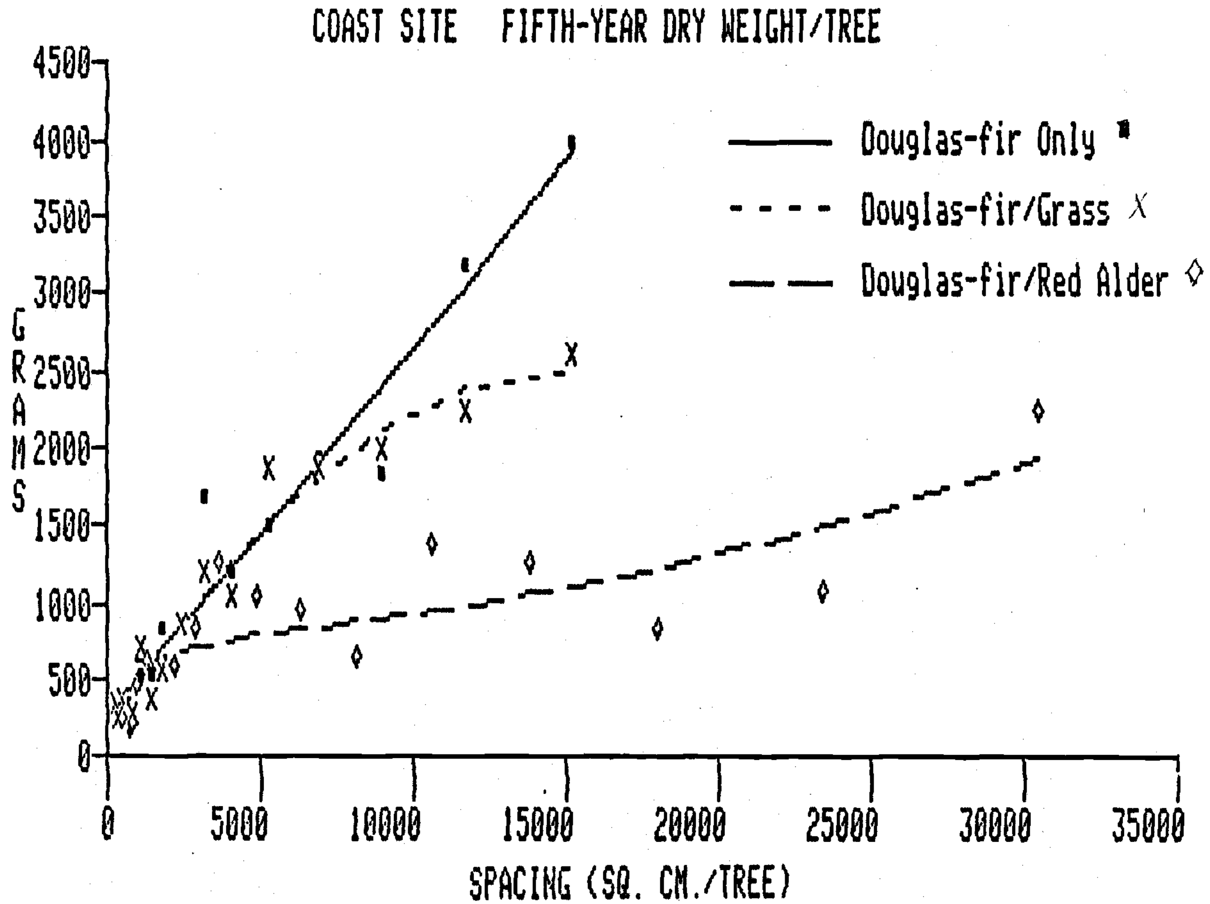

FIGURE 28c. FIFTH-YEAR DRY WEIGHT/TREE FOR THE COAST SITE WITH THE DOUGLAS-FIR/RED ALDER TREES ADJUSTED FOR ABSOLUTE DENSITY OF THE DOUGLAS-FIR TREES.

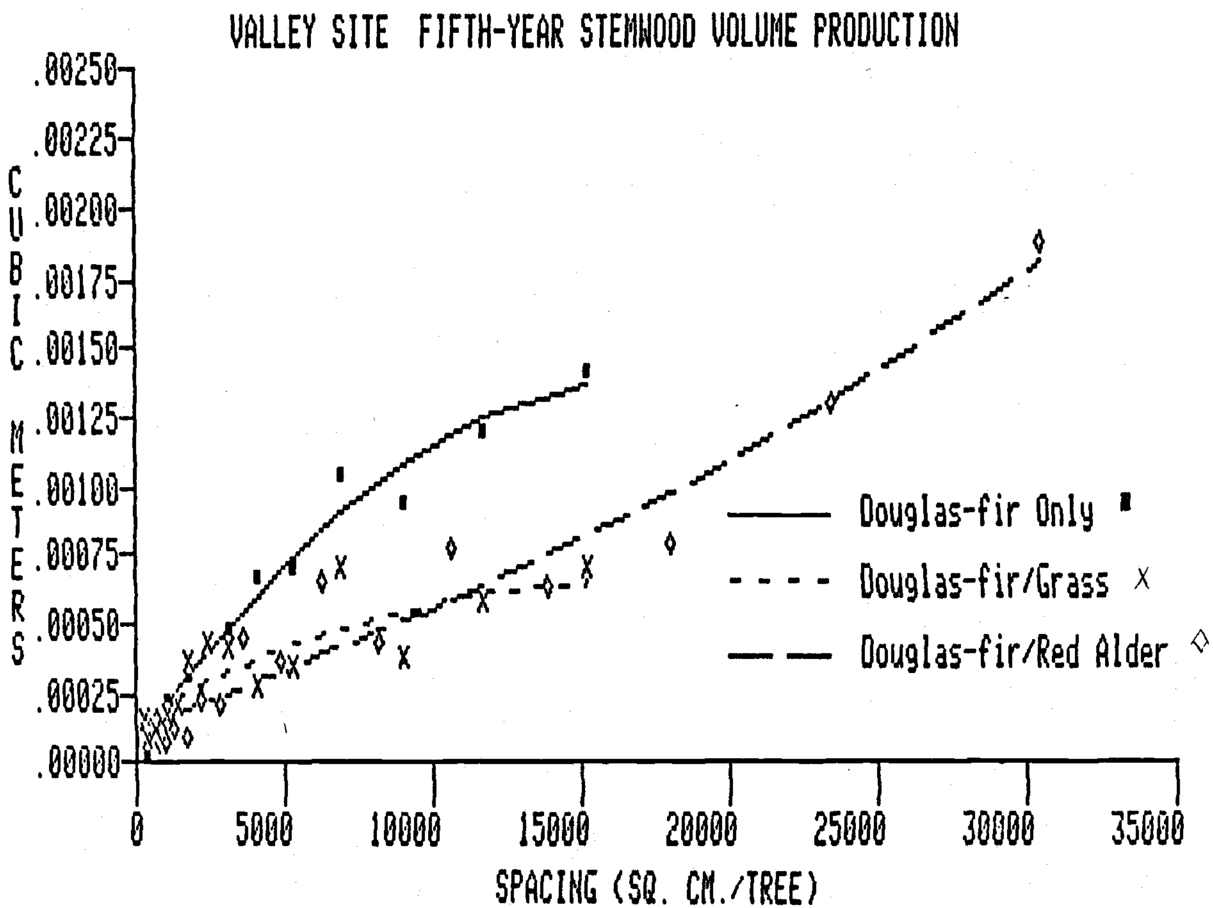

FIGURE 29a. FIFTH-YEAR STEMWOOD VOLUME PRODUCTION/TREE FOR THE VALLEY SITE WITH THE DOUGLAS-FIR/RED ALDER TREES ADJUSTED FOR ABSOLUTE DENSITY OF DOUGLAS-FIR TREES.

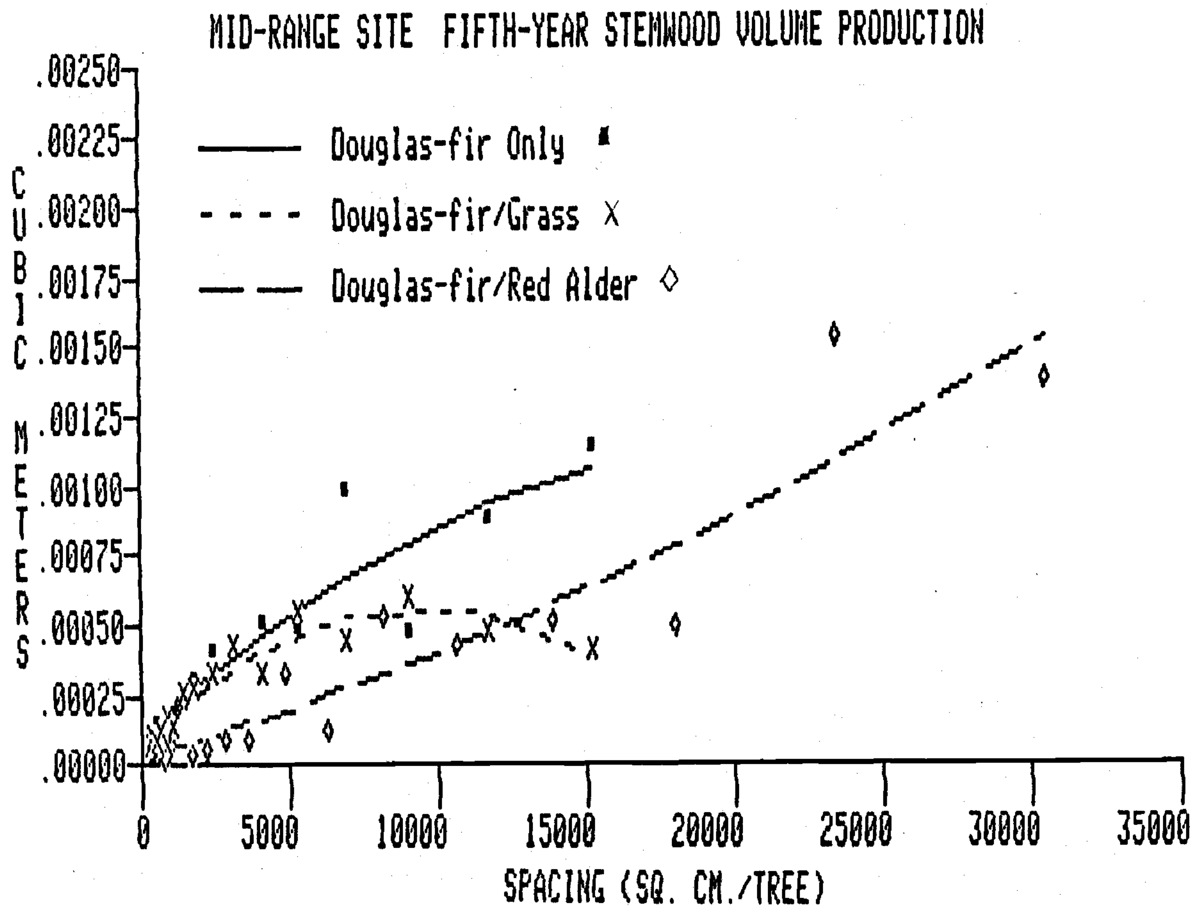

FIGURE 29b. FIFTH-YEAR STEMWOOD VOLUME PRODUCTION/TREE FOR THE MID-RANGE SITE WITH THE DOUGLAS-FIR/RED ALDER TREES ADJUSTED FOR ABSOLUTE DENSITY OF DOUGLAS-FIR TREES.

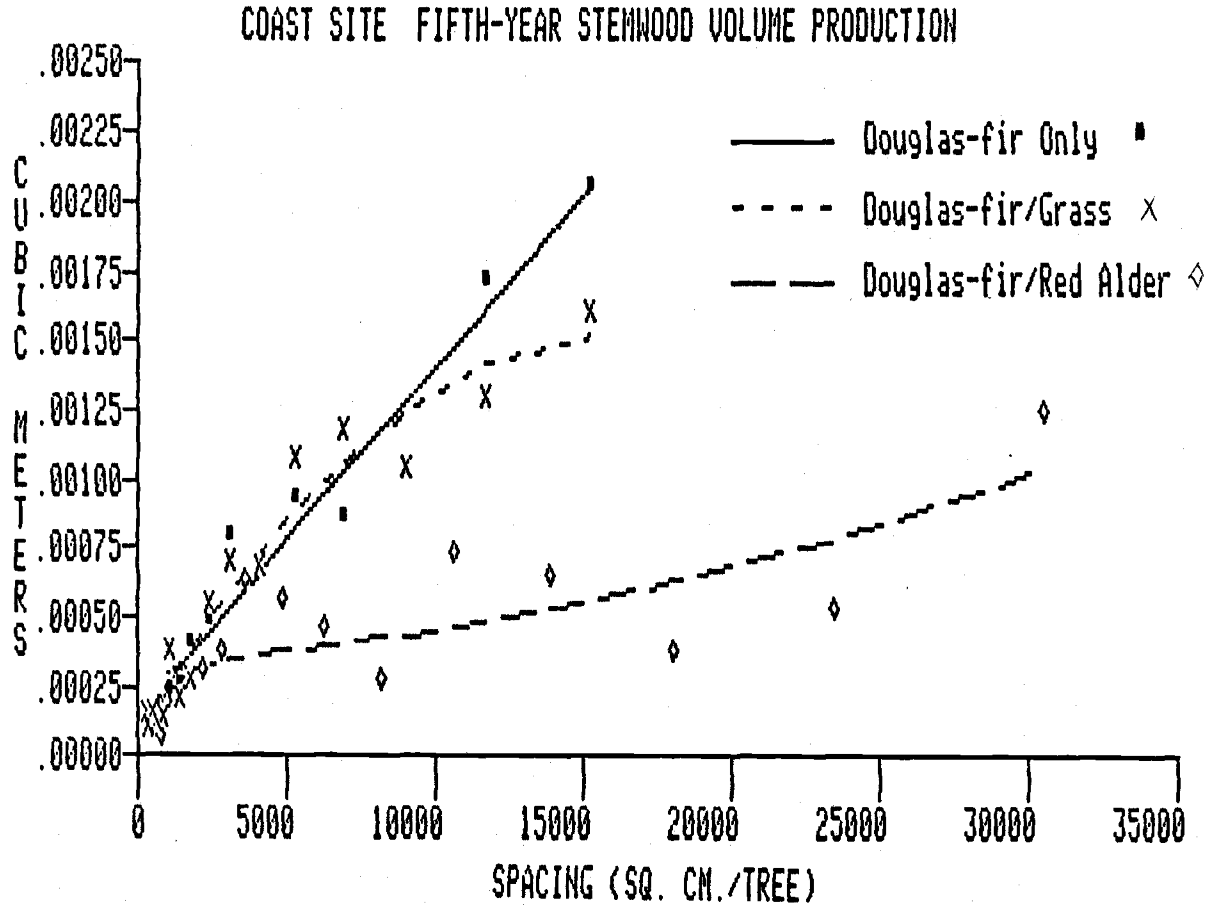

FIGURE 29c. FIFTH-YEAR STEMWOOD VOLUME PRODUCTION/TREE FOR THE COAST SITE WITH THE DOUGLAS-FIR/RED ALDER TREES ADJUSTED FOR ABSOLUTE DENSITY OF DOUGLAS-FIR TREES.

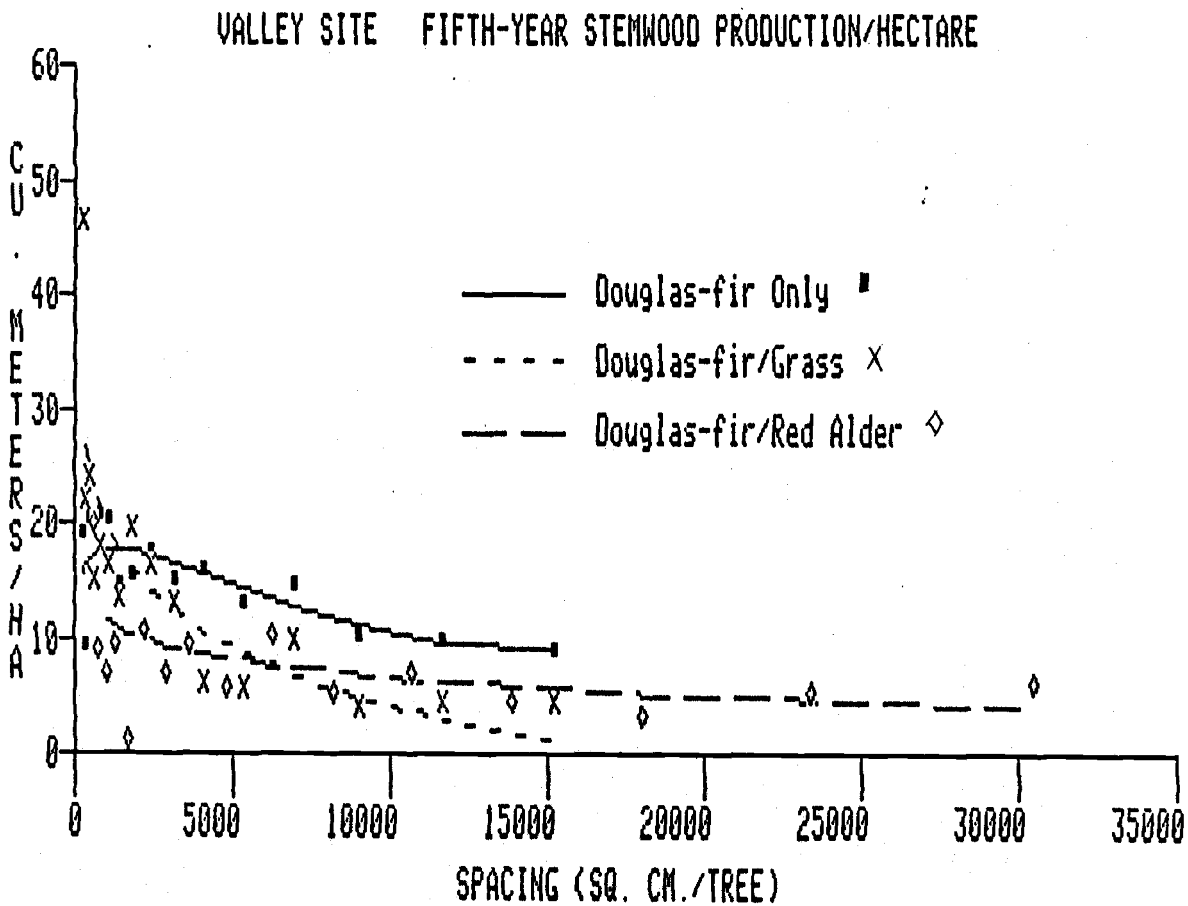

FIGURE 30a. FIFTH-YEAR STEMWOOD VOLUME PRODUCTION/HECTARE FOR THE VALLEY SITE WITH THE DOUGLAS-FIR/RED ALDER TREES ADJUSTED FOR ABSOLUTE DENSITY OF THE DOUGLAS-FIR TREES.

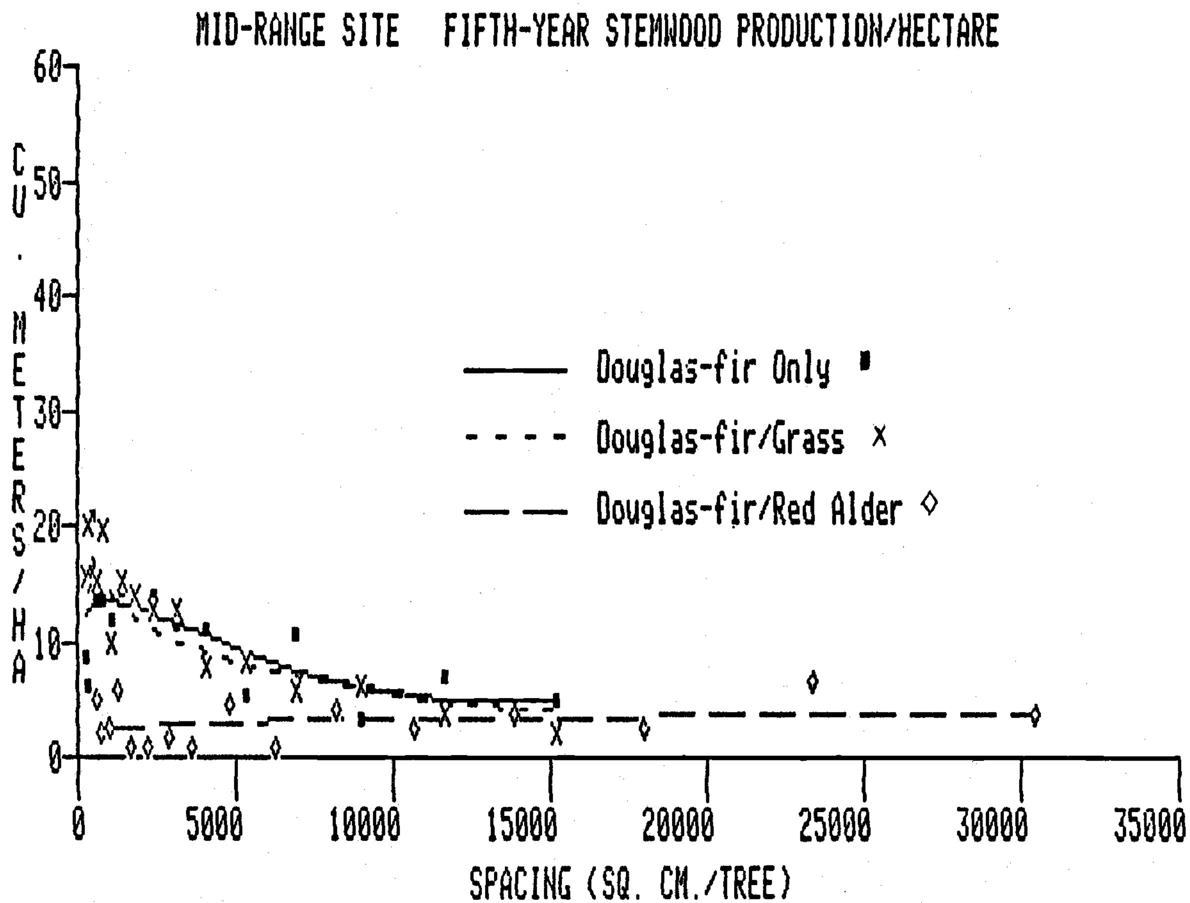

FIGURE 30b. FIFTH-YEAR STEMWOOD VOLUME PRODUCTION/HECTARE FOR THE MID-RANGE SITE WITH THE DOUGLAS-FIR/RED ALDER TREES ADJUSTED FOR THE ABSOLUTE DENSITY OF DOUGLAS-FIR TREES.

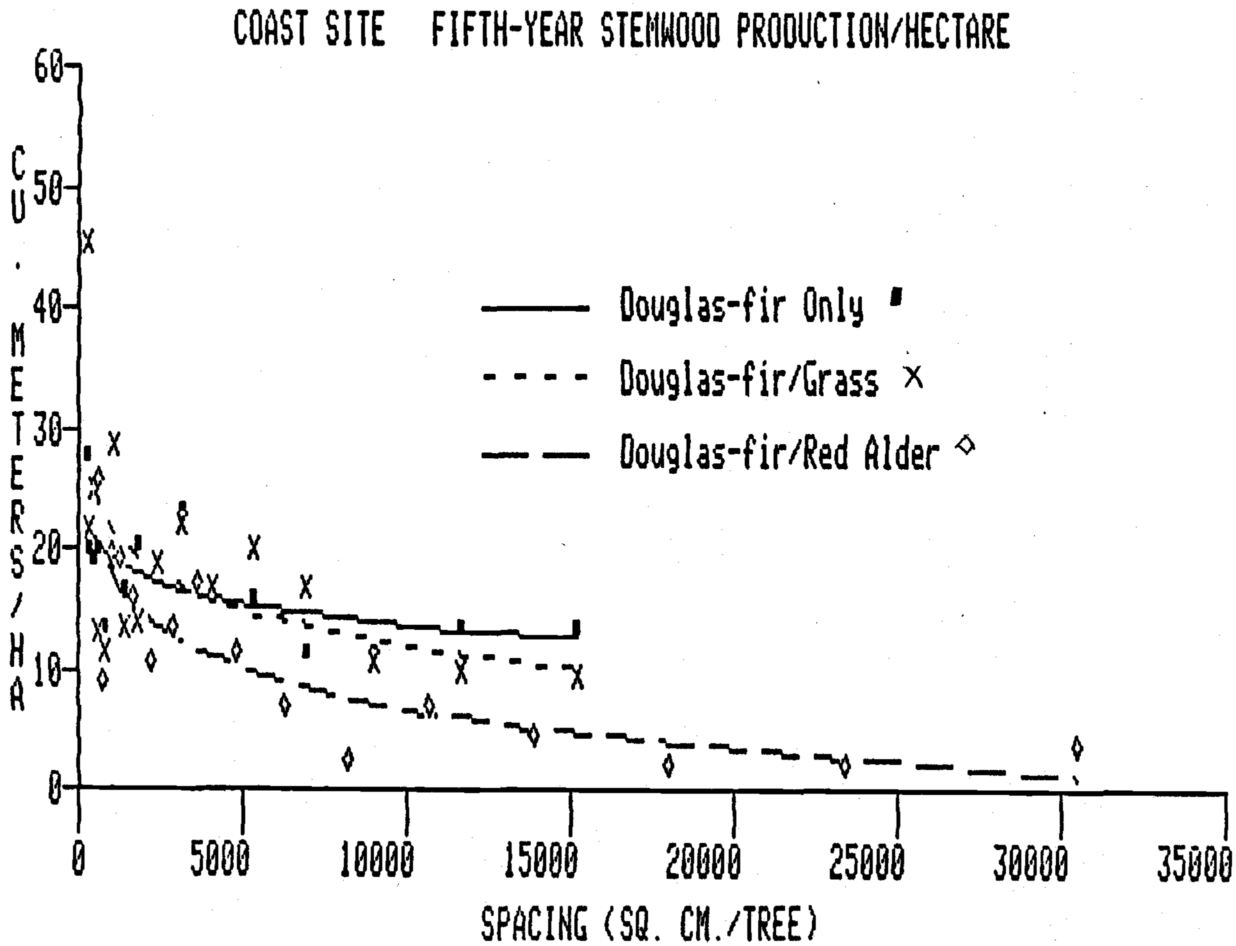

FIGURE 30c. FIFTH-YEAR STEMWOOD VOLUME PRODUCTION/HECTARE FOR THE COAST SITE WITH THE DOUGLAS-FIR/RED ALDER TREES ADJUSTED FOR THE ABSOLUTE DENSITY OF DOUGLAS-FIR TREES.

self-shading is at a minimum. Although the Douglas-fir Only trees do not have overhead shading as do the Douglas-fir/Red Alder trees, crown overlap and self-shading have resulted in partial shading of the crowns. The ratios of these trees fall between the other two types. These differences in leaf area/leaf weight ratios are reflected in the leaf area/tree and leaf area index curves (Figures 18a, 18b, 18c, 19a, 19b, and 19c). Low leaf biomass of the Douglas-fir/Grass trees at the valley and mid-range sites and the Douglas-fir/Red Alder trees at the coast also contribute to low leaf area values.

When converted to leaf area index, the high density trees have such a large foliage biomass/ hectare that the leaf area indices reach high levels. As with leaf area, the differences in leaf biomass and the leaf area/leaf weight ratios result in the Douglas-fir/Red Alder trees having the highest leaf area indices, followed by the Douglas-fir Only trees, and then the Douglas-fir/Grass trees. Again, the Douglas-fir/Red Alder values are based on the total tree population density rather than the absolute density of Douglas-fir, so values are doubled. At the mid-range site the Douglas-fir/Red Alder trees at high densities are so suppressed that they are not maintaining substantial crowns. Lower leaf area indices result.

When growth measurements are placed on a leaf area basis, an index of the amount of growth/photosynthetic unit is obtained. Growth efficiency is the ratio of stemwood volume production/leaf area index (Waring, 1983). At the valley and mid-range sites, the values for the Douglas-fir Only and Douglas-fir/Grass trees are similar. However, the Douglas-fir/Grass trees exhibit poorer growth than the Douglas-fir Only trees. The trees also appear to be less vigorous, with the needles being chlorotic.

Several reasons for the similarity in growth efficiency can be postulated. First, these results are based on aboveground measurements only. Keyes and Grier (1981) found that belowground production accounted for significant amounts of annual production of trees, especially on dry sites. If the belowground biomass is incorporated, the relationships may change. The data on these are forthcoming and will be the subject of future publications.

Another possibility is the low leaf area and leaf weight of the Douglas-fir/Grass trees.

Since sun leaves produce more photosynthate/unit of leaf area than shade leaves (Hamilton, 1969; Kira, Shinozaki, and Hozumi, 1969), the foliage of the Douglas-fir/Grass trees may be capable of producing more biomass/leaf area. This does not seem likely, since the trees have approximately half the biomass of the Douglas-fir trees at the mid- and low densities. If the trees had been producing biomass equal to or more efficiently than the Douglas-fir Only trees for five years, then the trees should have accumulated more standing biomass, provided respiration losses were proportional.

Finally, in vigorous young Douglas-fir trees, crown buildup is occurring so that there is a greater retention of older needles. These older needles are less efficient photosynthetically than current needles (Hamilton, 1969). However, old needles allow for additional storage capacity and nutrient reserves for future growth. At the valley site, this is confounded by needle loss which occurs in association with the grass. The Douglas-fir/Grass trees may be carrying low leaf areas and weights due to early needle loss. At the coast, all trees are affected by a needle blight, so that retention of older needles is poor. In this case, similar values for growth efficiency would be expected, since grass establishment was delayed.

The Douglas-fir/Red Alder trees at the valley and mid-range sites have lower values for growth efficiency than the Douglas-fir Only trees. This is due in part to the high LAI values and low light levels. The shade needles found on these trees did not produce as much stemwood volume/unit of leaf area as the needles on the Douglas-fir Only and Douglas-fir/Grass trees. At the coast, the values of growth efficiency of the Douglas-fir/Red Alder trees are not as far below those of the Douglas-fir Only trees as on the other sites.

Shade needles generally utilize low light intensities more efficiently than sun leaves (Krueger and Ruth, 1969; Kellomaki and Hari, 1980; Kellomaki and Kanninen, 1980). Brix (1967) found that Douglas-fir growing under low light intensities had a higher rate of net photosynthesis relative to the rate of light saturation than seedlings grown at high light intensities. Working with Scots pine, Kellomaki and Hari (1980) speculated that suppressed trees are more efficient in utilizing scarce resources than dominant trees. Under heavily shaded conditions, crown and stem growth were greater than expected based on the supply of photosynthate. With unshaded trees, this trend was reversed (Kellomaki and Kanninen, 1980). It has been postulated that the tendency for both suppressed and dominant trees to increase the specific leaf area in the lower portions of the crown is in response to the prevailing low light conditions and increasing competition (Makela, Kellomaki, and Hari, 1980; Kellomaki and Oker-blom, 1981). Even though shade needles and suppressed trees may be more efficient at utilizing low light levels, the dominant trees had greater growth in absolute terms (Kellomaki and Hari, 1980).

Some experiments have shown that wood production/leaf area decreased with shading (Rangnekar and Forward, 1973; Ericsson, et al., 1980). The decrease resulted from lower photosynthetic efficiency as well as a lower priority for stemwood growth over other growth tissues (Ericsson, et al., 1980; Kellomaki and Kanninen, 1980; Waring, 1983). Waring (1983) reported that plants under less competition for light had higher values for growth efficiency.

Various levels of growth efficiency can be expected from shaded or suppressed trees, based upon the parameters measured and the conditions examined. Suppressed trees may appear to have higher values for growth efficiency due to a lack of needle retention reducing the leaf area values. Although suppressed or shaded trees may be more efficient in terms of utilizing scarce resources, such as light, growth in absolute terms is less than growth of dominant or less-shaded trees. In this study, shaded trees (Douglas-fir/Red Alder trees) had lower values for growth efficiency as well as less absolute growth than the less-shaded trees (Douglas-fir Only and Douglas-fir/Grass) for most densities.

The basal area growth/LAI curves (Figures 23a, 23b, and 23c) show similar trends as the growth efficiency curves (Figures 20a, 20b, and 20c) at the valley and mid-range sites. The coast is different in that the Douglas-fir Only curve falls below that of the Douglas-fir/Red Alder trees (on a total tree population basis), which is comparable to the Douglas-fir/Grass curve. Although the Douglas-fir Only and the Douglas-fir/Grass trees had similar basal area growth, the Douglas-fir Only trees maintained a greater leaf area. Hence, the ratios for basal area growth/LAI would be lower. On the contrary, the Douglas-fir/Red Alder trees had less growth as well as lower leaf areas, resulting in higher ratios. If the basal area growth was adjusted for absolute space of the Douglas-fir trees in the Douglas-fir/Red Alder treatment, the growth would be much less, and the ratios would be smaller.

