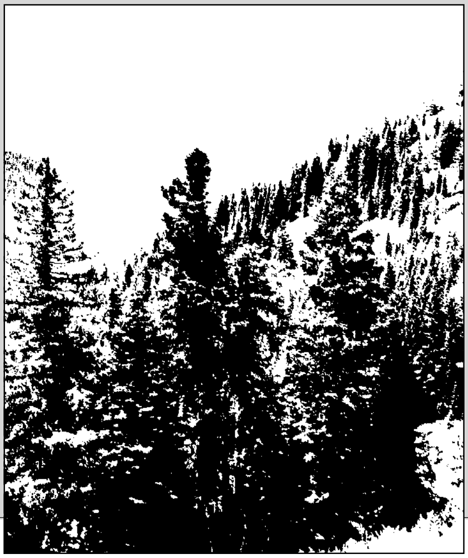
Research Contribution 18 March 1998

EXTENDING SOUTHWEST OREGON'S DOUGLAS-FIR DOMINANT HEIGHT GROWTH EQUATION TO OLDER AGES

by

David W. Hann



College of
Forestry

Forest Research Laboratory
Oregon State University

The Forest Research Laboratory of Oregon State University was established by the Oregon Legislature to conduct research leading to expanded forest yields, increased use of forest products, and accelerated economic development of the State. Its scientists conduct this research in laboratories and forests administered by the University and cooperating agencies and industries throughout Oregon. Research results are made available to potential users through the University's educational programs and through Laboratory publications such as this, which are directed as appropriate to forest landowners and managers, manufacturers and users of forest products, leaders of government and industry, the scientific community, and the general public.

The Author

David W. Hann is professor of forest biometrics in the Department of Forest Resources, Oregon State University, Corvallis.

Acknowledgment

This study was funded by the Forest and Rangeland Ecosystem Science Center of the Biological Resources Division, US Geological Survey, USDI.

To Order Copies

Copies of this and other Forest Research Laboratory publications are available from:

Forestry Publications Office
Oregon State University
227 Forest Research Laboratory
Corvallis, Oregon 97331-7401

Phone: (541) 737-4271
FAX: (541) 737-3385
email: forspub@frl.orst.edu

Please indicate author(s), title, and publication number if known.

EXTENDING SOUTHWEST OREGON'S DOUGLAS-FIR DOMINANT HEIGHT GROWTH EQUATION TO OLDER AGES

by

David W. Hann

Table of Contents

Introduction

Growing concerns about the environmental and sociological effects of traditional silviculture have focused attention upon the use of alternative, nontraditional silvicultural practices designed to enhance biological diversity and to meet multiple objectives for both individual stands and entire forest landscapes. The main intent in these nontraditional silvicultural practices is to create variation in the stand through the introduction of multiple species, multiple tree sizes, multiple canopy layers, and/or clumpy spatial distribution of trees within the stand. One means of introducing variation into a stand is to manage it to allow the development of older tree cohorts.

Development of nontraditional silvicultural prescriptions will require a stand development model that can predict the responses of all types of stand structures to alternative cutting strategies (such as thinning, shelterwood cutting, uneven-aged cutting, and patch cutting strategies), to fertilization, to pruning, and to genetic improvement. Of particular interest is the effect of these nontraditional treatments on stand growth rate, wood quality, wildlife habitat, and general "biological diversity" (Franklin 1988).

ORGANON is a stand development model (Hann *et al.* 1995) designed to operate on a personal computer. The program's architecture is a single-tree/distance-independent (Munro 1974) stand development model that incorporates crown attributes in many of its functions. This type of architecture was chosen because it has the capability of predicting the future development and resulting wood quality attributes of even-aged, two-storied, uneven-aged, and all-aged stands with either pure or mixed species composition. Treatments possible with this architecture include fertilization, pruning, and innumerable alternative cutting treatments. Finally, new trees can be added to the stand during simulation through an ingrowth routine.

The ORGANON model has the necessary structure to be applicable to both traditional and nontraditional silviculture. As a result, ORGANON has been used to project and evaluate such practices in southwest Oregon (Lewis and Brush 1990) and in the Willamette Valley (Birch and Johnson 1992, Briggs and Fight 1992). The model has even been used to project the development of old-growth stands (Lewis and Bonn 1989) and to evaluate spotted owl (Lewis and Pierle 1990) and other wildlife habitat needs (McComb 1994). Although many of these applications involved extrapolations beyond the basic data used to develop ORGANON, they indicate that the architecture of ORGANON is sufficiently adaptable to meet the needs of nontraditional silviculture.

