

SMC Quarterly News

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Dave Briggs, SMC Director

From the Director

With the current economic climate restricting the ability of many to travel, we decided to reduce expenses for the Spring Meeting by holding it as a webinar at the UW College of Forest Resources. This eliminated facility expense and travel costs for SMC faculty, staff and students, and the webinar system, that we began using in 2008 for TAC and other meetings, allowed those who could not travel to minimize costs by participating from their local office. While this produced savings for all, the downside was that we only had a business meeting as attention spans tend to wane with long webinar-based meetings. Therefore, we did not have the benefit of research presentations or the camaraderie of being together. Hopefully, we will be able to return to our usual style next year. We are currently investigating options for the Fall Meeting and are looking at the possibility of combining our meeting with a workshop; "Best Management Practices for Soil Productivity in the Douglas-fir Region" that The Northwest Forest Soils Council and Western Forestry and Conservation Association is planning September 22 at the Little Creek Casino in Kamilche, WA. We have tentatively scheduled the SMC Fall meeting at the casino on the 23rd of September. We are looking at the possibility of adding a field trip as well as other possible locations. If you have a suggestion please let me know soon as we would like to have a place finalized by the end of May.

Our proposal to join the NSF Center for Advanced Forest Systems (CAFS) was approved in February. NSF funding of the UW CAFS site totals \$70,000/year for five years. While we were not able to attend the CAFS meeting in February, we decided to invest this year's funds into three areas in our proposal to join CAFS. These are (1) to complete instrumentation of paired-tree fertilization

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and genetic gain/Type IV installations to monitor local environmental conditions, (2) to further explore the use of terrestrial and aerial LIDAR to measure leaf-area index, and biomass components, and (3), to expand the database for developing local wood density models to assess wood quality and to convert stem volume to dry weight for carbon and energy estimation.

With the exception of a small number of installations that are inaccessible due to snow or washouts, field work planned for 08/09 is completed and we expect that the database update will be available around mid-June.

In this issue:

The feature article in this issue “*Errors in Converting Volume to Dry Weight, Carbon and Energy - The 20 Year UW Pack Forest Highway Thinning Project as a Case Study*” by David Briggs, Rapeepan Kantavichai, Eric C. Turnblom, and Rob Harrison discusses issues associated with using published wood density values or biomass equations to estimate dry weight which is the basis for determining carbon and energy content of stands. Few have published direct comparisons of these approaches with actual dry weights. We used thinning and biosolids experiments at Pack Forest for which we have wood density from x-ray densitometry to estimate dry weight of 20-year growth and found large errors when published wood density or biomass equations were used. Also in this issue

- An announcement of a CONIFERS update
- A description of a new project by Aaron Weiskittel, David W. Hann, and Peter J. Gould that will use the database
- An update on the Type V installations (paired tree fertilizations and a request for you to help fill some gaps
- Abstracts of recent articles

CONIFERS Notes #17 Version 4.11 Release date, January 1, 2009 from Martin Ritchie, Biometrician mritchie@fs.fed.us

We have released a new version of the simulator: Version 4.11. There are three changes between 4.10 and 4.11. The first is a correction to the swo.txt species file distributed with the simulator. It is a very subtle change. Second, some errors in the help system (Conifers32.chm) were corrected. Finally, there are updates to the fill-in missing-crown-ratio function. The URL below is the site to visit if you want to download version 4.11:

http://www.fs.fed.us/psw/programs/ecology_of_western_forests/projects/conifers.

Bert Hasselberg and Bill Bizack, SMC field crew members measuring 2008 growth on Type IV's at 601 Donkey Creek. The bottom image represents an “average tree”.



New SMC Database Project

Individual dominance stability and sources of variation for three species with varying levels of shade tolerance

Aaron Weiskittel, University of Maine, David W. Hann, Oregon State University and Peter J. Gould, PNW Research Station.