The dry weight/leaf area curves (Figures 25a, 25b, and 25c) are comparable in rank on all sites, with the Douglas-fir/Grass trees having the highest values and the Douglas-fir/Red Alder trees the lowest, despite having twice as much space per conifer (but not per tree). Given the differences in the basal area growth/LAI curves at the coast site, lower ratios for the Douglas-fir Only curves would be expected. However, the similarity in ranking among sites indicates that although different directions in allocation may have occurred at the coast site, the end result, in terms of biomass/leaf area, is the same. Although both parameters are dynamic, leaf area is more greatly influenced by current conditions than dry weight and could be responding to disease organisms or extreme environmental conditions. Satoo (1962) found that the diameter of a stem reflected a longer history than than the history of the leaves. Comparisons of dry weight/leaf area may be valid only under similar environmental conditions.

With the emphasis on leaf area relations, more precise methods of estimating leaf area are needed. One method that has been postulated is the relationship between leaf area and sapwood basal area (Grier and Waring, 1974; Waring, et al., 1977; Whitehead, 1978; Waring, Schroeder, and Oren, 1982). This experiment shows that leaf area/sapwood basal area ratios for young Douglas-fir trees vary with competitor type and density. Equations would have to be derived for trees growing under different conditions, including different sites, and possibly different competitors. Some of the values, especially those for the Douglas-fir/Grass trees, are relatively constant. This indicates that once more information is obtained, the ratio may prove useful for estimating leaf area if the factors involved can be delineated.

CONCLUSIONS

The Nelder design allows for the study of competition at a continuous range of densities. Problems may arise with maintenance of the plots and mortality, but with adjustments in the analyses, these problems can be minimized. Superimposition of tree-sized competitors conflicts with the basic design assumptions, in some respects, limiting certain stand-level interpretations of growth data.

Results vary with the time interval of the experiment. Although results were not different among sites and some densities after three years, the fifth-year results indicate differences among densities and sites, as well as competitors. These differences are becoming more accentuated with time, so that interpretations of the results change. Since forestry deals with long-term results, more studies over longer periods of time are needed to establish trends that would be useful in evaluating short-term studies.

From this study, several conclusions can be reached.

1. At high densities, intra-specific competition is more apparent than inter-specific competition

when the competitor is grass.

2. Competition by grass or red alder decreases height, diameter, and biomass of Douglas-fir. Reductions vary by site and density of the plantation as well as by competing species.

3. Effects of competition by grass are only severe during the initial years of a plantation. Once canopy closure occurs, grass competition decreases, then ceases.

4. Competition from red alder becomes more accentuated with time, as the Douglas-fir trees fall behind the alder in height growth.

5. At the end of four growing seasons, no nitrogen accretion was apparent from the presence of red alder. There were no differences in percent nitrogen in Douglas-fir foliage among competitor types. However, trees at higher densities had lower nutrient concentrations than those at low densities, showing the effects of demand on a limited supply.

6. In young stands, maximum height growth may not occur at the spacing characterized by maximum biomass of individual trees. Douglas-fir trees need a minor degree of crowding to stimulate allocation of resources toward height growth. Severe crowding decreases height growth.

7. Leaf area per tree is a function of individual leaf weight, stand density, and competitor type. Density and competitor type reflect shading and the formation of different percentages of shade needles.

8. Douglas-fir growing under the canopy of red alder have a higher leaf area:leaf weight ratio than Douglas-fir trees growing with grass or other Douglas-fir only.

9. In this study, high leaf area index correlated with low productivity/tree due to crowding. On a per hectare basis, productivity was directly related to LAI, with some qualifications for competitor type.

10. Growth efficiency is not an estimate of tree vigor in young stands in regards to aboveground biomass. If belowground biomass is incorporated, growth efficiency may prove an adequate indicator of tree vigor, but this thesis did not address that question.

11. Growth efficiency of young Douglas-fir trees is not the highest in the most vigorous trees where crown buildup is occurring. The retention of inner crown needles which contribute little photosynthate may allow for additional storage capacity and nutrient reserves for future mobilization toward growth.

The near-inactive photosynthetic status of the old needles reduces efficiency of net assimilation.

12. For the coast area typified in this study, light has a greater influence on photosynthesis than nutrient supply or moisture stress. The interaction between light intensity and temperature probably limits photosynthesis.

13. Significant interactions among site, competitor, and density confound the ability to establish generalities about the effects of competition.

Future research needs to explore the leaf area relations of trees. The process of crown maintenance and buildup is essential to insure survival and growth of trees. Studies which quantify the effects of competition are needed to develop growth models for young Douglas-fir trees. The potential growth that is lost due to competition will result in decreased future yields and/or longer rotations. The extent to which this can be tolerated within the forest industry can be examined by combining biological data with economic criteria.

LITERATURE CITED

Allen, S. E., H. M. Grimshaw, J. A. Parkinson, and C. Quarmby. 1974. Chemical analysis of ecological materials. John Wiley and Sons, New York.

Anderson, Y. O. 1955. Seasonal development of sun and shade leaves. Ecology 36(3):430-439.

Barker, H. 1968. Methods of measuring leaf area surface area of some conifers. Dep. Publ. For. Brit. Can. No. 1219.

Beardsell, M. F., P. G. Jarvis, and B. Davidson. 1972. A null-balance diffusion porometer suitable for use with leaves of many shapes. J. Appl. Ecol. 9(3):677-690.

Belanger, R. P., and W. D. Pepper. 1978. Seedling density influences the early growth of planted sycamore. For. Sci. 24(4):493-496.

Bennett, F. A. 1960. Spacing and early growth of planted slash pine. J. For. 58:966-967.

———. 1963. Growth and yield of planted conifers in relation to initial spacing and stocking. Proc. Soc. Amer. For. 1962:22-26.

Binkley, D. 1982. Case studies of red alder and Sitka alder in Douglas-fir plantations:

nitrogen fixation and ecosystem production. Ph.D. thesis, Oregon State University, Corvallis, OR.

Boyer, W. D. 1968. Foliage weight and stem growth of longleaf pine. USDA For. Serv. Res. Note SO-86.

Bramble, W. C., H. N. Cope, and H. H. Chisman. 1949. Influence of spacing on growth of red pine in plantations. J. For. 47:726-732.

Brix, H. 1967. An analysis of dry matter production of Douglas-fir seedlings in relation to temperature and light intensity. Can. J. Bot. 45:2063-2072.

Byrnes, W.R., and W. C. Bramble. 1955. Growth and yield of plantation-grown red pine at various spacings. J. For. 53:562-565.

Collins, A. B., III. 1967. Density and height growth in natural slash pine. USDA For. Serv. Res. Pap. SE-27.

Curtis, R. O., and D. L. Reukema. 1970. Crown development and site estimates in a Douglas-fir plantation spacing test. For. Sci. 16(3): 287-301.

Del Rio, E., and A. Berg. 1979. Specific leaf area of Douglas-fir reproduction as affected by light and needle age. For. Sci. 25(1): 183-186.

Drew, A. P., and S. W. Running. 1975. Comparison of two techniques for measuring surface area of conifer needles. For. Sci. 21(3):231-232.

Emmingham, W. H. 1974. Physiological responses in four Douglas-fir populations in three contrasting environments. Ph.D. thesis, Oregon State University, Corvallis, OR.

Ericsson, A., S. Larsson, and O. Tenow. 1980. Effects of early and late season defoliation on growth and carbohydrate dynamics in Scots pine. J. Appl. Ecol. 17:747-769.

Eversole, K. R. 1955. Spacing tests in a Douglas-fir plantation. For. Sci. 1:14-18.

Friend, D. T. C. 1961. A simple method of measuring light values in the field. Ecology 42(3):577-580.

Fritschen, L. J. 1963. Construction and evaluation of a miniature net radiometer. J. Appl. Meteor. 2(1):165-172.

———. 1965. Miniature net radiometer improvements. J. Appl. Meteor. 4:528-531.

Gholz, H. L., F. K. Fitz, and R. H. Waring. 1976. Leaf area differences associated with old-growth forest communities in the western Oregon Cascades. Can. J. For. Res. 6:49-57.

Grier, C. C., and R. H. Waring. 1974. Conifer foliage mass related to sapwood area. For. Sci. 20(3):205-206.

Grime, J. P. 1977. Evidence for the existence of three primary strategies in plants and its relevance to ecological and evolutionary theory. Amer. Nat. 111(982):1169-1192.

———. 1979. Plant strategies and vegetation processes. John Wiley and Sons, Chichester, UK.

Hall, G. S. 1965. Wood increment and crown distribution relationships in red pine. For. Sci. 11(4):438-448.

Hamilton, G. J. 1969. The dependence of volume increment of individual trees on dominance, crown dimensions, and competition. Forestry 42(2):133-144.

Harms, W. R., and O. G. Langdon. 1976. Development of loblolly pine in dense stands. For. Sci. 22(3):331-337.

Harper, J. L. 1977. Population biology of plants. Academic Press, London, UK.

Harrington, C. A., and D. L. Reukema. 1983. Initial shock and long-term stand development following thinning in a Douglas-fir plantation. For. Sci. 29(1):33-46.

Keeney, D. R., and J. M. Bremner. 1966. Comparison and evaluation of laboratory methods of obtaining an index of soil nitrogen availability. Agron. J. 58:498-503.

Kellomaki, S., and P. Hari. 1980. Ecophysiological studies on young Scots pine stands: I. Tree class as indicator of needle biomass, illumination, and photosynthetic capacity of crown system. Silva Fenn. 14(3):227-242.

———, and M. Kanninen. 1980. Eco-physiological studies on young Scots pine stands: IV. Allocation of photosynthates for crown and stem growth. Silva Fenn. 14(14):397-408.

———, and P. Oker-blom. 1981. Specific needle area of Scots pine and its dependence on light conditions inside the canopy. Silva Fenn. 15(2):190-198.

Keyes, M. R., and C. C. Grier. 1981. Above- and below-ground net production in 40-year old Douglas-fir stands on low and high productivity sites. Can. J. For. Res. 11:599-605.

Kira, T., K. Shinozaki, and K. Hozumi. 1969. Structure of forest canopies as related to their primary productivity. Plant and Cell Physiol. 10:129-142.

Krueger, K. W. 1967. Foliar mineral content of forest- and nursery-grown Douglas-fir seedlings. USDA For. Serv. Res. Pap. PNW-45.

Krueger, K. W., and R. H. Ruth. 1969. Comparative photosynthesis of red alder, Douglas-fir, Sitka spruce, and western hemlock seedlings. Can. J. Bot. 47:519-527.

Larson, P. R., and J. G. Isebrands. 1972. The relation between leaf production and wood weight in first-year root sprouts of two Populus clones. Can. J. For. Res. 2:98-104.

Lavender, D. P. 1970. Foliar analysis and how it is used a review. Oreg. St. Univ. For. Res. Lab Res. Note 52.

Lidicker, W. Z., Jr. 1979. A clarification of interactions in ecological systems. Biosci. 29(8):475-477.

Makela, A., S. Kellomaki, and P. Hari. 1980. Eco-physiological studies on young Scots pine stands: III. Photosynthate allocation for needle growth and wood formation in current-year shoots. Silva Fenn. 14(3):258-263.

Miller, R. E., and M. D. Murray. 1978. The effects of red alder on growth of Douglas-fir. In Utilization and management of alder. Edited by D G. Briggs, D. S. DeBell, and W. A. Atkinson. USDA For. Serv. Gen. Tech. Rep. PNW-70. pp. 283-306.

Mitchell, R. G. 1974. Estimation of needle populations on young, open-grown Douglas-fir by regression and life table analysis. USDA For. Serv. Res. Pap. PNW-181.

Moeur, M. 1981. Crown width and foliage weight of northern Rocky Mountain conifers. USDA For. Serv. Res. Pap. INT-283.

Mohler, C. L., P. L. Marks, and D. G. Spruegel. 1978. Stand structure and allometry of trees during self-thinning of pure stands. J. Ecol. 66:599-614.

Nelder, J. A. 1962. New kinds of systematic designs for spacing experiments. Biometrics 18:283-307.

Newman, K. 1979. Sapwood basal area as an estimator of individual tree growth. M.S. thesis, Oregon State University, Corvallis, OR.

Newton, M. 1973. Forest rehabilitation in North America: some simplifications. J. For. 71(3): 159-162.

———, B. A. El Hassan, and J. Zavitkovski. 1968. Role of red alder in western Oregon forest succession. In Biology of alder. Edited by J. M. Trappe, J. F. Franklin, R. F. Tarrant, and G. H. Hansen. USDA Pacific Northwest Forest and Range Experiment Station, Portland, OR. pp. 73-84.

Rangnekar, P. V., and D. F. Forward. 1973. Foliar nutrition and wood growth in red pine: effects of darkening and defoliation on the distribution of ^{14}C-photosynthate in young trees. Can. J. Bot. 51:103-108.

Reukema, D. L. 1961. Crown development and its effect on stem growth of six Douglas-firs. J. For. 59:370-371.

———. 1970. Forty-year development of Douglas-fir stands planted at various spacings. USDA For. Serv. Res. Pap. PNW-100.

———. 1979. Fifty-year development of Douglas-fir stands planted at various spacings. USDA For. Serv. Res. Pap. PNW-253.

Ritchie, G. A., and T. M. Hinckley. 1975. The pressure chamber as an instrument for ecological research. Advances in Ecol. Res. 9: 165-254.

Satoo, T. 1962. Notes on Kittredge method of estimation of leaves of forest stand. J. Jap. For. Soc. 44(10):267-272.

———, R. Kunugi, and A. Kumekawa. 1956. Materials for the studies of growth in stands. III. Amount of leaves and production of wood in an aspen (Populus davidiana) second growth in Hokkaido. Bull. Tokyo Univ. For. 52:33-51.

Schroeder, P. E., B. McCandlish, R. H. Waring, and D. A. Perry. 1982. The relationship of maximum canopy leaf area to forest growth in eastern Wasington. Northwest Sci. 56(2): 121-130.

Silver, G. T. 1962. Distribution of Douglas-fir foliage by age. For. Chron. 38(4):433-438.

Smith, R. B., R. H. Waring, and D. A. Perry. 1981. Interpretating foliar analysis from Douglas-fir as weight per unit of leaf area. Can. J. For. Res. 11(3):593-598.

Snedecor, G. W., and W. G. Cochran. 1980. Statistical methods seventh edition. The Iowa State University Press, Ames, Iowa.

Unterschuetz, P. W. F. Ruetz, R. R. Geppert, and W. K. Ferrell. 1974. The effect of age, pre-conditioning, and water stress on transpiration rates of Douglas-fir (Pseudotsuga menziesii) seedlings of several ecotypes. Physiol. Plant. 32:214-221.

van den Driessche, R. 1968. Growth analysis of four nursery-grown conifer species. Can. J. Bot. 46:1389-1395.

———. 1971. Growth of one-year-old Douglas-fir plants at four spacings. Ann. Bot. 35:117-126.

Waring, R. H. 1980. Site, leaf area, and phytomass production in trees. New Zeal. For. Serv. FRI Tech. Rep. No. 70. p. 125-135.

Waring, R. H. 1983. Estimating forest growth and efficiency in relation to canopy leaf area. In Advances in ecological research volume 13. Edited by A. MacFadyen and E. D. Ford. Academic Press, London. pp. 327-349.

———, and B. D. Cleary. 1967. Plant moisture stress: evaluation by pressure bomb. Science 155(3767):1248-1254.

———, W. H. Emmingham, H. L. Gholz, and C. C. Grier. 1978. Variations in maximum leaf area of coniferous forests in Oregon and its ecological significance. For. Sci. 24(1):131-140.

———, H. L. Gholz, C. C. Grier, and M. L. Plummer. 1977. Evaluating stem conducting tissue as an estimator of leaf area in four woody angiosperms. Can. J. Bot. 55(11):1474-1477.

———, K. Newman, and J. Bell. 1981. Efficiency of tree crowns and stemwood production at different canopy leaf densities. Forestry 54(2):129-137.

———, P. E. Schroeder, and R. Oren. 1982. Applications of the pipe model theory to predict canopy leaf area. Can. J. For. Res. 12:556-560.

Weetman, G. F. , and R. Harland. 1964. Foliage and wood production in unthinned black spruce in northern Quebec. For. Sci. 10(1):80-88.

Westoby, M. 1977. Self-thinning driven by leaf area not by weight. Nature 265:330-331.

Whitehead, D. 1978. The estimation of foliage area from sapwood basal area in Scots pine. Forestry 51(2):137-149.

Zedaker, S. M. 1981. Growth and development of young Douglas-fir in relation to intra- and inter-specific competition. Ph.D. thesis, Oregon State University, Corvallis, OR.

APPENDICES

TABLE A1. EQUATIONS USED TO ESTIMATE LEAF AREA/TREE. In the equations, LFWGT=leaf weight and LFWGT*LNSP=leaf weight*natural logarithm of spacing. Standard errors of the coefficients, F values, coefficients of variation, and R-squared values from the regression are given. Intercepts were not significantly different from zero. All F values are significant at α=0.01.

TREATMENTS	LFWGT+LFWGT*LNSP		F VALUE	C.V.	R^2
Douglas-fir Only	192.2665	-9.7032	9471.49	12.69	0.986
S.E.	14.1188	1.7682			
Douglas-fir/Grass	148.3713	-5.3337	2731.28	10.31	0.991
S.E.	10.7375	1.3475			
Douglas-fir/Red Alder	146.5683	-3.2534	2163.89	11.87	0.988
S.E.	14.1797	1.7434			

TABLE A2. EQUATIONS FOR ESTIMATING DRY WEIGHT FROM FRESH WEIGHT. Standard errors of the coefficients, F values, coefficients of variation, and R-squared values from the regression are given. Intercepts were not significantly different from zero.

TREATMENT	FRWGT	S.E.	F VALUE	C.V.	R^2
Valley					
Douglas-fir Only	0.39622	0.00517	5884.22***	9.79	0.995
Douglas-fir/Grass	0.41813	0.00333	15784.24***	5.46	0.998
Douglas-fir/Red Alder	0.39387	0.00245	25842.44***	4.65	0.999
Mid-Range					
Douglas-fir Only	0.37673	0.00530	5060.68***	10.22	0.994
Douglas-fir/Grass	0.39403	0.00314	15747.37***	6.49	0.998
Douglas-fir/Red Alder	0.36160	0.00372	9442.76***	8.68	0.997
Coast					
Douglas-fir Only	0.36850	0.00538	4690.91***	11.16	0.994
Douglas-fir/Grass	0.37556	0.00246	23395.02***	5.32	0.999
Douglas-fir/Red Alder	0.37668	0.00713	2794.60***	14.92	0.989

*** α=0.01

TABLE A3. EQUATIONS FOR ESTIMATING WOOD WEIGHT FROM DRY WEIGHT. Standard errors of the coefficients, F values, coefficients of variation, and R-squared values from the regression are given. Intercepts were not significantly different from zero.

TREATMENT	DRYWGT	S.E.	F VALUE	C.V.	R^2
Valley					
Douglas-fir Only	0.66073	0.00658	10093.00***	7.36	0.997
Douglas-fir/Grass	0.67433	0.00806	7005.77***	8.16	0.996
Douglas-fir/Red Alder	0.64079	0.00628	10410.01***	7.32	0.997
Mid-Range					
Douglas-fir Only	0.65948	0.00745	7832.45***	8.04	0.996
Douglas-fir/Grass	0.65209	0.00733	7920.60***	9.06	0.996
Douglas-fir/Red Alder	0.66474	0.00536	15408.97***	6.89	0.998
Coast					
Douglas-fir Only	0.72523	0.00640	12843.34***	6.70	0.998
Douglas-fir/Grass	0.71572	0.00739	9374.40***	8.31	0.997
Douglas-fir/Red Alder	0.74994	0.00508	21819.23***	5.39	0.999

*** $\alpha = 0.01$

TABLE A4. EQUATIONS FOR ESTIMATING BASAL DIAMETER FROM DIAMETER AT 15 CM. Standard errors of coefficients, F values, coefficients of variation, and R-squared values from the regression are given. Intercepts were not significantly different from zero.

TREATMENT	D15	S.E.	F VALUE	C.V.	R^2
Valley					
Douglas-fir Only	1.0509	0.0290	1313.95***	19.51	0.978
Douglas-fir/Grass	1.0693	0.0218	2397.57***	13.44	0.988
Douglas-fir/Red Alder	1.1371	0.0464	599.40***	27.60	0.955
Mid-Range					
Douglas-fir Only	1.1226	0.0175	4137.40***	10.82	0.993
Douglas-fir/Grass	1.0279	0.0291	1249.64***	17.62	0.980
Douglas-fir/Red Alder	1.0143	0.0257	1553.02***	17.05	0.986
Coast					
Douglas-fir Only	1.0111	0.0317	1015.64***	23.17	0.971
Douglas-fir/Grass	1.1466	0.0292	1539.11***	18.62	0.981
Douglas-fir/Red Alder	1.0475	0.0335	976.82***	24.71	0.970

*** α=0.01

TABLE A5. EQUATIONS FOR ESTIMATING BASAL DIAMETER FOR 1981 FROM BASAL DIAMETER FOR 1982. Standard errors of coefficients, F values, coefficients of variation, and R-squared values from the regression are given. Intercepts were not significantly different from zero. LNSP=natural logarithm of spacing.

TREATMENT	D82	S.E.	D82*LNSP	S.E.	F VALUE[1]	C.V.	R^2
Valley							
Douglas-fir Only	1.1568	0.1055	-0.0718	0.0116	1324.43	12.94	0.989
Douglas-fir/Grass	1.1011	0.1023	-0.0711	0.0124	1009.24	14.94	0.987
Douglas-fir/Red Alder	0.7763	0.0560	-0.0281	0.0062	6000.22	6.19	0.998
Mid-Range							
Douglas-fir Only	1.1890	0.0766	-0.0808	0.0083	1533.59	11.79	0.991
Douglas-fir/Grass	1.1768	0.1392	-0.0870	0.0158	455.79	22.38	0.970
Douglas-fir/Red Alder	1.0002	0.1386	-0.0561	0.0146	1392.77	13.63	0.991
Coast							
Douglas-fir Only	0.9380	0.1341	-0.0397	0.0150	1456.90	13.58	0.990
Douglas-fir/Grass	0.8586	0.0877	-0.0354	0.0098	1765.27	11.91	0.992
Douglas-fir/Red Alder	1.0006	0.0602	-0.0543	0.0068	4861.10	7.49	0.997

[1]F values are significant at α=0.01.

TABLE B1. ANALYSIS OF VARIANCE FOR PERCENT NITROGEN IN DOUGLAS-FIR FOLIAGE.

SOURCE OF VARIATION	D.F.	SUM OF SQ.	MEAN SQ.	F
Site	2	4.159	2.0795	29.25***
Plot(Site)	9	0.64	0.0711	
Competitor	2	0.079	0.0395	1.65
Site*Co	4	0.192	0.048	2.00
Plot(Site)*Co	18	0.44	0.024	
Density	1	1.587	1.587	31.74***
Site*Density	2	0.045	0.0225	0.45
Plot(Site)*Dens	9	6.45	0.05	
Co*Dens	2	0.032	0.0160	0.50
Site*Co*Dens	4	0.085	0.0212	0.67
Plot(Site)*Co*Dens	18	0.573	0.0318	
Error	72	1.825	0.0253	
Mean	1	464.456		
Total	144	474.563		

* α=0.1 ** α=0.05 *** α=0.01

TABLE B2. ANALYSIS OF VARIANCE OF PERCENT PHOSPHORUS IN DOUGLAS-FIR FOLIAGE.

SOURCE OF VARIATION	D.F.	SUM OF SQ.	MEAN SQ.	F
Site	2	0.0551	0.02755	52.98***
Plot(Site)	9	0.0047	0.00052	
Competitor	2	0.0149	0.00745	27.90***
Site*Co	4	0.0025	0.000625	2.34
Plot(Site)*Co	18	0.0048	0.000267	
Density	1	0.0185	0.0185	37.00***
Site*Density	2	0.0031	0.00155	3.10
Plot(Site)*Dens	9	0.0045	0.00050	
Co*Dens	2	0.0037	0.00185	0.71
Site*Co*Dens	4	0.0014	0.00035	0.14
Plot(Site)*Co*Dens	18	0.0467	0.00259	
Error	72	0.1793	0.00249	
Mean	1	3.8601		
Total	144	3.9897		

* α=0.1 ** α=0.05 *** α=0.01

TABLE B3. ANALYSIS OF VARIANCE FOR BULK DENSITY OF SOILS (SITE AND COMPETITOR COMPARISONS).

SOURCE OF VARIATION	D.F.	SUM OF SQ.	MEAN SQ.	F
Site	2	0.393	0.1965	15.35**
Plot(Site)	9	0.115	0.0128	
Competitor	2	0.013	0.0065	3.55
Site*Co	4	0.047	0.0118	6.45**
Plot(Site)*Co	18	0.033	0.00183	
Error	36	0.215	0.00597	
Mean	1	46.291		
Total	72	47.107		

* α=0.1 ** α=0.05 *** α=0.01

TABLE B4. ANALYSIS OF VARIANCE FOR BULK DENSITY OF SOILS (COMPARISONS OF SITE AND DENSITY AMONG RED ALDER TREATMENTS).

SOURCE OF VARIATION	D.F.	SUM OF SQ.	MEAN SQ.	F
Site	2	0.3205	0.1603	26.72***
Plot(Site)	9	0.058	0.006	
Density	1	0.087	0.087	17.76***
Site*Density	2	0.040	0.020	4.08
Plot(Site)*Density	9	0.044	0.0049	
Error	24	0.1635	0.0068	
Mean	1	28.774		
Total	48	29.487		

* α=0.1 ** α=0.05 *** α=0.01

TABLE B5. ANALYSIS OF VARIANCE FOR AVAILABLE NITROGEN IN SOILS (SITE AND COMPETITOR COMPARISONS)

SOURCE OF VARIATION	D.F.	SUM OF SQ.	MEAN SQ.	F
Site	2	6301	3150	12.02**
Plot(Site)	9	2354	262	
Competitor	2	446	223	2.08
Site*Competitor	4	374	94	0.88
Plot(Site)*Co	18	1924	107	
Error	36	1693	47	
Mean	1	69627		
Total	72	82719		

* α=0.1 ** α=0.05 *** α=0.01

TABLE B6. ANALYSIS OF VARIANCE FOR AVAILABLE NITROGEN IN SOILS (COMPARISONS AMONG SITES AND DENSITIES IN RED ALDER TREATMENTS)

SOURCE OF VARIATION	D.F.	SUM OF SQ.	MEAN SQ.	F
Site	2	2815	1408	4.25
Plot(Site)	9	2983	331	
Density	1	285	285	5.00
Site*Density	2	69	34	0.60
Plot(Site)*Density	9	510	57	
Error	24	1109	46	
Mean	1	47188		
Total	48	54959		

TABLE B7. ANALYSIS OF VARIANCE FOR TOTAL NITROGEN IN SOILS (SITE AND COMPETITOR COMPARISONS)

SOURCE OF VARIATION	D.F.	SUM OF SQ.	MEAN SQ.	F
Site	2	2.55	1.28	18.29**
Plot(Site)	9	0.60	0.07	
Competitor	2	0.07	0.04	4.00
Site*Competitor	4	0.14	0.04	4.00
Plot(Site)*Co	18	0.22	0.01	
Error	36	0.54	0.02	
Mean	1	37.52		
Total	72	41.64		

* α=0.1 ** α=0.05 *** α=0.01

TABLE B8. ANALYSIS OF VARIANCE FOR TOTAL NITROGEN IN SOILS (COMPARISONS AMONG SITE AND DENSITIES IN RED ALDER TREATMENTS)

SOURCE OF VARIATION	D.F.	SUM OF SQ.	MEAN SQ.	F
Site	2	2.36	1.18	19.67**
Plot(Site)	9	0.56	0.06	
Density	1	0.02	0.02	2.00
Site*Density	2	0.02	0.01	1.00
Plot(Site)*Density	9	0.07	0.01	
Error	24	0.05	0.002	
Mean	1	26.77		
Total	48	29.85		

*α=0.1 **α=0.05 ***α=0.01

TABLE C1. AVERAGE PREDAWN MOISTURE STRESS (IN BARS) AND STANDARD DEVIATIONS THROUGHOUT THE GROWING SEASON FOR THE VALLEY SITE. Each mean represents six trees.

	Sample Date				
	7/22/82	7/26/82	8/09/82	8/23/82	9/07/82
Douglas-fir Only					
High Density	11.1±0.61	14.2±0.75	14.7±0.60	16.3±0.40	16.9±0.61
Medium Density	10.5±0.51	11.2±0.45	14.0±0.43	16.1±0.61	16.7±0.40
Low Density	8.6±0.92	9.5±1.07	10.9±0.26	12.5±0.39	12.9±0.38
Douglas-fir/Grass					
High Density	11.2±0.59	12.6±0.68	14.3±0.20	16.2±0.71	17.5±0.40
Medium Density	10.3±0.99	12.3±0.25	13.6±0.34	15.6±0.61	16.5±0.40
Low Density	9.9±0.58	10.8±0.29	12.5±0.35	14.7±0.30	15.1±0.21
Douglas-fir/Red Alder					
High Density	11.7±0.49	14.3±0.53	15.9±0.47	18.0±0.49	18.2±0.40
Medium Density	11.3±0.29	13.3±0.87	14.6±0.82	16.5±0.52	16.8±0.64
Low Density	10.2±1.43	12.0±0.43	12.6±0.42	14.7±0.58	15.2±0.44

TABLE C2. AVERAGE PREDAWN MOISTURE STRESS (IN BARS) AND STANDARD DEVIATIONS THROUGHOUT THE GROWING SEASON FOR THE MID-RANGE SITE. Each mean represents six trees.

	Sample Date				
	7/23/82	7/28/82	8/11/82	8/25/82	9/09/82
Douglas-fir Only					
High Density	8.8±0.92	10.7±1.08	8.8±0.49	11.7±0.51	13.4±1.54
Medium Density	7.7±0.43	8.5±0.56	7.5±0.49	10.4±0.68	12.4±0.96
Low Density	5.8±0.49	6.4±0.80	5.8±0.58	8.4±0.79	8.8±0.98
Douglas-fir/Grass					
High Density	10.6±0.34	11.8±0.75	10.5±0.33	15.0±0.87	16.1±1.24
Medium Density	8.1±0.65	9.2±1.08	8.5±0.75	13.2±0.77	12.6±1.67
Low Density	6.1±0.67	7.3±0.25	6.1±0.26	9.1±0.82	11.0±0.53
Douglas-fir/Red Alder					
High Density	10.2±0.89	14.2±2.75	13.0±2.61	17.0±1.50	17.4±1.08
Medium Density	7.3±0.20	12.2±0.67	10.2±0.32	14.3±0.64	14.4±0.38
Low Density	6.2±0.22	7.0±0.99	6.3±0.92	11.6±0.93	11.8±0.43

TABLE C3. AVERAGE PREDAWN MOISTURE STRESS (IN BARS) AND STANDARD DEVIATIONS THROUGHOUT THE GROWING SEASON FOR THE COAST SITE. Each mean represents six trees.

	Sample Date			
	8/16/82	8/20/82	8/27/82	9/11/82
Douglas-fir Only				
High Density	7.8±0.29	8.8±0.38	9.3±1.14	6.6±0.34
Medium Density	6.6±1.07	7.8±0.32	8.2±0.69	6.4±0.38
Low Density	5.3±0.29	6.4±0.31	6.8±0.90	4.5±0.40
Douglas-fir/Grass				
High Density	6.8±0.94	8.2±0.70	8.1±0.58	7.5±0.40
Medium Density	5.2±0.19	6.5±0.16	6.2±1.24	6.3±0.75
Low Density	5.4±0.68	6.1±0.59	6.0+0.88	4.5±0.80
Douglas-fir/Red Alder				
High Density	7.0±1.51	8.8±0.30	8.5±0.75	7.4±0.41
Medium Density	7.0±0.51	8.1±0.52	7.9±0.67	6.3±0.66
Low Density	5.3±0.19	6.4±0.30	6.3±1.14	5.0±0.80

TABLE C4. ANALYSIS OF VARIANCE FOR PREDAWN MOISTURE STRESS FOR SAMPLE DATES 7/21/82 AT THE VALLEY SITE AND 7/23/82 AT THE MID-RANGE SITE.