Dominant height growth equations play a critical role in the ORGANON model, where they are used to predict the site index of a stand (Hann and Scrivani 1987) and the potential height growth rate of individual trees (Hann and Ritchie 1988; Ritchie and Hann 1990). As part of the original development of the Southwest Oregon version of ORGANON (SWO-ORGANON), Hann and Scrivani (1987) developed dominant height growth equations for Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco) and ponderosa pine (Pinus ponderosa Dougl. ex Laws.) using stem analysis data sets with an upper age of approximately 125 years at breast height. However, adapting SWO-ORGANON for application to nontraditional silvicultural treatments requires extending the model to ages of 250 years or more. Therefore, the objective of this study was to determine whether the existing dominant height growth equations of Hann and Scrivani (1987) could be extrapolated to ages of 250 years or beyond.

Data Collection

The data used to evaluate the extension of the Douglas-fir dominant height growth equation to ages between 125 and 250+ years came from 72 "older" stands previously measured for other objectives. The target population for these "older" stands was defined as follows:

1. Stand structure should be uniform, so that the species mix, competitive structure, and resulting potential management practices are essentially unchanged throughout the stand.
2. There should be common bedrock, landform, and soil associations, and a similar aspect (±60°), slope (±20%), and elevation (±500 ft) throughout the stand.
3. A majority of the overstory trees should be 150 years old or older, breast height age.
4. The stand should contain a minimum of 100 ft^2 of basal area, and 70% of this basal area should be in conifers.
5. Ninety percent of the total stand conifer basal area should be in Douglas-fir, white fir (*Abies concolor* (Gord. & Glend.) Lindl. ex Hildebr.), grand fir (*Abies grandis* (Dougl. ex D. Don) Lindl.), ponderosa pine, sugar pine (*Pinus lambertiana* Dougl.), and/or incense-cedar (*Libocedrus decurrens* Torr.); Douglas-fir must be a significant component of the overstory canopy layer.

The 72 "older" stands were randomly sampled across age, site quality, and stand structure, based on all combinations of the following: three age classes (150–200 years, 201–250 years, and 251+ years), three site-quality classes (low, medium, and high), and three percent-basal-area-in-overstory classes, in which number of replications differed by class (three replications with 20% to 50% of basal area in the overstory, three with 50% to 80% in the overstory, and two with 80% to 100% in the overstory). This sampling design, therefore, created 27 classes, for which three replicates were randomly chosen from 18 classes and two from 9 classes.

The following approach was used to classify and identify the 72 stands:

1. In order to identify potential candidate stands, existing BLM and USFS stand inventory information was sorted and screened according to the criteria for defining the target populations.
2. Candidate stands were further screened through the use of aerial photo interpretation and existing topological and soils maps.

3. Tentative “final” candidate stands were then randomly chosen for field reconnaissance, based on the classification scheme described above, to confirm that they met the criteria for the target population and that no physical or administrative obstacles existed that would prevent measurements being taken in the stand. Tentative “final” stands that did not pass field inspection were dropped, and a substitute stand was randomly selected for field reconnaissance. This process continued until all replicates in each of the 27 classes were identified.

From the 72 “older” stands, 30 stands, selected from stands not reserved from tree cutting, were used for the stem analysis work needed to evaluate the Hann and Scrivani (1987) equations. These stands included the full range in site quality found in the 72 stands (i.e., 10 stands each of low, medium, and high site quality based upon measured site indices).

Two undamaged free-growing dominant Douglas-firs in each stand were selected for stem analysis according to the following criteria for site-quality trees:

1. They came from the dominant crown class; predominant and open-grown trees were not used.
2. The increment cores taken at breast height showed no irregular radial growth patterns caused by suppression or damage.
3. The crown appeared to be in good health for a tree of its age.
4. There was no apparent disease, insect, or other damage to the bole or top that would affect height.

The trees were felled and sectioned at breast height and at 10-foot intervals above breast height. A 1- to 2-inch-thick “cookie” was cut from the top of each section, and the section’s age was determined in the field along two radii with the aid of a 20-power pocket magnifying glass. When growth rings were too close together for accurate counting in the field, sections were transported back to the office, smoothed with a belt sander, and rings were counted along the two radii by using a binocular microscope with up to 30-power magnification.

Data Analysis

Data Screening Procedures

An initial screening of each site tree’s data was done by graphing the following values across breast height age:

1. actual dominant height growth and predicted dominant height growth based on the tree’s height at breast height age of 50 as site index according to Hann and Scrivani’s (1987) equation; and
2. site index predicted from the Hann and Scrivani (1987) dominant height growth equation numerically solved to express site index

as a function of dominant height and age.

The first graph should have a sigmoidal shape over age, and the dominant heights should monotonically increase with age. This graph is useful for determining whether the tree experienced hidden height damage in the past. The actual data and the predicted curve for undamaged and free-growing trees should overlay each other, with some random error in the actual data, from 10 to 125 years (the age range for Hann and Scrivani's (1987) equation). If the Hann and Scrivani (1987) equation is applicable to older ages, this congruence should occur across the entire range of ages.