It is commonly assumed that dominant individuals remain dominant over time in a given stand, particularly in plantations. An earlier analysis using SMC data indicated that individuals were relatively dynamic with respect to dominance over time (Marshall *et al.*, 1997) at very young ages. There is some indication that different types of tree growth patterns exist in any given stand, namely individuals who have an early growth peak (“shooters”) and others with a latter peak in growth (“stayers”). Some researchers have suggested that the point where the two growth patterns cross over varies by species and possibly other stand factors such as density and site index. This analysis will attempt to assess the dominance stability of individuals of Douglas-fir, red alder, and western hemlock using the long-term datasets of the SMC, Hardwood Silviculture Cooperative (HSC), and Levels-of-Growing Stock (LOGS). The results will be helpful for understanding within stand dynamics and the key factors that control it, which will help guide future forest growth and yield modeling efforts.

Marshall, D., Hanus, M., Hann, D.W., 1997. Changes in tree position over time. In, Co-op Correspondent Spring Issue. University of Washington College of Forest Resources, Stand Management Cooperative, Seattle, WA, pp8-9.

TYPE V INSTALLATIONS (Paired-tree fertilization study)

In March, the SMC field crew measured and fertilized 22 Type V installations in Washington and Oregon. Type V installations are the new “single Tree” studies designed to look at site specific response to fertilization. The B.C. Ministry of Forests installed, measured, and fertilized 6 installations mostly on Vancouver Island. With the 6 sites established in 2007-2008 we now have 34 Type V installations.

We are looking for more sites to install this summer. Stands need to be at least 90% Douglas fir, between 15 and 25 years old, and 250-400 TPA. Uniformity of slope, aspect and soils is important. In a uniform stand we can usually get the installation to fit in 10 acres. If you would like to participate in this study please contact Kim Littke (kimhanft@gmail.com, 206-543-4978).



The SMC would like to thank Greg Goodfrey at Dyno-Nobel for supplying 2 tons of urea for Type V fertilizer trials.



Bert Hasselberg, SMC field crew member loading the 2 tons of urea.

Errors in Converting Volume to Dry Weight, Carbon and Energy - The 20 Year UW Pack Forest Highway Thinning Project as a Case Study

David Briggs (Professor), Rapeepan Kantavichai (PhD Student), Eric C. Turnblom (Associate Professor), Rob Harrison (Professor), College of Forest Resources, University of Washington, Seattle, WA.

Forest biomass has great potential for energy production and carbon sequestration. Forest managers and investors are seeking methods to integrate carbon and energy into their forest planning, marketing, and timber investment decision support tools. They desire accurate information on how much carbon, energy and conventional log products is available in a specific forest or region, where it is located for planning flow logistics, and how it will change in the future. Forest inventories, yield tables, and growth and yield models have focused on estimating and predicting the volume of stem wood convertible into logs for traditional products such as lumber and veneer. Wood volume of a stand is not adequate for addressing information needs with respect to carbon and energy. One problem is that wood contains about 49% carbon/dry lb and about 8300 btu/dry lb and 9000 btu/dry lb for hardwoods and conifers respectively (Bowyer et al. 2007). Since these products are estimated from dry weight, there is a need to convert from stem wood volume to dry weight. In addition to stem wood, bark, branches and tops, foliage, stump and roots all contain carbon and energy, so there is a need to consider the dry weight of these components in a more complete, integrated management and utilization decision framework.

Conversion from wood volume to dry weight can be done by multiplying cubic volume of stem wood by wood specific gravity (SG), also known as relative or basic density, SG expresses dry weight per unit green volume relative to the density of water (1g/cc or 62.4lb/cuft). Many use the average published SG for a species (Wood Handbook 1999) but this average assumes all trees have the same SG regardless of age, treatment history, and growing environment. It is well known that SG of a species has a strongly non-linear pattern with age (Jozsa & Middleton 1994, Megraw 1986, Jordan et al. 2008), has a geographic gradient (USFS 1964, Jordan et al. 2008), and is affected by treatments, soil, and weather (Bower et al 2005, Kantavichai et al. 2009). After conversion of stem wood to dry weight, some method must be employed to account for the weight of other tree components useful for carbon storage and energy.

