AN ABSTRACT OF THE THESIS OF

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Title: The Role of Density and Proportion in Allometric Equations of Douglas-fir and Red Alder Seedlings

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Allometric equations are useful tools for predicting tree biomass when direct measurements are impractical. Any factor affecting plant growth can be a significant variable in allometric equations. Density and species proportion are spatial variables that influence tree growth and should be considered when developing allometric equations. This consideration is especially pertinent when developing equations for use in replacement series experiments (de Wit, 1960), where density and species proportion are treatment variables.

Allometric equations for three-year-old Douglas-fir (*Pseudotsuga menziesii*) and red alder (*Alnus rubra*) were developed as part of a replacement series experiment in Belfair, Washington. The primary objective of the study was to generate equations for predicting seedling component biomass. Another objective was to test the significance of density and proportion in biomass prediction. Douglas-fir and red alder biomass components were best predicted by stem diameter, total height, and crown width. Density was a significant variable for predicting Douglas-fir leaf biomass and total biomass. However, density was positively correlated with biomass, contrary to normal yield-density relationships, and so was excluded from the model. The percent cover of weed species on the plot was a significant variable for predicting Douglas-fir root biomass. Red alder total biomass was correlated with proportion, indicating that biomass was higher when sample trees were surrounded by a higher number of red alder than of Douglas-fir. Generally, the most significant spatial variable for predicting Douglas-fir biomass was the percent cover of weed species. The most significant spatial variable for predicting red alder biomass was the distance to the nearest neighboring tree. Suggestions for determining the roles of density and proportion in allometric equations for use in replacement series experiments are given.

The Role of Density and Proportion in Allometric Equations of Douglas-fir and Red Alder Seedlings

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CHAPTER 1

INTRODUCTION AND OBJECTIVES OF STUDY

Allometry

Allometry is the study of the change in growth of various parts of an organism (Grier, Lee, and Archibald, 1984). Allometric equations have been used widely in forest research to determine tree biomass values, because they provide estimates of biomass when direct sampling is impractical or prohibitive to the experimental design (Satoo and Madgwick, 1982). Allometric equations relate difficult-measured parameters (e.g., leaf biomass, root biomass) to parameters that are measured more easily. Most authors estimate tree size by stem diameter, tree height, or a combination of these values and correlate tree size with tree biomass (Satoo and Madgwick, 1982). Since allometry describes the change in proportion of parts of a tree due to growth, any factor that affects tree growth can be significant in allometric equations. Such factors may include site characteristics, plant density, plant spatial arrangement, and species proportion. Satoo and Madgwick (1982), in a summary of forest biomass studies, believe that predicting tree biomass from stem diameter may be applicable generally to stems and entire trees, but not to tree canopies. Canopy components also are affected by growth stage, stand density, and site conditions (Satoo and Madgwick, 1982). Leaf biomass increases with total biomass when trees are young, but later becomes independent of total biomass. No differences in leaf biomass could be attributed to stand density when stand canopies of Pinus banksiana, P. densiflora, and

P. sylvestris closed (Satoo and Madgwick, 1982). Root biomass often is not considered in plant allometrics. When root biomass has been considered, it varies in response to plant densities. Studies have shown positive, negative, and no responses to density (Satoo and Madgwick, 1982).

Allometric equations for plant populations usually require logarithmic transformations. The distribution of seedling biomass becomes positively skewed and often achieves a log-normal distribution under competitive conditions (Hutchings and Budd, 1981). An advantage of fitting a logarithmic equation for plant biomass is that the resultant form of the equation is flexible, while accounting for variances of weight with tree size (Satoo and Madgwick, 1982). The transformed model also meets statistical assumptions of constant variance and random error.

A disadvantage of logarithmic transformations is they are not linear. Thus, when the distribution of ln(Y) at X is normal, the distribution of Y will be skewed. The antilog of ln(Y) is the median of the skewed distribution, not the mean (Baskerville, 1972). However, the mean of the biomass is the value of interest. Several factors have been developed to correct for this bias in data transformation (Mountford and Bunce, 1973; Baskerville, 1972). Flewelling and Piennar (1981) summarized these correction factors and presented guidelines for choosing the proper factor based on model use, sample size, and mean squared error term. Another disadvantage of logarithmic transformations is that the sum of the estimates of the component tree parts may not equal the estimate of the total tree (Kozak, 1970). Therefore, stratification of sampling material improves the reliability of the biomass estimates (Madgwick, 1971).

Plant Competition

A goal of plant competition research is to elucidate the factors contributing to changes in plant growth. It is agreed generally that important factors to consider when studying plant interactions are plant density and species proportion. Plant density directly affects plant growth. Plant biomass production is related to the resources available to plants and is approximately linear to the uptake of the limiting resource (Spitters, 1983ab). Therefore, competition among plants is reflected in their relative biomass accumulation. The "law of constant final yield" (Kira et al., 1953) is based on the principle that low plant densities have a larger space available to them. Thus, plant biomass responds to alterations in density in a plastic manner. At high plant densities, however, biomass reaches an equilibrium and no longer responds to increases in density [Fig. 1.1]. Similarly, the "reciprocal yield law" (Shinozaki and Kira, 1956) indicates that individual plants size will decrease with increasing plant density. This observation occurs because the resources available to individual plants diminishes as the number of plants in a given area increases [Fig. 1.2].

In addition to plant density, species proportion also may affect plant biomass. Species proportion is the relative density of each species in a mixture, and can be expressed as a ratio. Expansion of the "reciprocal yield law" by Spitters (1983ab) to include multiple species indicates that in a mixture the relative density of one species will influence the yield of other species in the mixture. By considering species proportion, effects of interspecific competition on plant biomass can be addressed. It is unlikely that plants will behave as individuals when interacting with individuals of the same or differing species.

The effects of density and proportion are dependent on plant size and resource availability (Harper, 1977). According to the "reciprocal yield law" [Fig. 1.2], plant biomass decreases as density increases. However, at low densities plants do not experience competitive inhibition, so biomass is not affected until a threshold density is attained [Fig. 1.3]. The threshold density represents the time or number of plants when density-induced stress occurs. Any factor that decreases the rate of plant growth can be

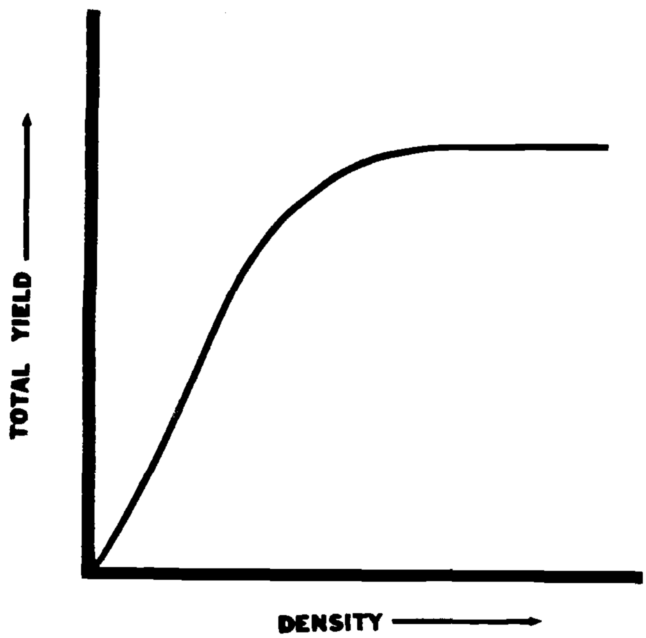

FIGURE 1.1. Law of Constant Final Yield.

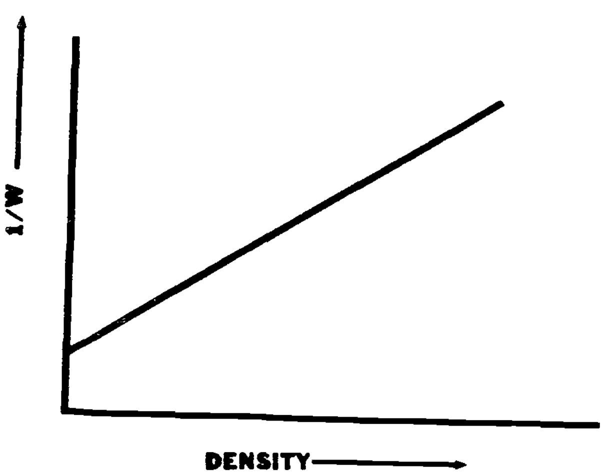

FIGURE 1.2. Reciprocal Yield Law, where W is individual plant yield.

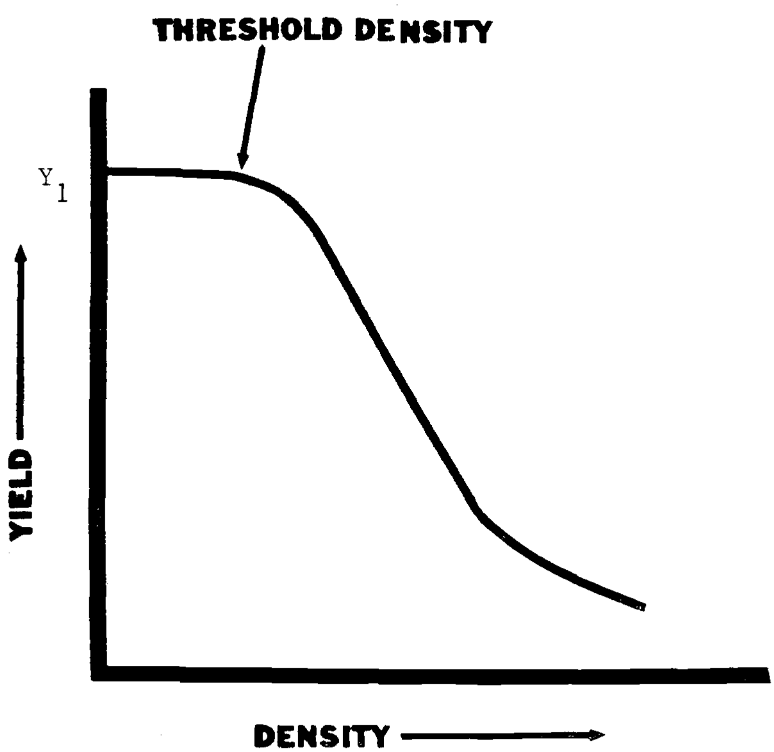

FIGURE 1.3. Individual Yield vs. Density, where Y_1 is individual yield in the absence of competetive stress due to density.

expected to delay the onset of density stress and interspecific interactions and to reduce the intensities of stress and interactions (Harper, 1977).

Many experimental designs have been employed to study the influence of various factors on intra- and interspecific competitive interactions (Radosevich, 1987). An often used approach is the replacement series experiment. In this approach, total plant density is constant while the species proportions vary to pure stands of each species (de Wit, 1960; Jolliffe, 1984). The replacement series is believed to allow separation of interspecific competitive effects from those of intraspecific competition. The experimental density is usually arbitrarily chosen in these experiments. The degree of interaction between the species is often dependent on the chosen density even though the density throughout the experiment remains constant (Jolliffe et al., 1984). Jolliffe et al. (1984) advise that replacement series be replicated over a range of densities to improve the interpretation of replacement series experiments.

Species proportion also must be considered as a factor when allometric equations are used to estimate plant biomass in replacement series experiments. Species proportion is a discrete variable in these types of experiments. If proportion is treated as a variable during the experimental analysis, it also must be treated as a variable in initial calculations that provide the data for analysis. Ignoring species proportion during allometric calculations of biomass assumes that it is constant throughout the experiment. Interspecific competition also may influence plant biomass accumulation differently than intraspecific competition. If this is the case, relative species density (proportion) should more accurately account for differences in plant biomass than total density alone. The role of density and species proportion in competitive interactions must be understood to accurately interpret the factors affecting inter- and intraspecific competition. If they are not adequately considered, they become confounding factors or unaccounted sources of experimental variation.

Competition with Douglas-fir and Red Alder

Douglas-fir (Pseudotsuga menziesii) and red alder (Alnus rubra) have been the subjects of many experiments on inter- and intra-specific competition. Tarrant (1961) observed that interplanting Douglas-fir and red alder increased Douglas-fir size and total stand biomass over Douglas-fir monocultures. This observation has been confirmed by Binkley (1983), Binkley et al. (1984), Bormann and Gordon (1984), Miller and Murray (1978), and Atkinson and Hamilton (1978). Binkley et al. (1984) observed that natural seeding of Sitka alder (Alnus sinuata) into a Douglas-fir plantation increased current average dbh (diameter at breast height, approximately 1.5 m), five-year average basal area growth, and stem biomass increment. In another study, Binkley (1983) observed that the influence of red alder on Douglas-fir growth was mediated by site factors. On a nitrogen deficient site, average Douglas-fir diameter was larger in the presence of red alder. However, the presence of red alder on a fertile site was correlated with decreased Douglas-fir biomass. Unfortunately, density and species proportion have never been considered as independent variables in such studies.

Density has been considered in the development of allometric equations for plant species in monoculture. Bormann and Gordon (1984) found that accounting for stand density in allometric equations for five-year-old red alder increased the predictability of their equations for tree growth. Stand density strongly affected average tree dimensions. In another study with juvenile red alder, Smith and De Bell (1974) found that differences in tree size and biomass were associated with differences in stand density, as a measure of tree crowding. They concluded that stand density (degree of crowding) is at least as important as site quality in determining yield of fully stocked red alder stands. Honer (1971) observed significant differences in allometric equations for balsam fir biomass when trees were grown in open vs. closed stands.

Allometric equations also may be influenced by the proportion of plant species in an experiment. Brand (1986a) found that the interspecific competition due to surrounding shrubs affected the allometric relationship of height to basal area for Douglas-fir. Douglas-fir growth vigor was more strongly related to the degree of intraspecific competition than basal area or height measures (Brand, 1986b). Oliver (1984) evaluated the effects of tree spacing with shrub association on ponderosa pine (*Pinus ponderosa*) growth. He found that shrub crown cover was related significantly to periodic annual increment in diameter, height, and stem volume of the pine. There also appeared to be an interaction between density and interspecific competition, because spacing significantly influenced diameter increment only when most shrubs were removed.

Study Objectives

Douglas-fir and red alder may respond to density and species proportion in a way that can be quantified in allometric equations for biomass. The significance of density and species proportion as independent variables also should be considered in competition research. This consideration is imperative in replacement series experiments where density and species proportions influence the inter- and intraspecific interactions of the species.

The objective of this study is to develop allometric equations for three-year-old Douglas-fir and red alder seedlings. This is a necessary component of a more inclusive replacement series experiment.[1] A second objective of the study is to determine the significance of tree density and species proportion as predictors of tree biomass.

[1]Hibbs, D. E. and S. E. Radosevich. Intra- and Interspecific Interactions between Red Alder and Douglas-fir. USDA Grant Proposal, 1984, 84-CRCR-1434.

CHAPTER 2

THE ROLE OF DENSITY AND PROPORTION IN ALLOMETRIC EQUATIONS FOR DOUGLAS-FIR AND RED ALDER SEEDLINGS

ABSTRACT

Allometric equations for three-year-old Douglas-fir (*Pseudotsuga menziesii*) and red alder (*Alnus rubra*) seedlings were developed. Two types of equations were generated for each species. The first equations contained both dimensional and spatial (density and proportion) independent variables to predict biomass. The second type of equations contained only spatial variables to predict biomass. Fifteen measures of density and one measure of proportion were considered (Appendix 1).