Unfortunately, trees that are not free growing can also display a sigmoidal shape over age, particularly if changes in the level of competition experienced by the tree occur gradually over time. The second graph is therefore useful in detecting suppression. An undamaged free-growing tree will exhibit, with variation, a general horizontal relationship between age and predicted site index (i.e, predicted site index should not change with breast height age). Again, this should be particularly true in the 10- to 125-year age range of the Hann and Scrivani (1987) equation. An increasing trend in predicted site index would indicate competition early in the tree's development (probably from non-tree vegetation) followed by release from competition (perhaps a gradual release if other trees were also competing with it). A decreasing trend in predicted site index, followed by an increasing trend in older ages, would indicate that the tree had been relatively free growing at a very early age, experienced increasing competition (probably from other trees) at later ages, and finally achieved dominance.

The presence of both of these trends can be evaluated statistically by regressing predicted site index at each section on section breast height age and then testing whether the estimate of the slope para-meter on age is significantly different from zero. In order to determine the expected statistical significance level for this parameter (for free-growing site-quality trees between 10 and 125 years), the three stem analysis trees more than 100 years old were extracted from the data set originally used to derive the Hann and Scrivani (1987) equation, and the appropriate simple linear regression analysis was performed on each tree. In all three cases, the slope parameter was not significantly different from zero at $\alpha = 0.1$ (i.e., the relationship between site index and age was very weak).

The same data set was used to determine the maximum difference between predicted site index at each section and the average predicted site index for all sections between 10 and 125 years of age. Results from this analysis indicated that, for site-quality trees, the difference should not exceed ±10% of the average site index.

These findings were used to develop the following two rules for determining whether the new stem analysis trees were of site quality. Sections aged 10 to 125 years were tested according to the following criteria:

1. The simple linear regression of predicted site index at each section on section age should have a parameter estimate on age that is not significantly different from zero at $\alpha = 0.1$.
2. The difference between predicted site index at each section and the average predicted site index should not exceed ±10% of the average site index.

Statistical Analysis Procedures

For each tree remaining after data screening, height was predicted at each section's breast height age by using the Hann and Scrivani (1987) dominant height growth equation and the average of the tree's predicted site index values from Hann and Scrivani (1987) for section ages between 10 and 125 years. Residuals were formed by subtracting actual from predicted height for each section age and tree. Previous work in predicting tree heights indicated that the variance in residuals increased with tree size (Larsen and Hann 1987). Therefore, percent residuals were also computed by dividing each residual by predicted dominant height and multiplying the quotient by 100, thus producing the second type of residual.

The mean residual, variance of the residuals, and the resulting estimate of the sampling error of the mean residual were computed for ages 10 to 125 years (corresponding to the range of the data set used to develop the Hann and Scrivani (1987) equation), for ages 126+ years, and for the entire data set. An unbiased model would result in a zero value for the mean residual. Therefore, an approximate 99% confidence interval about each mean residual was computed to determine the likelihood that the population's mean residual was zero.

The confidence interval is approximate because Monserud (1984) found that the residuals for dominant height growth of Douglas-fir followed a first-order autoregressive scheme with a positive coefficient of correlation between the residuals. As a result, the estimate of the standard error of the mean used in computing this confidence interval is negatively biased, resulting in the confidence interval being narrower than it should be at the 99% level (Kmenta 1986).

Trends in the residuals were evaluated by plotting the residuals over predicted dominant height, breast height age, and site index. The data were also divided into nine age classes (1–25, 26–50, 51–75, 76–100, 101–125, 126–150, 151–175, 176–200, and 201+ years), and the following values were computed for each age class:

1. mean residual;
2. variance of the residuals;
3. standard error of the mean residual; and
4. approximate 99% confidence interval about the mean residual.

The graphs of residuals over predicted dominant height and the computed variances for each age class were used to evaluate the presence of heteroskedasticity for the two types of residuals. The residual type displaying closest agreement with the assumption of homogeneous variance was then used for the remainder of the analysis.

Lack-of-fit of the Hann and Scrivani (1987) model to the validation data set was evaluated by examining the following:

1. the graphs of residuals over predicted dominant height, breast height age, and site index;
2. the trend in mean residuals and approximate 99% confidence intervals across breast height age classes; and
3. the use of Draper and Smith's (1981) F-test to evaluate lack-of-fit across breast height age.

Although segmenting the data into nine age classes is likely to reduce the effect of autocorrelation within each class, the resulting 99% confidence intervals are probably still conservative in their width. The probable effect of autocorrelation on the F-test for lack-of-fit is to underestimate the mean square error for the pure error in the denominator of the test. As a result, the computed F-statistic is probably inflated for the α level of the test.

Results

Examination of the individual tree graphs and application of the screening rules for breast height ages of 10 through 125 years to the 60 "older" stem analysis trees resulted in the elimination of 56 trees from the analysis data set. Two trees were rejected because the graphs indicated they had experienced either severe damage or severe long-lasting suppression. Thirty-four trees were rejected because the simple linear regression analysis indicated a significant *increasing* trend of predicted site index across age (e.g., Figure 1A), and nine trees were rejected because of a significant *decreasing* trend (e.g., Figure 1B). Eleven trees were rejected because one or more sections had predicted site index values that differed from the average predicted site index by more than ±10% (e.g., Figure 1C).