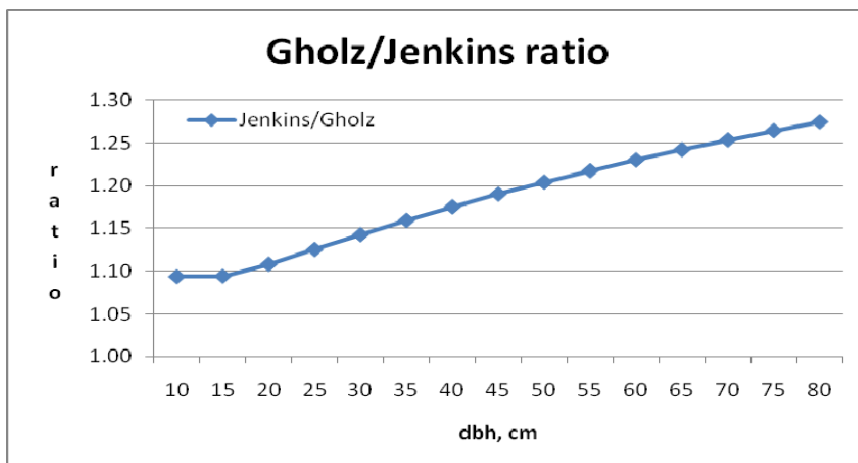
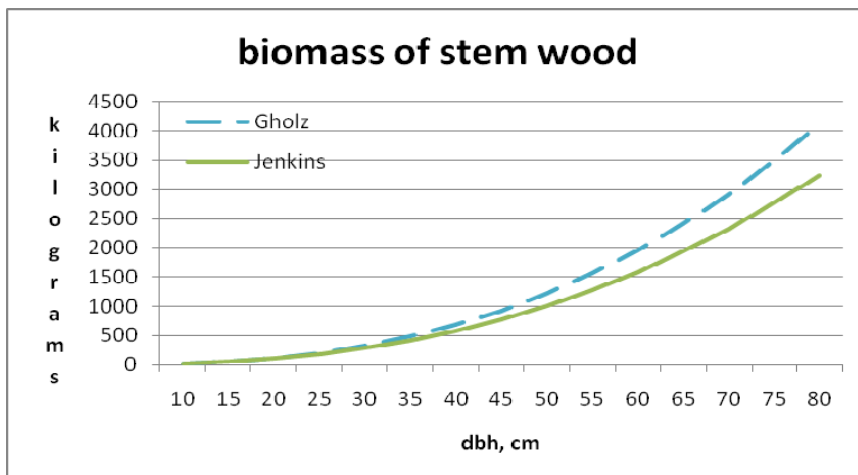
Conversion can also be done using biomass equations which estimate dry weight of stem wood as well as the other above and below ground components of a tree. Two biomass equation approaches have been commonly used

1. Gholz et al. (1979) estimate dry weight of stem wood, bark, branches and tops, foliage, stump and roots using the power function $B = a_0 DBH^{a_1}$, often re-expressed as $\ln(B) = \ln a_0 + a_1 \ln DBH$, where B is the dry weight (kg) of a biomass component and DBH is the tree DBH (cm). In the case of Douglas-fir stem wood, they pooled data for 99 trees from four studies; 10 trees from a 450m elevation site (28-99cm dbh) plus 4 trees from a 1300m elevation site from one study, 5 old-growth trees from a 500m elevation site (78-162cm dbh) in a second study, 70 trees from a 100m elevation site (1.8-19cm dbh) in a third study, and 10 trees (2.3-23cm dbh) in the fourth study. The fewer, larger, higher elevation trees were sampled in Oregon while the more numerous, smaller, lower elevation trees were sampled in Washington.

- Jenkins et al (2004) use a procedure based on two exponential equations. First, they estimate total aboveground biomass using the equation $AB = \text{EXP}(b_0 + b_1 \ln DBH)$. To get the aboveground biomass corresponding to a given component such as stem wood, they estimate the ratio of the component to aboveground biomass using the equation $\text{RATIO} = \text{EXP}(c_0 + c_1/DBH)$. The product of AB and RATIO yields the dry weight of the biomass component. In developing these equations for Douglas fir, they pooled the data used by Gholz et al with 66 trees from additional studies increasing the sample size to 165 trees.