SOURCE OF VARIATION	D.F.	SUM OF SQ.	MEAN SQ.	F
Site	1	190.00	190.00	26.54**
Plot(Site)	2	14.31	7.16	
Competitor	2	4.67	2.34	9.67**
Site*Competitor	2	7.57	3.78	15.62**
Plot(Site)*Co	4	0.97	0.24	
Density	2	138.89	69.44	112.00***
Site*Density	2	20.26	10.13	16.34**
Plot(Site)*Dens	4	2.48	0.62	
Co*Dens	4	9.61	2.40	5.29
Site*Co*Dens	4	4.68	1.17	2.58
Plot(Site)*Co*Dens	8	3.63	0.454	
Error	72	21.04	0.29	
Total	107	418.12		

* α=0.1 ** α=0.05 *** α=0.01

TABLE C5. ANALYSIS OF VARIANCE FOR PREDAWN MOISTURE STRESS FOR 7/26/82 (VALLEY), 7/28/82 (MID-RANGE), AND 8/16/82 (COAST).

SOURCE OF VARIATION	D.F.	SUM OF SQ.	MEAN SQ.	F
Site	2	943.45	471.72	102.10***
Plot(Site)	3	13.86	4.62	
Competitor	2	66.68	33.34	16.59***
Site*Competitor	4	22.13	5.53	2.75
Plot(Site)*Co	6	12.05	2.01	
Density	2	316.67	158.34	92.06***
Site*Density	4	54.02	13.50	7.85**
Plot(Site)*Density	6	10.30	1.72	
Co*Dens	4	29.09	7.27	6.38*
Site*Co*Dens	8	25.64	3.20	2.81
Plot(Site)*Co*Dens	12	13.72	1.14	
Error	108	49.12	0.455	
Total	161	1556.75		

* α=0.1 ** α=0.05 *** α=0.01

TABLE C6. ANALYSIS OF VARIANCE FOR PREDAWN MOISTURE STRESS FOR 8/09/82 (VALLEY), 8/11/82 (MID-RANGE), AND 8/20/82 (COAST).

SOURCE OF VARIATION	D.F.	SUM OF SQ.	MEAN SQ.	F
Site	2	1199.34	599.67	214.17***
Plot(Site)	3	8.40	2.80	
Competitor	2	55.05	27.52	16.19***
Site*Competitor	4	20.15	5.04	2.96
Plot(Site)*Co	6	10.23	1.70	
Density	2	300.24	150.12	156.38***
Site*Density	4	29.45	7.36	7.67**
Plot(Site)*Density	6	5.74	0.96	
Co*Dens	4	20.97	5.24	4.52
Site*Co*Dens	8	13.63	1.70	1.47
Plot(Site)*Co*Dens	12	13.90	1.16	
Error	108	22.79	0.21	
Total	161	1699.89		

* α=0.1 ** α=0.05 *** α=0.01

TABLE C7. ANALYSIS OF VARIANCE FOR PREDAWN MOISTURE STRESS FOR 8/23/82 (VALLEY), 8/25/82 (MID-RANGE), AND 8/27/82 (COAST).

SOURCE OF VARIATION	D.F.	SUM OF SQ.	MEAN SQ.	F
Site	2	1808.66	904.33	1507.22***
Plot(Site)	3	1.80	0.60	
Competitor	2	98.34	49.17	38.41***
Site*Competitor	4	84.51	21.13	16.51***
Plot(Site)*Co	6	7.66	1.28	
Density	2	296.76	148.38	96.35***
Site*Density	4	37.21	9.30	6.04**
Plot(Site)*Density	6	9.23	1.54	
Co*Dens	4	31.71	7.93	7.93**
Site*Co*Dens	8	13.99	1.75	1.75
Plot(Site)*Co*Dens	12	11.95	1.00	
Error	108	61.42	0.57	
Total	161	2463.23		

* α=0.1 ** α=0.05 *** α=0.01

TABLE C8. ANALYSIS OF VARIANCE FOR PREDAWN MOISTURE STRESS FOR 9/07/82 (VALLEY), 9/09/82 (MID-RANGE), AND 9/11/82 (COAST).

SOURCE OF VARIATION	D.F.	SUM OF SQ.	MEAN SQ.	F
Site	2	2910.48	1455.24	635.48***
Plot(Site)	3	6.87	2.29	
Competitor	2	43.72	21.86	49.68***
Site*Competitor	4	26.61	6.65	15.12***
Plot(Site)*Co	6	2.61	0.44	
Density	2	351.04	175.52	1350.15***
Site*Density	4	35.86	8.96	68.96***
Plot(Site)*Density	6	0.80	0.13	
Co*Dens	4	19,83	4.96	19.07***
Site*Co*Dens	8	30.68	3.84	14.75***
Plot(Site)*co*Dens	12	3.06	0.26	
Error	108	62.58	0.58	
Total	161	3494.15		

* α=0.1 ** α=0.05 *** α=0.01

TABLE D1. EQUATION FOR OZALID CALIBRATION.

Log_{10} Langleys=-.45037+.38256*number of ozalid stacks penetrated.

Standard deviation of the intercept=$4.87\text{X}10^{-3}$
Standard deviation of the slope =$2.47\text{X}10^{-2}$

Correlation coefficient=.984; R^2=.968

TABLE D2. MEAN VALUES AND STANDARD DEVIATIONS FOR AMOUNT OF LIGHT PENETRATION (IN LANGLEYS/DAY) AT THE VALLEY SITE ON JULY 21, 1982.

	DOUGLAS-FIR ONLY		DOUGLAS-FIR/GRASS		DOUGLAS-FIR/RED ALDER	
	MEAN	S.D.	MEAN	S.D.	MEAN	S.D.
HIGH DENSITY						
0 cm	2.05	0.71	2.12	0.56	4.30	2.23
75 cm	1.81	1.14	8.42	12.14	10.30	8.15
150 cm	80.06	137.70	35.50	33.05	43.88	35.66
Top	207.13	93.53	250.62	81.08	44.80	35.36
MEDIUM DENSITY						
0 cm	2.81	3.27	6.92	6.31	3.01	1.97
75 cm	36.10	39.31	24.82	15.35	10.98	9.08
150 cm	131.48	127.82	199.80	127.47	47.65	35.68
Top	261.85	101.97	227.65	131.64	40.20	12.43
LOW DENSITY						
0 cm	7.22	5.16	23.65	17.33	4.95	6.31
75 cm	77.92	48.94	118.99	119.29	13.65	5.48
150 cm	179.78	109.29	222.23	106.26	80.28	49.24
Top	386.70	129.31	421.82	180.10	89.42	28.07
OPEN	758.7 ± 81.7					

TABLE D3. ANALYSIS OF VARIANCE FOR AMOUNT OF LIGHT PENETRATION AT THE VALLEY SITE ON JULY 21, 1982.

SOURCE OF VARIATION	D.F.	SUM OF SQ.	MEAN SQ.	F
Plot	1	79253.5	79253.5	
Competitor	2	232514.2	116257.1	8.87
Plot*Competitor	2	26206.8	13103.4	
Density	2	173588.6	86794.3	11.69
Plot*Density	2	14848.8	7424.4	
Height	3	898795.3	299598.4	1.54
Plot*Height	3	584047.3	194682.4	
Competitor*Density	4	32154.7	8038.7	1.38
Plot*Co*Dens	4	23341.6	5835.4	
Competitor*Height	6	302743.8	50457.3	8.72*
Plot*Co*Height	6	34733.6	5788.9	
Density*Height	6	55306.7	9217.8	2.42
Plot*Density*Height	6	22891.7	3815.3	
Co*Dens*Height	12	395291.1	32940.9	4.97**
Plot*Co*Dens*Height	12	79504.8	6625.4	
Error	72	898231	12475.4	
Mean	1	1262278.5		
Total	144	3979732.0		

* α=0.10 ** α=0.05

TABLE D4. MEAN VALUES AND STANDARD DEVIATIONS FOR AMOUNT OF LIGHT PENETRATION (IN LANGLEYS/DAY) AT THE VALLEY SITE ON SEPTEMBER 7, 1982.

	DOUGLAS-FIR ONLY		DOUGLAS-FIR/GRASS		DOUGLAS-FIR/RED ALDER	
	MEAN	S.D.	MEAN	S.D.	MEAN	S.D.
HIGH DENSITY						
0 cm	2.49	0.68	3.18	3.05	8.75	6.31
75 cm	2.50	1.69	3.52	2.04	9.07	5.08
150 cm	28.22	25.28	47.68	35.32	50.22	34.48
Top	133.08	91.51	157.58	77.30	101.90	46.09
MEDIUM DENSITY						
0 cm	1.30	0.57	3.25	2.02	4.32	1.39
75 cm	7.70	6.38	14.32	12.51	27.05	21.68
150 cm	81.88	29.18	126.92	79.77	75.98	44.90
Top	182.48	80.03	195.33	97.48	110.22	22.12
LOW DENSITY						
0 cm	6.98	7.94	11.85	4.90	11.01	13.29
75 cm	27.58	8.65	100.42	83.93	15.80	11.25
150 cm	145.98	112.29	166.25	21.62	64.18	43.08
Top	234.50	107.40	262.65	64.17	109.42	39.47
OPEN	296.7±34.5					

TABLE D5. ANALYSIS OF VARIANCE FOR AMOUNT OF LIGHT PENETRATION AT VALLEY SITE ON SEPTEMBER 7, 1982.

SOURCE OF VARIATION	D.F.	SUM OF SQ.	MEAN SQ.	F
Plot	1	36523	36523	
Competitor	2	31885	15942	7.32
Plot*Competitor	2	4354	2177	
Density	2	56027	28014	5.71
Plot*Density	2	9814	4907	
Height	3	541942	180647	28.80*
Plot*Height	3	18830	6277	
Competitor*Density	4	32822	8206	2.18
Plot*Co*Dens	4	15033	3758	
Competitor*Height	6	51270	8545	7.26*
Plot*Co*Height	6	7060	1177	
Density*Height	6	25968	4328	1.47
Plot*Density*Height	6	17678	2946	
Co*Dens*Height	12	11713	976	0.30
Plot*Co*Dens*Height	12	39343	3279	
Error	70	102586	1425	
Mean	1	695510		
Total	142	1698358		

* α=0.10

TABLE D6. MEAN VALUES AND STANDARD DEVIATIONS FOR AMOUNT OF LIGHT PENETRATION (IN LANGLEYS/DAY) AT THE MID-RANGE SITE ON JULY 22, 1982.

	DOUGLAS-FIR ONLY		DOUGLAS-FIR/GRASS		DOUGLAS-FIR/RED ALDER	
	MEAN	S.D.	MEAN	S.D.	MEAN	S.D.
HIGH DENSITY						
0 cm	3.52	1.21	2.58	0.91	7.35	5.02
75 cm	3.80	1.38	4.25	1.31	18.20	4.28
150 cm	100.25	87.95	141.40	81.88	36.20	12.94
Top	496.25	152.45	608.60	69.10	41.60	13.87
MEDIUM DENSITY						
0 cm	2.15	0.30	3.28	0.38	6.98	3.39
75 cm	9.60	7.56	9.18	4.09	15.10	11.00
150 cm	308.15	121.80	432.72	241.38	16.00	6.86
Top	585.12	159.26	740.42	63.53	15.85	6.87
LOW DENSITY						
0 cm	4.40	2.47	15.80	6.97	2.75	0.60
75 cm	73.40	48.97	136.85	90.08	6.18	2.14
150 cm	223.88	131.06	483.32	216.68	63.22	73.76
Top	623.18	81.05	664.65	75.48	70.42	33.77

OPEN 875.0 ± 39.2

TABLE D7. ANALYSIS OF VARIANCE FOR AMOUNT OF LIGHT PENETRATION AT MID-RANGE SITE FOR JULY 22, 1982.

SOURCE OF VARIATION	D.F.	SUM OF SQ.	MEAN SQ.	F
Plot	1	21	21	
Competitor	2	1541775	770888	39.36*
Plot*Competitor	2	39170	19585	
Density	2	147902	73951	24.09*
Plot*Density	2	6139	3070	
Height	3	4087922	1362641	3692.79***
Plot*Height	3	1108	369	
Competitor*Density	4	45999	11500	4.85
Plot*Co*Dens	4	9493	2373	
Competitor*Height	6	1787859	297976	19.60**
Plot*Co*Height	6	91216	15203	
Density*Height	6	129959	21660	5.31*
Plot*Density*Height	6	24473	4079	
Co*Density*Height	12	134228	11186	7.27***
Plot*Co*Dens*Height	12	18452	1538	
Error	72	566776	7872	
Mean	1	3969890		
Total	144	12602382		

* α=0.10 ** α=0.05 *** α=0.01

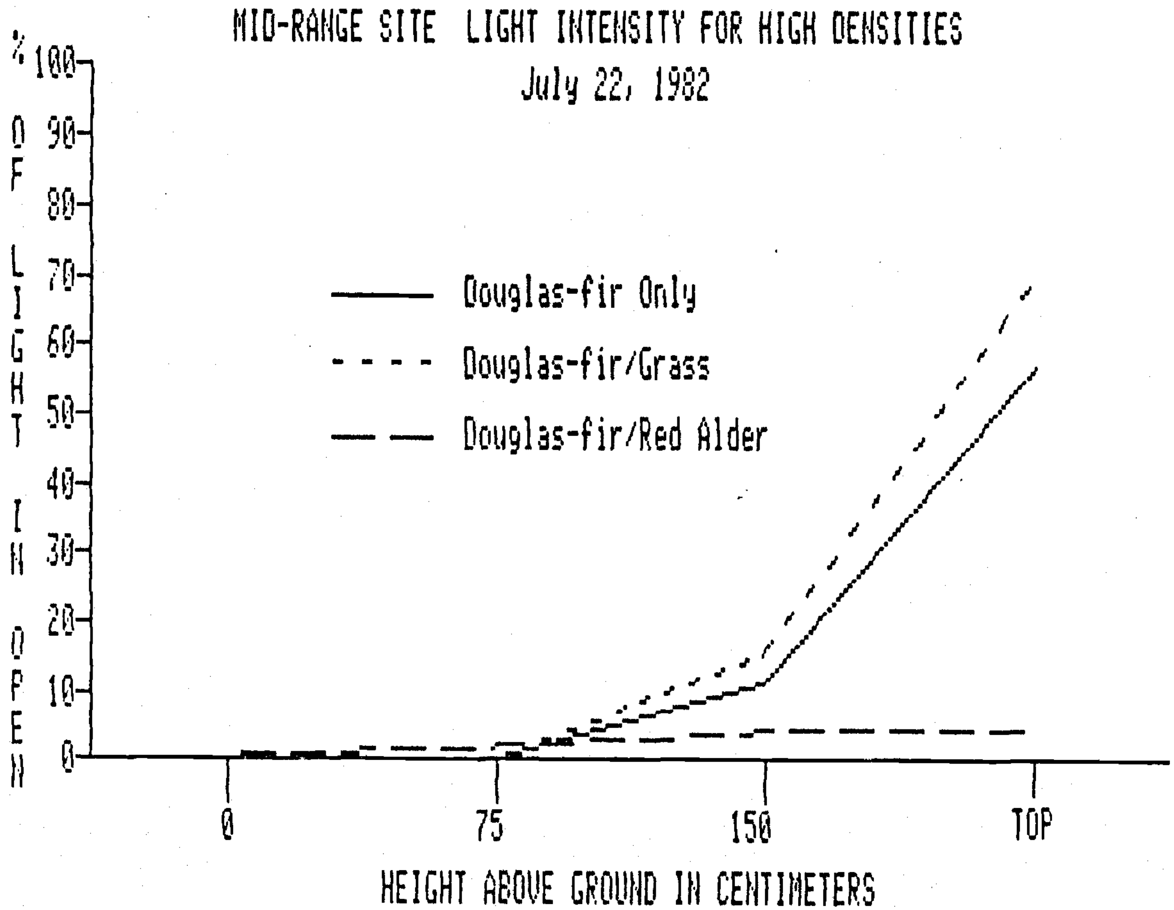

FIGURE D1. PERCENT OF LIGHT IN THE OPEN FROM THE OZALID STACKS FOR THE HIGH DENSITIES AT THE MID-RANGE SITE.

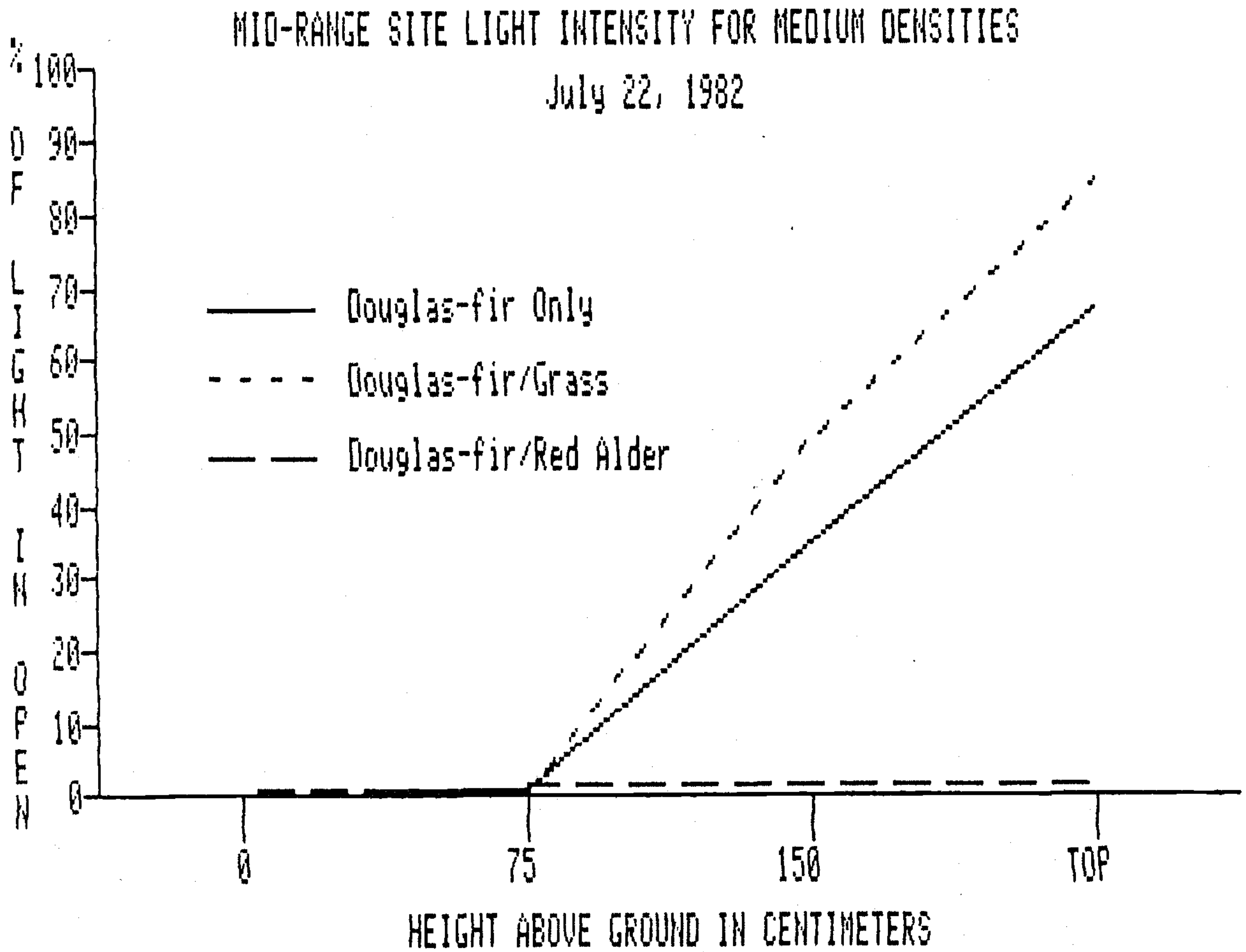

FIGURE D2. PERCENT OF LIGHT IN THE OPEN FROM OZALID STACKS FOR THE MEDIUM DENSITIES AT THE MID-RANGE SITE.

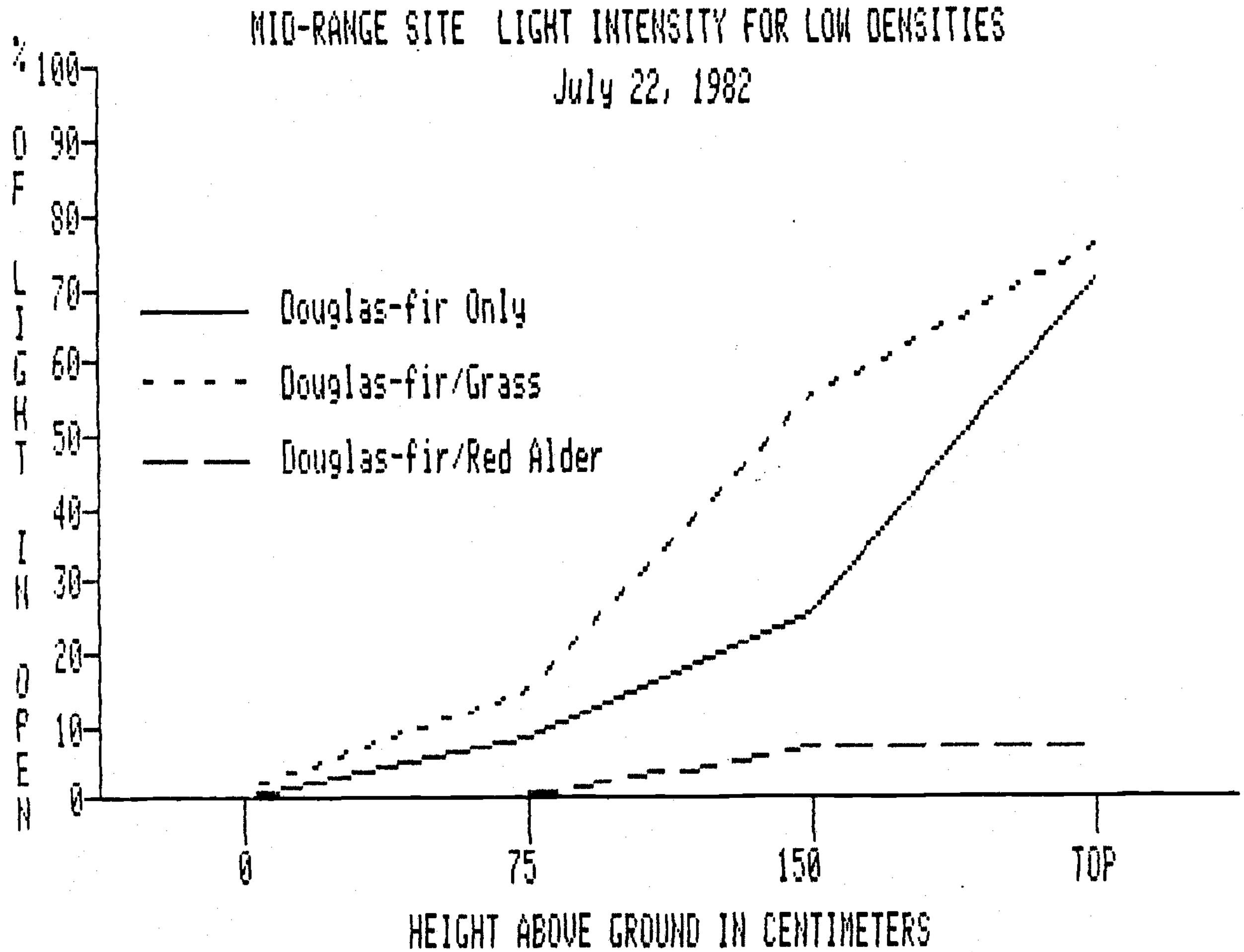

FIGURE D3. PERCENT OF LIGHT IN THE OPEN FROM OZALID STACKS FOR THE LOW DENSITIES FOR THE MID-RANGE SITE.

TABLE D8. MEAN VALUES AND STANDARD DEVIATIONS FOR AMOUNT OF LIGHT PENETRATION (IN LANGLEYS/DAY) AT THE MID-RANGE SITE ON SEPTEMBER 9, 1982.

	DOUGLAS-FIR ONLY		DOUGLAS-FIR/GRASS		DOUGLAS-FIR/RED ALDER	
	MEAN	S.D.	MEAN	S.D.	MEAN	S.D.
HIGH DENSITY						
0 cm	7.82	8.47	2.45	1.73	14.88	12.54
75 cm	2.62	0.79	1.55	0.72	37.50	27.59
150 cm	81.50	67.10	80.45	32.74	88.32	36.46
Top	144.00	92.32	196.22	65.49	95.70	10.85
MEDIUM DENSITY						
0 cm	1.68	0.53	4.32	5.13	11.98	4.92
75 cm	7.22	4.19	7.70	6.13	30.62	15.33
150 cm	171.90	75.33	196.10	109.15	36.60	24.65
Top	205.30	46.44	277.58	50.79	37.12	19.26
LOW DENSITY						
0 cm	2.68	0.79	24.10	20.28	2.05	0.66
75 cm	58.30	34.49	80.00	28.60	19.00	20.25
150 cm	131.00	109.70	171.78	124.53	49.07	32.59
Top	214.68	72.83	254.40	82.42	76.05	31.23

OPEN 328.8 ± 37.8

TABLE D9. ANALYSIS OF VARIANCE FOR AMOUNT OF LIGHT PENETRATION AT MID-RANGE SITE FOR SEPTEMBER 9, 1982.

SOURCE OF VARIATION	D.F.	SUM OF SQ.	MEAN SQ.	F
Plot	1	193	193	
Competitor	2	113597	56798	100.35**
Plot*Competitor	2	1133	566	
Density	2	17484	8742	11.21
Plot*Density	2	1560	780	
Height	3	587135	195712	54.76***
Plot*Height	3	10721	3574	
Competitor*Density	4	35162	8790	3.23
Plot*Co*Density	4	10892	2723	
Competitor*Height	6	124481	20747	4.09
Plot*Co*Height	6	30432	5072	
Density*Height	6	310	51.7	0.01
Plot*Density*Height	6	30152	5025	
Co*Density*Height	12	54320	4527	24.47***
Plot*Co*Dens*Height	12	2225	185	
Error	69	172873	2505	
Mean	1	869820		
Total	141	2062490		

* α=0.10 ** α=0.05 *** α=0.01

TABLE D10. MEAN VALUES AND STANDARD DEVIATIONS FOR AMOUNT OF LIGHT PENETRATION (IN LANGLEYS/DAY) AT THE COAST SITE ON AUGUST 16, 1982.

	DOUGLAS-FIR ONLY		DOUGLAS-FIR/GRASS		DOUGLAS-FIR/RED ALDER	
	MEAN	S.D.	MEAN	S.D.	MEAN	S.D.
HIGH DENSITY						
0 cm	2.60	1.39	1.82	1.05	2.43	1.89
75 cm	2.98	2.79	2.12	0.96	2.42	1.20
150 cm	96.12	79.81	93.18	165.71	43.30	33.70
Top	216.25	104.63	321.92	42.88	107.88	39.95
MEDIUM DENSITY						
0 cm	1.52	0.48	4.26	5.91	3.45	1.20
75 cm	7.33	8.49	6.15	5.38	13.05	5.04
150 cm	175.55	133.38	127.72	62.90	101.08	54.69
Top	283.00	43.86	297.10	59.08	266.80	55.93
LOW DENSITY						
0 cm	1.28	0.38	2.78	1.27	6.72	3.87
75 cm	60.02	58.70	81.12	96.51	67.02	48.24
150 cm	187.70	64.40	236.22	77.31	179.38	37.27
Top	252.22	28.67	324.12	57.89	192.82	113.59
OPEN	440.4 ± 44.3					

TABLE D11. ANALYSIS OF VARIANCE FOR AMOUNT OF LIGHT PENETRATION AT COAST SITE ON AUGUST 16, 1982.

SOURCE OF VARIATION	D.F.	SUM OF SQ.	MEAN SQ.	F
Plot	1	434	434	
Competitor	2	44788	22394	2.12
Plot*Competitor	2	21175	10588	
Density	2	82378	41189	15.90
Plot*Density	2	5179	2590	
Height	3	1394750	464917	170.99***
Plot*Height	3	8157	2719	
Competitor*Density	4	17467	4367	0.85
Plot*Co*Density	4	20581	5145	
Competitor*Height	6	65556	10926	2.36
Plot*Co*Height	6	27742	4624	
Density*Height	6	69087	11514	3.98
Plot*Density*Height	6	17353	2892	
Co*Density*Height	12	27346	2279	1.39
Plot*Co*Dens*Height	12	19605	1634	
Error	71	259047	3649	
Mean	1	1589959		
Total	143	3670604		

* α=0.10 ** α=0.05 *** α=0.01

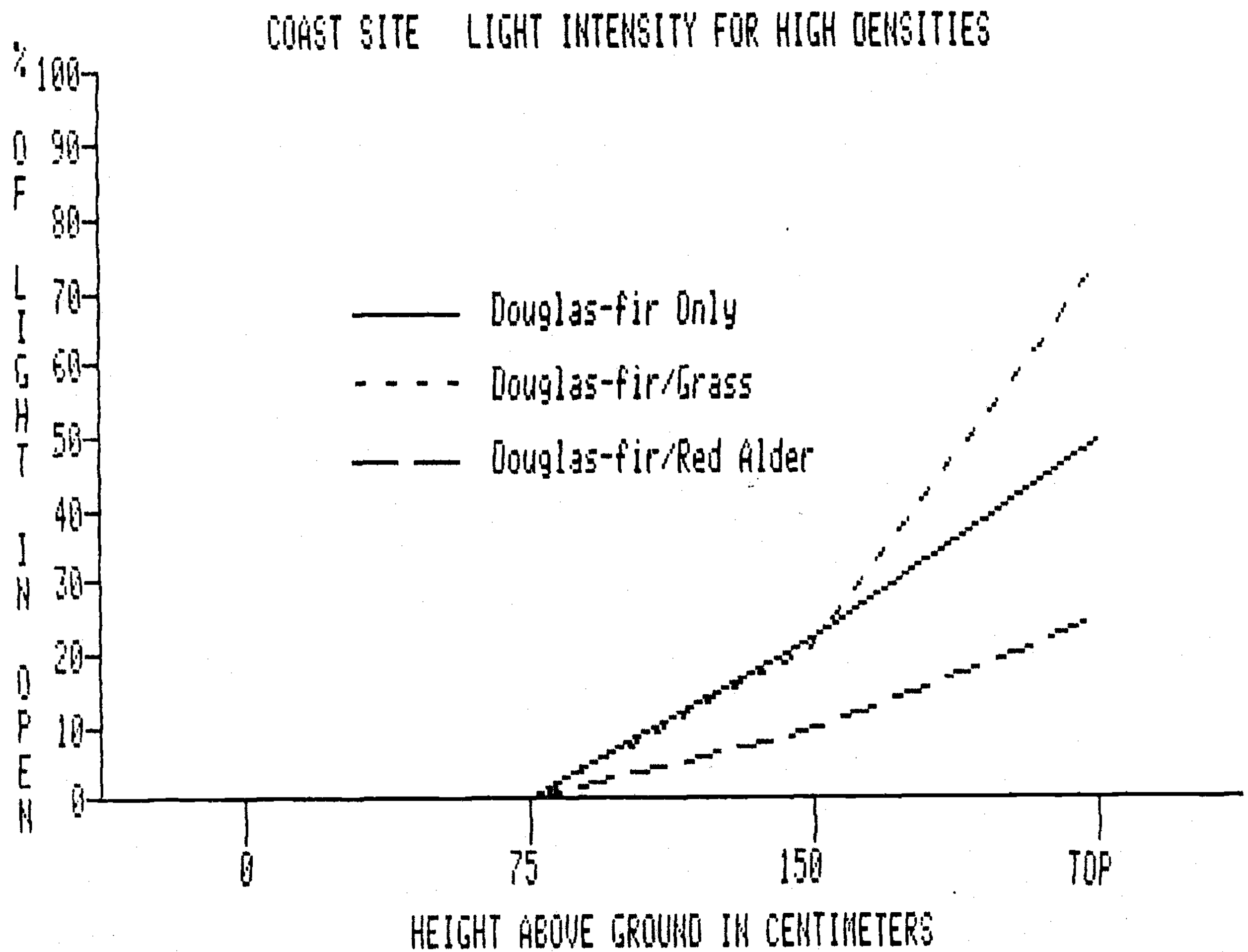

FIGURE D4. PERCENT OF LIGHT IN THE OPEN FROM OZALID STACKS FOR THE HIGH DENSITIES AT THE COAST SITE FOR AUGUST 16, 1982.