In order to increase sample size for the analysis, the second selection rule was relaxed by allowing trees to be accepted when only the difference for the youngest section age exceeded ±10% of the average value. This change added three trees, resulting in a total of seven trees available for data analysis (Table 1).

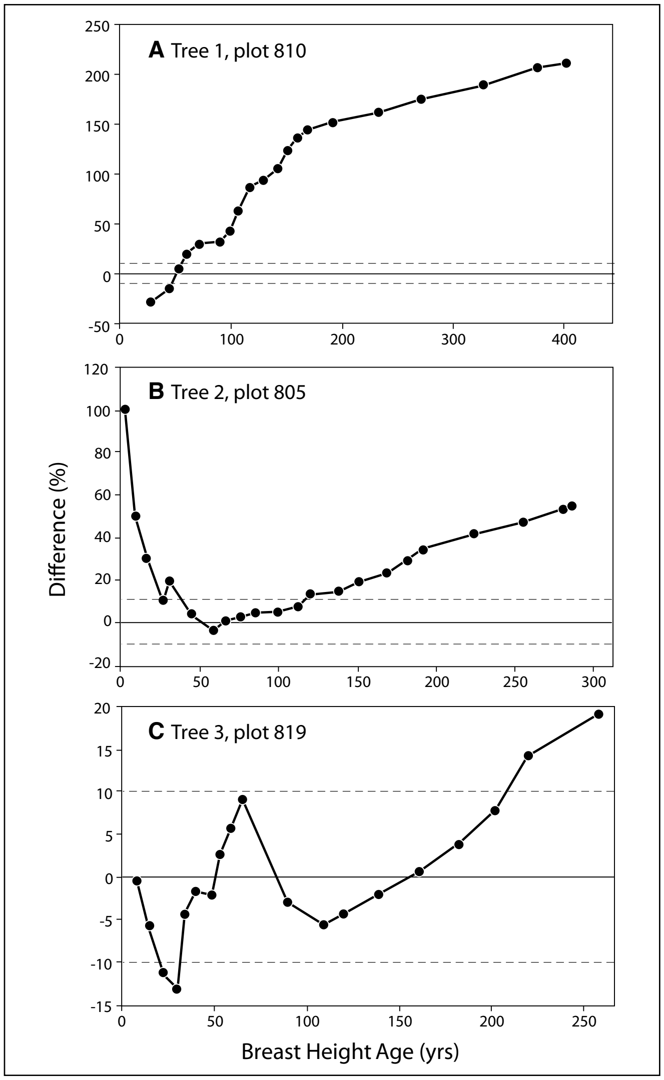


Figure 1. Example of trees exhibiting significant A) increasing and B) decreasing trends for predicted site index across breast height age in the first 100 years and C) tree in which one or more sections had predicted section site index values that differed from the average predicted site index by more than ±10% in the first 100 years.

Table 1. Summary of data analysis trees.

Site tree	Breast height age (years)	Total height (feet)	Total height of tree at a breast height age of 50 years
802-1	206	207.5	98.5
814-2	245	196.9	91.2
824-2	200	167.7	79.5
825-1	235	197.2	84.3
825-2	221	186.2	86.0
828-1	212	215.5	109.1
828-2	166	168.2	90.1
Means	212	191.3	91.2

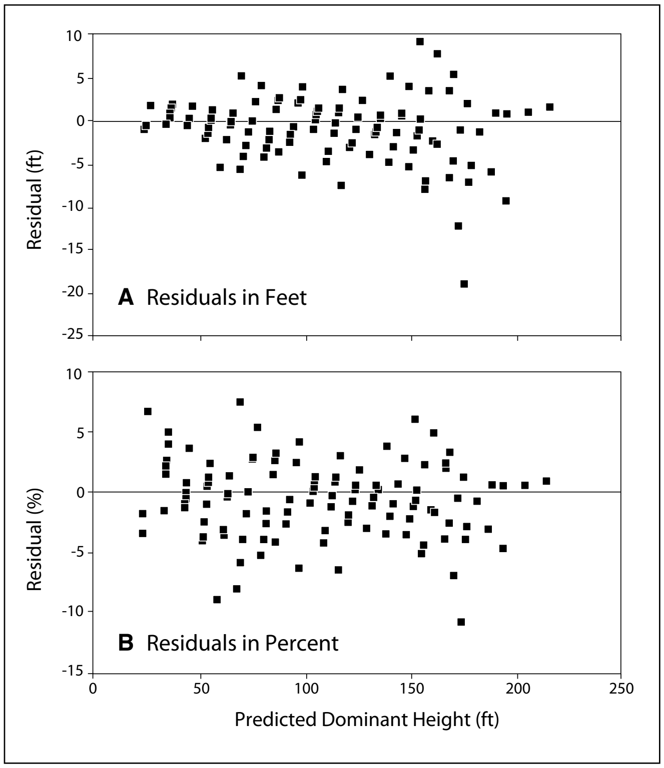


Figure 2. Residuals, in A) feet, and B) percent, plotted across predicted dominant height for the seven site-quality trees.