Douglas-fir and red alder component biomass was best predicted by stem diameter, total height, and crown width. Density was a significant variable for predicting Douglas-fir leaf biomass and total biomass. However, density was positively correlated with biomass, contrary to normal yield-density relationships, and so was excluded from the final biomass models. The percent cover of weed species surrounding the sample trees was a significant variable for predicting Douglas-fir root biomass. Red alder total biomass was correlated with species proportion indicating that red alder biomass was higher when sample trees were surrounded by a larger number of red alder than Douglas-fir. Red alder root nodules also were significantly correlated with the percent cover of annual species surrounding sample trees. When considering only spatial variables in the models, Douglas-fir component biomass was correlated significantly with the total percent cover of weed species. Red alder biomass was correlated with the distance to the nearest neighboring tree.

INTRODUCTION

The need for allometric equations in plant competition experiments is obvious when plant biomass values are required, but direct sampling is not possible. The biomass generally is predicted from allometry by estimates of tree size (Satoo and Madgwick, 1982). Since allometry describes the change in proportion of parts of a tree due to growth, any factor that affects tree growth can be significant in allometric equations. Such factors may include site characteristics, plant density, plant spatial arrangement, and species proportion. It is especially germane in competition research using replacement series experiments to separate interspecific from intraspecific interactions to consider the effects of density and proportion on allometric equations. In replacement series experiments, plant density is an arbitrarily chosen fixed value and species proportion ranges from 1:1 mixtures to pure stands (monocultures) of each species (de Wit, 1960). Density and proportion influence the degree of interference (Harper, 1977; Jolliffe et al., 1984). It is, therefore, important to have a mechanism to account for species differences due to experimental density and proportion. Jolliffe et al. (1984) advise that replacement series be replicated over a range of densities to improve the interpretation of the experimental results. Understanding the effects of density and proportion on plant interference and quantifying these factors in allometric equations facilitates interpretation of inter- and intraspecific competition.

Douglas-fir (Pseudotsuga menziesii) and red alder (Alnus rubra) have been the subjects of many experiments on inter- and intraspecific competition (Tarrant, 1961; Binkley, 1983; Binkley et al., 1984; Bormann and Gordon, 1984; Miller and Murray, 1978; Atkinson and Hamilton, 1978). Unfortunately, density and species proportion have never been considered as independent variables in such studies.

Density has been considered in the development of allometric equations for plant species in monoculture. Bormann and Gordon (1984) found that accounting for stand density in allometric equations for five-year-old red alder increased the predictability of their equations for tree growth. Allometric equations also may be influenced by the proportion of plant species in an experiment. Brand (1986a) found that the interspecific competition due to surrounding shrubs affected the allometric relationship of height to basal area for Douglas-fir.

An objective of this experiment is to develop allometric equations for three-year-old Douglas-fir and red alder seedlings.[1] A second objective is to determine the significance of tree density and species proportion as predictors of tree biomass.

METHODS

Study Area

The study was established on a portion of a 34 ha clearcut near Belfair, Washington that was harvested during the summer of 1984. The elevation of the area is approximately 150 m. The original stand was railroad logged in the early 1900's. It was dominated by 70 year-old Douglas-fir (*Pseudotsuga menziesii*) with scattered madrone (*Arbutus menziesii*) and red alder (*Alnus rubra*). The site index of the original stand was 107 according to McArdle's 100-year site index (McArdle et al., 1961).

The soil is classified as a Shelton Gravelly Sandy Loam. It is characterized by glacial till parent material and a hardpan approximately one meter below the surface. The soil contains 62% rock by weight. Total bulk density is 1.5 g/cm^3. The soil has

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[1]Hibbs, D. E. and S. E. Radosevich. Intra- and Interspecific Interactions between Red Alder and Douglas-fir. USDA Grant Proposal, 1984, 84-CRCR-1434.

low water-holding capacity. Drainage occurs rapidly in the top horizons but slowly in the lower horizons. Parts of the site are saturated from December to March. Average total nitrogen on the site ranges from 1200 ppm at 0.15 cm to 430 ppm at 60-90 cm. The site receives 140-200 cm of precipitation per year, most of which falls from December to March.[2] Therefore, the soil during the summer months is extremely dry. In September, 1986, the soil contained 18% water by volume. Prior to the establishment of the study, the vegetation on the site was 8% shrub species and 24% herb species.[3]

Field Procedures

In March, 1985, two-year-old nursery grown Douglas-fir seedlings and one-year-old wild red alder seedlings were planted in a replacement series experiment [Fig. 2.1]. Originally, the study had eleven treatments consisting of monocultures of Douglas-fir and red alder, and a 1:1 mixture of Douglas-fir and red alder, each planted at four spacings (30 cm, 45 cm, 60 cm, and 85 cm between neighboring trees). The 85 cm spacing was implemented for monocultures only due to the original experimental design. The plot sizes ranged from 1.44 m^2 with the 30 cm spacing to 5.76 m^2 with the 60 cm spacing. Each plot contained nine sample trees surrounded by a row of border trees [Fig. 2.2]. The experiment was arranged in a randomized complete block with three blocks. Blocks were chosen according to topographic variation which was indicative of a soil moisture gradient.

An array of measurements was taken when the trees were planted. These measurements were repeated at the end of the first growing season (October, 1985) and at the end of the second growing season, when the experiment was harvested (September, 1986). Measurements included total height of the seedling, stem diameter 2 cm above

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[2]Washington DNR Soil Survey, 1981.

[3]Harrington, T. and B. Yoder, personal communication, 1987.

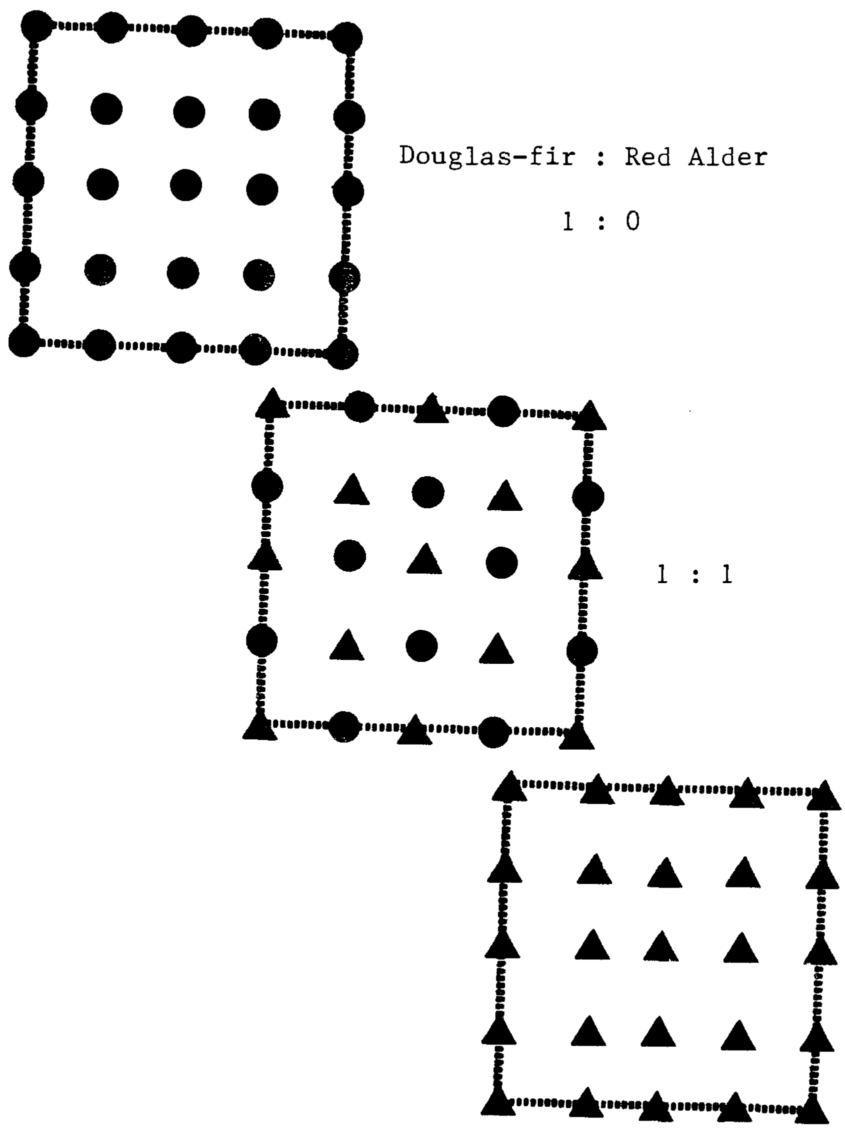


FIGURE 2.1. Replacement Series Design showing monocultures of Douglas-fir (▲) and red alder (●) and a 1:1 proportion of each species. Total density of this hypothetic experiment is 25 trees.

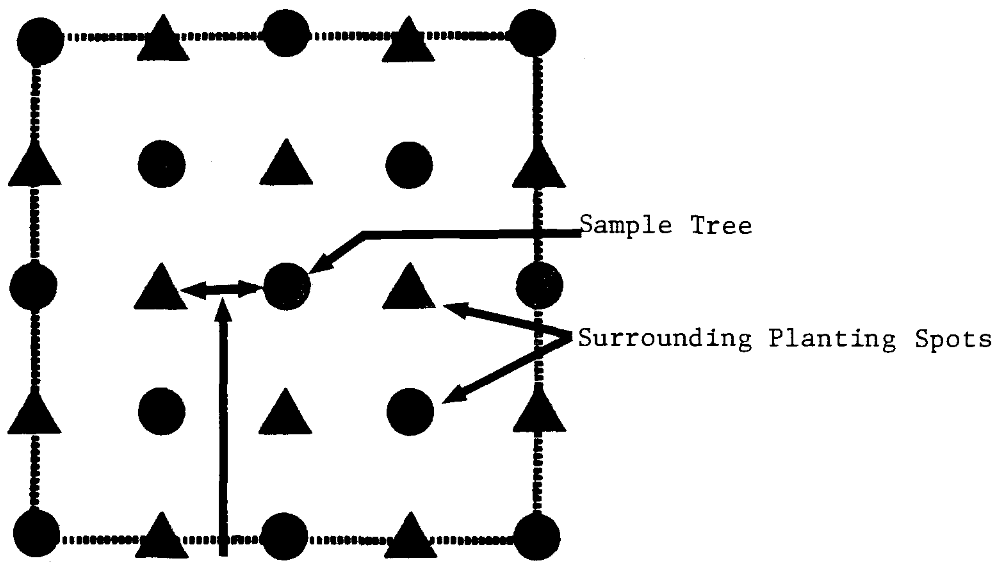
the ground, crown width measured in two perpendicular directions, and length from the ground to the first live branch. In addition to these measurements, samples of ten to twenty trees of each species were partitioned into biomass components, dried and weighed when the experiment was established and after the first growing season. These measurements of total, stem, leaf, and root biomass and the above-mentioned field measurements were used to derive preliminary allometric equations. Other weed species were not removed during the experiment. However, the percent cover of plant species other than trees was ocularly estimated on each plot after each growing season.

At harvest (September, 1986) the trees were measured, excavated, and transported to Oregon State University. Roots and foliage were cleaned of dirt and other debris, separated into above-ground and below-ground components, and dried at 70°F. for 72 hours. After drying, the Douglas-fir needles were separated from the branches. Red alder leaves were discarded because the trees were harvested after leaf abscission had begun. Each tree component was weighed. A random sample of red alder root nodules from 27 seedlings was taken. The nodules were removed from the root system prior to drying.

Data Collection and Analysis

Allometric equations were to be developed for each treatment and compared among monocultures and species mixtures. However, tree mortality required a revision of this method of data collection and analysis. Thus, data were analyzed on the basis of individual trees rather than as groups of trees, since the density and the species proportion surrounding surviving trees could be obtained readily by measurements of distance among individuals.

Several measurements of density were used [Fig. 2.2]. One measurement of density was based on the number of occupied planting spots (potential n = 8) surrounding each sample tree. This number was expanded to trees per m^2. The disadvantage of this



% Total = Percent cover of all annual and shrub species on the plot.

% Shrubs = Percent cover of all shrub species on the plot.

% Annual = percent cover of all herbaceous species on the plot.

Ba = Basal area of the stems on the plot (cm^2/m^2).

Ca = Crown area of the stems on the plot (cm^2/m^2).

Dist = Distance to the nearest neighboring tree.

Ba/Dist = Basal area of the stems on the plot divided by the distance to the nearest neighboring tree.

Ca/Dist = Crown area on the plot divided by the distance to the nearest neighboring tree.

Dens = Density of the stems occupying the eight planting spots around the sample tree ($trees/m^2$).

DensDF = Density of Douglas-fir occupying the eight planting spots around the sample tree ($trees/m^2$).

DensRA = Density of red alder occupying the eight planting spots around the sample tree ($trees/m^2$).

Prop = Number of Douglas-fir seedlings/total number of seedlings surrounding the sample tree.

Avedist = Average distance to eight surrounding neighbors.

FIGURE 2.2. Density, cover, and proportional measurements collected to determine the influence of density and proportion on Douglas-fir (▲) and red alder (●) biomass.

method was that the expansion factor from the number of occupied planting spots to trees per m^2 was different for each treatment. Thus, densities obtained for sample trees in different treatments were not calculated on the same basis. This method also assumed that only trees affecting the sample tree were those directly surrounding it. Another measure of density was based on the average distance to the eight surrounding trees. This measurement assumed that surrounding trees were equally spaced around the sample tree. The third measurement of density was based on the distance from the sample tree to the closest neighboring tree. The fourth density measurement was based on the total tree basal area per plot as calculated by the sum of the cross-sectional stem areas. The fifth measurement was similar to the fourth, but was based on the total crown area per plot as calculated by the sum of the cross-sectional crown areas. To incorporate distance to the nearest neighboring tree with a measure of tree size, basal area per nearest distance and crown area per nearest distance also were calculated.

Proportion was calculated as the number of Douglas-fir trees that occupied the eight planting spots surrounding a sample tree divided by the total number of planting spots that were occupied. Proportion ranged from zero to unity, with zero indicating no Douglas-fir and all red alder surrounded the sample tree. Unity indicated all Douglas-fir and no red alder surrounded the sample tree.

The regression procedure in SAS (SAS Institute, 1985) was used to generate allometric equations for Douglas-fir and red alder biomass from dimensional and spatial variables. In this analysis, density and proportion were tested as significant variables. Equations also were developed using only density and proportion as independent variables. This procedure allowed an assessment of variation in tree component biomass explained by only spatial factors.

RESULTS AND DISCUSSION

Biomass Values

A list of abbreviations and definitions is shown in Appendix 1. Means and standard deviations of tree biomass and dimensions are shown in Appendices 2-6. Significant differences between means were calculated using Scheffe's statistic (SAS Institute, 1985). This test is valid for all possible comparisons of means with different sample sizes. Of the fifteen density measurements, the most significant density descriptors of Douglas-fir biomass were basal area and the total percent cover of weed species [App. 2 & 3]. As will be discussed later, basal area and the percent total cover of weeds have low predictive abilities for Douglas-fir biomass, but are significant when stepwise regression is applied to spatial measurements alone. According to Scheffe's statistic, means of total biomass, leaf biomass, root biomass, total height, and stem diameter were different between basal area 0 - 3.0 cm^2/m^2 and 12.1 - 14.0 cm^2/m^2 [App. 2]. There were no discernible differences among means at different percent covers [App. 3].