Figure 1 provides a comparison of stem wood dry weight of Douglas-fir over a range of DBH as predicted by the Gholz and Jenkins equations. Both are monotonically increasing functions of DBH and the Gholz equation estimates zero dry weight when DBH is zero whereas the Jenkins equation has a positive intercept. These equations soon cross and, with the exception of very small trees, the Gholz equation predicts higher values. It should be noted that the first derivative, interpreted as the incremental change in dry weight per incremental change in DBH, is always positive and is solely a function of DBH. Consequently, any silvicultural treatment or other factor that produces a DBH increase will be predicted to produce a positive effect on the incremental dry weight, a contradiction to many studies that show positive, negative or no effect of treatments and environmental factors on SG and hence dry weight.

Figure 1. Comparison of Gholz and Jenkins Stem Wood Dry Weight vs DBH for Douglas-fir



Issues with these biomass equations are (a) the sample size is small, poorly distributed, and lacks trees representing silvicultural treatments, (b) they are based on dbh only and consequently assume all trees of the same dbh have the same dry weight regardless of tree height (site class), age, treatment history, climate, soil, etc., (c) the underlying relationship with SG that they imply is unknown, and (d) accuracy tests of these equations for specific stands are few. Harrison et al. (2009) found that the Gholz equations overestimated stem wood dry weight of a 47-year old Douglas-fir stand by 17%. While such errors may be tolerable for rough, broad regional estimates of carbon and energy content of forests, they produce uncertainties that may not be acceptable to management planners or investors.

The objective of this article is to compare the dry weight of Douglas-fir stem wood grown on a specific site under alternative treatment regimes with estimates based on the Wood Handbook average SG and the Gholz et al. and Jenkins et al. biomass equations.

Materials and Methods

The 15-ac (6 ha) experimental stand, located on the University of Washington's Charles Lathrop Pack Experimental Forest near Eatonville, WA, was stocked with Douglas-fir that naturally established following a severe fire in 1922. When the study was established in 1977, the stand was estimated to be 55-yr-old with approximately 800 trees/ac (1977 trees/ha) and with about 75% under 7 in. (18cm) dbh (Edmonds and Cole 1980). During 1977, half of the stand was commercially thinned, removing most of the trees under 7 in. (18cm) dbh. Records indicate that thinning removed about 2500 cuft/ac (71 cum ha), reducing stand density and cubic volume by 67%, and 46% respectively and increasing average dbh by about 2 in (6 cm) (Table 1). Six 1/5-ac (0.08 ha) plots were randomly located in each of the thinned and unthinned portions of the stand. In the winter of 1977-78, three of the six plots in the thinned and unthinned areas were randomly selected and treated with 42.2 tons/ac (84 tonne/ha) of dewatered sewage (18% solids) depositing a 1-in (2.5 cm) depth of biosolids. This application rate was not selected on the basis of soil or tree nutrition status; instead, it was chosen to test application technology and to examine issues such as runoff. Re-treatment with 21 tons/ac (47 tonne/ha) occurred in 1980 and 1989 and the thinned area was thinned again in late 1995. In early summer 1998, four trees in each plot (48 trees in total) were harvested using a stratified random sample based on the plot quadratic mean diameter. The biosolids supplier, University of Washington, and USFS collaborated to conduct a lumber recovery study to examine the effects of treatments on subsequent log and lumber quality and value (Sonne et al. 2004). Sample trees were bucked into 32 -ft (10m) woods lengths for harvesting and then into 16-ft (5m) logs for sawmilling.