Examination of the graphs of residuals expressed in feet (Figure 2A) and as percentages (Figure 2B) across predicted dominant height, along with the computed residual variances across age classes for the two types of residuals, indicated that when residuals were expressed as a percentage (and therefore weighted by predicted dominant height), they were more homogeneous than when they were unweighted. Therefore, residuals in percent were used for the remainder of the analysis.

The graphs of percent residuals across predicted dominant height (Figure 2B) and site index (Figure 3) do not indicate any significant trends. The graph of percent residuals across breast height age (Figure 4) seems to indicate that the Hann and Scrivani (1987) equation may underpredict dominant heights at ages above 175 years. Table 2 shows the mean residual, variance of the residuals, standard error of the mean residual, and approximate 99% confidence interval about the mean residual for various age classes and for the overall data set. Figure 5 shows

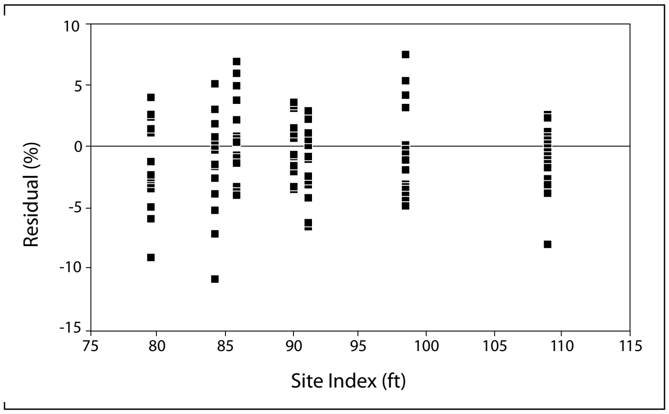


Figure 3. Residuals, in percent, plotted across site index for the seven site-quality trees.

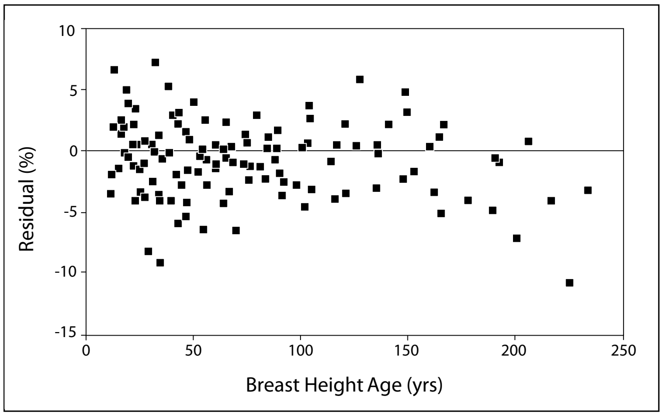


Figure 4. Residuals, in percent, plotted across breast height age for the seven site-quality trees.

the mean residuals and approximate 99% confidence intervals across breast height age classes. In all cases, the approximate 99% confidence intervals include zero, indicating that the apparent change in the older ages is not statistically significant.

Finally, the F-statistic for lack-of-fit across breast height age was computed as 2.158 with 9 and 108 degrees of freedom. The critical F-values are 1.97 for $\alpha = 0.05$ and 2.56 for $\alpha = 0.01$. Given that the F-statistic is probably inflated because of autocorrelation, this result is a further confirmation that there is no significant trend in residuals across breast height age for this limited validation data set.

Table 2. Summary of percent residuals by age classes, where residual is defined as predicted minus observed dominant height.

		Percent Residuals				
					99% Confidence interval	
Age class	Number	Mean	Variance	Standard error of mean	Upper	Lower
1–25	19	1.53	7.9397	0.65	3.39	-0.33
26–50	29	-0.51	14.9196	0.72	1.47	-2.49
51–75	21	-0.50	6.0781	0.54	1.03	-2.03
76–100	14	-0.29	3.6351	0.51	1.25	-1.82
101–125	11	0.03	8.2932	0.87	2.78	-2.72
126–150	9	1.86	9.1641	1.01	5.24	-1.53
151–175	6	-0.51	7.6982	1.13	4.06	-5.07
176–200	4	-2.05	4.6594	1.08	4.26	-8.35
201+	5	-4.39	19.1687	1.96	4.63	-13.40
1–125	94	-0.54	9.3618	0.32	0.29	-1.37
126+	24	-1.23	14.6371	0.78	0.97	-3.42
All	118	-0.68	10.3955	0.30	0.10	-1.46