The most significant density measurement describing red alder biomass was distance to the nearest neighboring tree. All the variables, except nodule biomass, were different between a distance of 30-60 cm [App. 4]. For crown width, all of the distances are significantly different.

Means and standard deviations for each species by proportion are listed in Appendices 5 and 6. For both species, there were no significant differences in tree biomass means attributable to proportion. These data were used to develop allometric equations for Douglas-fir and red alder biomass and to test the significance of density and proportion for predicting biomass.

Allometric Equations using Dimensional and Spatial Variables

Allometric equations developed to estimate biomass for three-year-old Douglas-fir and red alder seedlings required logarithmic transformations to meet statistical assumptions of normal distribution, constant variance, and random error. The red alder nodule biomass equations did not require transformation. Equations were generated for seedling components of growth, rather than total biomass only. According to Kozak (1970), predicting biomass for component parts improves the reliability of estimates. Logarithmic transformations result in statistically biased biomass estimates. However, Madgwick and Satoo (1975), in a simulated sample of trees for biomass prediction, found that bias due to transformation was minor compared to the variation among replicated samples. Correction factors are based on the mean squared error (MSE) of the model predicting biomass. Since the MSE's generated in this analysis are similar to those generated by Madgwick and Satoo, correction factors were not used in biomass predictions. The allometric equations for Douglas-fir and red alder follow the general form:

$$\ln \hat{Y}_i = \hat{B}_0 + \hat{B}_1 \ln X_1 + \hat{B}_2 \ln X_2 + \ldots \hat{B}_i \ln X_i$$

where: $\hat{Y}$ = the independent variable, biomass

X_i = the independent variables, either dimensional or spatial

$\hat{B}_i$ = the slopes.

These equations are listed in Table 2.1.

Variables were selected according to the following criteria: significance of independent variables ($|t| > p = 0.06$), Mallow's Cp statistic (Draper and Smith, 1981), adjusted R^2, MSE, and multicollinearity of the variables. In all equations no variables have a variance inflation factor greater than 4.0 which indicates low multicollinearity (Gunst and Mason, 1980). In spite of the large number of variables available for model selection, few independent variables were necessary to adequately predict tree biomass. The

TABLE 2.1. Allometric equations for Douglas-fir and red alder.

Species	Y	Intercept	$\ln(D^2H)$	$\ln(C^2H)$	ln(Diam)	Prop	Dens	% Total	R^2	MSE
Douglas-fir	ln(Stbio)	-4.7	0.7	0.1	--*	--	--	--	0.91	0.03
	ln(Lfbio)	-4.0	--	0.3	1.6	--	0.01	--	0.83	0.06
		-3.9	--	0.3	1.5	--	--	--	0.81	0.06
	ln(Rtbio)	-3.5	--	0.1	1.8	--	--	0.002	0.79	0.07
	ln(Totbio)	-2.7	--	0.2	1.7	--	0.005	--	0.91	0.03
		-2.7	--	0.2	1.6	--	--	--	0.91	0.03
Red alder	ln(Stbio)	-6.4	0.8	0.2	--	--	--	--	0.91	0.05
	ln(Rtbio)	-3.1	--	--	2.3	--	--	--	0.87	0.06
	ln(Totbio)	-3.5	--	0.2	2.0	-.14	--	--	0.94	0.04

*Blank spaces indicate variables were not significant in the equations.

The equation for red alder nodule biomass did not require transformation and is: Nodbio = 1.06 + .00015(D^2H) - .04(% Annual) $R^2 = 0.65$ MSE = 0.3

Y refers to dependent variables, ln(Stbio), ln(Lfbio), ln(Rtbio), ln(Totbio) which aredefined respectively as the natural logarithms of stem biomass, leaf biomass, root biomass, and total biomass. Intercept refers to the Y-intercept of the allometric equations. Independent variables are $\ln(D^2H)$, $\ln(C^2H)$, ln(Diam), Prop, Dens, % Total, and % Annual, which are defined respectively as the natural logarithm of (stem diameter)^2 * total height, natural logarithm of (average crown width)^2 * total height, natural logarithm of stem diameter, proportion (number of Douglas-fir seedlings/total number of seedlings surrounding the sample tree), density of the stems occupying the eight planting spots surrounding the sample tree, percent cover of all herbaceous and shrub species on the plot, and percent cover of all herbaceous species on the plot. R^2 is the coefficient of determination. MSE is the mean squared error of the model.

variables selected for the equations of tree components were similar for the two species. The equations for Douglas-fir and red alder stem biomass incorporated the same variables. These two equations have significantly different slopes ($\alpha \leqslant .01$) and significantly different coefficients for $\ln C^2H$ ($\alpha \leqslant .01$), but the coefficients for $\ln D^2H$ are not significantly different.

Tree density was not a significant factor for predicting Douglas-fir or red alder stem and total biomass. However, the effects of tree density may not yet be apparent because of the severity of the environmental conditions. Abrams (1985) found significant differences in growth rates between stands of _Quercus spp._, but the differences could not be correlated with changes in stand density. Instead, growth rates were correlated with edaphic factors.

The allometric equations for Douglas-fir root biomass show that root biomass was sensitive to interspecific interactions. Root biomass decreased with increasing weed cover. The detection of interspecific interaction in roots and not in other plant parts may be due to three facrors: (1) greater sensitivity of roots to moisture and nutrient depletion by weeds, (2) large root systems in proportion to other plant components, and (3) length of time the experiment was in progress. These factors may have enabled the detection of interspecific interaction in roots while this effect was not detected for other plant parts. Although below-ground competition may eventually affect above-ground allometry, the results of this experiment indicate that below-ground interspecific interactions are not yet affecting Douglas-fir above-ground biomass.

Although direct measurements of soil moisture content and soil nutrient availability were not made during the course of this experiment, it is plausible that moisture and nutrients were limiting to the seedlings because of site characteristics. Soil measurements taken when the study was established indicated that available nitrogen and water-holding capacity were low and bulk density was high. Resource limitations would be accentuated by higher densities of competing species. Roots are more sensitive to cold, heat, and desiccation than above-ground parts (Larcher, 1980). Therefore, water and nutrient limitations combined with higher sensitivity of roots than in other plant parts could lead to less root biomass when there was a high percent cover of competing species.

Theoretically, the intensity of density effects is influenced by the size of the interacting individuals. Douglas-fir root biomass sensitivity to the presence of weeds may indicate that the roots grew larger in proportion to other plant parts. Thus, roots were able to interact significantly, whereas other tree components could not. Roots may attain a larger size relative to above-ground parts due to a shift in carbohydrate allocation under environmental stress. The annual plants and shrubs that invaded the plots after the experiment was established utilized resources that could have been available to the trees. The trees, therefore, may have experienced stress due to depleted moisture and nutrient level caused by weed presence. Allocation patterns can be altered in plants under stress to favor root growth (Waring and Schlesinger, 1985). Concurrently, roots experienced less moisture stress than the shoot, and so can receive an improved carbohydrate supply, enabling active growth. Nutritionally stressed Scots pine allocated more than 60% of their photosynthate below ground. In contrast, trees receiving nutrient supplements allocated less than 40% of their photosynthate below ground (Linder and Axelsson, 1982, in Waring and Schlesinger, 1985). Keys and Grier (1981) studied net production of forty-year-old Douglas-fir on high- and low-productivity sites. The low site they chose was in western Washington and had a soil similar in type, water-holding capacity, and nutrient content to the soil used in this experiment. They found above-ground net production on the high site was 13.7 MT/ha compared with 7.3 MT/ha on the low site. Below-ground net production on the high site was 4.1 MT/ha compared with 8.1 MT/ha on the low site. The difference in total net production between the two sites was small (2.4 MT/ha). They concluded that the difference in above-ground productivity may be due to a greater need for investment in roots on harsh sites. Baskerville (1960), in studies of production in mixed balsam fir stands, found that roots form a greater proportion of total stand biomass in dense stands than in sparse stands.

In addition to an altered allocation pattern, the differential growing seasons of plant components also may have enabled roots to grow larger and, consequently, to develop interspecific interactions. In temperate regions, root elongation begins earlier and ends later than shoot elongation (Kozlowski, 1971). Root elongation may continue for several weeks after shoots stop growing in species whose shoots are preformed in the buds, such as Douglas-fir (Koslowski, 1971). Douglas-fir seedling roots have two flushes of growth. One flush occurs in the early spring and the other in the late fall. Shoots usually have only a single flush of growth and then growth declines to a low level during the summer (Cleary et al., 1982). The longer growing season of roots is due to a wider range of optimum temperatures for root growth than for above-ground parts (Larcher, 1980).

Density was a significant factor for predicting Douglas-fir leaf biomass and total biomass [Table 2.1]. For leaf biomass, the inclusion of density in the allometric equation slightly improved the predictability of the equation. For total biomass, the inclusion of density did not significantly change the equation or its predictability. The coefficient for density in both equations was positive, indicating larger tree size was correlated with higher density. Positive coefficients may reflect a sheltering effect by neighboring seedlings from harsh environmental conditions, a reduction in weed competition through shading, or microsite differences. It is plausible that water, soil, and nutrient availabilities were not homogeneous over the site. Higher resource availability would be correlated with higher survival and growth rates. Regardless of the mechanism that caused the density interaction, the variable in these equations did not represent density effects alone since size is not positively correlated with density according to the "reciprocal yield law." Therefore, density was not included in the allometric equations for Douglas-fir leaf and total biomass, although it was a significant variable.

Red alder total biomass increased when the sample tree was surrounded by a higher proportion of its own species. This increase in biomass may indicate microsite improvement by red alder or a microsite difference that was present before the red alder were planted. Red alder root nodules fix atmospheric nitrogen, and convert it to a form utilized by plants. Studies have demonstrated improved soil characteristics and increased soil nitrogen when red alder was present in a stand. A twenty-year-old red alder stand can accumulate 6 MT/ha of nitrogen from nitrogen-fixation and 160 MT/ha from litter fall (Zavitkovski and Stevens, 1971). In a study near Olympia, Washington, soil nitrogen accumulated at a nearly constant rate of 35 kg/ha/yr in the mineral soil beneath five to forty-year-old red alder stands. Organic matter content also was 20% higher and bulk density was lower than in an adjacent Douglas-fir stand (Bormann and DeBell, 1981). A heavy red alder understory added 870 kg/ha of nitrogen to the top 50 cm of soil in a mixed Douglas-fir/red alder stand (Berg and Doerksen, 1975). Increased soil and foliar nitrogen often is correlated with increased Douglas-fir biomass (Binkley et al., 1984; Binkley, 1983; Miller and Murray, 1979; Tarrant, 1961). Higher Douglas-fir biomass was not significantly correlated with higher proportion of red alder in this study. Perhaps the effect of species proportion on Douglas-fir would have been more apparent if the experiment had been extended another growing season.

Red alder nodule biomass decreased as the percent cover of herbaceous plants increased [Table 2.1]. Photosynthate supply is the major limiting factor in nitrogen fixation and nodule formation (Wheeler and McLaughlin, 1979). Low light levels inhibit nodule formation (Dawson and Gordon, 2979). Herbaceous plants surrounding the red alder shaded the seedling trees and may have decreased the amount of photosynthate produced by the red alder. Lower photosynthate levels would lead to lower carbohydrates available to the nodule bacteria. Decreased nodule biomass also may be the result of lower soil moisture. Nodule forming bacteria are sensitive to moisture level (Waring and Schlesinger, 1985). The coarse soil on the site has a low moisture-holding capacity and the presence of herbaceous plants would deplete the moisture level further. Therefore, the percent cover of herbaceous plants may be related to nodule biomass due to a depletion of soil moisture.

Allometric Equations Using Only Spatial Variables

The roles of density and proportion of trees and other vegetation for predicting tree biomass when no other source of variation was considered also were determined. Density and proportion measures alone were regressed against tree biomass. The density measures available for model selection were: density (trees/m^2), density of Douglas-fir (trees/m^2), density of red alder (trees/m^2), percent cover of herbaceous plants, percent cover of shrubs, percent cover of herbaceous plants + shrubs, basal area (cm^2/m^2), crown area (cm^2/m^2), distance to the nearest neighboring tree (cm), average distance to the neighboring tree (cm), basal area divided by the nearest distance, the crown area divided by the nearest distance, and the lograithms of these variables [App. 1]. The equations are of the form:

$$\ln\hat{Y}_i = \hat{B}_0 + \hat{B}\, X_i$$

where $\hat{Y}$ = the dependent variable, biomass

X_i = an independent spatial variable.

The equations are listed in Table 2.2.

TABLE 2.2. Equations for Douglas-fir and red alder biomass when spatial measurements alone were considered.

Species	Y	Intercept	% Total	Dist	R^2	$p(F > \hat{F})$
Douglas-fir	ln(Stbio)	3.4	-.006	--*	0.08	0.0008
	ln(Lfbio)	3.0	-.006	--	0.07	0.0019
	ln(Rtbio)	2.5	-.008	--	0.13	0.0001
	In(Totbio)	4.1	-.006	--	0.10	0.0002
Red alder	ln(Stbio)	2.7	--	0.04	0.30	0.0001
	ln(Rtbio)	2.0	--	0.03	0.30	0.0001
	ln(Totbio)	3.1	--	0.03	0.31	0.0001
	Nodbio	No variables significant at .05 level.				

*Blank spaces indicate variables were not significant in the equations.

Y refers to dependent variables ln(Stbio), ln(Lfbio), ln(Rtbio), ln(Totbio), and Nodbio which are defined respectively as the natural alogarithms of stem biomass, leaf biomass, root biomass, and total biomass, and as nodule biomass. Intercept refers to the Y-intercept of the allometric equations. Independent variables are % Total and Dist which are defined respectively as the percent cover of all herbaceous and shrub species on the plot, and the distance to the nearest neighboring tree. R^2 is the coefficient of determination. MSE is the mean squared error of the models. $P(F > \hat{F})$ is the conditional probability of observing a value of F as extreme as the observed value given that the null hypothesis is true (slope = 0).

These results indicate that Douglas-fir and red alder are sensitive to different spatial variables which have different levels of predictability. The only significant density measure to predict the biomass of Douglas-fir was the percent cover of weed species surrounding the sample trees. Total percent cover was significant for all Douglas-fir components of biomass as well as for total biomass. However, not considering weed species in the equations, density (as measured by the logarithm of basal area) was the most significant indicator. The equations generated have little predictive ability and do not account for variability in biomass, indicating that density does not play a major role in predicting Douglas-fir biomass at this time. For red alder, the only significant density measure to predict biomass was the distance to the nearest neighboring tree. The distance to the nearest tree alone accounted for 30% of the variation in biomass. Nodule biomass could not be predicted from spatial parameters alone. Proportion was not a significant predictor for Douglas-fir and red alder without other parameters being considered in the model. When analyzing experimental data where density is a variable, it is important to determine which measure of density most accurately predicts biomass.

Allometric equations generated in this study can be quantitatively compared to equations generated in other studies if they utilize the same variables and transformations. Without these similarities, the equations can only be qualititatively compared. For example, Zavitkovski and Stevens (1972) generated allometric equations for red alder biomass but used (stem diameter)^2 x height and [stem diameter)^2 * height]^2 as independent variables. These equations cannot be compared with the equations from this study which use (stem diameter)^2 x height, (crown diameter)^2 * height, and stem diameter as independent variables. Numerous equations have been generated for Douglas-fir biomass, most using stem diameter as the only independent variable (Tholz et al., 1979).