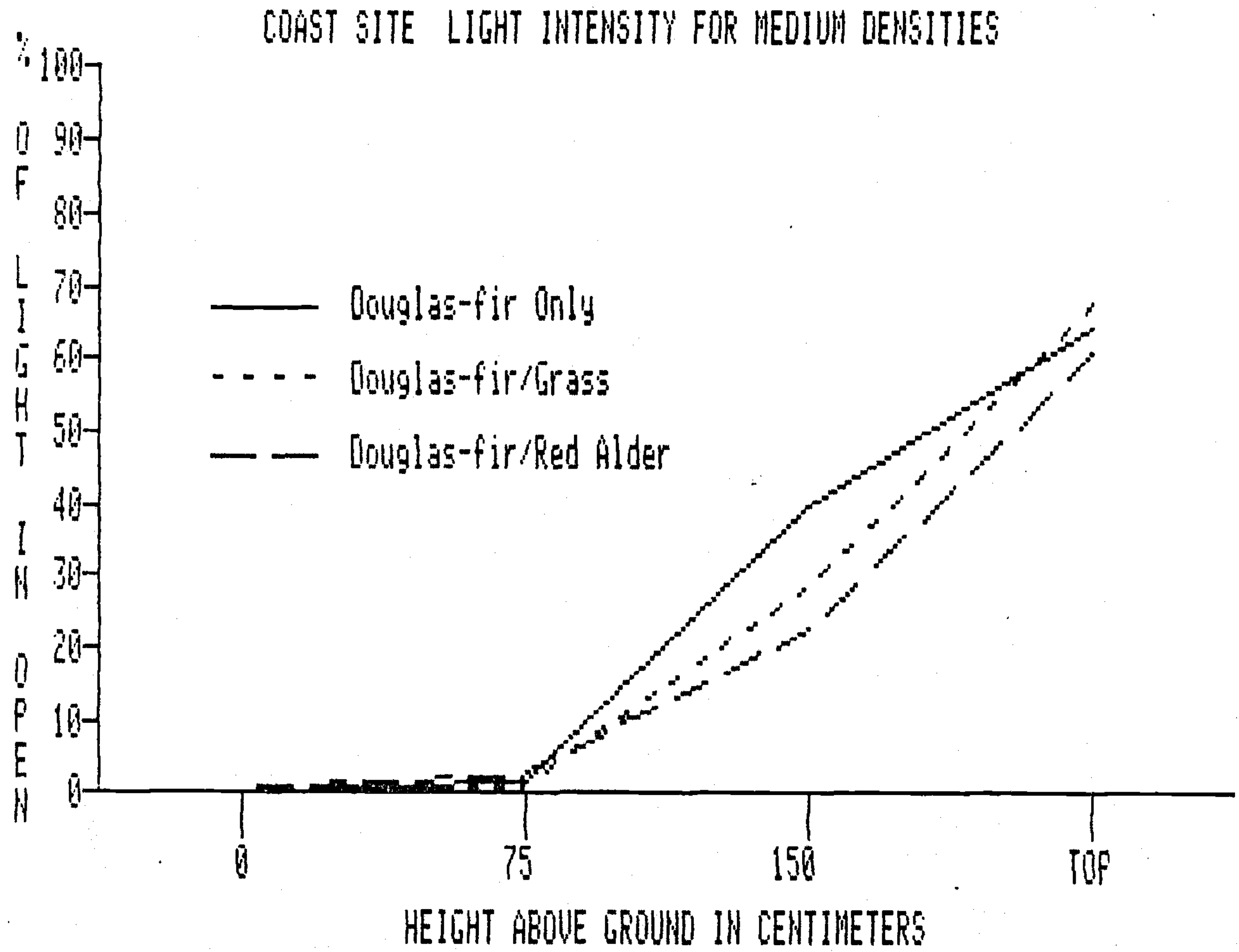

FIGURE D5. PERCENT OF LIGHT IN THE OPEN FROM OZALID STACKS FOR THE MEDIUM DENSITIES AT THE COAST SITE FOR AUGUST 16, 1982.

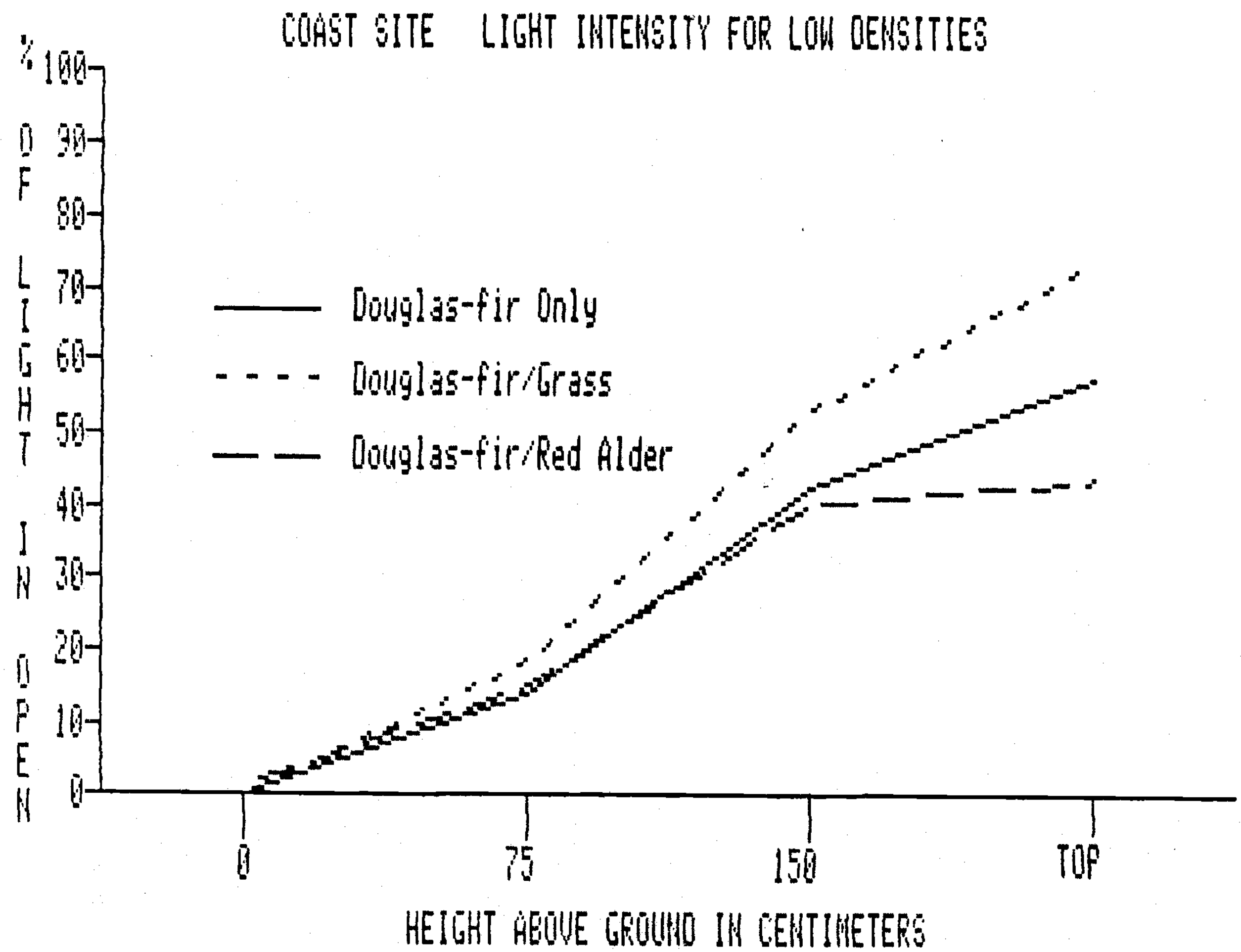

FIGURE D6. PERCENT OF LIGHT IN THE OPEN FROM THE OZALID STACKS FOR LOW DENSITIES AT THE COAST SITE FOR AUGUST 16, 1982.

TABLE D12. MEAN VALUES AND STANDARD DEVIATIONS FOR AMOUNT OF LIGHT PENETRATION (IN LANGLEYS/DAY) AT THE COAST SITE ON SEPTEMBER 11, 1982.

	DOUGLAS-FIR ONLY		DOUGLAS-FIR/GRASS		DOUGLAS-FIR/RED ALDER	
	MEAN	S.D.	MEAN	S.D.	MEAN	S.D.
HIGH DENSITY						
0 cm	0.86	0.06	0.82	0.19	0.86	0.06
75 cm	1.27	0.21	0.84	0.19	1.38	0.40
150 cm	16.00	5.22	11.05	9.69	7.70	3.54
Top	31.17	5.95	48.50	14.63	30.00	2.94
MEDIUM DENSITY						
0 cm	0.98	0.15	0.90	0.04	0.98	0.15
75 cm	1.90	0.37	4.94	5.01	2.98	1.63
150 cm	14.27	8.73	15.80	9.83	11.42	4.15
Top	32.55	3.72	37.65	8.52	26.70	6.53
LOW DENSITY						
0 cm	0.90	0.04	1.12	0.66	1.64	0.68
75 cm	4.28	2.22	7.30	5.37	6.25	4.51
150 cm	19.52	4.87	27.10	9.61	25.12	12.95
Top	30.35	1.56	43.47	11.08	35.25	12.48

OPEN 58.8 ± 4.7

TABLE D13. ANALYSIS OF VARIANCE FOR AMOUNT OF LIGHT PENETRATION AT COAST SITE FOR SEPTEMBER 11, 1982.

SOURCE OF VARIATION	D.F.	SUM OF SQ.	MEAN SQ.	F
Plot	1	2	2	
Competitor	2	454	227	3.01
Plot*Competitor	2	151	75.5	
Density	2	554	277	5.23
Plot*Density	2	106	53	
Height	3	24515	8172	125.72***
Plot*Height	3	194	65	
Competitor*Density	4	203	51	0.50
Plot*Co*Density	4	404	101	
Competitor*Height	6	736	123	1.64
Plot*Co*Height	6	452	75	
Density*Height	6	1046	174	3.59
Plot*Density*Height	6	291	48.5	
Co*Density*Height	12	141	11.8	0.44
Plot*Co*Dens*Height	12	324	27	
Error	66	1947	29.5	
Mean	1	25332		
Total	138	56852		

* α=0.10 ** α=0.05 *** α=0.01

TABLE E1. FIFTH-YEAR HEIGHT CURVE EQUATIONS. SPAC=spacing, LNSP=natural logarithm of spacing, and S2=spacing-squared. Standard errors for the LNSP term, F values, coefficients of variation, and R-squared values are given. Intercepts were not significantly different from zero. All F values are significant at α=0.01.

TREATMENT	SPAC	LNSP	S.E.	S2	F	C.V.	R^2
Valley							
Douglas-fir Only	$-3.02\text{X}10^{-5}$	.33995	.01	$-5\text{X}10^{-10}$	785.82	7.19	.996
Douglas-fir/Grass	$-2.26\text{X}10^{-4}$	.35106	.01	$1\text{X}10^{-08}$	764.22	7.23	.996
Douglas-fir/Red Alder	$-3.70\text{X}10^{-5}$	.29322	.01	$4\text{X}10^{-09}$	482.92	9.23	.994
Mid-Range							
Douglas-fir Only	$-1.55\text{X}10^{-4}$	.34569	.01	$7\text{X}10^{-09}$	539.38	8.64	.994
Douglas-fir/Grass	$-1.54\text{X}10^{-4}$	.33168	.01	$5\text{X}10^{-09}$	743.45	7.34	.996
Douglas-fir/Red Alder	$8.03\text{X}10^{-5}$	.22184	.02	$-2\text{X}10^{-09}$	129.69	18.12	.977
Coast							
Douglas-fir Only	$-6.24\text{X}10^{-5}$	.34821	.01	$3\text{X}10^{-09}$	625.53	8.07	.995
Douglas-fir/Grass	$-3.25\text{X}10^{-6}$	.32385	.01	$-1\text{X}10^{-09}$	436.73	9.64	.993
Douglas-fir/Red Alder	$-2.68\text{X}10^{-4}$	.39226	.01	$1\text{X}10^{-08}$	490.42	9.06	.994

TABLE E2. FIFTH-YEAR DIAMETER CURVE EQUATIONS. SPAC=spacing, LNSP= natural logarithm of spacing, and S2=spacing-squared. Standard errors for the LNSP term, F values, coefficients of variation, and R-squared values for the regression are given. Intercepts were not significantly different from zero. All F values are significant at α=0.01.

TREATMENT	SPAC	LNSP	S.E.	S2	F	C.V.	R^2
Valley							
Douglas-fir Only	$3.26X10^{-3}$	2.90172	.16	$-1X10^{-07}$	848.47	7.27	.996
Douglas-fir/Grass	$9.68X10^{-4}$	3.2252	.17	$-4X10^{-08}$	502.25	9.15	.994
Douglas-fir/Red Alder	$1.20X10^{-3}$	3.3393	.31	$2X10^{-08}$	219.00	14.27	.986
Mid-Range							
Douglas-fir Only	$2.39X10^{-3}$	2.94938	.25	$-9X10^{-08}$	293.23	12.23	.990
Douglas-fir/Grass	$2.09X10^{-3}$	2.8047	.13	$-1X10^{-07}$	773.60	7.38	.996
Douglas-fir/Red Alder	$1.89X10^{-3}$	2.4598	.34	$-7X10^{-09}$	142.66	18.03	.979
Coast							
Douglas-fir Only	$3.25X10^{-3}$	3.06507	.21	$-8X10^{-08}$	573.17	8.97	.995
Douglas-fir/Grass	$3.38X10^{-3}$	2.99618	.24	$-1X10^{-07}$	404.10	10.52	.993
Douglas-fir/Red Alder	$-4.05X10^{-4}$	4.01496	.38	$6X10^{-08}$	143.79	17.08	.980

TABLE E3. FIFTH-YEAR DRY WEIGHT/TREE CURVE EQUATIONS. SPAC=spacing, LNSP=natural logarithm of spacing, and S2=spacing-squared. Standard errors for the LNSP term, F values, coefficients of variation, and R-squared values for the regression are given. Intercepts were not significantly different from zero. All F values are significant at α=0.01.

TREATMENT	SPAC	LNSP	S.E.	S2	F	C.V.	R^2
Valley							
Douglas-fir Only	.2647	23.6804	12.65	$-7X10^{-6}$	197.63	17.83	.985
Douglas-fir/Grass	.07861	52.0243	12.83	$-2X10^{-6}$	64.38	27.44	.955
Douglas-fir/Red Alder	.09574	51.8583	19.28	$9X10^{-6}$	126.89	24.34	.977
Mid-Range							
Douglas-fir Only	.187297	33.2192	18.32	$-6X10^{-6}$	56.80	31.67	.950
Douglas-fir/Grass	.119507	37.3078	6.50	$-6X10^{-6}$	168.82	16.68	.983
Douglas-fir/Red Alder	.143389	11.4558	17.76	$2X10^{-6}$	73.71	33.24	.961
Coast							
Douglas-fir Only	.2095	42.9497	19.30	$1X10^{-6}$	143.54	21.97	.980
Douglas-fir/Grass	.2979	25.6848	12.98	$-1X10^{-6}$	209.33	17.04	.986
Douglas-fir/Red Alder	$3.66X10^{-3}$	98.4026	23.53	$4X10^{-6}$	35.90	36.32	.923

TABLE E4. FIFTH-YEAR DRY WEIGHT/HECTARE EQUATIONS. INTER=intercept, SPAC=spacing, LNSP=natural logarithm of spacing, and S2=spacing-squared. Standard errors for the INTER, SPAC, and LNSP terms, F values coefficients of variation, and R-squared values for the regression are given. Intercepts were not included if they did not differ significantly from zero. All F values are significant at $\alpha=0.01$.

TREATMENT	INTER	SPAC	LNSP	S2	F	C.V.	R^2
Valley							
Douglas-fir Only	82326.69	0	- 6519.76	0	17.65	23.17	.558
S.E.	12042.87		1551.98				
Douglas-fir/Grass	336979.09	17.7209	-46113.69	$-7X10^{-4}$	10.83	50.14	.730
S.E.	85378.05	9.64	14163.77				
Douglas-fir/Red Alder	0	-11.763	7989.54	$6X10^{-4}$	10.70	63.13	.781
S.E.		5.07	1568.0				
Mid-Range							
Douglas-fir Only	0	- 6.085	5161.90	$2X10^{-4}$	33.21	36.58	.917
S.E.		1.95	602.59				
Douglas-fir/Grass	110712.76	0	-11270.66	0	150.19	18.26	.915
S.E.	7136.19		919.65				

(TABLE E4. continued)

TREATMENT	INTER	SPAC	LNSP	S2	F	C.V.	R^2
Douglas-fir/Red Alder	0	- 4.037	3503.13	$2X10^{-4}$	10.07	62.81	.770
S.E.		2.62	811.15				
Coast							
Douglas-fir Only	96242.33	0	- 7791.92	0	24.70	20.73	.638
S.E.	12166.64		1567.83				
Douglas-fir/Grass	123829.90	0	-11567.48	0	12.52	44.90	.472
S.E.	25369.00		3269.34				
Douglas-fir/Red Alder	247665.51	1.126	-27120.23	$4X10^{-5}$	13.96	37.94	.777
S.E.	92190.53	10.41	15293.92				

TABLE E5. FIFTH-YEAR HEIGHT GROWTH EQUATIONS. SPAC=spacing, LNSP=natural logarithm of spacing, and S2=spacing-squared. Standard errors of the LNSP term, F values, coefficients of variation, and R-squared values for the regression are given. Intercepts were not significantly different from zero. All F values are significant at α=0.01.

TREATMENT	SPAC	LNSP	S.E.	S2	F	C.V.	R^2
Valley							
Douglas-fir Only	$8.02\text{X}10^{-5}$	.055828	.001	$-4\text{X}10^{-09}$	253.26	13.24	.988
Douglas-fir/Grass	$-7.26\text{X}10^{-6}$	.073562	.001	$3\text{X}10^{-10}$	417.44	9.90	.993
Douglas-fir/Red Alder	$4.45\text{X}10^{-5}$	.040912	.001	$-7\text{X}10^{-10}$	227.12	14.44	.987
Mid-Range							
Douglas-fir Only	$7.71\text{X}10^{-5}$	.049837	.001	$-4\text{X}10^{-09}$	431.00	10.19	.993
Douglas-fir/Grass	$4.57\text{X}10^{-5}$	.063944	.001	$-3\text{X}10^{-09}$	221.29	13.81	.987
Douglas-fir/Red Alder	$8.36\text{X}10^{-5}$	.019136	.001	$-2\text{X}10^{-09}$	115.96	22.09	.975
Coast							
Douglas-fir Only	$6.17\text{X}10^{-5}$	.067160	.001	$-3\text{X}10^{-09}$	649.62	8.17	.995
Douglas-fir/Grass	$9.90\text{X}10^{-5}$	.061730	.001	$-5\text{X}10^{-09}$	274.39	12.71	.989
Douglas-fir/Red Alder	$-1.58\text{X}10^{-5}$	.086207	.001	$1\text{X}10^{-09}$	163.42	15.90	.982

TABLE E6. FIFTH-YEAR BASAL AREA/HECTARE EQUATIONS. INTER=intercept, SPAC=spacing, LNSP=natural logarithm of spacing, and S2=spacing-squared. Standard errors for the INTER and LNSP terms, F values, coefficients of variation, and R-squared values for the regression are given. Intercepts were not included if they did not differ significantly from zero. All F values are significant at α=0.01.

TREATMENT	INTER	SPAC	LNSP	S2	F	C.V.	R^2
Valley							
Douglas-fir Only	110.716	0	-10.209	0	55.60	20.37	.799
S.E.	10.62		1.36				
Douglas-fir/Grass	275.681	.01233	-36.391	$-5X10^{-7}$	25.58	30.74	.865
S.E.	50.24		8.33				
Douglas-fir/Red Alder	161.048	0	-16.350	0	14.42	58.19	.507
S.E.	33.40		4.30				
Mid-Range							
Douglas-fir Only	0	$-7.9X10^{-3}$	5.680	$3X10^{-7}$	47.49	31.24	.941
S.E.			0.51				
Douglas-fir/Grass	108.038	0	-10.978	0	142.17	18.61	.910
S.E.	7.14		0.92				

(TABLE E6. continued)

TREATMENT	INTER	SPAC	LNSP	S2	F	C.V.	R^2
Douglas-fir/Red Alder	0	$-7.02X10^{-3}$	4.762	$3X10^{-7}$	9.77	66.41	.765
S.E.			0.96				
Coast							
Douglas-fir Only	107.027	0	- 9.502	0	84.93	14.56	.858
S.E.	8.00		1.03				
Douglas-fir/Grass	138.878	0	-13.679	0	16.93	47.19	.547
S.E.	25.8		3.32				
Douglas-fir/Red Alder	221.836	$1X10^{-3}$	-24.286	$3X10^{-8}$	14.41	37.25	.783
S.E.	81.24		13.47				

TABLE E7. FIFTH-YEAR BASAL AREA GROWTH/TREE EQUATIONS. SPAC=spacing, LNSP= natural logarithm of spacing, and S2=spacing-squared. Standard errors for the LNSP term, F values, coefficients of variation, and R-squared for the regression are given. Intercepts were not significantly different from zero. All F values are significant at α=0.01.

TREATMENT	SPAC	LNSP	S.E.	S2	F	C.V.	R^2
Valley							
Douglas-fir Only	1.31×10^{-3}	3.54×10^{-6}	0	-4×10^{-08}	687.59	11.28	.994
Douglas-fir/Grass	6.36×10^{-4}	.179446	.05	-2×10^{-08}	89.38	24.43	.968
Douglas-fir/Red Alder	5.26×10^{-4}	.237569	.07	1×10^{-07}	118.95	22.80	.975
Mid-Range							
Douglas-fir Only	8.48×10^{-4}	.138349	.07	-2×10^{-08}	90.69	26.19	.968
Douglas-fir/Grass	9.99×10^{-4}	.112366	.03	-5×10^{-08}	292.30	13.51	.990
Douglas-fir/Red Alder	5.27×10^{-4}	.102450	.08	1×10^{-08}	62.31	34.31	.954
Coast							
Douglas-fir Only	8.87×10^{-4}	.139941	.04	-4×10^{-09}	302.56	15.00	.990
Douglas-fir/Grass	1.11×10^{-3}	.138340	.04	-3×10^{-08}	254.22	15.39	.988
Douglas-fir/Red Alder	1.86×10^{-4}	.350366	.09	1×10^{-08}	39.62	35.89	.930

TABLE E8. FIFTH-YEAR BASAL AREA GROWTH/HECTARE EQUATIONS. INTER=intercept, SPAC=spacing, LNSP=natural logarithm of spacing, and S2= spacing-squared. Standard errors of the INTER and LNSP term, F values, coefficients of variation, and R-squared values for the regression are given. Intercepts were not included if they did not differ significantly from zero. All F values are significant at α=0.05.

TREATMENT	INTER	SPAC	LNSP	S2	F	C.V.	R^2
Valley							
Douglas-fir Only	29.424	0	-2.181	0	21.25	17.97	.600
S.E.	3.67		0.47				
Douglas-fir/Grass	58.554	0	-5.831	0	53.45	27.80	.790
S.E.	6.18		0.79				
Douglas-fir/Red Alder	63.221	0	-6.157	0	13.09	51.26	.483
S.E.	13.20		1.70				
Mid-Range							
Douglas-fir Only	0	-2.40×10^{-3}	2.1949	9×10^{-8}	57.39	27.47	.950
S.E.			0.20				
Douglas-fir/Grass	40.345	0	-3.747	0	87.32	16.65	.862
S.E.	3.11		0.40				

(TABLE E8. continued)

TREATMENT	INTER	SPAC	LNSP	S2	F	C.V.	R^2
Douglas-fir/Red Alder	25.560	0	-2.150	0	6.77	43.95	.326
S.E.	6.41		0.82				
Coast							
Douglas-fir Only	35.268	0	-2.839	0	52.21	14.04	.789
S.E.	3.04		0.39				
Douglas-fir/Grass	53.245	0	-4.975	0	15.97	39.79	.533
S.E.	9.66		1.24				
Douglas-fir/Red Alder	80.203	0	-8.096	0	42.66	32.98	.753
S.E.	9.61		1.23				

TABLE E9. FIFTH-YEAR STEMWOOD VOLUME PRODUCTION/TREE EQUATIONS. SPAC= spacing, LNSP=natural logarithm of spacing, and S2=spacing-squared. Standard errors for the LNSP term, F values, coefficients of variation, and R-squared values for the regression are given. Intercepts were not significantly different from zero. All F values are significant at α=0.01.

TREATMENT	SPAC	LNSP	S.E.	S2	F	C.V.	R^2
Valley							
Douglas-fir Only	1.51×10^{-3}	.070081	.04	-4×10^{-8}	383.63	13.16	.992
Douglas-fir/Grass	5.40×10^{-4}	.221258	.07	-2×10^{-8}	47.58	32.65	.941
Douglas-fir/Red Alder	6.20×10^{-4}	.21456	.09	3×10^{-8}	104.34	26.50	.972
Mid-Range							
Douglas-fir Only	9.18×10^{-4}	.150933	.10	-2×10^{-8}	52.79	34.01	.946
Douglas-fir/Grass	1.53×10^{-4}	.128070	.04	-5×10^{-8}	134.44	19.49	.978
Douglas-fir/Red Alder	6.27×10^{-4}	.044377	.12	2×10^{-8}	38.42	48.53	.928
Coast							
Douglas-fir Only	1.27×10^{-3}	.171137	.09	-3×10^{-9}	168.79	20.51	.983
Douglas-fir/Grass	1.77×10^{-3}	.116679	.08	-6×10^{-8}	157.85	20.00	.981
Douglas-fir/Red Alder	-1.16×10^{-5}	.472969	.14	-2×10^{-8}	25.83	43.79	.896

TABLE E10. FIFTH-YEAR STEMWOOD VOLUME GROWTH/HECTARE EQUATIONS. INTER= intercept, SPAC=spacing, LNSP=natural logarithm of spacing, and S2=spacing-squared. Standard errors of the INTER and LNSP terms, F values, coefficients of variation, and R-squared values are given. Intercepts were not included if they did not differ significantly from zero. All but the Coast Douglas-fir/Grass equation F value are significant at $\alpha=0.01$. This curve is significant at $\alpha=0.05$.

TREATMENT	INTER	SPAC	LNSP	S2	F	C.V.	R^2
Valley							
Douglas-fir Only	0	$-2.4X10^{-3}$	2.892	$7X10^{-8}$	99.15	20.40	.971
S.E.			0.22				
Douglas-fir/Grass	69.901	0	-7.143	0	31.93	40.30	.695
S.E.	9.80		1.26				
Douglas-fir/Red Alder	51.707	0	-4.538	0	13.08	35.80	.483
S.E.	9.73		1.25				
Mid-Range							
Douglas-fir Only	0	$-2.4X10^{-3}$	2.290	$8X10^{-8}$	37.17	34.14	.925
S.E.			0.26				

(TABLE E10. continued)

TREATMENT	INTER	SPAC	LNSP	S2	F	C.V.	R^2
Douglas-fir/Grass	42.065	0	-3.971	0	62.61	20.85	.817
S.E.	3.89		0.50				
Douglas-fir/Red Alder	0	0	0.82064	0	25.91	55.83	.787
S.E.			0.11				
Coast							
Douglas-fir Only	36.734	0	-2.490	0	13.67	18.42	.494
S.E.	5.22		0.67				
Douglas-fir/Grass	52.576	0	-4.415	0	8.02	40.17	.364
S.E.	12.09		1.55				
Douglas-fir/Red Alder	97.334	0	-9.859	0	35.45	36.74	.717
S.E.	12.84		1.65				

TABLE E11. FIFTH-YEAR HEIGHT/DIAMETER RATIO EQUATIONS. INTER=intercept and LNSP=natural logarithm of spacing. Standard errors, F values, coefficients of variation, and R-squared values for the regression are given. All F values are significant at α=0.01.

TREATMENT	INTER	S.E.	LNSP	S.E.	F	C.V.	R^2
Valley							
Douglas-fir Only	.221485	.001	-.017398	.001	590.46	3.92	.977
Douglas-fir/Grass	.211303	.001	-.016477	.001	317.77	5.25	.958
Douglas-fir/Red Alder	.151628	.010	$-9.9\text{X}10^{-3}$	.0001	27.67	11.96	.664
Mid-Range							
Douglas-fir Only	.23453	.001	-.019206	.001	282.83	6.32	.953
Douglas-fir/Grass	.229389	.001	-.018193	.001	216.54	6.64	.939
Douglas-fir/Red Alder	.137452	.010	$-7.6\text{X}10^{-3}$	.0001	29.79	8.57	.680
Coast							
Douglas-fir Only	.229046	.001	-.018637	.001	478.81	4.77	.972
Douglas-fir/Grass	.206524	.001	-.015715	.001	167.30	6.82	.923
Douglas-fir/Red Alder	.207549	.001	-.016241	.001	163.52	7.38	.921

TABLE E12. FIFTH-YEAR LEAF AREA/TREE EQUATIONS. SPAC=spacing, LNSP=natural logarithm of spacing, and S2=spacing-squared. Standard errors of the LNSP term, F values, coefficients of variation, and R-squared values for the regression are given. Intercepts were not significantly different from zero. All F values are significant at α=0.01.

TREATMENT	SPAC	LNSP	S.E.	S2	F	C.V.	R^2
Valley							
Douglas-fir Only	$9.36X10^{-4}$	.124567	.04	$-3X10^{-08}$	177.79	18.10	.983
Douglas-fir/Grass	$2.62X10^{-4}$	.18401	.04	$-7X10^{-09}$	62.42	27.53	.954
Douglas-fir/Red Alder	$4.10X10^{-4}$	.21955	.07	$4X10^{-08}$	129.97	23.95	.977
Mid-Range							
Douglas-fir Only	$6.92X10^{-4}$	.13542	.06	$-3X10^{-08}$	54.77	31.41	.948
Douglas-fir/Grass	$3.94X10^{-4}$	.14879	.02	$-2X10^{-08}$	152.41	17.35	.981
Douglas-fir/Red Alder	$6.16X10^{-4}$	.03702	.06	$4X10^{-09}$	83.69	31.05	.965
Coast							
Douglas-fir Only	$6.47X10^{-4}$	.14805	.05	$-7X10^{-10}$	133.82	22.07	.978
Douglas-fir/Grass	$8.18X10^{-4}$	.084467	.03	$-3X10^{-08}$	185.41	17.83	.984
Douglas-fir/Red Alder	$3.66X10^{-5}$	.29127	.06	$1X10^{-08}$	37.44	35.44	.926

TABLE E13. FIFTH-YEAR LEAF AREA INDEX EQUATIONS. INTER=intercept, SPAC=spacing, LNSP=natural logarithm of spacing, and S2=spacing-squared. Standard errors of the INTER and LNSP terms, F values, coefficients of variation, and R-squared values are given. Intercepts were not included if they did not differ significantly from zero. All but two of the equations were significant at α=0.01. These equations, Valley and Mid-range Douglas-fir/Red Alder, were significant at α=0.10.

TREATMENT	INTER	SPAC	LNSP	S2	F	C.V.	R^2
Valley							
Douglas-fir Only	51.953	0	- 4.893	0	42.43	25.11	.752
S.E.	5.82		0.75				
Douglas-fir/Grass	177.882	.015	-25.8	$-1X10^{-3}$	14.22	46.13	.838
S.E.	41.726	.007	7.17				
Douglas-fir/Red Alder	77.198	$2.5X10^{-3}$	- 9.016	$-8X10^{-8}$	3.21	47.62	.445
S.E.	38.76		6.43				

(TABLE E13. continued)

TREATMENT	INTER	SPAC	LNSP	S2	F	C.V.	R^2
Mid-Range							
Douglas-fir Only	44.011	0	- 4.157	0	25.48	32.73	.645
S.E.	6.38		0.82				
Douglas-fir/Grass	85.348	3.3×10^{-3}	-10.936	-1×10^{-7}	39.02	24.44	.907
S.E.	13.78		2.28				
Douglas-fir/Red Alder	66.146	3.8×10^{-3}	- 8.831	-1×10^{-7}	2.01	64.17	.334
S.E.	30.75		5.10				
Coast							
Douglas-fir Only	70.764	2.6×10^{-3}	- 8.435	-1×10^{-7}	12.44	26.06	.756
S.E.	18.27		3.03				
Douglas-fir/Grass	53.50	0	- 5.348	0	23.04	43.02	.622
S.E.	8.64		1.11				
Douglas-fir/Red Alder	64.588	-7×10^{-4}	- 6.481	5×10^{-8}	17.74	32.90	.816
S.E.	24.37		4.04				

TABLE E14. FIFTH-YEAR STEMWOOD VOLUME PRODUCTION/TREE/LEAF AREA/TREE EQUATIONS. SPAC=spacing, LNSP=natural logarithm of spacing, and -squared. Standard errors of the LNSP term, F values, coefficients of variation, and R-squared values are given. Intercepts did not significantly differ from zero. All F values are significant at α=0.01.