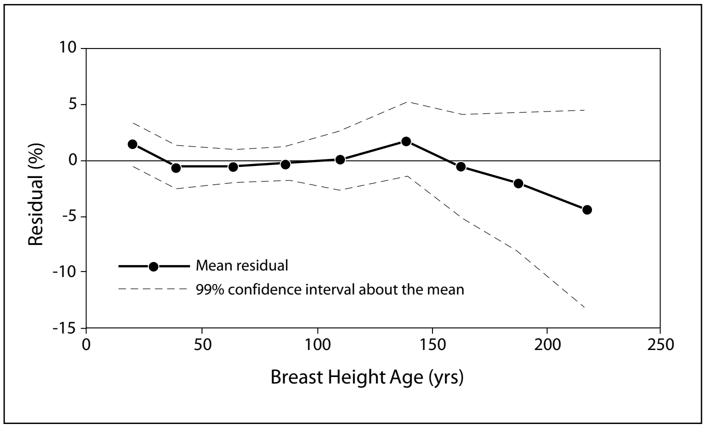


Figure 5. Mean residual and approximate 99% confidence intervals about the mean residual, plotted across breast height age.

Discussion

For many of the trees originally selected as being of site quality, analysis of their first 100 years of development revealed signs of reduced height growth due to competition from non-tree vegetation, hardwood tree species, and possibly other conifers in non-even-aged stands. Detecting these reduced early height growth rates from increment cores and external tree characteristics proved to be very difficult. When graphs of dominant height and predicted site index over breast height age indicated a problem in identifying true site-quality trees, field selection procedures were changed to emphasize selecting site trees from stands with a more even-aged structure. This increased the selection success rate from 2 in 30 (6.7%) for the first half of the sample to 5 in 30 (16.7%) for the second half. Unfortunately, the requirements of the Environmental Assessment under which this work was conducted limited flexibility in responding to this problem by restricting the selection to the few stands previously identified in the assessment.

The trees exhibiting early reduced height growth rates and stature often compensated by increasing height growth rates later in their development (e.g., Figure 6). This behavior is in concordance with the findings of Peet (1976, 1981) that tree growth is more a function of tree size than tree age, and with the hypothesis of Ryan and Yoder (1997) that tree height and height growth are limited "by increased hydraulic resistance resulting from increased xylem path length in taller trees with longer branches" (p. 238). Oliver and Larson (1996) reported that during "times of unsuppressed growth, small trees which were formerly suppressed by high shade grow at a rate which parallels height growth of dominant trees which were never suppressed on the same site" (p. 63). This behavior is reflected in the height growth rate equations used in ORGANON, where, given site quality, potential height growth rate is defined by the tree's height rather than its age (Hann and Ritchie 1988; Ritchie and Hann 1990).

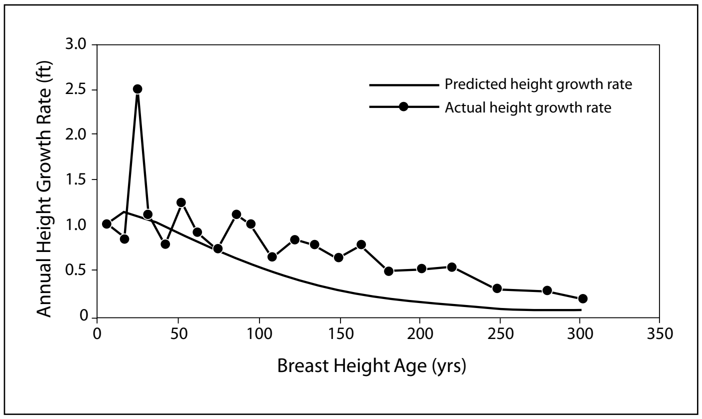


Figure 6. Example of a tree that had experienced early height growth rate suppression (resulting in an underestimate of site index) and exhibited increased height growth rates at older ages.

Analysis of the seven site-quality trees indicates that the Hann and Scrivani (1987) dominant height growth equation for Douglas-fir (and resulting site index estimates from this equation) can be extrapolated to breast height ages of up to 245 years without loss of accuracy or precision (Figure 7). For six of the seven trees, predicted dominant height was within ±5% of actual dominant height for all ages over 100 years (Figures 7A–C and 7E–G). For the one exception (Figure 7D), predicted dominant height was within ±5% of actual dominant height for breast height ages between 100 and 178 years and within ±10% for all ages over 100 years.

This study illustrates the difficulty in selecting true site-quality trees in older stands, particularly if the stand does not have an even-aged structure.

Although it appears that dominant height growth of Douglas-fir can "recover" from early suppression, the length of time to full recovery is most likely dependent upon the severity and duration of the suppression phase. Therefore, the best strategy for determining site quality in older stands is to measure age and height on many candidate site-quality trees to find those that have recovered most from possible early suppression. These trees will have the highest computed site index values for the stand.