Qualitative comparisons can be made between the equations generated in this study and those generated for red alder by Bormann and Gordon (1984). They assessed the effects of stand density on red alder size and related stand density to nitrogenase activity. Their first premice was that higher photosynthetic rates would lead to greater nitrogenase activity. They hypothesized that trees in dense stands may have reduced foliage relative to the respiratory surface. Therefore, less photosynthate would be available for the below-ground system. They found that trees in high-density stands allocated less photosynthate to root nodules for nitrogen fixation. They also found that increased growing space was correlated with a greater leaf mass and a higher rate of nitrogen fixation per tree assuming that density effects occur regardless of the interacting species. Bormann and Gordon's findings are consistent with the results of this study. Red alder nodule biomass was negatively correlated with a higher percentage cover of herbaceous weeds.

Other similarities between the allometric equations generated by Bormann and Gordon and those generated in this study cannot be made for several reasons. First, Bormann and Gordon found that density was a significant variable for predicting root biomass. Density was not a significant variable for predicting root biomass in this study. Second, Bormann and Gordon did not use logarithmic transformations for the independent dimensional variables (dbh and $(dbh)^2$). Third, Bormann and Gordon used different independent variables to predict biomass than were used in this study. Statistical comparisons among allometric equations generated in different studies can only be made when the equations utilize the same variables and transformations.

SUMMARY

The roles of density and proportion in allometric equations for predicting biomass of Douglas-fir and red alder seedlings vary with the plant part being predicted and the method of density measurement. The total percent cover of weed species was a significant variable for predicting Douglas-fir root biomass when dimensional variables also were in the equation. When considering only spatial variables, the total percent cover of weeds was a significant variable in regression equations for Douglas-fir biomass, although the equations had little predictive power. Red alder total biomass was correlated with species proportion, indicating trees were larger when surrounded by a higher proportion of red alder than Douglas-fir. Red alder root nodules also were sensitive to the percent cover of annual species. Considering only spatial variables, red alder biomass was positively correlated with the distance to the nearest neighboring tree. Accounting for density and proportion in allometric equations for Douglas-fir and red alder seedlings can improve the predictability of the equations. However, the appropriate method of determining density should be evaluated for each species.

LITERATURE CITED

Abrams, M. D. 1985. Age-diameter relationships of Quercus species in relation to edaphic factors in gallery forest in northeast Kansas. For. Ecol. Manage. 13(3/4):181-194.

Baskerville, G. L. 1960. Dry-matter production in immature balsam fir stands: roots, lesser vegetation, and total stand. For. Sci. 12:49-53.

Berg, A., and A. Doerksen. 1975. Natural fertility of a heavily thinned Douglas-fir stand by understory red alder. Research Note No. 56, Oregon State University School of Forestry, Corvallis.

Binkley, D. 1983. Ecosystem production in Douglas-fir plantations: Interactions of red alder and site fertility. For. Ecol. Mgmt. 5:215-227.

Binkley, D., J. D. Lousier, and K. Cromack. 1984. Ecosystem effects of Sitka alder in a Douglas-fir plantation. For. Sci. 3(1):26-35.

Cleary, B. D., R. D. Greaves, and P. W. Owston. 1982. Seedlings. In: Cleary, B. D., R. D. Greaves, and R. K. Hermann (Eds.). Regenerating Oregon's Forests. Oregon State University School of Forestry, Corvallis, pp. 63-97.

Dawson, J. O., and J. C. Gordon. 1979. Photoassimilate supply and nitrogen fixation in Alnus. In: Gordon, J. C., C. T. Wheeler, and D. A. Perry (Eds.). Symbiotic Nitrogen Fixation Fixation in the Management of Temperate Forests. Proceedlings of a workshop. Oregon State University.

Draper, N., and H. Smith. 1981. Applied Regression: Analysis. 2nd ed. John Wiley and Sons, N.Y.

Gholz, H. L., C. C. Grier, A. G. Campbell, and A. T. Brown. 1979. Equations for estimating biomass and leaf area of plants in the Pacific Northwest. OSU For. Res. Lab., Research Paper 41.

Gunst, R. F., and R. L. Mason. 1980. Regression Analysis and Its Application: A Data-oriented Approach. Marcel Dakker, Inc., N.Y.

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

Kozlowski, T. T. 1971. Growth and Development of Trees, Vol. II: Cambial Growth, Root Growth, and Reproductive Growth. Academic Press, N.Y.

Larcher, W. 1980. Psychological Plant Ecology. Springer-Verlag, N.Y.

McArdle, R. E., W. H. Meyer, and D. Bruce. 1961. The Yield of Douglas-fir in the Pacific Northwest. Tech. Bull. No. 201, USDA.

Miller, R. E., and M. D. Murray. 1978. Effects of red alder on the growth of Douglas-fir. In: Briggs, D. G., D. S. DeBell, and W. A. Atkinson (Eds.). Utilization and Management of Alder. PNW Rng. and Exp. Sta., Gen. Tech. Rep., PNW-70. USDA, Portland, Oregon, pp. 288-306.

SAS Institute. 1985. SAS/STAT Guide for Personal Computers, Version 6 Edition. Cary, N.C.

Satoo, T., and H. A. I. Madgwick. 1982. Forest Biomass. Dr. W. Junk Pub., London.

Tarrant, R. F. 1961. Stand development and soil fertility in a Douglas-fir and red alder plantation. For. Sci. 7:238-246.

Waring, R. H., and W. H. Schlesinger. 1985. Forest Ecosystems: Concepts and Management. Academic Press, Orlando.

Wheeler, C. T., and M. E. McLaughlin. 1979. Environmental modulation of nitrogen fixation in actinomycete nodulated plants. In: Gordon, J. C., and C. T. Wheeler, and D. A. Perry (Eds.). Symbiotic Nitrogen Fixation in the Management of Temperate Forests. Proceedings of a workshop. Oregon State University, Corvallis.

Zavitkovski, J., and R. D. Stevens. 1971. Primary productivity of red alder ecosystems. Ecology 53(2):235-242.

CHAPTER 3

IMPLICATIONS AND IMPROVEMENTS OF THE STUDY

Considerations for Future Research

This study was initiated as part of a larger replacement series experiment to develop site-specific allometric equations and to determine the significance of density and species proportion for predicting tree biomass. The larger experiment addresses the effects of inter- and intraspecific competition between Douglas-fir and red alder on three sites in the Pacific Northwest: a high-productivity site on the Cascade Head Experimental Forest, Oregon, a medium-productivity site on the H. J. Andrews Experimental Forest, Oregon, and a low-productivity site near Belfair, Washington. The duration of the study is 25 years. This thesis addresses a narrow time frame on only one of the sites, but suggests considerations for the entire study.

Areas of consideration revealed by this study are: (1) significant factors to quantify for predicting tree biomass, (2) timing and duration of the measurements for developing allometric equations, and (3) site specificity of the equations. The important parameters revealed by this study for predicting tree seedling biomass are listed in Table 3.1. Choosing independent variables for model building can be an endless task. Independent variables can be differentiated into four classes: dimensional, spatial, growth, and interaction. Tree biomass has conventionally been predicted by dimensional parameters. Diameter, height, and crown width are widely accepted as the most significant variables for predicting tree biomass (Satoo and Madgwick, 1982). The additional spatial parameters, proportion, total percent cover, nearest distance, and basal area may fine-tune the equations to represent site factors. Various methods of measuring density have different predictive abilities and appear to be species-specific. Therefore, when incorporating density into an allometric equation, it is important

TABLE 3.1. Important variables for predicting tree seedling biomass

Estimate	Independent Variables: Major Importance	Variable in Model	Minor Importance[a]
lnStbio	Diameter	$\ln(D^2H)$	% Total[b]
	Height	$\ln(C^2H)$	ln(BA)[b]
	Crown width		Dist[c]
lnRtbio	Diameter	ln(Diam)	
	Height	$\ln(C^2H)$	ln(BA)[b]
	Crown width		Dist[c]
	% Total		
lnLfbio[b]	Diameter	ln(Diam)	% Total
	Height	$\ln(C^2H)$	ln(BA)
lnTotbio	Diameter	$\ln(D^2H)$	% Total[b]
	Height	$\ln(C^2H)$	ln(BA)[b]
	Crown width		Dist[c]
	Proportion[c]	Prop[c]	
Nodule	Diameter	D^2H	
	Height		
	% Annuals	% Annual	

[a] Variable needs further investigation or longer experimental period to determine significance.

[b] Applies to Douglas-fir only.

[c] Applies to red alder only.

Refer to Appendix 1 for definition of terms.

to determine which measure of density most accurately predicts biomass. Growth-type parameters, such as initial size and current growth rate, also may add predictive ability to allometric equations. In the beginning phases of this analysis, initial diameter and height were considered as independent variables. However, these variables were later excluded from the models for two reasons. First, future users of the equations are not guaranteed prior information about the sample trees. Second, growth parameters are conventionally used for modeling growth, not for predicting biomass (Ritchie and Hann, 1986; Valentine, 1986). Several interaction terms which incorporated size with density were suggested for model building but none of them were significant.

The proper timing of dimensional measurements and the duration of the experiment also are significant considerations. The measurements should be taken after cessation of the active growing period but before leaf abscission. Measurements also should extend through a sufficient number of growing seasons to adequately determine the significance of density and proportion. Two growing seasons may be a long enough period for seedlings planted on a higher-quality site. However, it was not long enough to detect density effects, other than those from herbaceous and shrub species, on Douglas-fir or red alder. The experimental period also was not long enough to detect proportion effects on Douglas-fir. New equations should be developed every three to five years until the trees have reached a stable growth rate [Fig. 1.1]. In dense stands, the stability of the allometric equations over time depends on when self-thinning begins (Smith, 1986).

Early growth rates are strongly affected by species, genotype, and environment (Daniel et al., 1979) [Fig. 3.1]. Variable growth rates in juvenile trees may cause the slope and the intercept of the equations to vary as the trees grow older. Site specificity of the equations is another important consideration, especially with juvenile trees. The resource availability and growing season on the site strongly affects the growth of tree components in

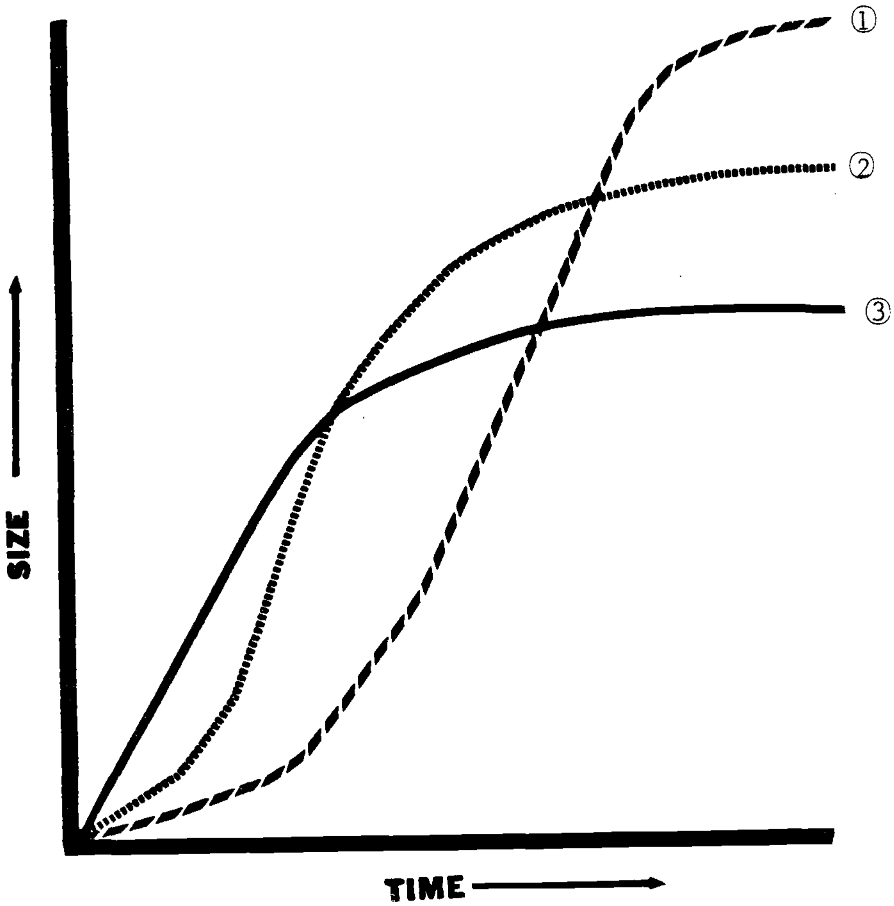


FIGURE 3.1. Theoretical patterns of growth. Tree different lines may represent three different genotypes, species, or sites. (Adapted from Daniel et al., 1979).

relation to one another (Harding and Grigal, 1986). Thus, allometric equations should be developed for each of the three sites for the Radosevich/Hibbs replacement series in progress.

Implications and Improvements for Future Research

The implications of the results of this study are pertinent to developing allometric equations for other sites. First, competition from weeds may greatly affect tree growth. Therefore, weed species should either be eliminated from the experiment or accurately quantified. Second, tree components have differential sensitivities to density and proportion and may react to these factors at different ages. For example, Douglas-fir root biomass is sensitive to percent cover of weeds at age 3, but may not be at age 10. Likewise, red alder stem biomass is not sensitive to density at age 3 but may be at a later age [Fig. 3.1].

Several aspects of this study could have been improved. These suggestions should be noted for future development of allometric equations. The original design was a replacement series experiment. Allometric equations were to be developed for each species at every density and proportion in the experiment. The equations would then have been tested to determine if there were significant differences in slope or intercept attributable to density and proportion. However, heavy seedling mortality confounded the geometry of the design so that density and proportion were no longer discrete variables. The original approach was abandoned in favor of an individual seedling approach. The density and proportion that each seedling experienced were used as continuous independent variables and tested for their significance in model selection.

Tree seedling mortality always is a concern when establishing an experiment in the field. The problem is magnified, however, when the experiment is established on a "poor" site and will only continue for two or three growing seasons. Therefore, it would be wise to implement a design that is not strongly affected by mortality but can still meet the objectives of developing allometric equations and testing the significance of density and proportion. Mead and Riley (1981) state that there are no adequate designs for investigating the effects of spatial arrangement in intercropping research. However, possible designs which incorporate density and species proportion are the Nelder design (Nelder, 1962) and the Addition Series (Spitters, 1983ab). Mead and Riley (1981) also propose a design in which the intimacy and the spatial arragnement of each species are varied between two species. Within these approaches, data can be analyzed on an individual plant basis.

The need for additional measurements often is apparent after a study has been completed. The objectives of this thesis did not include correlating environmental variables with parameters in the allometric equations. However, knowledge of the environment would facilitate and validate interpretation of the equations. Environmental factors of interest are soil moisture, soil nutrient content, and light availability. Additional plant parameters to quantify are plant moisture stress, total percent cover of all species including Douglas-fir and red alder, and percent crown cover that individual trees are experiencing. Ritchie and Hann (1986) found that the most influential variables in height growth analysis were tree position (tree height/height of surrounding trees) and crown competition factor.

Future research should focus on correlating environmental conditions with the variables in the allometric equations. Another focus should be determining how the equations change as the trees grow. Allometric relationships of red alder have been found to change over time. As the stand nears self-thinning the equations reach a stable level (Smith, 1986). In conjunction with determining how the equations change, inquiry should be made about sampling methods for larger trees. Biomass of tree components, especially roots, will be difficult to obtain. Helpful references on this subject are Valentine et al.(1984), Valentine and Hilton (1975), Santantonio et al. (1977), Jackson and Chittenden (1981), and Keyes and Grier (1981).