Table 1. Highway Thinning Site Characteristics by Treatment

Treatment	Quad. mean dbh		Total ht		Density		Volume		Growth tmt vs 78/97 control		Specific gravity 78/97 avg SG tmt vs control	
	1978	1997	1978	1997	1978	1997	1978	1997	78/97	control	avg SG	control
<i>Imperial</i>	<i>in</i>	<i>in</i>	<i>ft</i>	<i>ft</i>	<i>trees/ac</i>	<i>trees/ac</i>	<i>cu ft</i>	<i>cu ft</i>	<i>cu ft</i>			
Control	6.6	9.2	86	111	842	551	5494	9808	4314	0%	0.505	0%
Thin	8.4	12.2	80	103	262	158	3076	7134	4058	-6%	0.526	4%
Biosolids	6.7	10.6	80	110	702	388	4902	9294	4392	2%	0.466	-8%
Thin/Biosolids	8.7	13.9	79	108	250	120	2670	7957	5287	23%	0.463	-8%
<i>Metric units</i>	<i>cm</i>	<i>cm</i>	<i>m</i>	<i>m</i>	<i>trees/ha</i>	<i>trees/ha</i>	<i>cu m</i>	<i>cu m</i>	<i>cu m</i>			
Control	17	23	26	34	2081	1362	156	278	122	0%	0.505	0%
Thin	21	31	24	31	647	390	87	202	115	-6%	0.526	4%
Biosolids	17	27	24	34	1735	959	139	263	124	2%	0.466	-8%
Thin/Biosolids	22	35	24	33	618	297	76	225	150	23%	0.463	-8%

Note: thin volume removed from thin (2191 ft³) and thin x biosolids (3313 ft³) at end of 1995 are included in the 1998 volume totals.

A cross-section disk was removed from the top of the first 16-ft (5m) log of each tree for examination of wood properties. The average ring count of these disks was 35.4 years at study establishment and 56.4 years when harvested. Disks were taken to the Weyerhaeuser Technology Center (WTC) in Federal Way, WA. and a pith to bark sample was scanned on the WTC X-ray densitometry unit. Output data included width of earlywood (EWW) latewood (LWW), whole ring (RW) and percent latewood (LW%), and SG of earlywood (EWSG), latewood (LWSG), and whole ring (SG) calibrated to a basis of oven-dry weight and green volume. Disks from one tree in the control and one tree in the thinned/biosolids treatments were lost so the data set is comprised of 46 trees. For this analysis, the 20 year growth and SG data of the 1978 through 1997 growing seasons (Table 1) is used as the basis for estimating dry weight growth and associated carbon storage.

Procedures for estimating the 1978-1997 changes in dry weight of stem wood/ac were

1. “actual” stem wood dry weight/ac was obtained by calculating the per acre growth in standing volume from 1978 through 1997 and multiplying by the average treatment SG over that time obtained from the x-ray densitometry data.
2. “Wood Handbook” stem wood dry weight/ac was similarly obtained by substituting the published average Douglas-fir SG of 0.45 (Wood Handbook 1999, USFS 1965) for each treatment.
3. “Gholz” stem wood dry weight/ac was obtained by using the quadratic mean dbh (QMD) in their equation to estimate the stem wood dry weight of the QMD tree and multiplying by the trees per acre. We applied the procedure using the 1978 and 1997 data and subtracted to get the dry weight growth/ac.
4. “Jenkins” stem wood dry weight/ac was obtained by using the QMD in their above-ground biomass and stem wood ratio equations, multiplying to get the stem wood dry weight of the QMD tree, and multiplying by trees per acre. We applied the procedure using the 1978 and 1997 data and subtracted to get the dry weight growth/ac.

These 20 year dry weight growth/ac results were converted to carbon storage using the 49% carbon factor for dry wood.

The volume removed by the thinning in 1977 was converted to a product carbon pool assuming an average SG = 0.47 for years 0-35 of the sample trees, the 49% carbon factor, and 50% yield factor for long-term wood products such as lumber (Milota et al. 2005). The 0.47

SG is approximately the median value estimated from the x-ray densitometry data between the pith and age 35, the age of the disks at the top of the 16-ft (5m) log in 1977 when the thinning occurred.

Results and Discussion

Volume Change: Table 1 shows the standing volume at the start of 1978 and end of 1997. While stand volume increased for each treatment, thinning alone produced 6% less, biosolids alone produced 2% more, and the combination produced 23% more volume compared to the untreated control.