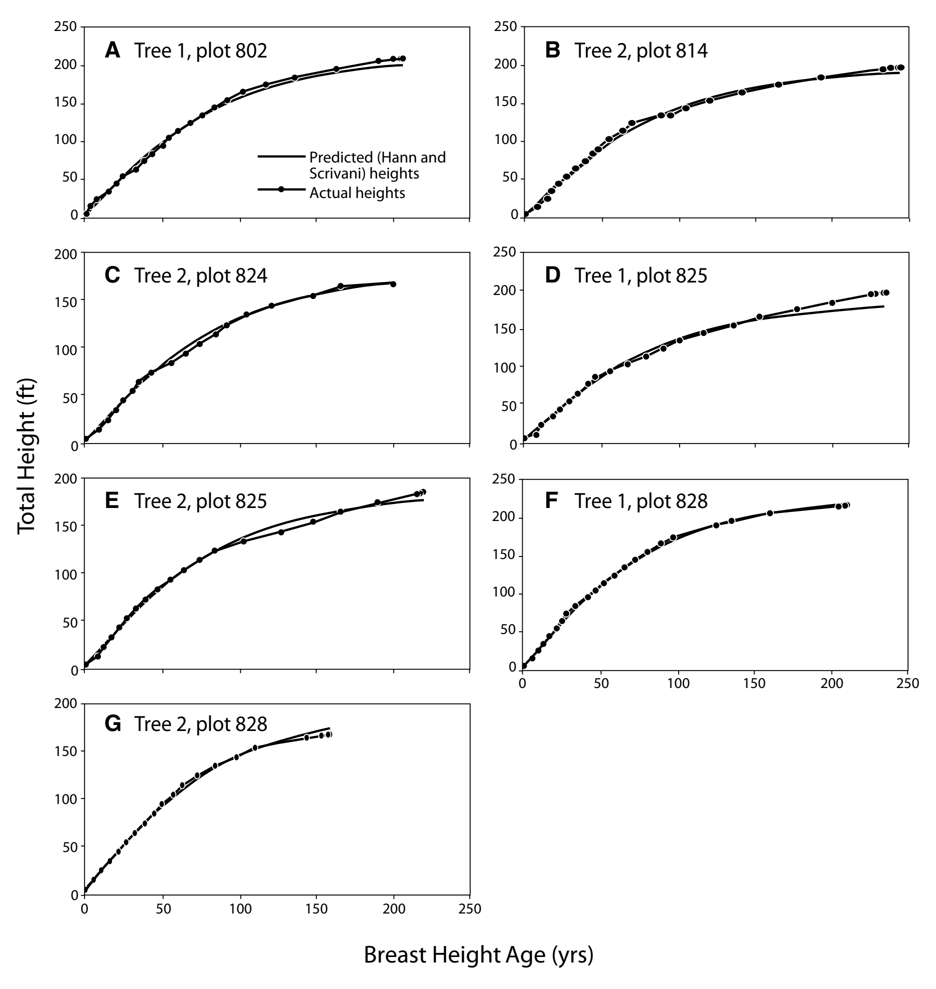


Figure 7. Predicted and actual dominant height growth for A) site tree 1 on plot 802 (site index averaged across 15–200 years); B) site tree 2 on plot 814 (14–239 years); C) site tree 2 on plot 824 (15–200 years); D) site tree 1 on plot 825 (12–226 years); E) site tree 2 on plot 825 (13–217 years); F) site tree 1 on plot 828 (11– 206 years); and G) site tree 2 on plot 828 (11–160 years).

Literature Cited

Birch, K.R., and K.N. Johnson. 1992. Stand-level wood production costs of leaving live, mature trees at regeneration harvest in coastal Douglas-fir stands. Western Journal of Applied Forestry 7:65–68.

Briggs, D.G., and R.D. Fight. 1992. Assessing the effects of silvicultural practices on product quality and value of coast Douglas-fir trees. Forest Products Journal 42(1):40–46.

Draper, N.R., and H. Smith. 1981. Applied Regression Analysis. Second edition. John Wiley & Sons, New York. 709 p.

Franklin, J.F. 1988. Structural and functional diversity in temperate forests. P. 166–175 *in* E.C. Wilson, ed. Biodiversity. National Academy Press, Washington, D.C.

Hann, D.W., A.S. Hester, and C.L. Olsen. 1995. ORGANON user's manual edition 5.0 incorporating: Southwest Oregon version and western Willamette Valley version. Department of Forest Resources, Oregon State University, Corvallis, Oregon. 127 p.

Hann, D.W., and M.W. Ritchie. 1988. Height growth rate of Douglas-fir: a comparison of model forms. Forest Science 34:165–175.