BIBLIOGRAPHY

Abrams, M. D. Age-diameter relationships of Quercus species in relation to edaphic factors in gallery forests in northeast Kansas. Forest Ecology Management, 1985, 13(3/4):181-194.

Atkinson, W. A., and W. I. Hamilton. The value of red alder as a source of nitrogen in a Douglas-fir/red alder mixed stand. In: Briggs, D. G., D. S. DeBell, and W. A. Atkinson (Eds.). Utilization and Management of Red Alder. PNW Forest and Range Experiment Station, USDA, Portland, Oregon, 1978, pp. 337-351.

Baskerville, G. L. Dry-matter production in immature balsam fir stands: Roots, lesser vegetation, and total stand. Forest Science, 1960, 12:49-53.

Baskerville, G. L. Use of logarithmic regression in the estimation of plant biomass. Canadian Journal of Forest Research, 1972, 2:49-53.

Berg, A., and A. Doerksen. Natural fertility of a heavily thinned Douglas-fir stand by understory red alder. Research Note No. 56. Oregon State University School of Forestry, Corvallis, 1975.

Binkley, D. Ecosystem production in Douglas-fir plantations: Interactions of red alder and site fertility. Forest Ecology and Management, 1983, 5:215-227.

Binkley, D., J. D. Lousier, and K. Cromack. Ecosystem effects of Sitka alder in a Douglas-fir plantation. Forest Science, 1984, 3(1):26-35.

Bormann, B. T., and D. S. DeBell. Nitrogen content and other soil properties related to age of red alder stands. Soil Science of America Journal, 1981, 45(2):428-432.

Bormann, B. T., and J. C. Gordon. Stand density effects in young red alder plantations: Productivity, photosynthate partitioning, and nitrogen fixation. Ecology, 1984, 65(2):394-402.

Brand, D. G. Competition-induced changes in developmental features of planted Douglas-fir in southwestern British Columbia. Canadian Journal of Forest Research, 1986, 16:191-196.

Brand, D. G. A competition index for predicting the vigour of planted Douglas-fir in southwestern British Columbia. Canadian Journal of Forest Research, 1985, 16:23-29.

Cleary, B. D., R. D. Greaves, and P. W. Owston. Seedlings. In: Regenerating Oregon's Forests. Cleary, B. D., R. D. Greaves, and R. K. Hermann (Eds.). Oregon State University School of Forestry, Corvallis, 1982, pp. 63-97.

Daniel, T. W., J. A. Helms, and F. S. Baker. Principles of Silviculture. New York: McGraw-Hill, 1979.

Dawson, J. O., and J. C. Gordon. Photoassimilate supply and nitrogen fixation in Alnus. In: Gordon, J. C., C. T. Wheeler, and D. A. Perry (Eds.). Symbiotic Nitrogen Fixation in the Management of Temperate Forests. Proceedings of a workshop held April 2-5, 1979, Oregon State University, Corvallis.

Draper, N., and H. Smith. Applied Regression Analysis, 2nd ed. New York: John Wiley and Sons, 1981.

Flewelling, J. W., and L. V. Pienaar. Multiple regression with log-normal errors. Forest Science, 1981, 27(2):281-289.

Grier, C., K. Lee, and R. Archibald. Effect of urea fertilization on allometric relations in young Douglas-fir trees. Canadian Journal of Forest Research, 1984, 14(6):900-904.

Gholz, H. C., C. C. Grier, A. G. Campbell, and A. T. Brown. Equations for estimating biomass and leaf area of plants in the Pacific Northwest. OSU Forest Research Lab., Research Paper 41, 1979.

Gunst, R. F., and R. L. Mason. Regression Analysis and Its Application: A Data-oriented Approach. New York: Marcel Dekker, Inc., 1980.

Harding, R. B., and D. R. Grigal. Site quality influences on biomass estimates for white spruce (Picea glauca) plantations. Forest Science, 1986, 32(2):443-446.

Harper, J. L. Population Biology of Plants. New York: Academic Press, 1977.

Honer, T. G. Weight relationships in open- and forest-grown balsam fir trees. In: Forest Biomass Studies, Young, H. E. (Ed.). Orono, Maine: University of Maine Press, 1971, pp. 65-78.

Hutchings, M. J., and C. S. J. Budd. Plant competition and its course through time. BioScience, 1981, 31(9):640-645.

Jackson, D. S., and J. Chittenden. Estimation of dry matter in P. radiata root systems. New Zealand Journal of Forest Science, 1982, 11:164-182.

Jolliffe, P. A., A. N. Minjas, and V. C. Runeckles. A reinterpretation of yield relationships in replacement series experiments. Journal of Applied Ecology, 1984, 21:227-243.

Keyes, M. R., and C. C. Grier. Above- and below-ground net productivity in a 40-year-old Douglas-fir stand on low- and high-productivity sites. Canadian Journal of Forest Research, 1981, 11:599-605.

Kira, T., H. Ogawa, and N. Sakazaki. Intraspecific competition among higher plants. I. Competition-yield-density interrelationship in regularly dispersed populations. J. Inst. Poly. Osaka City University, 1953, Vol. 4, Series D, pp. 1-16.

Kozak, A. Methods for ensuring additivity of biomass components by regression analysis. Forest Chronical, 1970, 46:402-404.

Kozlowski, T. T. Growth and Development of Trees, Vol. II: Cambial Growth, Root Growth, and Reproductive Growth. New York: Academic Press, 1971.

Larcher, W. Physiological Plant Ecology. New York: Springer-Verlag, 1980.

Madgwick, H. A. I. The accuracy and precision of estimates of the dry matter in stems, branches, and foliage in an old-field Pinus virginiana. In: Young, H. E. (Ed.). Forest Biomass Studies, 1971. University of Maine Press, Orono, Maine, pp. 105-112.

Madgwick, H. A. I., and T. Satoo. On estimating the above-ground weights of tree stands. Ecology, 1975, 56:1446-1450.

McArdle, R. E., W. H. Meyer, and D. Bruce. The Yield of Douglas-fir in the Pacific Northwest. USDA Technical Bulletin No. 201, 1961.

Mead, R., and J. Riley. A review of statistical ideas relevant to intercropping research. Journal of the Royal Statistical Society A, 1981, 144(4):462-509.

Miller, R. E., and M. D. Murray. Effects of red alder on the growth of Douglas-fir. In: Utilization and Management of Alder. Briggs, D. G., D. S. DeBell, and W. A. Atkinson (Eds.). PNW Forest and Range Experiment Station, USDA, Portland, Oregon. General Technical Report PNW-70, 1978, pp. 288-306.

Mountford, M. D., and R. G. H. Bunce. Regression sampling with allometrically related variables, with particular reference to production studies. Forestry, 1973, 46(2):203-212.

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

Oliver, W. W. Brush reduces growth of thinned ponderosa pine in northern California. Pacific Southwest Forest and Range Experiment Station, Research Paper PSW-172, 1984.

Radosevich, S. R. Experimental methods to study crop and weed interactions. In" Altieri, M. A., M. Z. Liebman (Eds.). Plant Competition and Other Ecological Approaches to Weed Control in Agriculture. CRC Press, 1987 [in press].

Ritchie, M. W., and D. W. Hann. Development of a tree height growth model for Douglas-fir. Forest Ecology Management, 1986, 15(2): 135-145.

SAS Institute. SAS/STAT Guide for Personal Computers, Version 6 Edition, 1985. Cary, N.C.: SAS Institute, Inc.

Santantonio, D., R. K. Hermann, and W. S. Overton. Root biomass studies in forest ecosystems. Pedobiologica, 1977, 17:1-31.

Satoo, T., and H. A. I. Madgwick. Forest Biomass. London: Dr. W. Junk Publishers, 1982.

Smith, J. H. G., and D. S. De Bell. Some effects of stand density on biomass of red alder. Canadian Journal of Forest Research, 1974, 4:335-340.

Smith, N. J. A Model of stand allometry and biomass allocation during the self-thinning process. Canadian Journal of Forest Research, 1986, 16:990-995.

Spitters, C. J. T. An alternative approach to the analysis of mixed cropping experiments. I. Estimation of competition effects. Netherlands Journal of Agricultural Science, 1983a, 31:1-11.

Spitters, C. J. T. An alternative approach to the analysis of mixed cropping experiments. II. Marketable yield. Netherlands Journal of Agricultural Science, 1983b, 31:143-145.

Shinozaki, K., and T. Kira. Intraspecific competition among higher plants. VII. Logistic theory of the C-D effect. Journal of the Institute of Polytechnics, Osaka City University, 1956, 7:35-72.

Tarrant, R. F. Stand development and soil fertility in a Douglas-fir and red alder plantation. Forest Science, 1961, 7:238-246.

Valentine, H. T., and S. J. Hilton. Sampling oak foliage by the randomized-branch method. Canadian Journal of Forest Research, 1977, 7:295-298.

Valentine, H. T., L. M. Tritton, and G. M. Furnival. Subsampling trees for biomass, volume, or mineral content. Forest Science, 1984, 30(3):673-681.

Valentine, H. T. Tree-growth models: Derivations employing the pipe-model theory. Journal of Theoretical Biology, 1986, 117(4):579-586.

Waring, R. H., and W. H. Schlesinger. Forest Ecosystems: Concepts and Management. Orlando: Academic Press, Inc., 1985.

Wheeler, C. T., and M. E. McLaughlin. Environmental modulation of nitrogen fixation in actinomycete nodulated plants. In: Gordon, J. C., C. T. Wheeler, and D. A. Perry (Eds.). Symbiotic Nitrogen Fixation in the Management of Temperate Forests. Proceedings of a workshop held April 2-5, 1979, Oregon State University, Corvallis.

White, E. H., W. L. Pritchett, and W. K. Robinson. Slash pine root biomass and nutrient concentrations. In: Forest Biomass Studies. Young, H. E. (Ed.). Orono, Maine: University of Maine Press, 1971, pp. 165-176.

Wit, C. T. de. On Competition. Vers. landbouwkd. onderz., 1960, No. 66.8.

Zavitovski, J., and R. D. Stevens. Primary Productivity of red alder ecosystems. Ecology, 1971, 53(2):235-242.

APPENDICES

APPENDIX 1. Abbreviations and definitions of terms available for model selection

Diam = Stem diameter measured 2 cm above the ground (mm).
ln(Diam) = Natural logarithm of Diam.

Ht = Total height of the tree seedling (cm).
ln(Ht) = Natural logarithm of Ht.

Crwdth = Average crown width of seedling (cm).
ln(Crwdth) = Natural logarithm of Crwdth.

D^2H = (diameter^2) x (height).
ln(D^2H) = Natural logarithm of D^2H.

C^2H = (crown width^2) x (Height).
ln(C^2H) = Natural logarithm of C^2H.

Totbio = Biomass of the total tree seedling (g).
ln(Totbio) = Natural logarithm of Totbio.

Stbio = Biomass of the tree stem, branches, and buds (g).
ln(Stbio) = Natural logarithm of Stbio.

Rtbio = Biomass of the tree roots (including nodules for red alder (g).
ln(Rtbio) = Natural logarith of Rtbio.

Lfbio = Biomass of the tree leaves (g).
ln(Lfbio) = Natural logarithm of Lfbio.

Nodbio = Biomass of the red alder root nodules (g).

% Total = Percent cover of all annual and shrub species on the plot.
% Shrubs = Percent cover of all shrub species in the plot.
% Annual = Percent cover of all herbaceous species on the plot.

Ba = Basal area of the stems on the plot (cm^2/m^2).
ln(Ba) = Natural logarithm of Ba.

Ca = Crown area of the stems on the plot (cm^2/m^2).
ln(Ca) = Natural logarithm of Ca.

Dist = Distance to the nearest neighboring tree.
Avedist = Average distance to eight nearest neighboring trees.

Ba/Dist = Basal area of the stems on the plot divided by the distance to the nearest neighboring tree.
CA/Dist = Crown area on the plot divided by the distance to the nearest neighboring tree.

Dens = Density of the stems occupying the eight planting spots around the sample tree (trees/m^2).
DensDF = Density of Douglas-fir occupying the eight planting spots around the sample tree (trees/m^2).
DensRA = Density of red alder occupying the eight planting spots around the sample tree (trees/m^2).
Prop = Number of Douglas-fir seedlings/total number of seedlings surrounding the sample tree.

APPENDIX 2. Means and standard deviations of Douglas-fir dimensions and biomass by basal area.

BA cm^2/m^2 *	n		Totbio (g)	Stbio (g)	Lfbio (g)	Rtbio (g)	Ht (cm)	Diam (mm)	Crwdth (cm)
0 - 3.0	21	$\bar{X}$	34.9[a]	16.9[a]	11.0[a]	7.0[a]	57.9[a]	9.5[a]	29.3[a]
		sd	15.0	8.3	5.2	2.6	14.7	1.4	10.3
3.1-6.0	17	$\bar{X}$	51.8[ab]	27.6[a]	16.7[ab]	9.2[ab]	65.1[ab]	10.5[ab]	29.8[a]
		sd	45.3	24.3	14.1	9.5	17.4	2.8	11.6
6.1-8.0	28	$\bar{X}$	62.9[ab]	31.4[a]	19.5[ab]	12.0[ab]	72.6[ab]	12.1[ab]	34.8[a]
		sd	33.4	16.6	11.1	6.6	14.6	2.8	7.8
8.1-12.0	14	$\bar{X}$	62.3[ab]	32.7[a]	18.0[ab]	11.6[ab]	77.4[ab]	12.4[ab]	33.3[a]
		sd	28.3	14.7	9.6	4.7	13.4	2.3	10.4
12.1-14.0	37	$\bar{X}$	63.2[b]	29.5[a]	21.2[b]	12.5[b]	74.6[b]	11.8[b]	37.0[a]
		sd	28.4	13.9	10.4	5.8	15.2	2.2	10.9
14.1-18.0	13	$\bar{X}$	50.8[ab]	24.6[a]	16.7[ab]	9.5[ab]	68.3[ab]	10.8[ab]	31.7[a]
		sd	21.5	10.4	7.6	4.6	10.4	1.7	8.0
18.1-20.0	9	$\bar{X}$	53.3[ab]	23.8[a]	19.2[ab]	10.3[ab]	70.0[ab]	9.0[ab]	31.9[a]
		sd	30.0	14.4	11.1	5.4	13.8	2.1	8.4

Note: Different letters indicate significantly different ($p < .05$) means (Scheffe's test).

*Refer to Appendix 1 for definition of terms.

APPENDIX 3. Means and standard deviations of Douglas-fir dimensions and biomass by % total cover of weed species.[a]

% Total *	n		Totbio (g)	Stbio (g)	Lfbio (g)	Rtbio (g)	Ht (cm)	Diam (mm)	Crwdth (cm)
10	31	$\bar{X}$	61.6	30.6	19.1	11.9	72.9	11.5	33.7
		sd	40.1	20.2	12.7	7.8	17.9	2.4	12.3
20	8	$\bar{X}$	80.9	35.6	28.5	16.8	79.6	13.2	40.9
		sd	25.9	12.7	10.4	4.7	11.8	1.6	14.2
30	13	$\bar{X}$	72.1	38.3	20.6	13.2	81.8	13.7	38.4
		sd	14.9	8.1	5.3	3.3	12.4	1.5	5.3
40	27	$\bar{X}$	61.3	29.6	20.5	11.2	70.3	11.7	32.5
		sd	33.1	16.1	11.4	6.7	14.2	2.7	7.8
50	22	$\bar{X}$	42.0	19.4	13.4	9.2	63.5	10.1	30.3
		sd	20.3	9.5	7.5	4.3	13.3	1.9	8.6
60	8	$\bar{X}$	40.4	19.2	13.0	8.3	68.9	10.0	35.3
		sd	25.2	12.6	8.0	5.6	15.6	2.2	10.9
70	15	$\bar{X}$	49.8	23.9	17.1	8.7	68.7	10.0	30.3
		sd	24.8	12.2	9.0	4.8	11.7	2.0	7.7
90	7	$\bar{X}$	37.8	18.5	12.4	6.9	62.7	9.4	31.6
		sd	23.6	12.7	7.9	3.8	21.1	1.4	14.8
100	8	$\bar{X}$	40.2	23.8	13.1	7.1	59.1	10.4	31.6
		sd	21.5	18.6	9.1	4.2	12.9	2.6	9.3

[a] No significant differences between means.