TREATMENT	SPAC	LNSP	S.E.	S2	F	C.V.	R^2
Valley							
Douglas-fir Only	$2.30\text{X}10^{-5}$	.15618	.001	$-1\text{X}10^{-09}$	532.50	8.82	.994
Douglas-fir/Grass	$-5.40\text{X}10^{-5}$	.20167	.001	$2\text{X}10^{-09}$	1892.74	4.62	.998
Douglas-fir/Red Alder	$-6.42\text{X}10^{-5}$	.16182	.001	$2\text{X}10^{-08}$	283.61	11.88	.990
Mid-Range							
Douglas-fir Only	$-8.11\text{X}10^{-5}$	.18622	.001	$6\text{X}10^{-09}$	670.74	7.83	.996
Douglas-fir/Grass	$3.95\text{X}10^{-5}$	.17722	.001	$-3\text{X}10^{-09}$	996.82	6.43	.997
Douglas-fir/Red Alder	$-7.39\text{X}10^{-5}$	.16341	.010	$4\text{X}10^{-09}$	93.14	20.80	.969
Coast							
Douglas-fir Only	$-8.74\text{X}10^{-6}$	.20605	.001	$-3\text{X}10^{-10}$	731.25	7.48	.996
Douglas-fir/Grass	$-4.66\text{X}10^{-5}$	.26965	.010	$1\text{X}10^{-09}$	294.62	11.73	.990
Douglas-fir/Red Alder	$-1.41\text{X}10^{-4}$	.25612	.010	$6\text{X}10^{-09}$	246.08	12.77	.988

TABLE E15. FIFTH-YEAR STEMWOOD VOLUME PRODUCTION/TREE/LEAF AREA INDEX EQUATIONS. SPAC=spacing, LNSP=natural logarithm of spacing, and S2=spacing-squared. F values, coefficients of variation, and R-squared values for the regression are given. Intercepts were not significantly different from zero. All F values are significant at α=0.01.

TREATMENT	SPAC	LNSP	S2	F	C.V.	R^2
Valley						
Douglas-fir Only	1.41×10^{-4}	-4.136×10^{-3}	2×10^{-09}	2478.10	6.21	.999
Douglas-fir/Grass	1.46×10^{-4}	-1.570×10^{-3}	1×10^{-09}	7413.80	3.50	.9996
Douglas-fir/Red Alder	1.13×10^{-4}	-6.448×10^{-4}	-6×10^{-10}	1725.64	7.00	.998
Mid-Range						
Douglas-fir Only	7.39×10^{-5}	7.536×10^{-3}	8×10^{-09}	577.32	13.48	.995
Douglas-fir/Grass	1.86×10^{-4}	-8.827×10^{-3}	-7×10^{-10}	2243.98	6.41	.999
Douglas-fir/Red Alder	9.23×10^{-5}	1.514×10^{-3}	3×10^{-09}	403.65	15.42	.993
Coast						
Douglas-fir Only	1.68×10^{-4}	-2.878×10^{-3}	1×10^{-09}	1672.79	7.41	.998
Douglas-fir/Grass	1.81×10^{-4}	3.118×10^{-3}	3×10^{-09}	655.80	11.72	.995
Douglas-fir/Red Alder	1.40×10^{-4}	3.772×10^{-3}	2×10^{-09}	1238.12	8.51	.998

TABLE E16. FIFTH-YEAR STEMWOOD VOLUME PRODUCTION/HECTARE/LEAF AREA INDEX EQUATIONS. INTER=intercept, SPAC=spacing, LNSP=natural logarithm of spacing, and S2=spacing-squared. Standard errors for the INTER and LNSP terms, F values, coefficients of variation, and R-squared values for the regression are given. Intercepts were not included if they did not differ significantly from zero. All F values are significant at α=0.01.

TREATMENT	INTER	SPAC	LNSP	S2	F	C.V.	R^2
Valley							
Douglas-fir Only	0	0	.16346	0	834.95	9.97	.992
S.E.			.001				
Douglas-fir/Grass	.3913	0	.1347	0	63.82	5.72	.820
S.E.	.13		.01				
Douglas-fir/Red Alder	0	$-3.7X10^{-5}$	.15841	$3X10^{-10}$	247.09	12.76	.988
S.E.			.001				
Mid-Range							
Douglas-fir Only	0	0	.16638	0	1305.71	7.92	.995
S.E.			.001				

(TABLE E16. continued)

TREATMENT	INTER	SPAC	LNSP	S2	F	C.V.	R^2
Douglas-fir/Grass	0	0	.18844	0	1098.46	8.68	.994
S.E.			.001				
Douglas-fir/Red Alder	0	0	.12074	0	169.93	22.29	.960
S.E.			.001				
Coast							
Douglas-fir Only	0	0	.19959	0	412.83	14.02	.983
S.E.			.001				
Douglas-fir/Grass	0	0	.24723	0	839.59	9.84	.992
S.E.			.001				
Douglas-fir/Red Alder	0	$-1.2X10^{-4}$	.24345	$6X10^{-9}$	431.56	9.66	.993
S.E.			.01				

TABLE E17. FIFTH-YEAR BASAL AREA GROWTH/TREE/LEAF AREA INDEX EQUATIONS. SPAC=spacing, LNSP=natural logarithm of spacing, and S2=spacing-squared. F values, coefficients of variation, and R-squared values for the regression are given. Intercepts were not significantly different from zero. All F values are significant at α=0.01.

TREATMENT	SPAC	LNSP	S2	F	C.V.	R^2
Valley						
Douglas-fir Only	1.36×10^{-4}	-5.197×10^{-3}	7×10^{-10}	321.23	17.16	.991
Douglas-fir/Grass	1.87×10^{-4}	-6.156×10^{-3}	-2×10^{-10}	6890.49	3.63	.9996
Douglas-fir/Red Alder	1.41×10^{-4}	3.875×10^{-4}	-5×10^{-09}	366.69	13.71	.992
Mid-Range						
Douglas-fir Only	9.17×10^{-5}	5.677×10^{-3}	6×10^{-09}	1183.71	9.24	.997
Douglas-fir/Grass	1.83×10^{-4}	-5.832×10^{-3}	4×10^{-09}	1300.76	8.76	,998
Douglas-fir/Red Alder	9.06×10^{-5}	.014362	4×10^{-10}	518.46	11.76	.994
Coast						
Douglas-fir Only	1.30×10^{-4}	8.538×10^{-4}	3×10^{-10}	879.89	9.90	.997
Douglas-fir/Grass	1.26×10^{-4}	.0130975	3×10^{-09}	628.58	11.48	.995
Douglas-fir/Red Alder	1.92×10^{-4}	-7.835×10^{-3}	-1×10^{-09}	862.43	10.21	.997

TABLE E18. FIFTH-YEAR BASAL AREA GROWTH/HECTARE/LEAF AREA INDEX EQUATIONS. SPAC=spacing, LNSP=natural logarithm of spacing, and S2=spacing-squared. Standard errors of the LNSP term, F values, coefficients of variation, and R-squared values for the regression are given. Intercepts were not significantly different from zero. All F values are significant at α=0.01.

TREATMENT	SPAC	LNSP	S.E.	S2	F	C.V.	R^2
Valley							
Douglas-fir Only	0	.13321	.001	0	589.39	11.75	.988
Douglas-fir/Grass	0	.18212	.001	0	2024.63	6.38	.997
Douglas-fir/Red Alder	-1.67×10^{-4}	.2012	.01	6×10^{-9}	211.04	13.88	.986
Mid-Range							
Douglas-fir Only	0	.15433	.001	0	208.52	19.71	.968
Douglas-fir/Grass	0	.19869	.001	0	597.65	11.88	.988
Douglas-fir/Red Alder	-2.56×10^{-4}	.26097	.01	1×10^{-8}	135.02	17.43	.978
Coast							
Douglas-fir Only	0	.14791	.003	0	300.45	16.24	.977
Douglas-fir/Grass	0	.19011	.004	0	272.54	16.99	.975
Douglas-fir/Red Alder	0	.17714	.001	0	1219.11	8.14	.994

TABLE E19. FIFTH-YEAR DRY WEIGHT/TREE/LEAF AREA/TREE EQUATIONS. SPAC= spacing, LNSP=natural logarithm of spacing, and S2=spacing-squared. Intercepts were not significantly different from zero. Standard errors for the LNSP term, F values, coefficients of variation, and R-squared values for the regression are given. All F values are significant at α=0.01.

TREATMENT	SPAC	LNSP	S.E.	S2	F	C.V.	R^2
Valley							
Douglas-fir Only	-.010497	36.2652	0.56	$5X10^{-7}$	4131.51	3.12	.999
Douglas-fir/Grass	-.024187	45.7254	1.01	$1x10^{-6}$	1705.73	4.84	.998
Douglas-fir/Red Alder	-.024369	39.290	1.30	$1X10^{-6}$	694.03	7.58	.996
Mid-Range							
Douglas-fir Only	-.019455	40.5340	0.78	$1X10^{-6}$	2408.21	4.08	.999
Douglas-fir/Grass	-.022718	43.1859	1.22	$1X10^{-6}$	1044.68	6.18	.997
Douglas-fir/Red Alder	-.038156	46.1569	3.24	$2X10^{-6}$	134.83	17.21	.978
Coast							
Douglas-fir Only	-.023151	49.4715	1.02	$1X10^{-6}$	2035.99	4.44	.998
Douglas-fir/Grass	-.027341	54.7931	1.18	$1X10^{-6}$	1809.50	4.70	.998
Douglas-fir/Red Alder	-.045772	59.9598	3.57	$2X10^{-6}$	194.24	14.33	.985

TABLE E20. FIFTH-YEAR DRY WEIGHT/HECTARE/LEAF AREA INDEX EQUATIONS. INTER= intercept, SPAC=spacing, LNSP=natural logarithm of spacing, and S2=spacing-squared. Standard errors of the INTER, SPAC, and LNSP terms, F values, coefficients of variation, and R-squared values are given. Intercepts were not included if they did not differ significantly from zero. All F values are significant at α=0.01.

TREATMENT	INTER	SPAC	LNSP	S2	F	C.V.	R^2
Valley							
Douglas-fir Only	984.68	0	201.83	0	1186.35	1.12	.988
S.E.	45.46		5.85				
Douglas-fir/Grass	2368.19	0	71.03	0	17.85	2.79	.560
S.E.	130.47		16.81				
Douglas-fir/Red Alder	0	-.2180	381.34	$9X10^{-6}$	713.61	7.48	.996
S.E.		.04	12.71				
Mid-Range							
Douglas-fir Only	1576.47	0	140.167	0	62.26	3.24	.816
S.E.	137.84		17.76				

(TABLE E20. continued)

TREATMENT	INTER	SPAC	LNSP	S2	F	C.V.	R^2
Douglas-fir/Grass	2059.37	0	87.62	0	69.60	1.86	.833
S.E.	81.49		10.5				
Douglas-fir/Red Alder	0	-.3185	439.85	$1X10^{-5}$	366.85	10.44	.992
S.E.		.06	19.43				
Coast							
Douglas-fir Only	0	-.2151	474.09	$9X10^{-6}$	770.45	7.22	.996
S.E.		.05	15.89				
Douglas-fir/Grass	0	-.2207	521.37	$9X10^{-6}$	343.11	10.80	.991
S.E.		.08	26.61				
Douglas-fir/Red Alder	0	-.3371	542.55	$1X10^{-5}$	712.95	7.48	.996
S.E.		.05	17.87				

TABLE E21. FIFTH-YEAR LEAF AREA/SAPWOOD BASAL AREA EQUATIONS. SPAC=spacing, LNSP=natural logarithm of spacing, and S2=spacing-squared. Standard errors for SPAC and LNSP terms, F values, coefficients of variation, and R-squared values for the regression are given. Intercepts were not significantly different from zero. All F values are significant at α=0.01.

TREATMENT	SPAC	S.E.	LNSP	S.E.	S2	F	C.V.	R^2
Valley								
Douglas-fir Only	.1145	.21	472.2023	67.97	$1X10^{-5}$	63.40	25.52	.955
Douglas-fir/Grass	-.2590	.05	504.9225	16.27	$1X10^{-5}$	821.26	6.98	.996
Douglas-fir/Red Alder	-.0454	.09	530.6789	28.91	$1X10^{-5}$	497.13	9.28	.994
Mid-Range								
Douglas-fir Only	.0111	.06	552.3234	21.05	$-7X10^{-6}$	769.46	7.27	.996
Douglas-fir/Grass	-.1993	.21	552.5264	66.41	$6X10^{-6}$	62.61	25.43	.954
Douglas-fir/Red Alder	.3118	.15	422.2314	48.86	$-1X10^{-5}$	156.00	16.61	.981
Coast								
Douglas-fir Only	-.1171	.10	462.1401	33.47	$5X10^{-6}$	196.90	14.32	.985
Douglas-fir/Grass	-.0403	.08	373.8266	25.98	$1X10^{-6}$	233.16	13.16	.987
Douglas-fir/Red Alder	-.1801	.06	464.7738	20.15	$7X10^{-6}$	484.89	9.11	.994

TABLE F1. MEAN VALUES, STANDARD ERRORS, AND COEFFICIENTS OF VARIATION FOR FIFTH-YEAR HEIGHT AT THE VALLEY SITE. Each value represents from one to twelve trees. Values are in meters.

SPACING	DOUGLAS-FIR ONLY			DOUGLAS-FIR/GRASS			DOUGLAS-FIR/RED ALDER		
cm^2/tree	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.
300	1.90	0.19	30.1	2.16	0.21	31.8	1.87	0.10	10.4
390	1.63	0.14	27.7	2.01	0.16	27.2	1.94	0.14	13.9
506	2.15	0.16	24.4	2.22	0.12	17.9	1.52	0.35	46.0
658	2.33	0.19	24.2	2.13	0.16	22.2	1.71	0.26	30.2
854	2.52	0.17	26.8	1.96	0.18	31.0	1.79	----	----
1110	2.57	0.10	13.9	2.12	0.14	22.3	2.03	0.29	28.4
1441	2.33	0.21	30.9	2.21	0.13	20.0	1.92	0.19	20.1
1827	2.58	0.11	13.6	2.38	0.16	23.7	2.48	0.30	20.9
2432	2.56	0.20	26.9	2.35	0.16	22.3	2.18	0.23	18.2
3159	2.56	0.20	27.1	2.16	0.17	27.6	2.52	0.46	36.6
4107	2.83	0.13	15.7	1.93	0.08	13.4	2.17	0.38	43.7
5339	2.73	0.16	20.4	2.00	0.10	16.4	2.62	0.30	27.7
6941	2.98	0.13	14.9	2.24	0.18	27.9	2.52	0.13	12.3
9024	2.69	0.12	16.1	2.02	0.10	17.3	2.51	0.44	39.4
11731	2.56	0.22	30.2	2.14	0.13	20.8	2.95	0.19	15.7
15250	2.85	0.15	18.4	2.26	0.11	16.5	3.26	0.20	14.9

TABLE F2. MEAN VALUES, STANDARD ERRORS, AND COEFFICIENTS OF VARIATION FOR FIFTH-YEAR HEIGHT AT THE MID-RANGE SITE. Each value represents from one to twelve trees. Values are in meters.

SPACING	DOUGLAS-FIR ONLY			DOUGLAS-FIR/GRASS			DOUGLAS-FIR/RED ALDER		
cm^2/tree	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.
300	1.95	0.19	23.8	1.95	0.15	21.3	1.59	0.34	36.7
390	1.57	0.17	29.0	2.26	0.10	13.0	1.16	0.29	43.4
506	2.29	0.20	24.9	1.88	0.15	25.4	1.59	0.68	60.5
658	2.14	0.21	29.2	2.03	0.22	34.7	2.12	0.56	36.9
854	2.11	0.14	19.3	2.09	0.18	29.4	1.11	0.23	35.1
1110	2.44	0.07	8.6	2.00	0.16	25.2	1.49	0.27	31.5
1441	2.34	0.15	20.9	2.20	0.14	19.8	1.47	0.38	52.3
1827	2.35	0.18	24.2	2.16	0.19	29.7	1.61	0.30	32.6
2432	2.43	0.16	20.2	2.22	0.16	23.7	2.14	0.24	22.9
3159	2.42	0.08	11.6	2.37	0.13	18.2	1.56	0.54	59.9
4107	2.30	0.23	33.4	1.96	0.15	27.0	2.59	0.23	19.6
5339	2.26	0.14	16.8	2.26	0.15	20.9	2.37	0.34	28.4
6941	2.65	0.17	19.5	2.09	0.10	16.0	2.53	0.19	18.4
9024	2.12	0.13	17.5	2.12	0.18	28.7	2.29	0.18	19.8
11731	2.28	0.16	22.9	2.12	0.10	16.1	3.07	0.21	16.6
15250	2.68	0.16	17.2	1.97	0.14	21.1	2.92	0.26	19.8

p. 247 missing from both paper copies.

Author unavailable to supply.

TABLE F4. ANALYSIS OF VARIANCE FOR FIFTH-YEAR HEIGHT.

SOURCE OF VARIATION	D.F.	SUM OF SQ.	MEAN SQ.	F
Site	2	16.532	8.266	2.503
Plot(Site) (3-1)(2-1)	3	9.908	3.303	
Competitor	2	11.446	5.723	3.502*
Site*Competitor	4	4.285	1.071	0.655
Plot(Site)*Co	6	9.806	1.634	
Density	15	59.808	3.99	8.14***
Site*Density	30	4.915	0.16	0.33
Plot(Site)*Density	45	21.894	0.49	
Co*Dens	30	16.827	0.56	2.44***
Site*Co*Dens	60	42.121	0.70	3.06***
Plot(Site)*Co*Dens	87	19.957	0.229	
Error	928	213.241	0.23	
Mean	1	6593.762		
Total	1213	7080.32		

* α=0.1 ** α=0.05 *** α=0.01

TABLE F5. MEAN VALUES, STANDARD ERRORS, AND COEFFICIENTS OF VARIATION FOR FIFTH-YEAR DIAMETER AT 15 CM AT THE VALLEY SITE. Each mean represents one to twelve trees. Values are in millimeters.

SPACING	DOUGLAS-FIR ONLY			DOUGLAS-FIR/GRASS			DOUGLAS-FIR/RED ALDER		
cm^2/tree	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.
300	17.3	2.3	40.4	20.0	2.9	48.7	22.0	2.4	21.6
390	13.9	1.8	41.9	17.2	1.6	32.6	16.5	1.0	12.6
506	19.6	1.8	29.9	20.9	1.3	21.1	16.2	3.0	37.1
658	21.7	1.7	23.9	20.1	1.6	23.4	21.2	3.1	29.1
854	23.2	2.1	31.9	20.8	2.4	39.3	20.0	---	----
1110	26.0	1.2	15.6	23.0	1.7	26.2	26.2	4.9	37.6
1441	23.3	2.2	33.1	24.0	1.9	25.7	26.8	2.4	18.2
1827	28.4	1.8	21.0	28.0	2.9	35.3	35.7	1.2	5.8
2432	31.1	2.8	30.7	31.0	3.0	32.5	27.5	6.1	44.5
3159	31.9	3.2	34.3	30.7	3.1	34.6	36.2	6.2	34.0
4107	37.6	2.0	18.5	28.6	1.5	16.8	30.2	5.3	42.8
5339	38.7	1.9	16.7	30.3	2.3	25.2	39.7	5.0	30.9
6941	44.8	2.3	17.9	37.7	3.9	35.5	38.8	3.1	19.5
9024	43.8	2.3	18.2	31.3	1.9	21.0	36.4	7.5	46.1
11731	46.0	4.6	34.4	36.4	2.7	24.3	49.7	4.2	21.0
15250	51.2	2.5	16.7	38.8	2.8	25.1	57.2	3.9	16.6

TABLE F6. MEAN VALUES, STANDARD ERRORS AND COEFFICIENTS OF VARIATION FOR FIFTH-YEAR DIAMETER AT 15 CM FOR MID-RANGE SITE. Each mean represents from one to twelve values. Values are in millimeters.

SPACING	DOUGLAS-FIR ONLY			DOUGLAS-FIR/GRASS			DOUGLAS-FIR/RED ALDER		
cm^2/tree	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.
300	15.0	1.8	29.8	16.0	2.1	36.3	17.3	2.9	29.0
390	13.7	1.7	33.3	18.8	1.5	24.7	13.7	3.4	42.9
506	22.4	2.9	37.1	16.8	2.0	37.4	15.5	6.5	59.3
658	19.1	2.6	40.1	17.9	2.2	38.1	26.0	9.0	49.0
854	21.0	2.4	34.0	21.5	2.5	37.9	15.7	4.3	47.0
1110	24.2	1.5	17.3	19.3	2.1	34.4	15.7	2.0	22.4
1441	25.4	2.3	28.9	25.3	2.3	28.6	16.5	4.0	48.1
1827	27.9	2.8	31.5	24.9	2.4	31.6	19.0	2.0	21.5
2432	31.6	2.8	28.2	26.8	2.6	32.4	30.8	4.4	28.5
3159	31.6	1.2	12.9	30.7	1.9	20.6	20.3	5.2	44.6
4107	32.4	3.4	34.4	27.6	2.1	26.2	32.4	1.1	7.7
5339	34.6	2.4	18.4	34.0	2.5	23.4	30.8	2.5	18.3
6941	44.2	2.3	15.4	32.0	1.6	16.5	34.5	2.3	16.3
9024	33.6	2.3	19.1	34.1	3.0	28.9	35.0	2.9	20.6
11731	43.5	2.6	19.6	32.0	2.2	22.7	49.0	6.8	34.1
15250	45.6	3.8	23.6	30.6	1.9	18.8	49.4	4.3	19.4

TABLE F7. MEAN VALUES, STANDARD ERRORS, AND COEFFICIENTS OF VARIATION FOR FIFTH-YEAR DIAMETER AT 15 CM FOR COAST SITE. Each mean represents one to twelve values. Values are in millimeters.

SPACING	DOUGLAS-FIR ONLY			DOUGLAS-FIR/GRASS			DOUGLAS-FIR/RED ALDER		
cm^2/tree	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.
300	17.2	3.0	51.8	22.2	2.5	36.1	20.2	5.5	53.9
390	17.2	2.1	40.6	18.3	3.0	48.9	15.2	3.2	41.9
506	19.2	2.1	34.1	21.4	2.3	32.8	23.8	3.0	25.4
658	22.2	3.4	46.4	20.9	1.6	21.0	26.2	3.7	28.2
854	20.0	2.1	33.9	19.5	3.1	44.8	24.5	6.2	50.8
1110	27.0	1.7	19.4	28.3	4.2	46.8	28.0	1.7	10.7
1441	25.9	2.9	37.2	21.4	3.1	48.3	30.0	6.6	43.8
1827	31.4	2.7	28.4	24.2	3.7	50.7	39.2	3.0	15.3
2432	31.5	3.8	40.1	34.0	3.0	27.7	35.0	6.3	36.2
3159	41.2	3.2	25.8	33.8	4.9	50.6	32.8	5.3	32.4
4107	37.2	3.8	35.2	36.8	3.2	30.1	27.0	3.1	25.8
5339	42.2	4.9	38.5	44.7	3.0	23.2	39.5	5.0	31.0
6941	44.5	2.5	18.8	45.7	3.3	25.1	38.0	5.4	34.8
9024	45.9	3.9	29.4	44.8	3.2	23.9	32.0	3.5	26.9
11731	56.7	3.7	21.8	47.8	4.9	33.8	36.2	2.7	18.1
15250	61.4	4.5	25.4	53.0	4.3	26.9	49.7	3.7	18.1

TABLE F8. ANALYSIS OF VARIANCE FOR FIFTH-YEAR DIAMETER AT 15 CM.

SOURCE OF VARIATION	D.F.	SUM OF SQ.	MEAN SQ.	F
Site	2	6492.21	3246.11	4.42
Plot(Site)	3	2202.53	734.18	
Competitor	2	3035.72	1517.86	5.41**
Site*Competitor	4	1106.09	276.52	0.99
Plot(Site)*Co	6	1682.11	280.35	
Density	15	109080.34	7272.02	70.1 ***
Site*Density	30	2895.95	96.53	0.93
Plot(Site)*Density	45	4666.04	103.69	
Co*Dens	30	4793.92	159.80	2.43***
Site*Co*Dens	60	7682.52	128.04	1.95***
Plot(Site)*Co*Dens	87	5722.78	65.78	
Error	931	77427.04	83.17	
Mean	1	1148385.75		
Total	1216	1375173		

* α=0.10 ** α=0.05 *** α=0.01

TABLE F9. MEAN VALUES, STANDARD ERRORS, AND COEFFICIENTS OF VARIATION FOR FIFTH-YEAR DRY WEIGHT/TREE FOR VALLEY SITE. Each mean represents from one to twelve trees. Values are in grams.

SPACING	DOUGLAS-FIR ONLY			DOUGLAS-FIR/GRASS			DOUGLAS-FIR/RED ALDER		
cm^2/tree	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.
300	213.6	72.5	101.8	406.8	157.7	128.6	308.0	84.0	54.6
390	123.9	36.2	87.7	213.6	54.1	87.8	162.0	21.3	26.3
506	238.2	44.5	62.0	350.6	50.9	45.9	157.0	78.5	100.1
658	319.0	54.7	51.4	291.0	59.5	61.3	313.2	121.0	77.3
854	396.8	89.6	78.2	331.2	83.2	87.0	242.0	----	----
1110	458.7	58.9	44.5	387.7	62.0	55.4	568.8	316.5	111.3
1441	507.1	107.9	73.7	444.5	90.9	67.8	546.0	152.1	55.7
1827	594.3	65.7	36.6	674.3	124.3	63.9	864.3	210.5	42.2
2432	1057.8	173.4	56.8	804.4	171.7	70.8	799.3	174.4	37.8
3159	812.5	137.7	58.7	784.1	159.1	70.3	1199.8	459.3	76.6
4107	1190.3	121.6	35.4	559.2	59.3	35.2	851.3	246.7	71.0
5339	1368.8	200.5	50.7	733.6	153.1	69.2	1610.8	393.8	59.9
6941	2063.4	271.4	45.6	1263.1	261.1	71.6	1304.8	223.5	42.0
9024	1706.3	207.0	42.0	734.7	104.7	49.3	1598.6	689.0	96.4
11731	2153.7	425.2	68.4	1111.9	186.7	55.7	3018.3	590.7	47.9
15250	2634.1	365.3	48.0	1354.6	208.2	53.2	4143.8	433.9	25.6

TABLE F10. MEAN VALUES, STANDARD ERRORS, AND COEFFICIENTS OF VARIATION FOR FIFTH-YEAR DRY WEIGHT AT MID-RANGE SITE. Each value represents two to twelve trees. Values are in grams.

SPACING	DOUGLAS-FIR ONLY			DOUGLAS-FIR/GRASS			DOUGLAS-FIR/RED ALDER		
cm^2/tree	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.
300	136.8	40.0	71.5	212.6	68.1	90.6	171.0	45.9	46.5
390	99.1	34.8	92.7	256.3	45.6	53.3	95.7	26.8	48.5
506	384.5	113.7	83.6	237.7	65.5	87.1	139.0	111.0	112.9
658	290.9	81.6	84.2	260.6	61.9	75.1	511.0	382.0	105.7
854	306.7	79.7	78.0	393.7	102.7	103.4	122.3	68.5	97.0
1110	419.4	70.0	47.2	263.9	61.6	73.8	173.7	88.3	88.1
1441	510.5	122.9	76.1	525.4	99.9	60.1	204.2	123.8	121.2
1827	628.7	117.6	59.1	520.6	115.4	73.5	229.7	97.0	73.2
2432	844.3	153.8	57.6	629.8	130.2	68.6	617.5	147.4	47.8
3159	835.4	71.0	28.2	722.4	102.4	47.0	339.3	204.7	104.5
4107	1044.5	207.5	65.9	590.9	96.3	56.4	851.8	110.4	29.0
5339	1001.1	146.4	38.7	888.8	128.5	45.7	910.0	203.0	44.6
6941	1862.8	196.9	31.7	712.5	96.8	45.1	1108.2	189.9	42.0
9024	923.4	129.1	39.5	914.1	190.6	69.2	1255.8	227.2	44.3
11731	1676.6	210.9	41.7	849.5	135.5	52.9	2648.5	668.2	61.8
15250	1951.5	387.1	56.1	725.1	113.9	47.1	2554.6	462.7	40.5

TABLE F11. MEAN VALUES, STANDARD ERRORS, AND COEFFICIENTS OF VARIATION FOR FIFTH-YEAR DRY WEIGHT/TREE AT COAST SITE. Each mean represents two to twelve trees. Values are in grams.

SPACING	DOUGLAS-FIR ONLY			DOUGLAS-FIR/GRASS			DOUGLAS-FIR/RED ALDER		
cm^2/tree	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.
300	262.3	109.2	124.9	364.9	101.7	58.2	361.2	185.6	102.7
390	226.1	57.2	84.0	267.6	108.2	121.4	196.2	100.5	102.5
506	262.9	61.1	73.5	379.9	77.8	61.4	474.8	150.0	63.2
658	358.0	103.5	86.8	272.0	43.7	45.6	617.5	233.2	75.5
854	308.3	67.6	69.3	284.5	93.5	92.9	597.2	402.3	134.7
1110	521.9	69.6	42.1	708.5	250.7	111.9	591.0	83.6	24.5
1441	550.1	161.2	97.2	376.1	98.8	87.1	841.0	403.0	95.8
1827	842.9	158.8	62.5	578.4	173.2	99.3	1263.5	158.7	25.1
2432	868.8	330.3	126.1	866.8	205.8	75.1	1048.5	396.5	75.6
3159	1696.2	238.6	46.7	1196.2	441.8	127.9	960.2	274.3	57.1
4107	1213.2	252.5	72.1	1067.8	231.8	75.2	661.4	230.3	77.9
5339	1504.5	300.9	66.3	1895.3	304.7	55.7	1387.5	363.2	64.1
6941	1956.3	271.7	46.1	1880.4	275.5	50.7	1285.0	439.5	83.8
9024	1844.0	321.9	60.5	2005.2	305.7	50.6	844.0	178.7	51.9
11731	3210.7	382.0	39.5	2262.2	555.7	81.5	1084.8	275.2	62.1
15250	3992.8	606.4	52.6	2611.8	466.4	59.2	2252.3	411.8	44.8

TABLE F12. ANALYSIS OF VARIANCE FOR FIFTH-YEAR DRY WEIGHT/TREE.

SOURCE OF VARIATION	D.F.	SUM OF SQ.	MEAN SQ.	F
Site	2	36975838	18487919	7.47*
Plot(Site)	3	7420732	2473577	
Competitor	2	24871363	12435682	9.82**
Site*Competitor	4	15459967	3864992	3.05
Plot(Site)*Competitor	6	7595533	1265922	
Density	15	505053705	33670247	64.09***
Site*Density	30	30705020	1023501	1.95**
Plot(Site)*Density	45	23641892	525375	
Co*Dens	30	46537787	1551260	4.37***
Site*Co*Dens	60	62914621	1048577	2.96***
Plot(Site)*Co*Dens	87	30853481	354638	
Error	926	477473505	515630	
Mean	1	1086757257		
Total	1211	2331389338		

* α=0.10 ** α=0.05 *** α=0.01

TABLE F13. VALUES FOR FIFTH-YEAR DRY WEIGHT/HECTARE FOR VALLEY SITE. Values were determined from sums, so no errors of estimation are available. Douglas-fir/Red alder values have been doubled to compensate for the half-density of Douglas-fir trees in that treatment. Values are in kilograms/hectare.

SPACING cm^2/tree	DOUGLAS-FIR ONLY KG/HA	DOUGLAS-FIR/GRASS KG/HA	DOUGLAS-FIR/RED ALDER KG/HA
300	53400	124000	103000
390	23800	54800	41500
506	43100	57700	31000
658	36400	33200	47600
854	46500	38800	7100
1110	41300	34900	51200
1441	35200	28300	37900
1827	29800	36900	35500
2432	43500	30300	24600
3159	25700	24800	38000
4107	29000	12500	20700
5339	25600	12600	30200
6941	29700	18200	18800
9024	18900	8100	14800
11731	18400	8700	25700
15250	17300	8900	27200

TABLE F14. VALUES FOR FIFTH-YEAR DRY WEIGHT/HECTARE FOR MID-RANGE SITE. Values were determined from sums, so no errors of estimation are available. Douglas-fir/Red alder values have been doubled to compensate for the half-density of Douglas-fir trees in that treatment. Values are in kilograms/hectare.