Hann, D.W., and J.A. Scrivani. 1987. Dominant-height-growth and site-index equations for Douglas-fir and ponderosa pine in southwest Oregon. Forest Research Laboratory, Oregon State University, Corvallis, Oregon. Research Bulletin 59. 13 p.

Kmenta, J. 1986. Elements of Econometrics. Second edition. Macmillan Publishing Company, New York. 786 p.

Larsen, D.R., and D.W. Hann. 1987. Height–diameter equations for seventeen tree species in southwest Oregon. Forest Research Laboratory, Oregon State University, Corvallis, Oregon. Research Paper 49. 13 p.

Lewis, R.A., and R.I. Bonn. 1989. Tests on the modeling of old-growth management regimes and unmanaged stand dynamics. Internal report. USDI Bureau of Land Management, Medford District, Medford, Oregon.

Lewis, R.A., and L. Brush. 1990. Silvicultural practices in environmentally sensitive areas. Internal report. USDI Bureau of Land Management, Medford District, Medford, Oregon.

Lewis, R.A., and R. Pierle. 1990. An ecological characterization of old-growth forests of the Ashland Resource Area and their potential management as spotted owl habitat. Internal report. USDI Bureau of Land Management, Medford District, Medford, Oregon.

McComb, W.C. 1994. High quality forestry: implications for wildlife associated with old, unmanaged conifer stands. P. 74–92 *in* High Quality Forestry Workshop: The Idea of Long Rotations. J.F. Weigand, R.W. Hayes, and J.L. Mikowski, eds. Center for International Trade in Forest Products, College of Forestry, University of Washington, Seattle, Washington. Special Paper 15. 265 p.

Monserud, R.A. 1984. Height growth and site index curves for inland Douglas-fir based on stem-analysis data and forest habitat type. Forest Science 30:943–965.

Munro, D.D. 1974. Forest growth models—a prognosis. P. 7–21 *in* Growth Models for Tree and Stand Simulation. J. Fries, ed. Department of Forest Yield Research, Royal College of Forestry, Stockholm, Sweden. Research Note 30. 379 p.

Oliver, C.D., and B.C. Larson. 1996. Forest Stand Dynamics. Update edition. John Wiley & Sons, New York. 520 p.

Peet, R.K. 1976. Successional patterns and tree population structure in Rocky Mountain forests. Bulletin of the Ecological Society of America 57:60.

Peet, R.K. 1981. Forest vegetation of the Colorado front range. Vegetatio 45:3–75.

Ritchie, M.W., and D.W. Hann. 1990. Equations for predicting the 5-year height growth of six conifer species in southwest Oregon. Forest Research Laboratory, Oregon State University, Corvallis, Oregon. Research Paper 54. 12 p.

Ryan, M.G., and B.J. Yoder. 1997. Hydraulic limits to tree height and tree growth. BioScience 47:235–242.

Hann, D.W. 1998. EXTENDING SOUTHWEST OREGON'S DOUGLAS-FIR DOMINANT HEIGHT GROWTH EQUATION TO OLDER AGES. Forest Research Laboratory, Oregon State University, Corvallis. Research Contribution 18. 16 p.

Hann and Scrivani (1987) developed dominant height growth equations for Douglas-fir in southwest Oregon using stem analysis data sets with an upper age of approximately 125 years at breast height. The objective of this study was to determine whether these equations could be extrapolated for ages of 250 years or more. Data for the evaluation came from stem analysis of 60 dominant trees located in 30 "older" stands. Intensive data screening indicated that 53 of these trees exhibited signs of reduced height growth during their first 100 years of development due to competition from non-tree vegetation, hardwood tree species, and possibly other conifers in non-even-aged stands. Analysis of the remaining seven site-quality trees indicated that the existing dominant height growth equation for Douglas-fir could be extrapolated to breast height ages of up to 245 years without loss of accuracy or precision.

Hann, D.W. 1998. EXTENDING SOUTHWEST OREGON'S DOUGLAS-FIR DOMINANT HEIGHT GROWTH EQUATION TO OLDER AGES. Forest Research Laboratory, Oregon State University, Corvallis. Research Contribution 18. 16 p.

Hann and Scrivani (1987) developed dominant height growth equations for Douglas-fir in southwest Oregon using stem analysis data sets with an upper age of approximately 125 years at breast height. The objective of this study was to determine whether these equations could be extrapolated for ages of 250 years or more. Data for the evaluation came from stem analysis of 60 dominant trees located in 30 "older" stands. Intensive data screening indicated that 53 of these trees exhibited signs of reduced height growth during their first 100 years of development due to competition from non-tree vegetation, hardwood tree species, and possibly other conifers in non-even-aged stands. Analysis of the remaining seven site-quality trees indicated that the existing dominant height growth equation for Douglas-fir could be extrapolated to breast height ages of up to 245 years without loss of accuracy or precision.

Forestry Publications Office
Oregon State University
227 Forest Research Laboratory
Corvallis, OR 97331-7401

Address Correction Requested