* Refer to Appendix 1 for definition of terms.

APPENDIX 4. Means and standard deviations for red alder dimensions and biomass by distance to the nearest neighboring tree.

Dist** (cm)	n		Totbio (g)	Stbio (g)	Rtbio (g)	Nodbio* (g)	Ht (cm)	Diam (mm)	Crwdth (cm)
30	22	$\bar{X}$	76.3^{a}	52.7^{a}	23.6^{a}	0.80^{a}	129.7^{a}	14.1^{a}	58.0^{a}
		sd	48.6	33.7	15.6	0.42	25.3	3.1	16.0
45	28	$\bar{X}$	126.2^{a}	92.4^{a}	33.9^{a}	1.26^{a}	147.3^{ab}	17.0^{a}	78.7^{b}
		sd	75.1	59.2	17.9	0.78	31.6	3.7	24.9
60	28	$\bar{X}$	220.5^{b}	162.9^{b}	57.6^{b}	1.44^{a}	166.6^{b}	21.2^{b}	94.3^{a}
		sd	139.2	114.4	31.8	1.04	40.7	5.1	26.0

*Sample sizes for Nodbio were 6, 7, and 9, respectively.

**Refer to Appendix 1 for definition of terms.

Note: Different letters indicate significantly different ($p \leqslant .05$) means (Scheffe's test).

APPENDIX 5. Means and standard deviations for Douglas-fir dimensions and biomass by proportion.

Prop*	n		Totbio (g)	Stbio (g)	Lfbio (g)	Rtbio (g)	Ht (cm)	Diam (mm)	Crwdth (cm)
0.4	7	$\bar{X}$	71.5^{a}	35.0^{a}	23.8^{a}	12.7^{a}	82.0^{a}	11.6^{ab}	42.1^{a}
		sd	35.6	17.4	12.2	7.7	19.5	3.3	11.9
0.5	18	$\bar{X}$	68.7^{a}	32.9^{a}	22.6^{a}	13.2^{a}	76.9^{a}	12.7^{a}	37.9^{a}
		sd	19.4	9.7	8.7	3.8	12.8	1.7	8.5
0.6	10	$\bar{X}$	52.2^{a}	26.2^{a}	16.4^{a}	9.6^{a}	67.8^{a}	10.9^{ab}	32.7^{a}
		sd	31.5	15.0	11.5	5.6	17.3	2.5	14.8
0.7	6	$\bar{X}$	42.5^{a}	19.8^{a}	14.6^{a}	8.1^{a}	65.0^{a}	10.4^{ab}	31.1^{a}
		sd	16.8	9.0	5.6	3.9	6.5	1.8	8.2
0.8	13	$\bar{X}$	50.5^{a}	25.2^{a}	15.9^{a}	9.4^{a}	70.8^{a}	10.8^{ab}	31.8^{a}
		sd	23.7	12.6	6.6	6.1	14.4	2.0	6.5
1.0	85	$\bar{X}$	53.6^{a}	26.4^{a}	17.1^{a}	10.5^{a}	68.2^{a}	11.0^{b}	32.1^{a}
		sd	33.8	17.4	11.2	6.5	15.8	2.6	9.9

Note: Different letters indicate significantly different ($p < .05$) means (Scheffe's test).

*Refer to Appendix 1 for definition of terms.

APPENDIX 6. Means and standard deviations of red alder dimensions and biomass by proportion.[a]

Prop**	n		Totbio (g)	Stbio (g)	Rtbio (g)	Nodbio* (g)	Ht (cm)	Diam (mm)	Crwdth (cm)
0.0	40	$\bar{X}$	133.5	96.9	36.5	1.35	146.6	16.8	71.5
		sd	121.1	98.2	28.1	1.16	39.1	5.3	24.6
0.4	4	$\bar{X}$	177.6	137.4	40.2	0.57	149.0	18.9	100.0
		sd	56.1	49.5	12.1	--	36.3	1.8	21.7
0.5	14	$\bar{X}$	208.5	154.8	53.6	1.06	163.8	20.7	93.8
		sd	130.9	100.8	32.2	0.30	38.5	5.3	29.5
0.6	12	$\bar{X}$	129.2	94.7	34.6	1.23	149.3	17.1	77.9
		sd	88.9	66.6	22.9	0.90	32.0	4.3	24.5
0.7	5	$\bar{X}$	127.9	87.4	40.5	1.62	138.0	17.7	71.5
		sd	72.3	52.1	21.0	1.07	28.0	3.8	24.7
0.8	2	$\bar{X}$	87.3	50.1	37.2	1.54	138.0	17.6	98.8
		sd	14.2	7.9	22.1	--	15.6	5.4	50.6
1.0	1	$\bar{X}$	54.4	37.8	16.6	0.40	131.0	13.5	55.5
		sd	--	--	--	--	--	--	--

*Sample sizes for Nodbio are 7, 1, 5, 5, 2, 3, and 1, respectively.

**Refer to Appendix 1 for definition of terms.

[a]No significant differences between means.

APPENDIX 7

Raw Data

841010 **VARIABLE FORMAT FORM** Page 1 of 3

DATACODE ________ DATE 5 / 11 / 85 (mo da yr) RECORDER Pam Bold

FORMAT TYPE ________

STUDYID BELDIM1.DAT

DATA TITLE: Douglas-fir and red alder initial planting data for dimensional analysis. - Belfair site

	VARIABLE NAME	COLUMNS[a] OCCUPIED	FORTRAN[b] FORMAT	CODED (✓)	UNITS	MISS.VAL. CODE	VARIABLE LABEL
1	TMT	1-2	F2.0		——		
2	REP	3	F1.0		——		
3	SPECIES	4	F1.0	✓	——		
4	TRNO	5-6	F2.0		——		
5	HTTOT	1X, 8-11 .1	F4.1		cm		
6	HTBLC	1X, 13-15 .1	F3.1		cm		
7	CRWDTH1	1X, 17-19	F3.0		cm		
8	CRWDTH2	20-22	F3.0		cm		
9	DIAM	1X, 24-26.1	F3.1		mm		
10	RTWDTH	1X, 28-31.1	F4.1		cm	"blank"	
11	RTLNGTH	32-35 .1	F4.1		cm	"blank"	
12							
13							
14							
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18							

a) Include spaces in the total columns occupied, e.g. 1X, A5 = 1-6 columns.
b) Valid formats are: A=alpha, I= whole integer, F=decimal, E=sci.notation.

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841010 **VARIABLE DEFINITION FORM** Page 2 of 3

(Complete one form for each format type)

DATACODE ________ **DATE** 5 / 11 / 85 (mo da yr) **RECORDER** Pam Bold

FORMAT TYPE ________

STUDYID 82DIM1.DAT

VARIABLE NAME	BRIEF DEFINITION OF EACH VARIABLE	PRECISION
TMT	Treatment number (1-11) assigned to each plot	—
REP	The replication (1-3) that the plot is a part of	—
SPECIES	Coded value for tree species	—
TRNO	The tree number of the tree measured	—
HTTOT	The total height of the tree from the ground	0.5 cm
HTBLC	The height from the ground to the first live branch	0.5 cm
CRWDTH1	The width of the crown measured perpendicular to plot	cm
CRWDTH2	The width of the crown measured parallel to plot	cm
DIAM	The diameter of the stem measured 3cm above ground	0.1 mm
RTWDTH	The width of the roots measured at the greatest point	0.5cm
RTLNGH	The length of the roots from the soil line	0.5cm

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841010 **VARIABLE CODE FORM** Page 3 of 3

(Complete one form for ALL format types)

DATACODE ______ **DATE** 5 / 11 / 85 (mo da yr) **RECORDER** Pam Bold

STUDYID BELDIM1.DAT

VARIABLE NAME	CODE VALUE	BRIEF DESCRIPTION OF EACH CODED VALUE
SPECIES	1	Douglas-fir
	2	red alder

___ CONTINUED, Reverse side

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111	1	380	35	10	16	46		
111	2	330	35	9	10	32		
111	3	430	30	26	13	58		
111	4	300	20	19	21	37		
111	5	310	40	12	15	39		
111	6	380	30	23	18	42	160	205
111	7	295	25	10	13	50		
111	8	360	90	9	11	46	130	270
111	9	255	15	11	9	37	95	205
121	1	400	40	18	10	44		
121	2	420	30	14	31	56		
121	3	380	30	18	13	45		
121	4	490	95	11	7	47	120	235
121	5	450	60	23	40	64		
121	6	385	20	9	8	42	80	210
121	7	430	25	23	19	52	150	190
121	8	400	80	15	22	43		
121	9	380	45	9	21	37		
131	1	300	35	11	20	58	150	270
131	2	450	20	10	25	46		
131	3	490	20	10	15	49		
131	4	335	5	13	16	52		
131	5	380	5	15	11	50	180	180
131	6	470	40	20	17	57		
131	7	310	15	11	8	44	135	240
131	8	460	15	9	14	60		
131	9	270	15	14	14	42		
211	1	350	55	7	18	29		
211	2	440	60	13	15	48	130	220
211	3	355	50	18	11	36		
211	4	285	25	5	13	47	160	205
211	5	310	70	9	7	38		
211	6	325	20	9	14	39		
211	7	355	20	14	13	42		
211	8	380	60	17	25	48		
211	9	310	75	9	11	33		
221	1	430	35	25	24	52		
221	2	385	55	19	13	41		
221	3	395	25	21	9	46	105	210
221	4	420	20	25	17	52		
221	5	490	40	14	23	50		
221	6	600	60	32	26	64	180	200
221	7	510	15	16	6	58		
221	8	390	60	11	25	42	130	230
221	9	485	40	15	31	72		
231	1	310	30	11	16	36	180	210
231	2	490	175	10	11	50		
231	3	460	20	9	13	50		
231	4	490	75	25	29	61		
231	5	450	20	10	14	36		
231	6	450	35	17	14	51	100	230
231	7	510	30	17	21	68	120	170
231	8	430	35	23	15	48		

231	9	460	20	15	22	50		
311	1	310	40	11	12	35		
311	2	390	40	17	25	45		
311	3	410	35	8	9	46		
311	4	460	40	13	21	55	210	190
311	5	340	30	13	13	39		
311	6	345	30	10	11	30		
311	7	285	30	11	20	33	90	170
311	8	460	40	10	26	52		
311	9	400	20	25	15	51	210	210
321	1	460	30	19	21	74	300	290
321	2	450	55	24	17	56	130	190
321	3	355	50	18	20	39		
321	4	420	70	24	32	48		
321	5	390	30	24	37	49	85	220
321	6	370	30	19	15	42		
321	7	380	35	15	14	40		
321	8	360	60	17	21	36		
321	9	420	50	9	23	47		
323	1	320	35	11	19	48		
323	2	280	20	11	8	41		
323	3	400	40	15	28	56	150	205
323	4	455	50	17	28	56	210	220
323	5	300	35	9	24	52		
323	6	430	40	30	25	43		
323	7	350	15	12	12	40	85	295
323	8	395	75	7	9	42		
323	9	290	15	9	10	38		
411	1	375	85	14	8	42	100	240
411	2	270	30	10	14	30		
411	3	310	150	6	8	40		
411	4	350	40	12	16	36		
411	5	445	30	21	30	52	140	250
411	6	270	115	6	6	32		
411	7	270	15	14	13	36		
411	8	265	20	12	8	37	80	160
411	9	445	55	23	15	56		
421	1	570	50	42	22	75		
421	2	450	70	27	24	51	180	320
421	3	350	50	5	7	42		
421	4	305	80	20	13	30	90	240
421	5	395	75	23	17	45		
421	6	380	10	30	24	45		
421	7	290	20	11	9	39		
421	8	380	50	10	14	46	150	260
421	9	400	50	8	9	47		
431	1	330	20	13	25	40		
431	2	290	80	5	5	30		
431	3	320	10	10	21	40	145	300
431	4	460	40	13	24	51		
431	5	285	20	12	16	32		
431	6	305	15	9	16	50	130	260
431	7	420	50	12	17	50		
431	8	350	10	16	12	50	170	270

431	9	495	15	19	23	84		
512	1	420	60	9	9	59	120	270
512	2	345	30	23	21	37		
512	3	450	65	7	5	49		
512	4	330	65	17	27	43		
512	5	335	11	6	5	38		
512	6	355	10	11	14	48	130	370
512	7	565	45	31	31	79		
512	8	235	30	6	6	31		
512	9	485	55	15	24	63	30	370
522	1	420	30	17	21	61	240	240
522	2	295	40	6	6	30		
522	3	510	40	13	9	65		
522	4	420	20	24	13	81		
522	5	360	60	16	12	46		
522	6	500	80	22	28	75	180	380
522	7	280	5	17	17	66		
522	8	425	40	20	15	49		
522	9	600	40	30	21	69		
532	1	420	35	7	11	42		
532	2	350	20	23	26	61		
532	3	420	70	20	16	59	260	150
532	4	365	15	8	13	43		
532	5	280	25	8	11	36	50	230
532	6	370	60	16	22	50		
532	7	590	155	17	15	60	90	240
532	8	290	120	6	14	40		
532	9	490	80	14	6	61		
612	1	490	60	13	17	50		
612	2	615	80	17	18	82		
612	3	480	75	7	9	53	100	295
612	4	325	45	7	7	36		
612	5	410	30	11	17	49	150	280
612	6	345	12	5	5	38		
612	7	360	12	7	4	42		
612	8	440	75	9	7	46		
612	9	530	115	26	23	76	240	250
622	1	535	20	24	28	58		
622	2	380	85	6	8	50		
622	3	350	40	18	7	42		
622	4	470	45	34	29	57	125	190
622	5	455	40	27	27	72		
622	6	285	30	15	12	71		
622	7	510	70	15	7	51		
622	8	385	15	9	8	47		
622	9	470	25	20	32	80	220	250
632	1	370	40	10	13	52		
632	2	470	40	13	14	46	100	305
632	3	440	45	15	20	63		
632	4	310	50	7	7	32		
632	5	530	20	15	28	45		
632	6	470	80	17	18	48		
632	7	310	60	11	12	45	100	290
632	8	440	110	23	13	55		