SPACING cm^2/tree	DOUGLAS-FIR ONLY KG/HA	DOUGLAS-FIR/GRASS KG/HA	DOUGLAS-FIR/RED ALDER KG/HA
300	22800	47200	42800
390	14800	49300	18400
506	50600	39100	13700
658	33200	33000	38800
854	26900	42300	10700
1110	25200	19800	11700
1441	29500	30400	14200
1827	28700	26100	9400
2432	28900	23700	25400
3159	24200	21000	8100
4107	23300	14400	17300
5339	10900	13900	11400
6941	20100	9400	16000
9024	6800	9300	13900
11731	13100	6600	22600
15250	8500	3600	14000

TABLE F15. VALUES FOR FIFTH-YEAR DRY WEIGHT/HECTARE FOR COAST SITE. Values were determined from sums, so no errors of estimation are available. Douglas-fir/Red alder values have been doubled to compensate for the half-density of Douglas-fir trees in that treatment. Values are in kilograms/hectare.

SPACING cm^2/tree	DOUGLAS-FIR ONLY KG/HA	DOUGLAS-FIR/GRASS KG/HA	DOUGLAS-FIR/RED ALDER KG/HA
300	65600	101000	120000
390	53100	51500	50300
506	43300	56300	93800
658	40800	27500	93800
854	30100	22200	69900
1110	39200	41000	39900
1441	35000	23900	58400
1827	42300	29000	69200
2432	32700	29700	43100
3159	49200	37900	30400
4107	29500	26000	13400
5339	25800	35500	26000
6941	25800	27100	18500
9024	20400	20400	9400
11731	25100	17700	9200
15250	26200	15700	14800

TABLE F16. MEAN VALUES, STANDARD ERRORS, AND COEFFICIENTS OF VARIATION FOR FIFTH-YEAR HEIGHT GROWTH FOR VALLEY SITE. Each mean represents one to twelve trees. Values are in meters.

SPACING	DOUGLAS-FIR ONLY			DOUGLAS-FIR/GRASS			DOUGLAS-FIR/RED ALDER		
cm^2/tree	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.
300	0.26	0.057	65.5	0.38	0.068	58.7	0.28	0.023	16.5
390	0.20	0.042	64.7	0.36	0.050	48.8	0.31	0.038	24.4
506	0.40	0.052	43.4	0.45	0.029	21.2	0.25	0.088	69.8
658	0.44	0.072	49.2	0.52	0.062	35.9	0.25	0.106	85.3
854	0.40	0.054	46.9	0.42	0.055	44.8	0.19	-----	----
1110	0.56	0.041	25.7	0.51	0.042	28.5	0.29	0.063	43.8
1441	0.52	0.063	42.3	0.55	0.028	17.1	0.35	0.099	56.8
1827	0.64	0.036	18.6	0.63	0.055	30.1	0.44	0.223	88.3
2432	0.64	0.060	32.3	0.64	0.045	23.2	0.45	0.003	1.3
3159	0.68	0.050	25.6	0.56	0.060	37.0	0.57	0.174	61.2
4107	0.78	0.039	18.5	0.55	0.030	17.7	0.55	0.113	50.3
5339	0.77	0.044	19.8	0.59	0.054	30.4	0.63	0.088	34.4
6941	0.88	0.041	16.1	0.64	0.055	29.3	0.56	0.020	8.6
9024	0.87	0.043	17.2	0.58	0.037	21.8	0.65	0.130	44.4
11731	0.78	0.063	28.0	0.65	0.049	25.3	0.81	0.043	12.8
15250	0.88	0.034	16.7	0.68	0.037	19.2	0.94	0.074	19.4

TABLE F17. MEAN VALUES, STANDARD ERRORS, AND COEFFICIENTS OF VARIATION FOR FIFTH-YEAR HEIGHT GROWTH AT MID-RANGE SITE. Each mean represents two to twelve trees. Values are in meters.

SPACING	DOUGLAS-FIR ONLY			DOUGLAS-FIR/GRASS			DOUGLAS-FIR/RED ALDER		
cm^2/tree	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.
300	0.27	0.039	35.5	0.29	0.051	50.2	0.20	0.028	24.3
390	0.21	0.050	64.0	0.40	0.023	17.5	0.14	0.025	31.1
506	0.38	0.048	36.5	0.33	0.054	51.7	0.24	0.185	111.3
658	0.34	0.046	40.3	0.41	0.065	49.8	0.24	0.080	47.1
854	0.39	0.040	30.8	0.42	0.053	42.0	0.09	0.012	22.3
1110	0.45	0.045	27.8	0.45	0.048	33.7	0.17	0.064	63.5
1441	0.50	0.035	21.9	0.60	0.050	26.5	0.23	0.083	73.2
1827	0.54	0.049	28.8	0.65	0.067	34.2	0.19	0.059	53.4
2432	0.60	0.057	30.1	0.68	0.051	24.1	0.44	0.120	55.3
3159	0.65	0.034	17.5	0.77	0.049	21.1	0.29	0.124	74.2
4107	0.66	0.075	38.1	0.65	0.051	27.2	0.58	0.044	16.7
5339	0.73	0.064	23.0	0.69	0.051	23.6	0.59	0.080	27.3
6941	0.85	0.078	27.5	0.70	0.039	18.6	0.69	0.030	10.7
9024	0.78	0.022	8.0	0.69	0.058	27.6	0.63	0.049	19.1
11731	0.78	0.050	21.5	0.68	0.035	17.2	0.97	0.048	12.2
15250	0.83	0.121	41.1	0.66	0.072	33.0	0.98	0.032	7.3

TABLE F18. MEAN VALUES, STANDARD ERRORS, AND COEFFICIENTS OF VARIATION FOR FIFTH-YEAR HEIGHT GROWTH AT COAST SITE. Each mean represents from two to twelve trees. Values are in meters.

SPACING	DOUGLAS-FIR ONLY			DOUGLAS-FIR/GRASS			DOUGLAS-FIR/RED ALDER		
cm^2/tree	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.
300	0.44	0.073	49.8	0.40	0.033	25.6	0.39	0.040	20.7
390	0.34	0.048	46.3	0.32	0.049	45.7	0.34	0.087	52.1
506	0.43	0.055	40.3	0.52	0.071	41.5	0.53	0.130	49.1
658	0.47	0.025	15.8	0.48	0.035	20.6	0.54	0.061	22.7
854	0.47	0.051	34.7	0.41	0.067	45.8	0.56	0.101	36.2
1110	0.56	0.037	20.9	0.55	0.063	36.6	0.80	0.168	36.6
1441	0.52	0.058	36.6	0.53	0.086	53.7	0.61	0.096	31.6
1827	0.65	0.038	19.4	0.52	0.069	43.4	0.66	0.055	16.7
2432	0.71	0.052	24.4	0.81	0.044	17.3	0.68	0.034	10.0
3159	0.81	0.063	25.7	0.77	0.075	34.1	0.66	0.116	35.1
4107	0.72	0.055	26.7	0.90	0.055	21.2	0.58	0.096	37.2
5339	0.86	0.051	19.6	1.01	0.054	18.6	0.78	0.060	18.8
6941	0.84	0.058	23.0	1.02	0.070	23.7	0.77	0.103	32.8
9024	0.90	0.064	24.4	0.89	0.074	27.6	0.66	0.084	31.1
11731	0.96	0.034	11.9	0.99	0.039	13.1	0.70	0.105	36.5
15250	0.94	0.056	20.5	0.96	0.061	20.9	0.92	0.109	29.1

TABLE F19. ANALYSIS OF VARIANCE FOR FIFTH-YEAR HEIGHT GROWTH.

SOURCE OF VARIATION	D.F.	SUM OF SQ.	MEAN SQ.	F
Site	2	4.53	2.265	4.10
Plot(Site)	3	1.66	0.553	
Competitor	2	1.24	0.62	5.79**
Site*Competitor	4	0.08	0.02	0.19
Plot(Site)*Co	6	0.64	0.107	
Density	15	36.62	2.44	54.22***
Site*Density	30	0.27	0.009	0.20
Plot(Site)*Dens	45	2.02	0.045	
Co*Dens	30	2.15	0.072	2.48***
Site*Co*Dens	60	5.37	0.0895	3.09***
Plot(Site)*Co*Dens	87	2.55	0.029	
Error	928	26.73	0.029	
Mean	1	448.25		
Total	1213	532.11		

* α=0.10   ** α=0.05   *** α=0.01

TABLE F20. VALUES FOR FIFTH-YEAR BASAL AREA/HECTARE FOR VALLEY SITE. Values were determined from sums, so no errors of estimation are available. Douglas-fir/Red alder values have been doubled to compensate for the half-density of Douglas-fir trees in that treatment. Values are in square meters/hectare.

SPACING cm^2/tree	DOUGLAS-FIR ONLY M^2/HA	DOUGLAS-FIR/GRASS M^2/HA	DOUGLAS-FIR/RED ALDER M^2/HA
300	58.8	96.0	126.7
390	32.4	59.6	54.8
506	54.7	62.2	40.7
658	42.2	36.2	53.6
854	49.5	39.8	9.2
1110	47.8	37.4	48.6
1441	29.6	28.8	39.2
1827	31.8	33.7	41.1
2432	31.2	28.4	24.4
3159	25.3	23.4	32.6
4107	27.0	14.3	17.4
5339	22.0	12.4	23.2
6941	22.7	16.1	17.0
9024	16.7	8.5	9.6
11731	14.2	8.1	16.5
15250	13.5	7.8	16.8

TABLE F21. VALUES FOR FIFTH-YEAR BASAL AREA/HECTARE FOR MID-RANGE SITE. Values were determined from sums, so no errors of estimation are available. Douglas-fir/Red alder values have been doubled to compensate for the half-density of Douglas-fir trees in that treatment. Values are in square meters/hectare.

SPACING cm^2/tree	DOUGLAS-FIR ONLY M^2/HA	DOUGLAS-FIR/GRASS M^2/HA	DOUGLAS-FIR/RED ALDER M^2/HA
300	29.4	44.7	58.8
390	22.0	53.4	28.4
506	51.9	36.5	18.6
658	32.7	31.9	40.3
854	30.4	39.0	17.0
1110	27.6	22.0	13.1
1441	29.3	29.1	14.8
1827	27.9	24.4	15.5
2432	26.9	21.3	30.6
3159	22.8	21.5	7.7
4107	18.4	14.6	16.7
5339	10.3	14.2	11.6
6941	16.6	10.6	13.5
9024	6.6	9.3	10.7
11731	11.6	6.3	16.1
15250	7.1	3.6	10.5

TABLE F22. VALUES FOR FIFTH-YEAR BASAL AREA/HECTARE FOR COAST SITE. Values were determined from sums, so no errors of estimation are available. Douglas-fir/Red alder values have been doubled to compensate for the half-density of Douglas-fir trees in that treatment. Values are in square meters/hectare.

SPACING cm^2/tree	DOUGLAS-FIR ONLY M^2/HA	DOUGLAS-FIR/GRASS M^2/HA	DOUGLAS-FIR/RED ALDER M^2/HA
300	58.1	107.5	106.8
390	54.6	50.6	46.5
506	47.7	53.3	87.9
658	44.1	34.8	81.9
854	30.7	23.3	55.2
1110	43.0	47.2	41.6
1441	33.5	22.9	49.0
1827	38.8	23.1	66.1
2432	29.4	31.1	39.6
3159	38.7	28.4	26.8
4107	26.5	25.9	11.6
5339	24.0	29.4	23.0
6941	20.5	23.6	16.3
9024	18.3	16.0	8.9
11731	19.7	14.0	8.8
15250	19.4	13.3	12.7

TABLE F23. MEAN VALUES, STANDARD ERRORS, AND COEFFICIENTS OF VARIATION FOR FIFTH-YEAR BASAL AREA GROWTH (AT 15 CM) AT VALLEY SITE. Each value represents from one to twelve trees. Values are in square centimeters.

SPACING	DOUGLAS-FIR ONLY			DOUGLAS-FIR/GRASS			DOUGLAS-FIR/RED ALDER		
cm^2/tree	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.
300	0.707	0.165	70.0	1.170	0.332	94.0	1.510	0.326	43.2
390	0.517	0.133	81.7	0.844	0.160	65.7	0.870	0.101	23.3
506	1.010	0.142	46.6	1.242	0.150	40.1	0.876	0.308	70.3
658	1.241	0.209	47.6	1.228	0.185	45.1	1.563	0.467	59.7
854	1.539	0.256	57.6	1.473	0.318	74.9	1.374	-----	----
1110	1.910	0.160	29.0	1.790	0.245	47.5	2.523	1.045	82.8
1441	1.730	0.292	58.5	2.010	0.282	46.5	2.462	0.461	37.4
1827	2.523	0.329	43.3	3.063	0.531	60.1	4.422	0.412	16.1
2432	3.396	0.478	48.7	3.811	0.774	67.4	3.093	0.997	64.5
3159	3.803	0.597	54.4	3.934	0.702	61.9	5.117	1.776	69.4
4107	5.021	0.531	36.6	3.265	0.340	34.6	3.793	1.098	70.9
5339	5.494	0.507	32.0	3.880	0.609	52.0	6.233	1.221	48.0
6941	7.779	0.763	34.0	6.655	1.181	61.5	5.892	0.943	39.2
9024	7.809	0.756	33.5	4.372	0.546	43.3	5.996	2.146	80.4
11731	9.510	1.643	59.9	6.178	0.864	46.4	9.930	1.697	41.9
15250	11.292	1.056	32.4	7.368	1.048	49.3	12.963	1.706	32.2

TABLE F24. MEAN VALUES, STANDARD ERRORS, AND COEFFICIENTS OF VARIATION FOR FIFTH-YEAR BASAL AREA GROWTH (AT 15 CM) AT MID-RANGE SITE. Each mean represents from one to twelve trees. Values are in square centimeters.

SPACING	DOUGLAS-FIR ONLY			DOUGLAS-FIR/GRASS			DOUGLAS-FIR/RED ALDER		
cm^2/tree	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.
300	0.531	0.111	51.3	0.735	0.196	75.5	0.793	0.263	57.5
390	0.545	0.137	66.7	1.022	0.164	48.1	0.597	0.264	76.7
506	1.433	0.353	69.6	0.957	0.259	85.6	0.891	0.640	101.5
658	1.120	0.280	75.1	1.160	0.232	63.4	2.419	1.477	86.3
854	1.610	0.373	69.6	1.771	0.437	81.9	0.838	0.432	89.3
1110	1.876	0.256	38.6	1.417	0.309	69.0	0.814	0.169	35.9
1441	2.245	0.461	64.9	2.558	0.425	52.5	1.084	0.524	96.7
1827	2.824	0.458	51.3	2.631	0.448	56.5	1.290	0.284	44.0
2432	3.747	0.630	53.2	3.193	0.559	58.1	3.554	0.842	47.4
3159	3.759	0.285	25.1	4.134	0.487	39.0	1.568	0.711	78.6
4107	4.521	0.796	58.4	3.623	0.513	49.1	3.880	0.265	15.3
5339	5.004	0.654	34.6	5.634	0.735	41.2	3.748	0.615	36.7
6941	8.477	0.847	30.0	5.138	0.519	33.5	4.674	0.602	31.5
9024	5.071	0.598	33.4	6.304	1.201	63.2	5.000	0.715	35.0
11731	8.962	1.096	40.6	5.702	0.780	45.4	10.903	2.946	66.2
15250	10.957	1.713	46.3	5.398	0.666	37.0	10.471	1.736	37.1

TABLE F25. MEAN VALUES, STANDARD ERRORS, AND COEFFICIENTS OF VARIATION FOR FIFTH-YEAR BASAL AREA GROWTH (AT 15 CM) AT COAST SITE. Each mean represents from two to twelve trees. Values are in square centimeters.

SPACING	DOUGLAS-FIR ONLY			DOUGLAS-FIR/GRASS			DOUGLAS-FIR/RED ALDER		
cm^2/tree	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.
300	0.865	0.323	111.9	1.489	0.314	66.8	1.321	0.605	91.5
390	0.840	0.185	73.0	1.126	0.352	93.8	0.742	0.328	88.5
506	1.037	0.200	60.9	1.457	0.264	54.4	1.598	0.392	49.0
658	1.467	0.444	90.8	1.332	0.200	42.5	2.128	0.547	51.4
854	1.173	0.237	64.0	1.330	0.436	92.6	2.081	1.125	108.1
1110	1.993	0.260	41.3	2.952	0.875	93.8	2.382	0.363	26.4
1441	2.043	0.476	77.2	1.748	0.413	78.3	3.318	1.401	84.5
1827	2.995	0.468	51.8	2.329	0.659	93.8	4.999	0.720	28.8
2432	3.389	0.917	89.7	4.119	0.700	53.7	4.500	1.527	67.8
3159	5.424	0.892	54.6	4.697	1.402	103.4	3.892	1.187	61.0
4107	4.739	0.825	60.3	4.981	0.812	56.5	2.706	0.567	46.8
5339	6.402	1.360	70.5	7.335	1.479	43.6	6.168	1.578	62.7
6941	6.651	0.727	36.3	7.914	1.084	47.5	5.939	1.630	67.2
9024	7.666	1.211	54.7	7.739	1.025	43.9	4.193	0.889	51.9
11731	11.537	1.327	38.2	9.378	1.955	69.2	5.320	0.824	38.0
15250	14.081	2.125	52.3	11.374	2.070	60.4	10.489	1.528	35.7

TABLE F26. ANALYSIS OF VARIANCE FOR FIFTH-YEAR BASAL AREA GROWTH/TREE.

SOURCE OF VARIATION	D.F.	SUM OF SQ.	MEAN SQ.	F
Site	2	183.34	91.67	2.43
Plot(Site)	3	113.27	37.76	
Competitor	2	110.93	55.46	2.37
Site*Competitor	4	114.83	28.71	1.23
Plot(Site)*Co	6	140.28	23.38	
Density	15	9781.13	652.08	79.14***
Site*Density	30	179.98	6.00	0.73
Plot(Site)*Density	45	370.68	8.24	
Co*Dens	30	440.02	14.67	4.64***
Site*Co*Dens	60	497.18	8.29	2.62***
Plot(Site)*Co*Dens	87	275.12	3.16	
Error	930	6391.03	6.87	
Mean	1	20582.22		
Total	1215	39180.01		

* α=0.10 ** α=0.05 *** α=0.01

TABLE F27. VALUES FOR FIFTH-YEAR BASAL AREA GROWTH/HECTARE FOR VALLEY SITE. Values were determined from sums, so no errors of estimation are available. Douglas-fir/Red alder values have been doubled to compensate for the half-density of Douglas-fir trees in that treatment. Values are in square meters/hectare.

SPACING cm^2/tree	DOUGLAS-FIR ONLY M^2/HA	DOUGLAS-FIR/GRASS M^2/HA	DOUGLAS-FIR/RED ALDER M^2/HA
300	17.7	35.8	50.3
390	11.0	21.6	22.3
506	18.3	22.5	17.3
658	12.6	14.0	23.8
854	18.0	17.2	4.0
1110	17.2	16.1	22.7
1441	12.0	12.8	17.1
1827	12.7	16.8	18.2
2432	14.0	14.4	12.7
3159	12.0	12.4	16.2
4107	12.2	7.3	9.2
5339	10.3	6.7	11.7
6941	11.2	9.6	8.5
9024	8.6	4.8	5.5
11731	8.1	4.8	8.5
15250	7.4	4.8	8.5

TABLE F28. VALUES FOR FIFTH-YEAR BASAL AREA GROWTH/HECTARE FOR MID-RANGE SITE. Values were determined from sums, so no errors of estimation are available. Douglas-fir/Red alder values have been doubled to compensate for the half-density of the Douglas-fir trees in that treatment. Values are in square meters/hectare.

SPACING cm^2/tree	DOUGLAS-FIR ONLY M^2/HA	DOUGLAS-FIR/GRASS M^2/HA	DOUGLAS-FIR/RED ALDER M^2/HA
300	8.9	16.3	19.8
390	8.2	19.6	11.5
506	18.9	15.8	8.8
658	12.8	14.7	18.4
854	14.1	19.0	7.4
1110	11.3	10.6	5.5
1441	13.0	14.8	7.5
1827	12.9	13.2	7.1
2432	12.8	12.0	14.6
3159	10.9	12.0	3.7
4107	10.1	8.8	7.9
5339	5.5	8.8	5.8
6941	9.2	6.8	6.7
9024	3.8	6.4	5.5
11731	7.0	4.5	9.3
15250	4.6	2.6	5.7

TABLE F29. VALUES FOR FIFTH-YEAR BASAL AREA GROWTH/HECTARE FOR COAST SITE. Values were determined from sums, so no errors of estimation are available. Douglas-fir/Red alder values have been doubled to compensate for the half-density of Douglas-fir trees in that treatment. Values are in square meters/hectare.

SPACING cm^2/tree	DOUGLAS-FIR ONLY M^2/HA	DOUGLAS-FIR/GRASS M^2/HA	DOUGLAS-FIR/RED ALDER M^2/HA
300	21.6	41.4	44.0
390	19.7	21.6	19.0
506	17.1	21.6	31.6
658	16.7	13.5	32.4
854	11.4	10.4	24.4
1110	15.0	22.2	16.1
1441	13.0	11.1	23.0
1827	15.0	11.7	27.4
2432	12.8	14.1	18.5
3159	15.7	14.9	12.3
4107	11.5	12.1	5.5
5339	11.0	13.7	11.6
6941	8.8	11.4	8.6
9024	8.5	7.9	4.6
11731	9.0	7.3	4.5
15250	9.2	6.8	6.9

TABLE F30. MEAN VALUES, STANDARD ERRORS, AND COEFFICIENTS OF VARIATION FOR FIFTH-YEAR STEMWOOD VOLUME PRODUCTION/TREE FOR VALLEY SITE. Values represent from one to twelve trees. Values are in cubic meters.

SPACING	DOUGLAS-FIR ONLY			DOUGLAS-FIR/GRASS			DOUGLAS-FIR/RED ALDER		
cm^2/tree	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.
300	0.00008	0.00002	96.2	0.00015	0.00006	121.0	0.00012	0.00003	56.6
390	0.00004	0.00001	99.8	0.00009	0.00002	92.0	0.00007	0.00001	37.3
506	0.00011	0.00002	61.9	0.00013	0.00002	49.2	0.00007	0.00004	112.5
658	0.00015	0.00003	63.5	0.00013	0.00003	57.8	0.00013	0.00006	102.7
854	0.00018	0.00004	73.3	0.00015	0.00004	89.2	0.00009	-------	-----
1110	0.00023	0.00002	34.4	0.00019	0.00003	61.0	0.00024	0.00013	111.3
1441	0.00022	0.00004	71.3	0.00021	0.00004	60.9	0.00021	0.00006	58.1
1827	0.00032	0.00005	54.4	0.00036	0.00007	70.7	0.00046	0.00012	45.7
2432	0.00043	0.00007	55.2	0.00044	0.00011	88.2	0.00037	0.00009	41.5
3159	0.00049	0.00009	65.1	0.00042	0.00010	85.5	0.00066	0.00035	106.3
4107	0.00067	0.00009	44.7	0.00028	0.00003	41.2	0.00044	0.00015	84.7
5339	0.00070	0.00010	48.1	0.00035	0.00007	68.1	0.00077	0.00017	55.1
6941	0.00105	0.00013	44.0	0.00070	0.00015	73.8	0.00063	0.00012	47.1
9024	0.00095	0.00011	40.3	0.00039	0.00006	57.2	0.00079	0.00039	109.7
11731	0.00119	0.00025	73.8	0.00059	0.00011	64.8	0.00130	0.00029	53.6
15250	0.00142	0.00018	43.5	0.00071	0.00012	60.8	0.00188	0.00034	43.9

TABLE F31. MEAN VALUES, STANDARD ERRORS, AND COEFFICIENTS OF VARIATION FOR FIFTH-YEAR STEMWOOD VOLUME PRODUCTION/TREE FOR MID-RANGE SITE. Values represent from two to twelve trees. Values are in cubic meters.

SPACING	DOUGLAS-FIR ONLY			DOUGLAS-FIR/GRASS			DOUGLAS-FIR/RED ALDER		
cm^2/tree	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.
300	0.00005	0.00002	73.2	0.00007	0.00003	100.4	0.00006	0.00002	70.9
390	0.00004	0.00002	95.4	0.00010	0.00002	54.0	0.00003	0.00002	82.6
506	0.00016	0.00004	77.8	0.00009	0.00003	118.0	0.00008	0.00007	126.4
658	0.00012	0.00004	96.0	0.00012	0.00003	78.8	0.00023	0.00018	107.1
854	0.00015	0.00004	84.3	0.00018	0.00006	113.8	0.00004	0.00003	107.5
1110	0.00020	0.00003	44.6	0.00014	0.00004	81.2	0.00005	0.00002	66.3
1441	0.00025	0.00006	81.7	0.00026	0.00006	66.0	0.00009	0.00005	124.2
1827	0.00032	0.00006	61.6	0.00028	0.00006	71.7	0.00009	0.00004	70.8
2432	0.00041	0.00007	55.3	0.00034	0.00007	71.9	0.00034	0.00009	53.8
3159	0.00040	0.00004	34.0	0.00044	0.00007	51.8	0.00014	0.00009	114.6
4107	0.00051	0.00011	73.4	0.00033	0.00006	64.8	0.00043	0.00006	32.9
5339	0.00050	0.00008	44.0	0.00055	0.00009	51.5	0.00043	0.00012	57.0
6941	0.00099	0.00013	40.3	0.00044	0.00006	45.4	0.00053	0.00010	46.2
9024	0.00048	0.00006	37.3	0.00060	0.00018	97.0	0.00050	0.00009	45.0
11731	0.00089	0.00016	57.9	0.00049	0.00008	57.0	0.00154	0.00052	82.1
15250	0.00115	0.00022	54.8	0.00042	0.00007	46.9	0.00138	0.00032	51.3

TABLE F32. MEAN VALUES, STANDARD ERRORS, AND COEFFICIENTS OF VARIATION FOR FIFTH-YEAR STEMWOOD VOLUME PRODUCTION/TREE FOR COAST SITE. Values represent from two to twelve trees. Values are in cubic meters.

SPACING	DOUGLAS-FIR ONLY			DOUGLAS-FIR/GRASS			DOUGLAS-FIR/RED ALDER		
cm^2/tree	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.
300	0.00011	0.00005	147.2	0.00016	0.00004	76.6	0.00016	0.00008	107.1
390	0.00009	0.00002	86.8	0.00011	0.00005	119.6	0.00007	0.00004	109.8
506	0.00012	0.00003	75.9	0.00017	0.00004	69.3	0.00020	0.00007	66.8
658	0.00018	0.00006	105.8	0.00013	0.00002	52.1	0.00026	0.00009	70.1
854	0.00014	0.00004	79.7	0.00015	0.00007	127.4	0.00028	0.00019	134.3
1110	0.00025	0.00004	51.9	0.00039	0.00016	132.8	0.00032	0.00007	37.8
1441	0.00027	0.00009	108.6	0.00021	0.00006	97.9	0.00039	0.00019	96.3
1827	0.00041	0.00008	63.7	0.00028	0.00010	114.0	0.00063	0.00010	32.2
2432	0.00050	0.00018	119.8	0.00055	0.00012	66.6	0.00056	0.00022	79.2
3159	0.00080	0.00014	56.9	0.00070	0.00027	134.4	0.00046	0.00018	76.2
4107	0.00067	0.00014	74.6	0.00070	0.00015	72.3	0.00028	0.00008	61.3
5339	0.00095	0.00025	88.3	0.00108	0.00015	47.5	0.00074	0.00023	76.3
6941	0.00087	0.00011	42.2	0.00118	0.00020	58.2	0.00066	0.00021	79.2
9024	0.00104	0.00020	65.5	0.00105	0.00019	59.6	0.00038	0.00009	57.0
11731	0.00173	0.00024	45.2	0.00130	0.00032	82.3	0.00053	0.00012	56.7
15250	0.00206	0.00038	63.7	0.00161	0.00039	80.0	0.00124	0.00027	52.8

TABLE F33. ANALYSIS OF VARIANCE FOR FIFTH-YEAR STEMWOOD VOLUME PRODUCTION/TREE.

SOURCE OF VARIATION	D.F.	SUM OF SQ.	MEAN SQ.	F
Site	2	1208.53	604.26	8.46*
Plot(Site)	3	214.19	71.40	
Competitor	2	397.2	198.6	3.12
Site*Competitor	4	520.1	130.02	2.04
Plot(Site)*Co	6	382.21	63.70	
Density	15	15591.6	1039.44	45.99***
Site*Density	30	878.07	29.27	1.30
Plot(Site)*Density	45	1017.2	22.60	
Co*Dens	30	1175.56	39.19	3.38***
Site*Co*Dens	60	1792.79	29.88	2.58***
Plot(Site)*Co*Dens	87	1007.94	11.59	
Error	927	16674.6	17.99	
Mean	1	29838.59		
Total	1212	70698.58		

* α=0.10 ** α=0.05 *** α=0.01

TABLE F34. VALUES FOR FIFTH-YEAR STEMWOOD VOLUME PRODUCTION/HECTARE FOR VALLEY SITE. Values were determined from sums, so no errors of estimation are available. Douglas-fir/Red alder values were doubled to compensate for the half-density of the Douglas-fir trees in that treatment. Values are in cubic meters/hectare.

SPACING cm^2/tree	DOUGLAS-FIR ONLY M^3/HA	DOUGLAS-FIR/GRASS M^3/HA	DOUGLAS-FIR/RED ALDER M^3/HA
300	19.2	46.9	40.2
390	9.5	22.3	18.4
506	20.5	24.4	14.0
658	15.4	15.2	19.0
854	21.0	18.0	2.7
1110	20.6	16.7	21.4
1441	14.9	13.6	14.4
1827	15.8	19.6	18.8
2432	17.8	16.5	11.5
3159	15.5	13.3	20.9
4107	16.2	6.2	10.7
5339	13.1	6.0	14.4
6941	15.1	10.1	9.1
9024	10.5	4.3	7.3
11731	10.2	4.6	11.1
15250	9.3	4.6	12.3

TABLE F35. VALUES FOR FIFTH-YEAR STEMWOOD VOLUME PRODUCTION/HECTARE FOR MID-RANGE SITE. Values were determined from sums, so no errors of estimation are available. Douglas-fir/Red alder values were doubled to compensate for the half-density of the Douglas-fir trees in that treatment. Values are in cubic meters/hectare.

SPACING cm^2/tree	DOUGLAS-FIR ONLY M^3/HA	DOUGLAS-FIR/GRASS M^3/HA	DOUGLAS-FIR/RED ALDER M^3/HA
300	8.6	15.9	9.8
390	6.3	20.2	4.3
506	21.2	15.3	5.1
658	14.0	15.4	11.8
854	13.5	19.8	2.4
1110	12.0	10.2	2.3
1441	14.5	15.3	4.0
1827	14.6	14.1	2.4
2432	14.0	12.7	9.2
3159	11.6	12.8	2.1
4107	11.4	7.9	8.7
5339	5.5	8.5	5.4
6941	10.7	5.9	7.6
9024	3.5	6.1	5.6
11731	7.0	3.8	13.1
15250	5.0	2.0	7.6

TABLE F36. VALUES FOR FIFTH-YEAR STEMWOOD VOLUME PRODUCTION/HECTARE FOR COAST SITE. Values were determined from sums, so no errors of estimation are available. Douglas-fir/Red alder values were doubled to compensate for the half-density of the Douglas-fir trees in that treatment. Values are in cubic meters/hectare.

SPACING cm^2/tree	DOUGLAS-FIR ONLY M^3/HA	DOUGLAS-FIR/GRASS M^3/HA	DOUGLAS-FIR/RED ALDER M^3/HA
300	27.8	45.7	51.9
390	20.2	22.0	18.5
506	19.4	25.0	39.8
658	20.2	13.3	38.9
854	13.6	11.6	32.6
1110	18.9	28.9	21.5
1441	16.9	13.5	27.1
1827	20.6	14.2	34.5
2432	18.9	18.8	22.9
3159	23.3	22.1	14.6
4107	16.2	17.0	5.7
5339	16.3	20.2	13.9
6941	11.5	16.9	9.5
9024	11.6	10.7	4.2
11731	13.5	10.2	4.5
15250	13.5	9.7	8.2

TABLE F37. MEAN VALUES, STANDARD ERRORS, AND COEFFICIENTS OF VARIATION FOR FIFTH-YEAR HEIGHT/DIAMETER RATIOS AT VALLEY SITE. Each mean represents from one to twelve trees. Values are in meters/millimeters.