Specific Gravity: Table 1 also shows the average SG over the 1978-97 growing seasons for the treatments

- SG is generally higher than the average of 0.45 reported for Douglas-fir in the Wood Handbook. This is consistent with the Western Wood Density Survey (USFS 1965) which shows higher than average SG for the region where Pack Forest is located.
- Thinning on this droughty site led to a 4% increase in SG. Others have also observed as SG increase after thinning dry, crowded sites. Thinning reduces competition for water which lengthens the growing season and production of dense latewood. In our case the 4% increase was not statistically significant compared to the control, most likely a result of our small sample size.
- Applying biosolids led to a statistically significant 7.8% decrease in SG compared to the control. Others have commonly reported decreased SG following fertilization (Cahill & Briggs 1992) and use of biosolids (Cole et al. 1984).
- Combining thinning and biosolids led to a statistically significant 8.3 decrease in SG compared to the control. However, the combination is not significantly different than biosolids alone, possibly a result of compensatory effects of thinning and biosolids on this droughty site. Other combined only report a larger combined decrease that either treatment alone (Cahill & Briggs 1992).

Actual Stem Wood Dry Weight and Carbon Storage: Table 2 and Figure 2a,b summarize 20-year stem wood growth/ac dry weight and carbon content at 49% carbon. The product carbon associated with the thinning in 1977 and the combined forest growth and product carbon pools are also presented (Fig 2c). The top section of Table 2 and Figure 2 show that

- Dry weight growth of thinning was only 2% less than the control (compared to 6% less volume), dry weight growth of biosolids alone dropped to 6% below the control (compared to 2% more volume), and dry weight growth of the thinning/biosolids combination was 12% above the control (compared to 23% more volume). Conversion of dry weight growth to carbon at 49% C preserves these latter relative differences.

Table 2. Actual vs Predicted 20-Year Stem wood Dry Weight and Carbon Content by Treatment for the Highway Thinning Site, tonne/ha

Treatment	Actual		Wood Handbook			Gholz Eq.			Jenkins Eq.		
	1978/98 growth	tmt vs control	1978/98 growth	tmt vs control	hnbk vs actual	1978/98 growth	tmt vs control	Gholz vs actual	tmt vs control	tmt vs control	Jenkins vs actual
stemwood biomass, dry weight											
Control	152	0%	136	0%	89%	84	0%	55%	72	0%	48%
Thinned	149	-2%	128	-6%	86%	124	47%	83%	106	47%	71%
Biosolids	143	-6%	138	2%	97%	108	29%	76%	92	29%	65%
Thinned x Biosolids	171	12%	166	23%	97%	208	148%	122%	176	148%	103%
stemwood carbon											
Control	75	0%	67	0%	89%	41	0%	55%	36	0%	48%
Thinned	73	-2%	63	-6%	86%	61	47%	83%	52	47%	71%
Biosolids	70	-6%	68	2%	97%	53	29%	76%	45	29%	65%
Thinned x Biosolids	84	12%	82	23%	97%	102	148%	122%	86	148%	103%
Product carbon, 1977 Thin											
Control	0	na	0	na	na	0		na	0		na
Thinned	20	na	19	na	96%	16		77%	14		71%
Biosolids	0	na	0	na	na	0		na	0		na
Thinned x Biosolids	20	na	19	na	96%	16		77%	14		71%
Combined forest growth & product pools											
Control	75	0%	67	0%	89%	41	0%	55%	36	0%	48%
Thinned	93	25%	82	23%	88%	76	85%	82%	66	86%	71%
Biosolids	70	-6%	68	2%	97%	53	29%	76%	45	27%	65%
Thinned x Biosolids	104	39%	101	52%	97%	118	185%	113%	101	183%	97%

Using Average SG to Estimate Stem Wood Dry Weight and Carbon: Table 2 and Figure 2a,b also show the effect of substituting the average SG for Douglas-fir of 0.45 for the actual SG's found for each treatment

- since the SG's of each treatment (Table 1) are higher than the average, stem wood dry weights predicted from the average SG are 86-97% of actual values for the treatments.
- Since a constant SG is used for all treatments, the % comparison between treatments reverts to the same values reported for stem volume. Thus the average fails to account for the treatment effects on SG and distorts the estimates of dry weight and associated carbon storage.