632	9	260	40	7	12	45		
712	1	355	35	13	11	42	110	190
712	2	420	65	20	26	58		
712	3	510	75	17	20	56	190	250
712	4	380	40	17	20	45		
712	5	450	60	10	16	46		
712	6	380	25	17	19	49	130	180
712	7	305	15	9	8	32		
712	8	440	40	29	27	48		
712	9	425	35	9	11	49		
722	1	590	50	15	9	57	90	220
722	2	435	150	6	6	48		
722	3	400	100	4	4	33		
722	4	250	25	6	3	33		
722	5	180	60	2	2	29		
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722	7	315	55	12	6	34		
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732	7	410	40	13	20	38	35	130
732	8	320	25	5	5	32		
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812	1	440	150	10	11	43	70	210
812	2	390	35	5	11	30		
812	3	715	70	24	21	65		
812	4	225	40	10	10	32		
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812	6	605	90	20	24	78		
812	7	525	55	13	12	48	90	200
812	8	450	110	4	11	48		
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822	2	300	45	11	6	58		
822	3	250	15	7	8	38		
822	4	430	90	11	14	51		
822	5	380	30	8	8	31		
822	6	600	100	25	15	17	140	280
822	7	210	20	6	5	28	100	180
822	8	395	30	6	11	41		
822	9	665	70	21	21	63		
832	1	370	60	7	7	34	90	180
832	2	210	70	5	5	33		
832	3	360	100	7	9	32		
832	4	530	90	33	21	59		
832	5	345	140	10	5	29		
832	6	340	40	6	3	36	20	215
832	7	355	10	12	13	44		
832	8	360	20	8	6	41		

832	9	510	40	12	20	60	105	240
911	1	360	30	19	12	58	210	210
912	2	445	110	8	10	41	30	270
911	3	465	30	15	21	64		
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911	5	350	40	9	6	40	90	300
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912	7	245	20	5	8	34		
911	8	480	35	24	23	64	210	190
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911	12	370	30	16	11	57	160	230
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911	15	450	35	21	26	50	160	230
912	16	450	100	7	6	41	90	240
911	17	335	20	6	10	39	190	210
912	18	460	35	22	15	48		
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922	2	370	30	18	12	36		
921	3	450	35	18	22	64	240	265
922	4	715	240	10	23	84		
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922	9	480	120	18	19	60		
921	10	270	25	5	5	39		
922	11	320	110	7	9	52	40	260
921	12	345	20	20	15	50		
921	13	390	35	22	20	48		
922	14	330	100	8	15	48	65	270
921	15	440	35	9	11	50	150	210
922	16	380	40	25	16	53		
921	17	395	55	22	20	53		
922	18	460	180	15	9	45	90	210
931	1	255	35	11	22	49		
932	2	340	60	18	16	52		
931	3	450	15	31	19	80		
932	4	365	30	15	11	63		
931	5	450	50	27	31	47		
932	6	235	35	13	14	56	220	260
932	7	380	110	5	5	46	95	215
931	8	310	30	9	7	39		
932	9	490	30	22	26	88		
931	10	330	30	11	14	41		
932	11	330	50	14	10	50		
931	12	520	30	34	28	70	180	220
931	13	510	60	17	10	60	230	240
932	14	440	110	16	13	52		
931	15	430	25	25	20	48		
932	16	380	35	18	24	72	120	240
931	17	420	20	12	16	50		

93218	300	20	10	14	42		
1012 1	450	80	13	10	68	240	260
1011 2	395	25	18	24	33		
1012 3	560	50	14	30	66	160	290
1011 4	410	115	7	11	40	80	190
1012 5	250	40	6	7	29		
1011 6	550	100	12	21	56		
1011 7	330	45	37	15	124	80	210
1012 8	385	20	18	14	48		
1011 9	520	60	24	21	59		
101210	340	25	3	8	29	170	150
101111	560	15	8	33	63	140	160
101212	310	20	7	9	38		
101213	310	60	6	7	39		
101114	410	20	14	17	47		
101215	520	35	20	20	67		
101116	320	35	20	13	45		
101217	500	65	17	21	50		
101118	450	70	16	28	57		
1022 1	460	40	14	21	51		
1021 2	505	150	21	11	55	220	200
1022 3	520	110	12	11	48		
1021 4	440	30	21	22	48	160	240
1022 5	530	60	27	19	59	270	280
1021 6	430	35	12	23	50		
1021 7	340	15	12	21	43		
1022 8	300	30	22	14	44		
1021 9	470	40	12	24	47		
102210	420	70	17	23	54		
102111	535	40	27	14	66		
102212	345	55	10	18	44		
102213	500	100	21	14	50	100	310
102114	480	20	21	19	59		
102215	360	40	15	8	35		
102116	390	20	17	8	32		
102217	470	140	20	17	49		
102118	530	30	13	27	60	170	180
1031 1	365	15	11	10	51		
1032 2	360	60	4	4	49	110	140
1031 3	345	30	27	18	38		
1032 4	275	40	7	5	34	60	180
1031 5	380	35	19	17	38	190	220
1032 6	420	65	17	21	62		
1032 7	280	35	2	2	31		
1031 8	280	15	10	16	50		
1032 9	530	60	18	34	71		
103110	400	15	22	19	50		
103211	330	30	6	17	43		
103112	410	50	17	20	60	310	240
103113	370	15	14	20	45	140	200
103214	450	25	10	9	40	60	280
103115	495	15	28	30	61	125	240
103216	310	35	4	4	34		
103117	330	120	7	6	30		

103218	380	15	10	7	31		
1111 1	440	15	14	12	48		
1112 2	455	20	17	16	52	160	320
1111 3	400	40	8	19	46	90	280
1112 4	420	50	10	15	53		
1111 5	435	30	19	31	52		
1112 6							
1112 7	465	150	5	19	41	90	190
1111 8	345	100	10	9	46	160	140
1112 9	290	50	7	8	40		
111110	340	60	9	18	42		
111211	495	65	11	15	48		
111112	340	100	7	11	42		
111113	280	10	18	14	36		
111214	345	120	5	5	41	140	220
111115	320	40	14	17	46	120	170
111216	520	60	11	19	74		
111117	335	40	14	13	40		
111218	350	10	5	8	47		
1122 1	330	50	10	8	39	170	160
1121 2	500	70	30	30	60		
1122 3	330	40	5	5	33	150	250
1121 4	480	65	22	19	53		
1121 5	270	10	9	8	40		
1121 6	315	10	20	15	55		
1121 7	510	40	25	18	54	105	210
1122 8	410	130	5	3	43		
1121 9	360	70	10	9	38		
112210	430	100	15	15	68		
112111	425	10	23	13	41	95	205
112212	555	90	22	16	72	220	310
112213	315	30	13	13	40		
112114	435	20	15	14	50		
112215	220	10	12	16	46		
112116	385	50	11	7	39	150	175
112217	530	35	25	12	55		
112118	400	20	17	14	37		
1131 1	320	50	12	13	38	80	240
1132 2	370	30	12	14	67	50	290
1131 3	425	40	13	12	65		
1132 4	270	50	21	18	43		
1131 5	410	20	15	11	67		
1132 6	240	40	13	15	45		
1132 7	270	110	3	3	33		
1131 8	290	20	9	21	40		
1132 9	420	90	27	22	78		
113110	350	15	14	29	48		
113211	435	55	10	6	48		
113112	385	20	23	20	48	115	200
113113	275	40	11	5	28	60	210
113214	455	70	6	12	50	90	250
113115	215	50	15	17	43		
113216	335	50	12	17	62	270	360
113117	390	150	9	9	39		
113218	385	30	22	21	78		

841010 **VARIABLE FORMAT FORM** Page 1 of 3

DATACODE ______ DATE 9 / 23 / 85 (mo da yr) RECORDER Pamela Bold

FORMAT TYPE ______ DATA TITLE: Douglas-fir and red alder measurements after first growing season - Belfair site

STUDYID ______ BELDIM2.DAT

	VARIABLE NAME	COLUMNS[a] OCCUPIED	FORTRAN[b] FORMAT	CODED (✓)	UNITS	MISS.VAL. CODE	VARIABLE LABEL
1	TmT	1-2	F2.0		—		
2	REP	3	F1.0		—		
3	SPECIES	4	F1.0	✓	—		
4	TRNO	5-6	F2.0		—		
5	HTTOT	1x, 8-11	F4.1		cm		
6	HTBLC	1x, 13-15	F3.1		cm		
7	CRWDTH1	1x, 17-19	F3.0		cm		
8	CRWDTH2	20-22	F3.0		cm		
9	DIAm	1x, 24-26	F3.1		mm		
10	DAm	36-37	F2.0	✓	—		
11							
12							
13							
14							
15							
16							
17							
18							

a) Include spaces in the total columns occupied, e.g. 1X, A5 = 1-6 columns.
b) Valid formats are: A=alpha, I= whole integer, F=decimal, E=sci.notation.

___ CONTINUED, reverse side. Please indicate comments about this file on reverse side.

Forest Science Data Bank, Forest Science Dept., Oregon State University
Corvallis, OR 97331-5704 503-754-2244

841010

VARIABLE DEFINITION FORM

Page 2 of 3

(Complete one form for each format type)

DATACODE ________ DATE 9 / 23 / 85 (mo da yr) RECORDER Pamela Bold

FORMAT TYPE ________

STUDYID BELDIM2.DAT

VARIABLE NAME	BRIEF DEFINITION OF EACH VARIABLE	PRECISION
TMT	Treatment number (1-11) assigned to each plot	—
REP	Replication (1-3) that the plot is a part of	—
SPECIES	Coded value for tree species	—
TRNO	The number of the tree measured	—
HTTOT	Total height of the tree from the ground	0.5 cm
HTBLC	Height from the ground to the first live branch	0.5 cm
CRWDTH 1	The width of the crown measured perpendicular to plot	1.0 cm
CRWDTH 2	The width of the crown measured parallel to the plot	1.0 cm
DIAM	Stem diameter measured 3.0 cm above ground	0.1 mm
DAM	Damage Code	—

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841010 **VARIABLE CODE FORM** Page 3 of 3

(Complete one form for ALL format types)

DATACODE ________ DATE 9 / 23 / 85 (mo da yr) RECORDER Pamela Bold

STUDYID BELDIM2.DAT

VARIABLE NAME	CODE VALUE	BRIEF DESCRIPTION OF EACH CODED VALUE
SPECIES	1	Douglas-fir
	2	Red alder
DAM	1	Dead
	2	Dead top
	3	Almost Dead
	4	Browse Damage
	5	Chlorotic
	6	Necrotic
	7	Bent or broken stem
	8	Curled or deformed leaves
	9	Insect Damage
	10	Laterals taller than leader

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111	1	520	40	23	16	62	
111	2	435	70	22	18	46	
111	3	535	25	20	27	84	
111	4	310	15	27	12	48	
111	5	400	40	18	15	51	
111	6	495	20	24	20	61	
111	7	405	30	15	12	51	
111	8	480	90	22	17	55	
111	9	355	20	15	21	50	
121	1						1
121	2						1
121	3	365	40	14	11	55	2
121	4	545	95	18	10	63	5
121	5	505	55	25	43	75	
121	6	460	25	15	14	55	
121	7	565	30	27	20	63	
121	8	480	105	17	21	49	
121	9	445	40	14	23	46	5
131	1	390	105	11	13	65	6
131	2	545	60	17	19	59	
131	3						1
131	4	400	155	21	21	92	
131	5	360	15	21	17	53	
131	6	560	80	22	23	70	
131	7	425	5	18	20	75	
131	8	625	25	22	25	92	
131	9	360	10	31	20	76	
211	1	360	60	12	10	49	
211	2	500	70	14	15	59	
211	3	330	75	10	12	49	2
211	4	355	30	17	15	47	
211	5	360	60	15	17	50	
211	6	390	10	16	17	55	
211	7	430	15	14	15	55	5
211	8	455	40	18	29	73	
211	9	370	70	12	12	43	
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221	2	450	95	18	11	52	
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221	4	510	50	17	15	73	
221	5	575	30	19	24	66	
221	6	685	65	27	26	84	
221	7	595	40	17	15	64	
221	8	450	60	15	19	46	
221	9	610	40	30	23	85	
231	1	360	40	7	12	49	
231	2						1
231	3	497	90	15	11	60	
231	4						1
231	5	560	90	19	14	62	
231	6	500	130	11	11	65	

231	7						1
231	8	500	60	17	16	62	
231	9	630	50	26	27	88	
311	1	340	50	16	19	57	10
311	2	465	50	17	36	56	
311	3	475	80	15	12	60	
311	4	520	70	16	24	71	
311	5	450	40	18	17	64	
311	6	390	35	13	10	52	
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311	8	720	60	32	33	105	
311	9	490	40	23	20	81	
321	1	600	40	28	20	100	
321	2	525	90	25	18	83	
321	3						1
321	4	540	70	19	31	71	
321	5	480	35	20	36	58	
321	6	435	40	20	17	63	
321	7	475	35	21	21	71	
321	8						1
321	9	540	60	24	19	72	
331	1	355	60	7	9	53	
331	2						1
331	3						1
331	4	520	70	29	6	55	
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331	6	465	60	34	43	58	
331	7						1
331	8	500	70	19	13	57	
331	9	355	40	15	11	40	
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441	7	385	20	17	19	66	
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421	1	580	90	42	30	82	2
421	2	510	85	16	30	62	
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431	2						1
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431	4	550	55	16	17	65	
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522	4	590	40	38	30	106	
522	5	650	90	31	19	60	
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522	8	540	50	43	32	70	
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532	1	690	10	31	27	86	
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612	4	700	65	32	39	76	
612	5	725	160	25	36	92	6
612	6						1
612	7						1
612	8	830	230	38	39	90	6
612	9	885	225	36	30	105	6
622	1	725	15	39	34	81	
622	2	640	35	25	13	83	6
622	3	375	40	23	14	51	
622	4	635	40	49	54	88	
622	5	775	30	40	33	94	
622	6	520	25	25	15	76	
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622	9	830	40	26	40	95	
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632	3						1
632	4						1
632	5	240	97	8	7	59	2

632	6	180	00	11	11	41	2
632	7	515	90	24	10	50	
632	8						1
632	9	615	120	32	19	70	
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341	2	505	60	40	30	70	
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341	7	365	10	17	12	58	
341	8	470	30	20	21	86	
341	9	505	40	16	14	66	
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722	2	670	00	35	39	82	
722	3						1
722	4	595	50	20	23	73	
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111218						1
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1121 2	610	90	22	30	70	
1122 3	660	45	29	34	76	
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1122 5	635	00	29	30	82	
1121 6	425	00	16	17	64	
1121 7	505	50	23	18	60	2
1122 8	510	120	24	47	73	
1121 9	515	65	17	18	72	
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112111	490	00	18	20	71	
112212	920	50	35	36	97	5
112213	850	70	52	47	106	
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112215	690	00	42	35	100	
112116	460	45	26	24	74	
112217	805	30	56	56	100	
112118	520	40	19	19	63	
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1132 2	760	35	39	36	125	
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1131 5	520	25	21	25	95	
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1132 9	1030	55	51	61	115	
113110	420	05	20	39	50	
113211	570	45	26	31	120	10
113112	465	15	22	17	70	
113113	340	55	11	6	45	

113214	725	25	54	76	105
113115	465	165	12	9	50
113216	960	95	52	55	112
113117	495	05	15	15	53
113218	980	60	61	48	135

841010 **VARIABLE FORMAT FORM** Page 1 of 3

DATACODE ________ DATE 12 / 2 / 86 (mo da yr) RECORDER Pam Bold

FORMAT TYPE ________

DATA TITLE: Dimensional measurements of DF and RA after second growing season, Belfair, WA (Final Harvest Data)

STUDYID BELDIM3.DAT

	VARIABLE NAME	COLUMNS[a] OCCUPIED	FORTRAN[b] FORMAT	CODED (✓)	UNITS	MISS.VAL. CODE	VARIABLE LABEL
1	TmT	1-2	F2.0		-		
2	REP	4	F1.0		-		
3	SPECIES	6	F1.0	✓	-		
4	TRNO	8-9	F2.0		-		
5	HTTOT	12-14	F3.0		cm		
6	HTBLC	17-18	F2.0		cm		
7	CRWD1	20-22	F3.0		cm		
8	CRWD2	24-26	F3.0		cm		
9	DIAM	28-30	F3.1		mm		
10	DAM	32-33	F2.0	✓	—		
11	ANNcomP	35-36	F2.0		%		
12	SHRBcomP	38-39	F2.0		%		
13							
14							
15							
16							
17							
18							

a) Include spaces in the total columns occupied, e.g. 1X, A5 = 1-6 columns.
b) Valid formats are: A=alpha, I= whole integer, F=decimal, E=sci.notation.