SPACING	DOUGLAS-FIR ONLY			DOUGLAS_FIR/GRASS			DOUGLAS-FIR/RED ALDER		
cm^2/tree	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.
300	0.117	0.009	21.9	0.117	0.007	20.8	0.086	0.004	9.6
390	0.125	0.009	22.0	0.120	0.004	12.6	0.118	0.002	2.6
506	0.112	0.005	13.9	0.107	0.003	8.0	0.093	0.012	25.0
658	0.107	0.004	12.0	0.107	0.003	8.8	0.081	0.003	7.8
854	0.099	0.003	11.5	0.098	0.005	16.9	0.089	-----	----
1110	0.101	0.006	22.2	0.094	0.003	10.8	0.079	0.004	9.9
1441	0.101	0.003	11.4	0.094	0.004	13.8	0.072	0.003	9.4
1827	0.092	0.003	11.9	0.091	0.006	24.3	0.069	0.006	15.4
2432	0.085	0.004	14.4	0.078	0.004	15.2	0.065	0.002	4.9
3159	0.083	0.003	13.9	0.072	0.002	11.3	0.069	0.002	5.0
4107	0.076	0.002	8.3	0.068	0.003	15.2	0.071	0.005	16.0
5339	0.070	0.002	8.9	0.068	0.003	15.5	0.092	0.002	7.7
6941	0.067	0.003	13.2	0.062	0.003	16.4	0.066	0.004	15.1
9024	0.062	0.003	14.5	0.065	0.002	9.1	0.072	0.006	17.0
11731	0.057	0.001	7.3	0.059	0.002	9.1	0.060	0.003	10.8
15250	0.056	0.002	10.7	0.060	0.003	16.2	0.057	0.002	7.2

TABLE F38. MEAN VALUES. STANDARD ERRORS, AND COEFFICIENTS OF VARIATION FOR FIFTH-YEAR HEIGHT/DIAMETER RATIOS FOR MID-RANGE SITE. Each mean represents from two to twelve trees. Values are in meters/millimeters.

SPACING	DOUGLAS-FIR ONLY			DOUGLAS-FIR/GRASS			DOUGLAS-FIR/RED ALDER		
cm^2/tree	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.
300	0.133	0.007	12.7	0.129	0.011	23.0	0.091	0.011	20.9
390	0.117	0.006	12.6	0.125	0.008	18.9	0.085	0.004	7.3
506	0.108	0.009	23.4	0.116	0.005	14.0	0.102	0.001	1.4
658	0.117	0.007	17.1	0.118	0.008	22.2	0.084	0.008	13.2
854	0.106	0.007	20.9	0.101	0.007	23.5	0.074	0.010	23.9
1110	0.103	0.005	13.4	0.108	0.006	18.6	0.094	0.005	9.9
1441	0.094	0.003	11.4	0.091	0.006	21.2	0.088	0.006	13.7
1827	0.088	0.005	16.9	0.089	0.004	14.2	0.084	0.003	6.6
2432	0.080	0.006	22.3	0.086	0.005	17.3	0.071	0.005	15.2
3159	0.077	0.003	11.8	0.078	0.002	10.2	0.073	0.011	27.0
4107	0.071	0.003	13.8	0.071	0.002	11.7	0.079	0.005	13.0
5339	0.066	0.004	15.4	0.067	0.002	11.2	0.072	0.006	17.9
6941	0.060	0.003	13.0	0.066	0.002	11.4	0.074	0.004	11.8
9024	0.064	0.004	17.8	0.062	0.002	11.5	0.066	0.004	14.8
11731	0.052	0.002	15.5	0.067	0.002	11.3	0.066	0.005	17.4
15250	0.061	0.005	25.2	0.065	0.004	18.9	0.059	0.002	8.1

TABLE F39. MEAN VALUES, STANDARD ERRORS, AND COEFFICIENTS OF VARIATION FOR FIFTH-YEAR HEIGHT/DIAMETER RATIOS FOR COAST SITE. Each mean represents from two to twelve trees. Values are in meters/millimeters.

SPACING	DOUGLAS-FIR ONLY			DOUGLAS-FIR/GRASS			DOUGLAS-FIR/RED ALDER		
cm^2/tree	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.
300	0.119	0.007	16.6	0.113	0.012	32.7	0.116	0.013	22.8
390	0.110	0.005	15.8	0.106	0.008	21.6	0.123	0.007	12.2
506	0.116	0.007	18.5	0.117	0.011	28.1	0.102	0.003	6.1
658	0.111	0.009	25.5	0.100	0.003	9.7	0.099	0.010	19.9
854	0.114	0.004	12.3	0.110	0.009	22.3	0.102	0.010	18.8
1110	0.098	0.006	19.6	0.088	0.007	24.9	0.095	0.005	9.4
1441	0.092	0.004	16.0	0.100	0.007	22.2	0.086	0.011	26.1
1827	0.088	0.004	15.6	0.096	0.007	22.6	0.072	0.005	15.2
2432	0.086	0.004	16.0	0.078	0.003	12.7	0.076	0.009	23.0
3159	0.079	0.007	27.6	0.081	0.006	27.3	0.073	0.004	10.0
4107	0.074	0.003	16.3	0.076	0.004	18.8	0.080	0.007	20.2
5339	0.068	0.005	23.8	0.069	0.004	17.6	0.068	0.006	20.8
6941	0.061	0.003	14.2	0.066	0.003	15.6	0.063	0.007	27.3
9024	0.057	0.002	13.7	0.061	0.003	16.3	0.063	0.006	24.2
11731	0.056	0.003	15.4	0.060	0.003	17.5	0.060	0.003	13.7
15250	0.050	0.002	16.2	0.056	0.002	14.9	0.051	0.003	13.3

TABLE F40. ANALYSIS OF VARIANCE FOR FIFTH-YEAR HEIGHT/DIAMETER RATIOS.

SOURCE OF VARIATION	D.F.	SUM OF SQ.	MEAN SQ.	F
Site	2	0.0007	0.00035	0.23
Plot(Site)	3	0.00463	0.00154	
Competitor	2	0.01415	0.00708	10.73**
Site*Competitor	4	0.00291	0.00073	1.11
Plot(Site)*Co	6	0.00393	0.00066	
Density	15	0.4779	0.0319	245.38***
Site*Density	30	0.01103	0.00037	2.85***
Plot(Site)*Density	45	0.00599	0.00013	
Co*Dens	30	0.00811	0.00027	3.38***
Site*Co*Dens	60	0.0127	0.00021	2.62***
Plot(Site)*Co*Dens	87	0.00716	0.00008	
Error	928	0.5526	0.00060	
Mean	1	8.62619		
Total	1213	9.728		

* α=0.10 ** α=0.05 *** α=0.01

TABLE F41. MEAN VALUES, STANDARD ERRORS, AND COEFFICIENTS OF VARIATION FOR FIFTH-YEAR LEAF AREA/TREE AT VALLEY SITE. Each mean represents from one to twelve trees. Values are in square meters.

SPACING	DOUGLAS-FIR ONLY			DOUGLAS-FIR/GRASS			DOUGLAS-FIR/RED ALDER		
cm^2/tree	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.
300	0.98	0.33	101.6	1.37	0.54	130.8	1.36	0.42	62.2
390	0.56	0.16	88.0	0.78	0.21	92.4	0.65	0.13	40.1
506	1.06	0.20	62.1	1.30	0.19	46.4	0.65	0.32	99.1
658	1.39	0.24	51.4	1.03	0.23	65.8	1.34	0.56	83.5
854	1.70	0.38	78.5	1.16	0.30	90.0	0.96	----	----
1110	1.93	0.25	44.5	1.37	0.22	56.2	2.52	1.45	115.3
1441	2.08	0.44	73.1	1.48	0.28	62.7	2.44	0.70	57.0
1827	2.41	0.27	36.8	2.33	0.43	64.5	3.86	1.27	57.1
2432	4.17	0.68	56.8	2.84	0.65	76.2	3.33	0.64	33.0
3159	3.14	0.53	58.9	2.67	0.55	70.8	4.58	1.45	63.4
4107	4.51	0.46	35.3	1.93	0.20	34.3	3.66	1.07	71.4
5339	5.07	0.74	50.7	2.48	0.51	68.1	6.80	1.65	59.6
6941	7.47	0.98	45.6	4.24	0.86	70.3	5.58	0.97	42.7
9024	6.03	0.73	42.1	2.43	0.33	46.8	6.69	2.87	96.1
11731	7.42	1.46	68.4	3.64	0.58	52.7	12.79	2.29	43.9
15250	8.82	1.22	48.1	4.31	0.65	52.5	17.22	1.79	25.4

TABLE F42. MEAN VALUES, STANDARD ERRORS, AND COEFFICIENTS OF VARIATION FOR FIFTH-YEAR LEAF AREA/TREE AT MID-RANGE SITE. Each mean represents from two to twelve trees. Values are in square meters.

SPACING	DOUGLAS-FIR ONLY			DOUGLAS-FIR/GRASS			DOUGLAS-FIR/RED ALDER		
cm^2/tree	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.
300	0.55	0.15	65.9	0.85	0.28	93.4	0.61	0.18	50.0
390	0.43	0.16	96.5	0.96	0.16	48.8	0.39	0.07	30.5
506	1.49	0.43	80.9	0.92	0.27	91.7	0.56	0.50	128.7
658	1.16	0.32	84.2	0.96	0.24	78.3	1.94	1.40	102.4
854	1.25	0.35	83.0	1.49	0.48	106.1	0.48	0.30	108.3
1110	1.61	0.24	41.2	1.00	0.24	74.2	0.68	0.35	89.8
1441	2.04	0.51	78.5	1.97	0.38	61.1	0.82	0.50	122.4
1827	2.42	0.46	60.3	1.95	0.43	73.0	0.82	0.29	62.1
2432	3.16	0.54	53.8	2.33	0.49	69.2	2.43	0.56	45.9
3159	3.17	0.28	28.8	2.65	0.37	46.1	1.35	0.83	106.1
4107	3.92	0.78	65.7	2.15	0.34	55.0	3.48	0.40	25.5
5339	3.57	0.58	43.3	3.17	0.45	45.3	3.87	0.74	38.4
6941	6.72	0.73	32.4	2.48	0.32	42.6	4.60	0.82	43.6
9024	3.27	0.45	38.7	3.12	0.63	67.4	4.97	0.84	41.3
11731	5.78	0.71	41.0	2.97	0.52	58.1	10.12	2.47	59.8
15250	6.31	1.33	59.8	2.47	0.41	49.4	10.02	1.72	38.4

TABLE F43. MEAN VALUES, STANDARD ERRORS, AND COEFFICIENTS OF VARIATION FOR FIFTH-YEAR LEAF AREA/TREE AT COAST SITE. Each mean represents from two to twelve trees. Values are in square meters.

SPACING	DOUGLAS-FIR ONLY			DOUGLAS-FIR/GRASS			DOUGLAS-FIR/RED ALDER		
cm^2/tree	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.
300	0.94	0.42	132.2	1.10	0.28	80.7	1.04	0.58	111.5
390	0.79	0.19	80.3	0.77	0.34	130.2	0.60	0.32	109.0
506	0.92	0.23	80.3	1.13	0.25	65.5	1.34	0.55	82.1
658	1.27	0.38	91.1	0.80	0.11	40.2	1.94	0.72	75.0
854	1.04	0.25	76.7	0.94	0.32	96.3	1.74	1.28	147.4
1110	1.76	0.26	47.5	2.29	0.94	130.3	1.92	0.29	26.1
1441	1.81	0.56	103.5	1.04	0.30	94.9	2.54	1.25	98.4
1827	2.70	0.54	66.8	1.60	0.49	101.9	3.76	0.48	25.5
2432	2.60	0.83	106.2	2.38	0.56	74.7	3.10	1.17	75.5
3159	5.33	0.79	49.0	3.44	1.28	128.6	2.86	0.90	62.7
4107	3.78	0.78	71.3	3.01	0.65	74.8	2.08	0.69	74.1
5339	4.54	0.94	68.4	5.20	0.84	56.3	4.10	1.02	60.9
6941	6.01	0.84	46.3	5.29	0.77	50.1	3.95	1.29	80.0
9024	5.51	0.94	58.8	5.58	0.82	48.9	2.54	0.52	50.6
11731	9.36	1.14	40.4	6.17	1.49	80.2	3.24	0.77	58.3
15250	11.30	1.69	51.9	7.00	1.22	57.9	6.56	1.11	41.4

TABLE F44. ANALYSIS OF VARIANCE FOR FIFTH-YEAR LEAF AREA/TREE.

SOURCE OF VARIATION	D.F.	SUM OF SQ.	MEAN SQ.	F
Site	2	136.4	68.2	2.16
Plot(Site)	3	94.8	31.6	
Competitor	2	514.9	257.4	21.45***
Site*Competitor	4	311.3	77.8	6.48**
Plot(Site)*Co	6	71.8	12.0	
Density	15	5341.7	356.1	63.1 ***
Site*Density	30	22.3	0.74	0.13
Plot(Site)*Dens	45	253.9	5.64	
Co*Dens	30	470.8	15.69	4.22***
Site*Co*Dens	60	996.3	16.60	4.46***
Plot(Site)*Co*Dens	87	323.3	3.72	
Error	926	4712.2	5.09	
Mean	1	12459.5		
Total	1211	25709.2		

* α=0.10 ** α=0.05 *** α=0.01

TABLE F45. MEAN VALUES, STANDARD ERRORS, AND COEFFICIENTS OF VARIATION FOR FIFTH-YEAR LEAF AREA INDEX AT VALLEY SITE. Each mean represents from one to twelve trees. Values are in square meters/square meters.

SPACING	DOUGLAS-FIR ONLY			DOUGLAS-FIR/GRASS			DOUGLAS-FIR/RED ALDER		
cm^2/tree	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.
300	32.8	11.1	101.6	45.7	18.0	130.8	45.4	14.1	62.2
390	14.2	4.2	88.0	20.1	5.4	92.4	16.8	3.4	40.1
506	20.9	3.9	62.1	25.7	3.8	46.4	12.9	6.4	99.1
658	21.1	3.6	51.4	15.7	3.4	65.8	20.4	8.5	83.5
854	19.9	4.5	78.5	13.6	3.5	90.0	11.2	---	----
1110	17.4	2.2	44.5	12.4	2.0	56.2	22.7	13.1	115.3
1441	14.4	3.0	73.1	10.3	1.9	62.7	16.9	4.8	57.0
1827	13.2	1.5	36.8	12.8	2.4	64.5	21.1	7.0	57.1
2432	17.2	2.8	56.8	11.7	2.7	76.2	13.7	2.6	33.0
3159	9.9	1.7	58.9	8.5	1.7	70.8	14.5	4.6	63.4
4107	11.0	1.1	35.3	4.7	0.5	34.3	8.9	2.6	71.4
5339	9.5	1.4	50.7	4.6	1.0	68.1	12.7	3.1	59.6
6941	10.8	1.4	45.6	6.1	1.2	70.3	8.0	1.4	42.7
9024	6.7	0.8	42.1	2.7	0.4	46.8	7.4	3.2	96.1
11731	6.3	1.2	68.4	3.1	0.5	52.7	10.9	2.0	43.9
15250	5.8	0.8	48.1	2.8	0.4	52.5	11.3	1.2	25.4

TABLE F46. MEAN VALUES, STANDARD ERRORS, AND COEFFICIENTS OF VARIATION FOR FIFTH-YEAR LEAF AREA INDEX AT MID-RANGE SITE. Each mean represents from two to twelve trees. Values are in square meters/square meters.

SPACING	DOUGLAS-FIR ONLY			DOUGLAS-FIR/GRASS			DOUGLAS-FIR/RED ALDER		
cm^2/tree	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.
300	18.2	4.9	65.9	28.3	9.3	93.4	20.5	5.9	50.0
390	11.0	4.0	96.5	24.6	4.0	48.8	9.9	1.8	30.5
506	29.5	8.4	80.9	18.1	5.2	91.7	11.0	10.0	128.7
658	17.6	4.9	84.2	14.5	3.6	78.3	29.4	21.3	102.4
854	14.6	4.1	83.0	17.4	5.6	106.1	5.6	3.5	108.3
1110	14.5	2.1	41.2	9.0	2.1	74.2	6.1	3.2	89.8
1441	14.2	3.5	78.5	13.7	2.6	61.1	5.7	3.5	122.4
1827	13.3	2.5	60.3	10.7	2.3	73.0	4.5	1.6	62.1
2432	13.0	2.2	53.8	9.6	2.0	69.2	10.0	2.3	45.9
3159	10.0	0.9	28.8	8.4	1.2	46.1	4.3	2.6	106.1
4107	9.5	1.9	65.7	5.2	0.8	55.0	8.5	1.0	25.5
5339	6.7	1.1	43.3	5.9	0.8	45.3	7.2	1.4	38.4
6941	9.7	1.0	32.4	3.6	0.5	42.6	6.6	1.2	43.6
9024	3.6	0.5	38.7	3.5	0.7	67.4	5.5	0.9	41.3
11731	4.9	0.6	41.0	2.5	0.4	58.1	8.6	2.1	59.8
15250	4.1	0.9	59.8	1.6	0.3	49.4	6.6	1.1	38.4

TABLE F47. MEAN VALUES, STANDARD ERRORS, AND COEFFICIENTS OF VARIATION FOR FIFTH-YEAR LEAF AREA INDEX AT COAST SITE. Each mean represents from two to twelve trees. Values are in square meters/square meters.

SPACING	DOUGLAS-FIR ONLY			DOUGLAS-FIR/GRASS			DOUGLAS-FIR/RED ALDER		
cm^2/tree	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.
300	31.2	13.8	132.2	36.8	9.4	80.7	34.6	19.3	111.5
390	20.3	4.9	80.3	19.8	8.6	130.2	15.3	8.3	109.0
506	18.1	4.6	80.3	22.3	4.9	65.5	26.5	10.9	82.1
658	19.2	5.8	91.1	12.2	1.7	40.2	29.4	11.0	75.0
854	12.1	2.9	76.7	11.0	3.7	96.3	20.4	15.0	147.4
1110	15.8	2.4	47.5	20.6	8.5	130.3	17.3	2.6	26.1
1441	12.5	3.9	103.5	7.2	2.1	94.9	17.6	8.7	98.4
1827	14.8	3.0	66.8	8.8	2.7	101.9	20.6	2.6	25.5
2432	10.7	3.4	106.2	9.8	2.3	74.7	12.8	4.8	75.5
3159	16.9	2.5	49.0	10.9	4.0	128.6	9.0	2.8	62.7
4107	9.2	1.9	71.3	7.3	1.6	74.8	5.1	1.7	74.1
5339	8.5	1.8	68.4	9.7	1.6	56.3	7.7	1.9	60.9
6941	8.7	1.2	46.3	7.6	1.1	50.1	5.7	1.9	80.0
9024	6.1	1.0	58.8	6.2	0.9	48.9	2.8	0.6	50.6
11731	8.0	1.0	40.4	5.3	1.3	80.2	2.8	0.7	58.3
15250	7.4	1.1	51.9	4.6	0.8	57.9	4.3	0.7	41.4

TABLE F48. ANALYSIS OF VARIANCE FOR FIFTH-YEAR LEAF AREA INDEX.

SOURCE OF VARIATION	D.F.	SUM OF SQ.	MEAN SQ.	F
Site	2	1539	769.5	0.57
Plot(Site)	3	4068	1356	
Competitor	2	597	298.5	1.48
Site*Competitor	4	612	153	0.76
Plot(Site)*Co	6	1213	202	
Density	15	58915	3928	14.99***
Site*Density	30	3241	108	0.41
Plot(Site)*Density	45	11800	262	
Co*Dens	30	4405	146.8	1.36
Site*Co*Dens	60	5902	98.4	0.91
Plot(Site)*Co*Dens	87	9393	108.0	
Error	926	114899	156.5	
Mean	1	186923		
Total	1211	433506		

* α=0.10 ** α=0.05 *** α=0.01

TABLE F49. MEAN VALUES, STANDARD ERRORS, AND COEFFICIENTS OF VARIATION FOR FIFTH-YEAR STEMWOOD VOLUME PRODUCTION/TREE/LEAF AREA FOR VALLEY SITE. Each value represents from one to twelve trees. Values are in cubic meters X 10000/square meter.

SPACING	DOUGLAS-FIR ONLY			DOUGLAS-FIR/GRASS			DOUGLAS-FIR/RED ALDER		
cm^2/tree	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.
300	0.81	0.04	14.1	1.11	0.10	31.0	0.96	0.16	33.4
390	0.83	0.06	21.5	1.14	0.09	26.8	1.13	0.12	20.7
506	1.07	0.07	22.4	1.17	0.06	15.5	1.12	0.20	34.9
658	1.02	0.06	16.8	1.34	0.11	25.1	0.85	0.08	19.4
854	1.06	0.06	20.9	1.32	0.12	30.5	0.98	----	----
1110	1.29	0.12	32.7	1.31	0.06	15.2	0.97	0.05	10.9
1441	1.05	0.06	20.2	1.44	0.10	23.5	0.85	0.06	13.5
1827	1.29	0.14	36.2	1.55	0.09	20.8	1.24	0.11	15.6
2432	1.12	0.08	25.1	1.49	0.08	17.6	1.10	0.06	8.6
3159	1.49	0.11	25.6	1.44	0.08	20.2	1.21	0.30	49.8
4107	1.43	0.06	14.4	1.42	0.06	15.2	1.07	0.10	22.8
5339	1.41	0.07	18.1	1.43	0.08	19.3	1.13	0.06	11.8
6941	1.41	0.07	16.7	1.58	0.11	24.5	1.14	0.06	13.9
9024	1.59	0.06	11.9	1.55	0.12	25.9	1.04	0.09	20.3
11731	1.51	0.09	20.8	1.55	0.10	21.0	1.01	0.09	22.9
15250	1.63	0.06	13.0	1.61	0.10	20.5	1.06	0.11	26.0

TABLE F50. MEAN VALUES, STANDARD ERRORS, AND COEFFICIENTS OF VARIATION FOR FIFTH-YEAR STEMWOOD VOLUME PRODUCTION/TREE/LEAF AREA FOR MID-RANGE SITE. Each value represents from two to twelve trees. Values are in cubic meters X 10000/square meter.

SPACING	DOUGLAS-FIR ONLY			DOUGLAS-FIR/GRASS			DOUGLAS-FIR/RED ALDER		
cm^2/tree	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.
300	0.93	0.06	15.8	0.85	0.08	26.8	0.90	0.26	50.2
390	1.01	0.08	21.3	1.09	0.05	13.8	0.75	0.34	78.4
506	1.32	0.25	53.0	1.15	0.16	44.9	1.52	0.13	12.1
658	1.03	0.06	16.6	1.25	0.07	17.4	1.14	0.08	10.6
854	1.30	0.19	44.8	1.29	0.12	29.7	0.85	0.22	45.1
1110	1.24	0.06	14.5	1.33	0.24	55.9	0.87	0.19	38.0
1441	1.23	0.08	20.7	1.28	0.05	11.7	0.98	0.09	18.9
1827	1.29	0.06	14.7	1.43	0.08	18.2	1.06	0.12	19.2
2432	1.28	0.10	23.6	1.41	0.05	11.9	1.33	0.29	44.2
3159	1.26	0.05	13.4	1.63	0.09	19.2	0.86	0.14	27.5
4107	1.26	0.09	23.8	1.43	0.08	20.3	1.25	0.15	26.1
5339	1.43	0.19	34.7	1.67	0.09	17.0	1.12	0.18	33.1
6941	1.44	0.13	26.9	1.78	0.08	15.3	1.13	0.06	14.1
9024	1.47	0.08	16.5	1.79	0.15	27.1	1.01	0.09	22.0
11731	1.49	0.10	23.3	1.67	0.13	25.4	1.39	0.14	23.8
15250	2.01	0.21	29.8	1.70	0.10	16.7	1.34	0.12	20.6

TABLE F51. MEAN VALUES, STANDARD ERRORS, AND COEFFICIENTS OF VARIATION FOR FIFTH-YEAR STEMWOOD VOLUME PRODUCTION/TREE/LEAF AREA FOR COAST SITE. Each value represents from two to twelve trees. Values are in cubic meters X 10000/square meter.

SPACING	DOUGLAS-FIR ONLY			DOUGLAS-FIR/GRASS			DOUGLAS-FIR/RED ALDER		
cm^2/tree	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.
300	1.02	0.10	29.5	1.78	0.47	83.4	1.37	0.33	48.8
390	1.10	0.11	33.6	1.53	0.12	22.8	1.19	0.06	10.9
506	1.25	0.10	24.2	1.49	0.11	21.4	1.89	0.33	34.8
658	1.38	0.13	28.2	1.62	0.17	29.1	1.34	0.05	7.3
854	1.35	0.16	37.3	1.50	0.16	29.9	1.95	0.27	27.4
1110	1.46	0.10	22.3	1.58	0.11	21.3	1.64	0.19	20.4
1441	1.56	0.11	22.7	1.91	0.14	25.1	1.59	0.11	14.1
1827	1.65	0.14	27.3	2.15	0.44	68.4	1.70	0.27	31.2
2432	1.71	0.16	31.8	2.36	0.14	19.3	1.75	0.04	4.4
3159	1.60	0.16	34.1	2.03	0.07	12.3	1.66	0.30	35.7
4107	1.68	0.11	22.6	2.31	0.18	26.8	1.39	0.10	16.2
5339	1.86	0.16	27.5	2.15	0.14	22.0	1.71	0.12	17.8
6941	1.51	0.09	19.8	2.14	0.13	20.4	1.75	0.18	24.6
9024	1.79	0.12	22.9	1.81	0.14	25.9	1.52	0.13	21.4
11731	1.82	0.10	18.5	2.08	0.09	14.0	1.69	0.16	22.9
15250	1.83	0.14	25.5	2.28	0.06	20.9	1.81	0.13	17.0

TABLE F52. ANALYSIS OF VARIANCE FOR FIFTH-YEAR STEMWOOD VOLUME PRODUCTION/TREE/LEAF AREA.

SOURCE OF VARIATION	D.F.	SUM OF SQ.	MEAN SQ.	F
Site	2	46.71	23.36	39.59**
Plot(Site)	3	1.78	0.59	
Competitor	2	18.62	9.31	12.17**
Site*Competitor	4	6.60	1.65	2.16
Plot(Site)*Co	6	4.59	0.765	
Density	15	39.47	2.63	14.61***
Site*Density	30	4.76	0.16	0.89
Plot(Site)*Density	45	7.93	0.18	
Co*Dens	30	10.91	0.36	2.00**
Site*Co*Dens	60	8.14	0.14	0.78
Plot(Site)*Co*Dens	87	15.34	0.18	
Error	925	148.41	0.16	
Mean	1	2562.16		
Total	1210	2875.42		

* α=0.10 ** α=0.05 *** α=0.01

TABLE F53. MEAN VALUES, STANDARD ERRORS, AND COEFFICIENTS OF VARIATION FOR FIFTH-YEAR STEMWOOD VOLUME PRODUCTION/TREE/LEAF AREA INDEX FOR VALLEY SITE. Each value represents from one to twelve trees. Values are in cubic meters X 10000/square meter/square meter.

SPACING	DOUGLAS-FIR ONLY			DOUGLAS-FIR/GRASS			DOUGLAS-FIR/RED ALDER		
cm^2/tree	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.
300	0.024	0.001	14.1	0.033	0.003	31.0	0.029	0.005	33.4
390	0.032	0.002	21.5	0.044	0.003	26.8	0.044	0.005	20.7
506	0.054	0.004	22.4	0.059	0.003	15.5	0.057	0.010	34.9
658	0.067	0.004	16.8	0.088	0.007	25.1	0.056	0.005	19.4
854	0.090	0.005	20.9	0.113	0.010	30.5	0.083	-----	----
1110	0.143	0.014	32.7	0.146	0.006	15.2	0.107	0.006	10.9
1441	0.151	0.009	20.2	0.208	0.015	23.5	0.123	0.008	13.5
1827	0.236	0.026	36.2	0.282	0.017	20.8	0.226	0.020	15.6
2432	0.272	0.020	25.1	0.361	0.019	17.6	0.267	0.013	8.6
3159	0.470	0.035	25.6	0.455	0.027	20.2	0.382	0.095	49.8
4107	0.587	0.024	14.4	0.583	0.027	15.2	0.441	0.041	22.8
5339	0.752	0.039	18.1	0.762	0.044	19.3	0.605	0.029	11.8
6941	0.981	0.047	16.7	1.099	0.078	24.5	0.793	0.045	13.9
9024	1.438	0.049	11.9	1.396	0.104	25.9	0.940	0.085	20.3
11731	1.768	0.106	20.8	1.815	0.115	21.0	1.182	0.111	22.9
15250	2.486	0.094	13.0	2.458	0.146	20.5	1.614	0.172	26.0

TABLE F54. MEAN VALUES, STANDARD ERRORS, AND COEFFICIENTS OF VARIATION FOR FIFTH-YEAR STEMWOOD VOLUME PRODUCTION/TREE/LEAF AREA INDEX FOR MID-RANGE SITE. Each value represents fom two to twelve trees. Values are in cubic meters X 10000/square meter/square meter.

SPACING	DOUGLAS-FIR ONLY			DOUGLAS-FIR/GRASS			DOUGLAS-FIR/RED ALDER		
cm^2/tree	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.
300	0.028	0.002	15.8	0.025	0.002	26.8	0.027	0.008	50.2
390	0.039	0.003	21.3	0.042	0.002	13.8	0.029	0.013	78.4
506	0.067	0.013	53.0	0.058	0.008	44.9	0.077	0.007	12.1
658	0.068	0.004	16.6	0.082	0.005	17.4	0.075	0.006	10.6
854	0.111	0.017	44.8	0.110	0.010	29.7	0.073	0.019	45.1
1110	0.138	0.007	14.5	0.148	0.026	55.9	0.096	0.021	38.0
1441	0.177	0.012	20.7	0.184	0.007	11.7	0.142	0.013	18.9
1827	0.236	0.011	14.7	0.262	0.014	18.2	0.194	0.022	19.2
2432	0.310	0.023	23.6	0.343	0.012	11.7	0.323	0.071	44.2
3159	0.398	0.016	13.4	0.515	0.030	19.2	0.271	0.043	27.5
4107	0.519	0.037	23.8	0.589	0.034	20.3	0.515	0.060	26.1
5339	0.763	0.100	34.7	0.891	0.048	17.0	0.597	0.099	33.1
6941	1.003	0.090	26.9	1.238	0.057	15.3	0.785	0.045	14.1
9024	1.324	0.077	16.5	1.613	0.132	27.1	0.910	0.082	22.0
11731	1.744	0.122	23.3	1.962	0.150	25.4	1.635	0.159	23.8
15250	3.065	0.323	29.8	2.587	0.144	16.7	2.041	0.188	20.6

TABLE F55. MEAN VALUES, STANDARD ERRORS, AND COEFFICIENTS OF VARIATION FOR FIFTH-YEAR STEMWOOD VOLUME PRODUCTION/TREE/LEAF AREA INDEX FOR COAST SITE. Each value represents from two to twelve trees. Values are in cubic meters X 10000/square meter/square meter.

SPACING	DOUGLAS-FIR ONLY			DOUGLAS-FIR/GRASS			DOUGLAS-FIR/RED ALDER		
cm^2/tree	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.
300	0.031	0.003	29.5	0.053	0.014	83.4	0.041	0.010	48.8
390	0.043	0.004	33.6	0.060	0.005	22.8	0.046	0.003	10.9
506	0.063	0.005	24.2	0.075	0.005	21.4	0.096	0.017	34.8
658	0.091	0.009	28.2	0.107	0.011	29.1	0.088	0.003	7.3
854	0.115	0.014	37.3	0.128	0.014	29.9	0.167	0.023	27.4
1110	0.162	0.011	22.3	0.175	0.012	21.3	0.182	0.021	20.4
1441	0.225	0.015	22.7	0.275	0.021	25.1	0.229	0.016	14.1
1827	0.301	0.025	27.3	0.392	0.081	68.4	0.311	0.049	31.2
2432	0.416	0.040	31.8	0.574	0.035	19.3	0.426	0.009	4.4
3159	0.504	0.052	34.1	0.641	0.023	12.3	0.524	0.093	35.7
4107	0.691	0.045	22.6	0.947	0.073	26.8	0.570	0.041	16.2
5339	0.994	0.082	27.5	1.147	0.073	22.0	0.912	0.066	17.8
6941	1.050	0.063	19.8	1.486	0.088	20.4	1.216	0.122	24.6
9024	1.612	0.107	22.9	1.631	0.127	25.9	1.373	0.120	21.4
11731	2.135	0.119	18.5	2.443	0.103	14.0	1.988	0.186	22.9
15250	2.788	0.206	25.5	3.477	0.305	29.1	2.761	0.192	17.0

TABLE F56. ANALYSIS OF VARIANCE FOR FIFTH-YEAR STEMWOOD VOLUME PRODUCTION/TREE/LEAF AREA INDEX.