___ CONTINUED, reverse side. Please indicate comments about this file on reverse side.

Forest Science Data Bank, Forest Science Dept., Oregon State University
Corvallis, OR 97331-5704 503-754-2244

841010 **VARIABLE DEFINITION FORM** Page 2 of 3

(Complete one form for each format type)

DATACODE ________ DATE 12 / 2 / 86 (mo / da / yr) RECORDER P. Bold

FORMAT TYPE ________

STUDYID BELDIM3.DAT

VARIABLE NAME	BRIEF DEFINITION OF EACH VARIABLE	PRECISION
TMT	Treatment (#1-11)	—
REP	Replication (#1-3, 4 on TMT3)	—
SPECIES	Coded value for species	—
TRNO	Tree number in plot (#1-9 monoculture, #1-18 mixture)	–
HTTOT	Total tree height from ground to ~~east~~ top	1.0 cm
HTBLC	Height from ground to first live branch	1.0 cm
CRWD1	Crown width measuring North - South	1.0 cm
CRWD2	Crown width measuring East - West	1.0 cm
DIAM	Stem diameter 2 cm above ground	0.1 mm
DAM	Coded value for damage	—
ANNCOMP	percentage cover of herbaceous plants on plot	5 %
SHRBCOMP	percentage cover of shrub plants on plot	5 %

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Forest Science Data Bank, Forest Science Dept., Oregon State University
Corvallis, OR 97331-5704 503-754-2244

810821

VARIABLE CODE SPECIFICATION FORM

DATA SET CODE ______________ STUDY ID BELDAM3.DAT Date/Initials 12-2-86 · PB

CARD TYPE __________ PAGE 3 of 3

VARIABLE (name)	CODE VALUE	DEFINITION OF CODE VALUE
SPECIES	1	Douglas-fir
	2	red alder
DAM	1	Dead
	2	Dead top
	3	Almost dead
	4	Browse damage
	5	Chlorotic
	6	Necrotic
	7	Bent or broken stem
	8	Curled or deformed leaves
	9	Insect damage
	10	Laterals taller than leader
	11	Branches below ground - largest stem measured
	12	Replanted 2-11-86

☐ Continued, Reverse

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Forest Science
Data Bank

1	1	1	1	75	6	39	44	119		55	10
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841010 **VARIABLE FORMAT FORM** Page 1 of 3

DATACODE ________ DATE 12 / 2 / 86 (mo / da / yr) RECORDER PB

FORMAT TYPE ________

STUDYID BELDIM3A.DAT

DATA TITLE: Root widths and lengths at final harvest, Belfair, WA (addition to BELDIM3.DAT)

	VARIABLE NAME	COLUMNS OCCUPIED[a]	FORTRAN FORMAT[b]	CODED (✓)	UNITS	MISS.VAL. CODE	VARIABLE LABEL
1	TMT	1-2	F2.0		—		
2	REP	4	F1.0		—		
3	SPECIES	6	F1.0	✓	—		
4	TRNO	8-9	F2.0		—		
5	RTWD	12-14	F3.0		cm		
6	RTLN	17-19	F3.0		cm		
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							

a) Include spaces in the total columns occupied, e.g. 1X, A5 = 1-6 columns.
b) Valid formats are: A=alpha, I= whole integer, F=decimal, E=sci.notation.

___ CONTINUED, reverse side. Please indicate comments about this file on reverse side.

Forest Science Data Bank, Forest Science Dept., Oregon State University
Corvallis, OR 97331-5704 503-754-2244

841010 **VARIABLE DEFINITION FORM** Page 2 of 3

(Complete one form for each format type)

DATACODE ______ DATE 12/2/86 (mo/da/yr) RECORDER PB

FORMAT TYPE ______

STUDYID BELDIM3A.DAT

VARIABLE NAME	BRIEF DEFINITION OF EACH VARIABLE	PRECISION
TMT	Treatment (#1-11)	—
REP	Replication (#1-3)	—
SPECIES	Coded value for species	—
TRNO	Tree number (#1-9 monocultures, #1-18 mixtures)	—
RTWD	Root width at widest point	1.0 cm
RTLN	Root length from root collar to longest point	1.0 cm

____ CONTINUED, reverse side

810821

VARIABLE CODE SPECIFICATION FORM

DATA SET CODE ________ STUDY ID BELDIM3A.DAT Date/Initials 12-2-86 PB

CARD TYPE ________ PAGE 3 of 3

VARIABLE (name)	CODE VALUE	DEFINITION OF CODE VALUE
SPECIES	1	Douglas-fir
	2	red alder

☐ Continued, Reverse

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Forest Science
Data Bank

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841010 **VARIABLE FORMAT FORM** Page __ of 3

DATACODE ________ DATE 5 / 14 / 85 (mo / da / yr) RECORDER Pam Bold

FORMAT TYPE ________

STUDYID BELBIO1.DAT

DATA TITLE: Initial planting dimensions + biomass of Douglas-fir and red alder seedlings - Belfair site. includes

	VARIABLE NAME	COLUMNS[a] OCCUPIED	FORTRAN[b] FORMAT	CODED (✓)	UNITS	MISS.VAL. CODE	VARIABLE LABEL
1	SPECIES	1	F1.0	✓			
2	TRNO	2-3	F2.0				
3	HTTOT	4-7	, F4.1		cm		
4	HTBLC	9-11	1x, F3.1		cm		
5	CRWDTH1	13-14	1X, F2.0		cm		
6	DIAM	15-17	, F2.0		mm		
7	RTWDTH	19-21	1X, F3.1		cm		
8	RTLNGTH	22-24	, F3.1		cm		
9	TBIO	26-28	1X, F3.1		g		
10	RTBIO	30-32	1X, F3.1		g		
11	STBIO	33-35	F3.1		g		
12	LFBIO	36-38	F3.1		g		
13	CRWDTH2	39-40	, F2.0		cm		
14	LEADER	42-44	1x, F3.1		cm		
15							
16							
17							
18							

a) Include spaces in the total columns occupied, e.g. 1X, A5 = 1-6 columns.
b) Valid formats are: A=alpha, I= whole integer, F=decimal, E=sci.notation.

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841010

VARIABLE DEFINITION FORM

Page 2 of 2

(Complete one form for each format type)

DATACODE ________ DATE 5 / 14 / 85 (mo da yr) RECORDER Pam Bold

FORMAT TYPE ________

STUDYID BELBIO1.DAT

VARIABLE NAME	BRIEF DEFINITION OF EACH VARIABLE	PRECISION
SPECIES	Coded value for tree species	
TRNO	The number assigned to the tree measured	
HTOT	Total height of seedling from soil level	0.5 cm
HTBLC	Height from ground to first live branch	0.5cm
CRWDTH 1	Width of the live crown at widest point; (initial) N.S for 1st yr.	cm
DIAM	Diameter of stem 3cm above ground	0.1mm
RTWDTH	Width of the roots at the widest point	0.5 cm
RTLNGTH	Length of roots from soil line	0.5 cm
TBIO	Total biomass of dried seedling with tare	0.1 g
RT BIO	Biomass of roots	0.1 g
STBIO	Biomass of stem	0.1 g
LF BIO	Biomass of leaves	0.1 g
CRWDTH 2	Width of crown E-W ; first growing season only	cm
Leader	Length of leader; first growing season only	0.5 cm

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841010 **VARIABLE CODE FORM** Page 1 of 3

(Complete one form for ALL format types)

DATACODE ________ DATE 5 / 14 / 85 (mo / da / yr) RECORDER Pam Bold

STUDYID BELBIO7.DAT

VARIABLE NAME	CODE VALUE	BRIEF DESCRIPTION OF EACH CODED VALUE
SPECIES	1	Douglas-fir; initial planting data
	2	red alder; initial planting data
	3	Douglas-fir; first growing season
	4	red alder; first growing season

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1 1	430	40	27	54	110280	281	047035030	
1 2	410	40	24	47	120230	235	022030019	
1 3	360	60	16	30	190215	191	010012011	
1 4	360	35	6	42	120215	190	014021029	
1 5	340	50	16	30	110200	160	009010012	
1 6	350	35	6	40	120180	179	020020013	
1 7	400	50	15	37	100240	180	012020020	
1 8	320	50	13	32	120220	163	015012010	
1 9	370	25	11	40	100210	183	013020025	
110	515	105	26	51	85175	207	015035030	
111	400	50	18	68	240230	270	050052040	
112	460	50	30	45	150220	210	020030030	
113	465	40	8	40	100230	180	010020020	
114	380	55	18	40	135200	185	011019020	
115	410	50	12	31	60230	161	008015013	
116	630	50	36	67	250210	309	042072060	
117	350	40	22	55	220210	240	039035034	
118	365	50	15	46	210215	192	020025020	
119	305	40	20	31	85370	159	010010010	
120	440	55	8	37	135235	179	017020012	
121	510	40	18	59	240290	248	029050036	
122	320	40	10	49	260210	169	011016010	
123	500	50	18	79	400250	328	060081050	
124	470	40	16	64	170250	292	042061052	
125	420	30	24	48	150230	210	025030026	
126	410	40	25	37	150280	190	013022020	
227	565	20	6	78	260390	290	090070	
228	380	95	7	50	185220	181	030027	
229	330	30	20	55	260300	210	040041	
230	550	35	29	88	240290	281	060091	
231	300	60	6	50	170300	178	030021	
232	440	35	26	61	250230	239	055050	
233	305	205	4	35	100190	150	013010	
234	410	70	12	60	360290	232	068040	
235	530	50	46	84	400520	379	130119	
236	330	40	29	52	210170	200	049030	
3 1	540	30	41	86	260280	389	16811810346	120
3 2	400	70	15	52	170310	117	45 34 3817	85
3 3	410	20	17	83	220280	277	153 74 5018	100
3 4	320	100	15	49	90250	89	51 23 1512	90
3 5	405	140	21	65	240140	131	54 47 3017	90
3 6	300	20	16	69	220220	134	39 50 4514	80
3 7	370	40	11	46	170230	102	51 25 2623	80
3 8	335	40	10	54	140150	75	24 27 2413	70
3 9	500	90	19	82	170220	223	84 77 6218	100
310	660	160	19103		210270	291	107140 4421	80
311	575	50	31102		340300	451	18115911121	80
312	520	00	29	91	250580	267	101101 6517	110

```
4 1 865  35 55133 480300 653 20929415051 560
4 2 640  40 40 96 250300 244  97 86 6133 340
4 3 950  00 63100 280410 508 204207 9744 660
4 41080  10 59153 410310 795 30532916158 770
4 5 865  00 41121 320340 556 18925211538 565
4 6 565  00 27 71 290550 217  95 85 3726 380
4 7 910  60 52116 360530 635 26725111749 590
4 8 430  40 18 49 160360  83  40 26 1713 190
4 9 410  30 30 74 380260 180 101 45 3430 215
410 655  20 43 83 330360 432 266 99 6732 365
411 830  00 52100 640310 491 18720310140 560
412 335  35 32 67 200190 115  46 41 2818 180
413 820  00 33112 320280 565 280191 9423 380
414 740  00 53109 210430 612 28621311322 460
415 990  00 82120 540350 785 39924813846 660
```

841010 **VARIABLE FORMAT FORM** Page 1 of 3

DATACODE ______ DATE 12 / 2 / 86 (mo / da / yr) RECORDER Pam Bold

FORMAT TYPE ______

STUDYID BELBIO2.DAT

DATA TITLE: Biomass and proximity values for DF & RA, Belfair, WA - Final harvest data

	VARIABLE NAME	COLUMNS[a] OCCUPIED	FORTRAN[b] FORMAT	CODED (✓)	UNITS	MISS.VAL. CODE	VARIABLE LABEL
1	TMT	1-2	F2.0		—		
2	REP	4	F1.0		—		
3	SPECIES	6	F1.0	✓	—		
4	TRNO	8-9	F2.0		—		
5	STBIO	11-14	F4.1		grams		
6	RTBIO	16-19	F4.1		grams		
7	LFBIO	21-23	F3.1		grams		
8	NOD	25-27	F3.2		grams		
9	DENS	29-31	F3.1		tr/m²		
10	DIST	33-36	F4.1		cm		
11	DENSDF	38-40	F3.1		tr/m²		
12	DENSRA	42-44	F3.1		tr/m²		
13	PROP	46-48	F3.1		—		
14							
15							
16							
17							
18							

a) Include spaces in the total columns occupied, e.g. 1X, A5 = 1-6 columns.
b) Valid formats are: A=alpha, I= whole integer, F=decimal, E=sci.notation.

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841010 **VARIABLE DEFINITION FORM** Page 2 of 3

(Complete one form for each format type)

DATACODE ________ DATE 12 / 2 / 86 (mo / da / yr) RECORDER PB

FORMAT TYPE ________

STUDYID BELBIO2.DAT

VARIABLE NAME	BRIEF DEFINITION OF EACH VARIABLE	PRECISION
TMT	Treatment (#1-11)	—
REP	Replication (#1-3)	—
SPECIES	Coded value for species	—
TRNO	Tree number in plot (#1-9 in monocultures, #1-18 in mixtures)	-
STBIO	Dry weight of stem + buds	0.1 g
RTBIO	Dry weight of roots (including nodules for RA)	0.1 g
LFBIO	Dry weight of DF needles (no RA data)	0.1 g
NOD	Dry weight of RA root nodules (sample of 30)	0.01 g
DENS.	Density (tr/m²) surrounding sample tree	0.1 trees
DIST	Average distance to 8 nearest trees	0.1 cm
DENSDF	Density of Douglas-fir surrounding sample tree	0.1 trees
DENSRA	Density of Red alder surrounding sample tree	0.1 trees
PROP	number of DF surrounding sample / total number of trees surrounding sample tree.	0.1

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810821

VARIABLE CODE SPECIFICATION FORM

DATA SET CODE ______ STUDY ID BELBIO2.DAT Date/Initials 12-2-86 -PB

CARD TYPE ______ PAGE 3 of 3

VARIABLE (name)	CODE VALUE	DEFINITION OF CODE VALUE
SPECIES	1	Douglas-fir
	2	red alder

☐ Continued, Reverse

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1	1	1	1	368	207	346	000	250	362	250	000	010
1	1	1	2	208	92	154	000	250	362	250	000	010
1	1	1	3	516	163	382	000	250	362	250	000	010
1	1	1	4	94	59	92	000	250	362	250	000	010
1	1	1	5	121	83	131	000	250	362	250	000	010
1	1	1	6	345	104	255	000	250	362	250	000	010
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1	2	1	3	117	53	105	000	222	437	222	000	010
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9	3	2	4	520	183	000	108	167	680	111	56	08
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9	3	2										
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9	1	1	8	321	134	239	000	194	433	111	83	05

9	1	1	10	241	171	228	000	139	543	83	56	05
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