SOURCE OF VARIATION	D.F.	SUM OF SQ.	MEAN SQ.	F
Site	2	10.32	5.16	27.16***
Plot(Site)	3	0.57	0.19	
Competitor	2	1.34	0.67	1.06
Site*Competitor	4	1.80	0.45	0.71
Plot(Site)*Co	6	3.76	0.63	
Density	15	691.78	46.12	922.4 ***
Site*Density	30	8.37	0.28	5.6 ***
Plot(Site)*Density	45	2.23	0.05	
Co*Dens	30	13.01	0.43	14.33***
Site*Co*Dens	60	4.77	0.08	2.67***
Plot(Site)*Co*Dens	87	2.6	0.03	
Error	925	37.01	0.04	
Mean	1	591.03		
Total	1210	1068.58		

* α=0.10   ** α=0.05   *** α=0.01

TABLE F57. VALUES FOR FIFTH-YEAR STEMWOOD VOLUME PRODUCTION/HECTARE/ LEAF AREA INDEX FOR VALLEY SITE. Values were determined from sums, so no errors of estimation are available. Douglas-fir/ Red alder values have been doubled to compensate for the half-density of Douglas-fir trees in that treatment. Values are in cubic meters/hectare/square meter/square meter.

SPACING cm^2/tree	DOUGLAS-FIR ONLY $M^3/HA/M^2/M^2$	DOUGLAS-FIR/GRASS $M^3/HA/M^2/M^2$	DOUGLAS-FIR/RED ALDER $M^3/HA/M^2/M^2$
300	0.78	1.12	0.88
390	0.89	1.11	1.10
506	1.07	1.14	1.09
658	0.97	1.29	0.93
854	1.06	1.33	0.98
1110	1.18	1.35	0.94
1441	1.04	1.44	0.85
1827	1.31	1.54	1.18
2432	1.04	1.54	1.12
3159	1.56	1.57	1.44
4107	1.48	1.44	1.20
5339	1.38	1.42	1.13
6941	1.40	1.65	1.13
9024	1.57	1.60	1.18
11731	1.61	1.61	1.02
15250	1.61	1.64	1.09

TABLE F58. VALUES FOR FIFTH-YEAR STEMWOOD VOLUME PRODUCTION/HECTARE/ LEAF AREA INDEX FOR MID-RANGE SITE. Values were determined from sums, so no errors of estimation are available. Douglas-fir/ Red alder values have been doubled to compensate for the half-density of Douglas-fir trees in that treatment. Values are in cubic meters/hectare/square meter/square meter.

SPACING cm^2/tree	DOUGLAS-FIR ONLY $M^3/HA/M^2/M^2$	DOUGLAS-FIR/GRASS $M^3/HA/M^2/M^2$	DOUGLAS-FIR/RED ALDER $M^3/HA/M^2/M^2$
300	0.94	0.84	0.64
390	0.98	1.09	0.58
506	1.08	1.02	0.94
658	1.06	1.27	0.80
854	1.23	1.24	0.57
1110	1.24	1.36	0.67
1441	1.23	1.34	0.70
1827	1.32	1.44	0.71
2432	1.07	1.45	0.92
3159	1.24	1.67	0.67
4107	1.30	1.52	1.23
5339	1.41	1.72	1.12
6941	1.47	1.79	1.14
9024	1.46	1.93	1.01
11731	1.54	1.64	1.52
15250	1.82	1.68	1.38

TABLE F59. VALUES FOR FIFTH-YEAR STEMWOOD VOLUME PRODUCTION/HECTARE/LEAF AREA INDEX FOR COAST SITE. Values were determined from sums, so no errors of estimation are available. Douglas-fir/Red alder values have been doubled to compensate for the half-density of Douglas-fir trees in that treatment. Values are in cubic meters/hectare/square meter/square meter.

SPACING cm^2/tree	DOUGLAS-FIR ONLY $M^3/HA/M^2/M^2$	DOUGLAS-FIR/GRASS $M^3/HA/M^2/M^2$	DOUGLAS-FIR/RED ALDER $M^3/HA/M^2/M^2$
300	1.19	1.49	1.50
390	1.08	1.48	1.21
506	1.29	1.49	1.50
658	1.40	1.64	1.32
854	1.34	1.59	1.60
1110	1.43	1.68	1.66
1441	1.47	2.05	1.54
1827	1.52	1.76	1.68
2432	1.93	2.30	1.80
3159	1.51	2.03	1.62
4107	1.76	2.32	1.34
5339	2.09	2.07	1.81
6941	1.45	2.22	1.66
9024	1.90	1.89	1.50
11731	1.42	2.12	1.63
15250	1.82	2.30	1.90

TABLE F60. MEAN VALUES, STANDARD ERRORS, AND COEFFICIENTS OF VARIATION FOR FIFTH-YEAR BASAL AREA GROWTH/TREE/LEAF AREA INDEX FOR VALLEY SITE. Each mean represents from one to twelve trees. Values are in square centimeters/square meter /square meter .

SPACING	DOUGLAS-FIR ONLY			DOUGLAS-FIR/GRASS			DOUGLAS-FIR/RED ALDER		
cm^2/tree	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.
300	0.033	0.005	46.7	0.037	0.006	51.9	0.038	0.007	36.8
390	0.046	0.004	26.8	0.053	0.006	38.0	0.055	0.006	23.3
506	0.059	0.007	41.8	0.056	0.004	21.3	0.120	0.055	92.0
658	0.067	0.009	39.1	0.092	0.010	31.9	0.087	0.010	23.5
854	0.095	0.008	28.4	0.148	0.028	64.8	0.123	-----	----
1110	0.127	0.018	48.4	0.160	0.012	26.8	0.139	0.017	24.1
1441	0.160	0.021	45.8	0.215	0.016	24.6	0.163	0.023	27.8
1827	0.196	0.017	28.1	0.294	0.043	50.9	0.239	0.046	33.6
2432	0.287	0.067	80.8	0.369	0.033	29.7	0.295	0.011	6.4
3159	0.432	0.041	32.6	0.521	0.034	22.8	0.357	0.031	17.4
4107	0.463	0.015	11.4	0.704	0.030	14.1	0.635	0.214	82.5
5339	0.641	0.049	26.5	0.907	0.054	19.9	0.600	0.102	41.8
6941	0.752	0.028	12.8	1.250	0.112	31.0	0.760	0.043	13.9
9024	1.438	0.087	23.9	1.668	0.092	19.2	0.969	0.083	29.7
11731	1.768	0.131	26.4	2.099	0.118	18.6	0.935	0.034	19.9
15250	2.118	0.135	22.0	2.728	0.147	18.7	1.139	0.028	14.6

TABLE F61. MEAN VALUES, STANDARD ERRORS, AND COEFFICIENTS OF VARIATION FOR FIFTH-YEAR BASAL AREA GROWTH/TREE/LEAF AREA INDEX FOR MID-RANGE SITE. Each mean represents from two to twelve trees. Values are in square centimeters/square meter /square meter .

SPACING	DOUGLAS-FIR ONLY			DOUGLAS-FIR/GRASS			DOUGLAS-FIR/RED ALDER		
cm^2/tree	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.
300	0.035	0.005	37.3	0.032	0.004	37.2	0.038	0.006	26.4
390	0.066	0.011	45.2	0.043	0.003	21.8	0.054	0.021	67.9
506	0.085	0.035	116.5	0.078	0.016	63.4	0.164	0.091	78.3
658	0.083	0.015	53.2	0.109	0.018	50.9	0.096	0.020	28.8
854	0.134	0.026	58.7	0.141	0.024	56.2	0.172	0.031	30.9
1110	0.132	0.007	15.9	0.173	0.026	47.6	0.182	0.049	46.5
1441	0.177	0.014	24.7	0.196	0.009	14.0	0.292	0.074	50.7
1827	0.239	0.019	25.6	0.298	0.030	33.1	0.326	0.060	32.2
2432	0.304	0.026	27.4	0.378	0.030	26.2	0.371	0.086	46.3
3159	0.381	0.013	11.6	0.517	0.030	19.2	0.525	0.150	49.5
4107	0.614	0.102	54.9	0.749	0.043	19.7	0.484	0.067	30.8
5339	0.773	0.070	23.9	1.004	0.063	20.0	0.601	0.079	26.3
6941	0.886	0.041	13.9	1.504	0.080	17.6	0.730	0.044	14.9
9024	1.457	0.097	18.8	2.010	0.167	27.5	0.939	0.046	12.0
11731	1.873	0.097	17.2	2.429	0.158	21.5	1.255	0.096	18.8
15250	2.938	0.357	34.4	3.638	0.327	27.0	1.634	0.126	17.2

TABLE F62. MEAN VALUES, STANDARD ERRORS, AND COEFFICIENTS OF VARIATION FOR FIFTH-YEAR BASAL AREA GROWTH/TREE/LEAF AREA INDEX FOR COAST SITE. Each mean represents from two to twelve trees. Values are in square centimeters/square meter /square meter .

SPACING	DOUGLAS-FIR ONLY			DOUGLAS-FIR/GRASS			DOUGLAS-FIR/RED ALDER		
cm^2/tree	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.
300	0.034	0.005	41.6	0.053	0.013	75.3	0.043	0.008	38.7
390	0.064	0.020	101.8	0.089	0.019	63.4	0.063	0.012	38.2
506	0.065	0.005	24.8	0.074	0.007	29.0	0.099	0.034	69.8
658	0.087	0.011	39.5	0.112	0.009	21.9	0.080	0.008	20.8
854	0.113	0.012	34.6	0.156	0.022	39.3	0.160	0.029	36.2
1110	0.135	0.013	30.9	0.175	0.011	20.1	0.139	0.011	13.1
1441	0.231	0.040	57.1	0.345	0.048	46.0	0.222	0.036	32.2
1827	0.245	0.028	38.5	0.497	0.163	108.7	0.247	0.034	27.4
2432	0.330	0.019	18.8	0.477	0.035	23.5	0.380	0.035	18.4
3159	0.364	0.056	50.8	0.618	0.103	57.5	0.502	0.110	43.9
4107	0.578	0.039	23.2	0.744	0.052	24.3	0.647	0.098	33.9
5339	0.759	0.046	20.0	0.827	0.067	28.3	0.795	0.027	8.4
6941	0.834	0.060	23.7	1.091	0.056	17.9	1.233	0.167	33.3
9024	1.309	0.070	18.4	1.377	0.131	31.5	1.669	0.292	42.9
11731	1.490	0.083	18.5	1.955	0.128	21.8	2.140	0.215	24.6
15250	2.081	0.175	29.1	2.733	0.253	30.7	2.527	0.165	16.0

TABLE F63. ANALYSIS OF VARIANCE FOR FIFTH-YEAR BASAL AREA GROWTH/TREE/LEAF AREA INDEX.

SOURCE OF VARIATION	D.F.	SUM OF SQ.	MEAN SQ.	F
Site	2	2.45	1.225	2.36
Plot(Site)	3	1.56	0.52	
Competitor	2	8.31	4.155	18.89***
Site*Competitor	4	3.35	0.838	3.81*
Plot(Site)*Co	6	1.33	0.22	
Density	15	608.22	40.55	779.81***
Site*Density	30	7.56	0.25	4.81***
Plot(Site)*Density	45	2.34	0.052	
Co*Dens	30	25.89	0.863	4.54***
Site*Co*Dens	60	16.87	0.28	1.47*
Plot(Site)*Co*Dens	87	16.85	0.19	
Error	925	194.25	0.21	
Mean	1	554.23		
Total	1210	1443.21		

* α=0.10   ** α=0.05   *** α=0.01

TABLE F64. VALUES FOR FIFTH-YEAR BASAL AREA GROWTH/HECTARE/LEAF AREA INDEX FOR VALLEY SITE. Values were determined from sums, so no errors of estimation are available. Douglas-fir/Red alder values were doubled to compensate for the half-density of the Douglas-fir in that treatment. Values are in square meters/hectare/square meter/square meter.

SPACING cm^2/tree	DOUGLAS-FIR ONLY $M^2/HA/M^2/M^2$	DOUGLAS-FIR/GRASS $M^2/HA/M^2/M^2$	DOUGLAS-FIR/RED ALDER $M^2/HA/M^2/M^2$
300	0.72	0.85	1.11
390	1.03	1.08	1.33
506	0.96	1.05	1.34
658	0.80	1.19	1.16
854	0.91	1.27	1.44
1110	0.99	1.30	1.00
1441	0.83	1.36	1.01
1827	1.05	1.31	1.14
2432	0.81	1.34	1.24
3159	1.21	1.47	1.16
4107	1.13	1.70	1.04
5339	1.08	1.56	0.92
6941	1.04	1.57	1.06
9024	1.30	1.80	0.89
11731	1.28	1.70	0.78
15250	1.28	1.71	0.75

TABLE F65. VALUES FOR FIFTH-YEAR BASAL AREA GROWTH/HECTARE/LEAF AREA INDEX FOR MID-RANGE SITE. Values were determined from sums, so no errors of estimation are available. Douglas-fir/Red alder values were doubled to compensate for the half-density of Douglas-fir trees in that treatment. Values are in square meters/hectare/square meter/square meter.

SPACING cm^2/tree	DOUGLAS-FIR ONLY $M^2/HA/M^2/M^2$	DOUGLAS-FIR/GRASS $M^2/HA/M^2/M^2$	DOUGLAS-FIR/RED ALDER $M^2/HA/M^2/M^2$
300	0.97	0.87	1.29
390	1.27	1.06	1.54
506	0.96	1.04	1.61
658	0.97	1.21	1.25
854	1.29	1.19	1.74
1110	1.16	1.42	1.58
1441	1.10	1.30	1.32
1827	1.16	1.35	2.10
2432	1.01	1.37	1.46
3159	1.10	1.56	1.16
4107	0.63	1.69	1.11
5339	1.40	1.78	1.21
6941	1.26	2.07	1.02
9024	1.56	2.02	1.00
11731	1.55	1.92	1.08
15250	1.66	2.17	1.05

TABLE F66. VALUES FOR FIFTH-YEAR BASAL AREA GROWTH/HECTARE/LEAF AREA INDEX FOR COAST SITE. Values were determined from sums, so no errors of estimation are available. Douglas-fir/Red alder values have been doubled to compensate for the half-density of the Douglas-fir trees in that treatment. Values are in square meters/hectare/square meter/square meter.

SPACING cm^2/tree	DOUGLAS-FIR ONLY $M^2/HA/M^2/M^2$	DOUGLAS-FIR/GRASS $M^2/HA/M^2/M^2$	DOUGLAS-FIR/RED ALDER $M^2/HA/M^2/M^2$
300	0.92	1.35	1.27
390	1.06	1.46	1.25
506	1.13	1.29	1.19
658	1.16	1.66	1.10
854	1.13	1.42	1.20
1110	1.13	1.29	1.24
1441	1.13	1.69	1.31
1827	1.11	1.45	1.33
2432	1.30	1.73	1.45
3159	1.02	1.36	1.36
4107	1.25	1.66	1.30
5339	1.41	1.41	1.51
6941	1.11	1.49	1.50
9024	1.39	1.39	1.65
11731	0.95	1.52	1.64
15250	1.25	1.62	1.60

TABLE F67. MEAN VALUES, STANDARD ERRORS, AND COEFFICIENTS OF VARIATION FOR FIFTH-YEAR DRY WEIGHT/TREE/LEAF AREA FOR VALLEY SITE. Each mean represents from one to twelve trees. Values are in grams/square meter .

SPACING	DOUGLAS-FIR ONLY			DOUGLAS-FIR/GRASS			DOUGLAS-FIR/RED ALDER		
cm^2/tree	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.
300	217.56	0.86	1.2	280.66	12.72	15.0	241.74	28.32	23.4
390	224.80	1.79	2.4	283.29	12.13	14.8	260.65	25.95	19.9
506	226.41	0.91	1.3	271.35	2.82	3.3	234.71	5.33	4.5
658	230.15	0.85	1.1	289.76	12.71	13.2	243.62	15.65	12.8
854	233.65	0.94	1.4	287.60	7.61	9.2	253.14	-----	----
1110	237.42	0.74	1.1	282.99	4.32	5.3	233.51	9.14	9.9
1441	242.46	0.98	1.4	296.25	11.93	13.4	226.38	6.90	9.4
1827	247.09	0.49	0.6	289.86	6.73	8.0	235.60	23.70	15.4
2432	254.90	1.72	2.3	287.86	2.90	3.3	237.56	6.24	4.9
3159	258.67	0.90	1.2	294.29	1.52	1.8	246.95	19.20	15.6
4107	263.80	0.16	0.2	290.35	4.70	5.4	245.03	12.13	12.1
5339	269.92	0.10	0.1	296.24	3.96	4.4	236.38	0.85	7.7
6941	276.32	0.12	0.2	298.26	4.78	5.6	235.00	3.11	3.8
9024	282.98	0.14	0.2	299.22	6.77	7.8	239.44	0.96	0.9
11731	290.06	0.13	0.2	301.79	7.45	8.2	231.60	6.92	7.3
15250	298.66	0.58	0.7	313.94	2.80	3.1	240.68	2.57	2.6

TABLE F68. MEAN VALUES, STANDARD ERRORS, AND COEFFICIENTS OF VARIATION FOR FIFTH-YEAR DRY WEIGHT/TREE/LEAF AREA FOR MID-RANGE SITE. Each mean represents from two to twelve trees. Values are in grams/square meter .

SPACING	DOUGLAS-FIR ONLY			DOUGLAS-FIR/GRASS			DOUGLAS-FIR/RED ALDER		
cm^2/tree	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.
300	239.92	13.93	14.2	260.98	14.26	15.5	286.63	64.39	38.9
390	245.24	17.90	19.3	264.79	10.97	12.4	236.43	32.31	23.7
506	254.67	18.99	21.1	279.55	19.67	22.3	397.92	162.08	57.6
658	246.30	11.95	14.6	275.12	11.48	13.2	254.24	13.12	7.3
854	266.60	28.58	32.2	280.06	19.16	22.7	278.63	22.16	13.8
1110	258.59	12.72	13.9	264.68	9.45	11.3	262.97	15.24	10.0
1441	261.22	15.97	19.3	267.42	3.93	4.6	243.89	6.82	5.6
1827	258.96	7.77	9.5	265.64	1.81	2.3	267.75	29.41	19.0
2432	262.59	6.76	8.1	275.42	5.03	6.1	253.31	12.73	10.1
3159	264.22	2.72	3.4	272.76	7.10	8.6	252.44	3.50	2.4
4107	267.24	2.60	3.2	270.62	4.75	6.1	244.59	11.44	10.5
5339	284.84	14.34	13.3	279.50	1.59	1.8	234.62	18.28	15.6
6941	277.70	2.51	2.7	284.69	3.38	3.9	242.24	8.03	8.1
9024	280.33	3.62	3.6	291.42	1.82	2.1	246.77	9.47	9.4
11731	290.32	5.15	5.9	290.93	3.66	4.2	259.57	2.44	2.3
15250	318.44	12.90	11.5	296.60	4.17	4.2	253.26	5.41	4.8

TABLE F69. MEAN VALUES, STANDARD ERRORS, AND COEFFICIENTS OF VARIATION FOR FIFTH-YEAR DRY WEIGHT/TREE/LEAF AREA FOR COAST SITE. Each mean represents from two to twelve trees. Values are in grams/square meter .

SPACING	DOUGLAS-FIR ONLY			DOUGLAS-FIR/GRASS			DOUGLAS-FIR/RED ALDER		
cm^2/tree	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.
300	277.21	19.70	21.3	318.54	8.28	8.2	344.69	47.78	27.7
390	291.75	18.66	21.2	345.24	18.61	16.2	360.32	26.34	14.9
506	297.68	21.92	23.3	344.72	21.92	19.1	469.98	100.16	42.6
658	310.74	23.76	22.9	333.48	10.27	8.7	319.91	5.75	3.6
854	316.99	26.48	26.4	322.35	12.18	10.7	420.80	59.61	28.3
1110	308.82	20.93	21.4	336.63	16.47	15.5	310.44	15.00	8.4
1441	359.32	50.98	47.1	375.41	27.39	24.2	336.96	24.60	14.6
1827	336.65	30.24	29.8	362.65	15.78	14.4	336.21	10.62	6.3
2432	308.95	10.33	11.1	360.52	13.38	11.7	334.65	7.07	4.2
3159	328.71	15.00	15.1	352.27	6.13	6.0	364.48	34.49	18.9
4107	321.77	7.95	8.6	353.08	2.43	2.4	319.09	14.60	10.2
5339	336.14	9.52	9.4	364.95	8.78	8.3	331.82	12.48	9.2
6941	325.92	4.66	4.7	355.42	4.35	4.2	328.31	13.52	10.1
9024	333.07	5.85	6.1	355.18	8.74	8.2	330.99	8.63	6.4
11731	344.86	2.78	2.7	364.62	5.25	4.8	328.82	10.00	7.4
15250	353.39	4.96	4.9	373.27	5.91	5.3	337.68	11.20	8.1

TABLE F70. ANALYSIS OF VARIANCE FOR FIFTH-YEAR DRY WEIGHT/TREE/LEAF AREA.

SOURCE OF VARIATION	D.F.	SUM OF SQ.	MEAN SQ.	F
Site	2	1348251	674126	150.91***
Plot(Site)	3	13402	4467	
Competitor	2	170890	85445	30.02***
Site*Competitor	4	113508	28377	9.97***
Plot(Site)*Co	6	17076	2846	
Density	15	136529	9102	5.86***
Site*Density	30	46802	1560	1.00
Plot(Site)*Density	45	69932	1554	
Co*Dens	30	228424	7614	11.66***
Site*Co*Dens	60	51156	853	1.31
Plot(Site)*Co*Dens	87	56819	653	
Error	926	1164415	1743	
Mean	1	104046131		
Total	1211	107913335		

* α=0.10 ** α=0.05 *** α=0.01

TABLE F71. VALUES FOR FIFTH-YEAR DRY WEIGHT/HECTARE/LEAF AREA INDEX FOR VALLEY SITE. Values were determined from sums, so no errors of estimation are available. Douglas-fir/Red alder values have been doubled to compensate for the half-density of Douglas-fir in that treatment. Values are in kilograms/hectare/square meter/square meter.

SPACING cm^2/tree	DOUGLAS-FIR ONLY $KG/HA/M^2/M^2$	DOUGLAS-FIR/GRASS $KG/HA/M^2/M^2$	DOUGLAS-FIR/RED ALDER $KG/HA/M^2/M^2$
300	2167	2964	2260
390	2229	2719	2478
506	2253	2701	2407
658	2298	2820	2330
854	2335	2860	2530
1110	2375	2823	2255
1441	2437	3005	2238
1827	2468	2893	2237
2432	2535	2828	2398
3159	2587	2934	2617
4107	2640	2902	2329
5339	2699	2957	2370
6941	2763	2978	2338
9024	2831	3027	2393
11731	2900	3048	2361
15250	2988	3139	2407

TABLE F72. VALUES FOR FIFTH-YEAR DRY WEIGHT/HECTARE/LEAF AREA INDEX FOR MID-RANGE SITE. Values were determined from sums, so no errors of estimation are available. Douglas-fir/Red alder values were doubled to compensate for the half-density of Douglas-fir trees in that treatment. Values are in kilograms/hectare/square meter/square meter.

SPACING cm^2/tree	DOUGLAS-FIR ONLY $KG/HA/M^2/M^2$	DOUGLAS-FIR/GRASS $KG/HA/M^2/M^2$	DOUGLAS-FIR/RED ALDER $KG/HA/M^2/M^2$
300	2501	2507	2787
390	2306	2669	2466
506	2579	2596	2506
658	2512	2728	2638
854	2451	2648	2546
1110	2602	2638	3362
1441	2498	2665	2487
1827	2597	2671	2806
2432	2669	2704	2544
3159	2635	2729	2510
4107	2668	2751	2445
5339	2805	2808	2353
6941	2772	2869	2408
9024	2831	2929	2526
11731	2898	2861	2616
15250	3091	2923	2552

TABLE F73. VALUES FOR FIFTH-YEAR DRY WEIGHT/HECTARE/LEAF AREA INDEX FOR COAST SITE. Values were determined from sums, so no errors of estimation are available. Douglas-fir/Red alder values have been doubled to compensate for the half-density of Douglas-fir trees in that treatment. Values are in kilograms/hectare/square meter/square meter.

SPACING cm^2/tree	DOUGLAS-FIR ONLY KG/HA/M^2/M^2	DOUGLAS-FIR/GRASS KG/HA/M^2/M^2	DOUGLAS-FIR/RED ALDER KG/HA/M^2/M^2
300	2800	3306	3482
390	2849	3463	3298
506	2869	3362	3538
658	2828	3381	3191
854	2973	3038	3433
1110	2971	2386	3084
1441	3046	3630	3318
1827	3119	3605	3360
2432	3342	3649	3381
3159	3182	3477	3362
4107	3207	3552	3173
5339	3316	3641	3388
6941	3254	3551	3248
9024	3344	3592	3317
11731	2641	3667	3351
15250	3533	3729	3437

TABLE F74. MEAN VALUES, STANDARD ERRORS, AND COEFFICIENTS OF VARIATION FOR FIFTH-YEAR LEAF AREA/TREE/SAPWOOD BASAL AREA FOR VALLEY SITE. Each mean represents from one to twelve trees. Values are in square meter /square meter .

SPACING	DOUGLAS-FIR ONLY			DOUGLAS-FIR/GRASS			DOUGLAS-FIR/RED ALDER		
cm^2/tree	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.
300	3100.3	460.1	44.5	3094.2	326.2	35.0	3566.4	529.2	29.7
390	2742.0	231.4	25.3	2944.5	259.5	30.5	3158.9	389.5	24.7
506	3220.9	239.8	24.7	3479.8	252.6	23.0	2542.6	623.5	49.0
658	3616.4	267.7	22.2	3040.5	316.6	31.2	3533.6	436.7	24.7
854	3435.8	299.7	30.2	2830.7	268.7	32.9	3252.0	-----	----
1110	3904.0	507.9	45.1	3144.9	199.5	22.0	3779.4	598.2	31.7
1441	4137.2	515.9	43.2	3159.2	195.9	20.6	4283.0	657.4	30.7
1827	4027.6	275.4	22.7	3362.5	278.8	28.7	3987.4	1026.5	44.6
2432	5018.4	645.8	44.6	3529.9	316.0	29.7	3996.4	158.1	6.9
3159	3617.1	274.0	26.2	3250.2	174.0	18.5	4414.9	462.5	21.0
4107	4196.7	126.8	10.5	3136.5	136.1	14.4	4203.5	632.7	36.9
5339	4316.7	316.0	25.4	3330.6	195.2	19.4	4881.0	594.6	29.8
6941	4812.2	182.5	13.1	3422.2	270.2	27.4	4737.5	284.9	14.7
9024	4039.6	236.6	20.3	3228.5	159.8	17.2	5166.5	535.2	23.2
11731	3994.7	281.0	24.4	3468.0	183.4	17.5	6861.1	642.8	22.9
15250	4281.7	261.9	21.2	3621.1	178.6	17.1	7193.7	410.9	14.0

TABLE F75. MEAN VALUES, STANDARD ERRORS, AND COEFFICIENTS OF VARIATION FOR FIFTH-YEAR LEAF AREA/TREE/SAPWOOD BASAL AREA FOR MID-RANGE SITE. Each mean represents from two to twelve trees. Values are in square meter /square meter .

SPACING	DOUGLAS-FIR ONLY			DOUGLAS-FIR/GRASS			DOUGLAS-FIR/RED ALDER		
cm^2/tree	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.
300	3184.4	256.4	19.7	4017.8	466.3	32.8	3074.3	485.3	27.3
390	2689.5	334.6	32.9	3858.9	243.8	19.0	4153.7	1775.6	74.0
506	3599.7	539.9	42.4	4837.9	1809.3	118.3	2096.8	1174.7	79.2
658	3767.0	375.8	29.9	3327.4	381.3	36.2	3419.0	653.8	27.0
854	3645.0	338.1	27.8	3670.1	398.4	36.0	2321.6	303.6	22.7
1110	3937.3	213.5	15.3	3672.0	318.9	27.5	3555.0	1063.2	51.8
1441	4097.8	276.4	21.3	4096.4	208.3	16.1	2933.6	710.9	48.5
1827	3951.6	284.1	22.7	3852.0	332.7	28.6	3045.1	659.3	37.5
2432	4537.6	450.5	31.4	4112.6	292.1	23.6	3947.4	646.2	32.7
3159	4637.8	142.8	10.2	4003.0	273.0	22.6	3556.6	849.7	41.4
4107	4650.1	465.7	33.2	3781.8	196.4	18.0	4928.3	471.8	21.4
5339	4377.7	348.0	21.0	3826.1	221.4	18.3	5322.7	615.4	23.1
6941	5026.7	228.9	13.7	3475.8	197.4	18.8	5537.3	329.2	14.6
9024	4126.2	279.8	19.2	3606.6	267.2	24.6	5763.2	275.8	11.7
11731	4422.5	237.0	17.8	4064.4	374.3	30.5	6045.8	458.4	18.6
15250	4032.7	388.9	27.3	3715.5	290.2	23.4	5978.3	444.5	16.6

TABLE F76. MEAN VALUES, STANDARD ERRORS, AND COEFFICIENTS OF VARIATION FOR FIFTH-YEAR LEAF AREA/TREE/SAPWOOD BASAL AREA FOR COAST SITE. Each mean represents from two to twelve trees. Values are in square meter /square meter .

SPACING	DOUGLAS-FIR ONLY			DOUGLAS-FIR/GRASS			DOUGLAS-FIR/RED ALDER		
cm^2/tree	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.	MEAN	S.E.	C.V.
300	3070.3	304.5	29.7	2660.6	312.5	37.1	2774.9	442.7	31.9
390	2708.8	293.5	35.9	2029.0	288.0	42.6	2570.4	436.0	33.9
506	2774.7	217.9	24.8	2884.9	169.0	17.6	2586.0	730.0	56.5
658	2822.2	259.0	27.5	2459.3	211.0	24.3	3426.6	359.8	21.0
854	2939.7	319.1	34.3	2564.0	410.6	45.3	2383.7	601.0	50.4
1110	3145.6	254.4	25.6	2741.4	227.6	26.3	3287.7	278.9	14.7
1441	2729.5	310.3	37.7	2140.2	229.5	35.6	3062.4	419.2	27.4
1827	3161.6	282.2	29.6	2512.7	391.5	51.7	3393.8	451.4	26.6
2432	3019.0	157.8	17.3	2429.7	188.7	24.6	2982.3	215.1	14.4
3159	4633.6	1004.3	71.9	2687.7	282.5	36.4	3305.7	688.6	41.7
4107	3100.2	197.7	22.1	2669.5	155.6	20.2	3328.0	433.0	29.1
5339	3166.3	201.3	21.1	3301.5	260.8	27.4	3386.2	145.0	10.5
6941	3945.0	378.5	31.8	3187.8	158.9	17.3	3174.4	477.3	36.8
9024	3260.7	151.8	16.1	3547.0	303.3	28.4	3164.6	398.5	30.8
11731	3807.6	240.8	21.0	3144.8	183.7	19.4	3130.9	398.4	31.2
15250	3885.6	423.9	37.8	3141.8	292.9	30.9	3457.9	198.7	14.1

TABLE F77. ANALYSIS OF VARIANCE FOR FIFTH-YEAR LEAF AREA/SAPWOOD BASAL AREA.

SOURCE OF VARIATION	D.F.	SUM OF SQ.[1]	MEAN SQ.[1]	F
Site	2	2158	1079	23.82**
Plot(Site)	3	136	45.3	
Competitor	2	970.3	485.2	11.15***
Site*Competitor	4	426.7	106.7	2.45
Plot(Site)*Co	6	261	43.5	
Density	15	1635.3	109.0	8.72***
Site*Density	30	395.7	13.2	1.06
Plot(Site)*Density	45	561	12.5	
Co*Dens	30	1213.7	40.5	0.66
Site*Co*Dens	60	1018.3	17.0	0.03
Plot(Site)*Co*Dens	87	5365	61.7	
Error	926	8006.3	8.6	
Mean	1	158052.7		
Total	1211	180200		

* α=0.10 ** α=0.05 *** α=0.01

[1] Sums of squares and mean squares have been multiplied by 0.00001 for simplification.