Using Biomass Equations to Estimate Stem Wood Dry Weight and Carbon: Table 2 and Figure 2a,b also show the predictions based on the Gholz and Jenkins biomass equations.

- These equations respectively estimate stem wood dry weight of the control, thinned only, biosolids only and thinned plus biosolids to be 55% and 48%, 83% and 71%, 76% and 65%, and 122% and 103 of the actual values. As expected from Fig 1 Gholz always predicts higher dry weights.
- Relative to the control, they predict stem wood dry weight to be
 - ✓ 47% higher in the thinned only treatment when it was actually 2% lower than the control
 - ✓ 29% higher in the biosolids only treatment when it as actually 6% lower than the control
 - ✓ 148% higher in the thin/biosolids treatment when it is actually only 12% higher than the control
- The errors associated with the biomass equation are substantial and inconsistent across treatments.

This example illustrates how failure to account for SG changes can distort estimates of dry weight and sequestered carbon. The issue with the DBH based biomass equations is the fact that they always assume that increasing DBH is associated with increasing SG. The data used to develop the Douglas-fir biomass equations seem to be based on large higher elevation old-growth and small, young low elevation unmanaged stands. Under these circumstances, larger DBH and higher SG could be expected with older age. However, the age-pattern and incremental changes in SG can be altered by treatments, and different sites and intensive management can produce the same dbh tree with very different ages. Furthermore, the Western Wood Density Survey (USFS 1965) shows th at SG of Douglas-fir has a geographic pattern and SG is influenced by soil and climate (Bower et al. 2004, Kantavichai et al. 2009). The data sets used in the biomass equations are insufficient to take these effects into account and consequently produce large errors. While the focus of these calculations was on conversion of volume to dry weight and carbon, similar problems and errors occur for estimating energy content.

To this point, the discussion focused on development of the carbon sequestered by trees growing in the forest. This can also provide a distorted impression since the thinning yielded logs of which a fraction was converted to products that continue to sequester carbon as components of buildings and other long-term structures (Lippke et al. 2004). When the product pool of stored carbon associated with the thinning is added to the forest carbon pools (Table 2, Fig 2c), the combined pools of the thinned and thin/biosolids treatments become much greater than the unmanaged control or biosolids alone.

Study Limitations: There are limitations that should keep in mind concerning this study. First, we have a single, low site, droughty soil that was naturally regenerated with a dense stand of Douglas-fir. Responses on other soil types and by plantations managed with different treatments or evaluated over a different age range may be different than our results. Second, the sample size of 12 tree per treatment may have limited the power of some of the significance tests. Third, the rate of biosolids application on this stand was designed to test biosolids application technologies and to assess nutrient cycling and other issues. Consequently, the responses observed on this site may differ from responses that would have occurred with commercial application rates.

Conclusion

This case study highlights the magnitude of potential error that can occur when attempting to estimate dry weight, carbon, or energy of local stands. Landowners attempting to manage for and market carbon or energy, or investors considering purchasing carbon credits or building bio-energy facilities, are likely to required more accurate estimates. Key components of this need are (1) testing the accuracy of inventory procedures, yield tables, and growth models to predict current and future standing volume, (2) having accurate models to predict SG to convert volume to dry weight, and (3) improving and verifying methods to include other components of tree biomass.

We currently have proposals in review to develop improved models of SG for PNW species and to investigate use of non-destructive testing technologies to obtain local SG information without the time and expense of current methods. The broad bio-geo-climatic transect and known management histories represented by the SMC installations presents a great resource for developing models and testing new technologies.

Acknowledgement. The original study and harvesting assessment was supported by a grant from the King County Department of Natural Resources, Seattle, WA. The USFS Pacific Northwest Experiment Station, Portland, OR., provided personnel and expertise to conduct the mill recovery study. The Stand Management Cooperative set up and maintained the experiment at the University of Washington College of Forest Resources Charles Lathrop Pack Forest, Eatonville, WA which provided the standing timber at harvest. The Weyerhaeuser Company conducted the x-ray densitometry at its Technology Center in Federal Way, WA.

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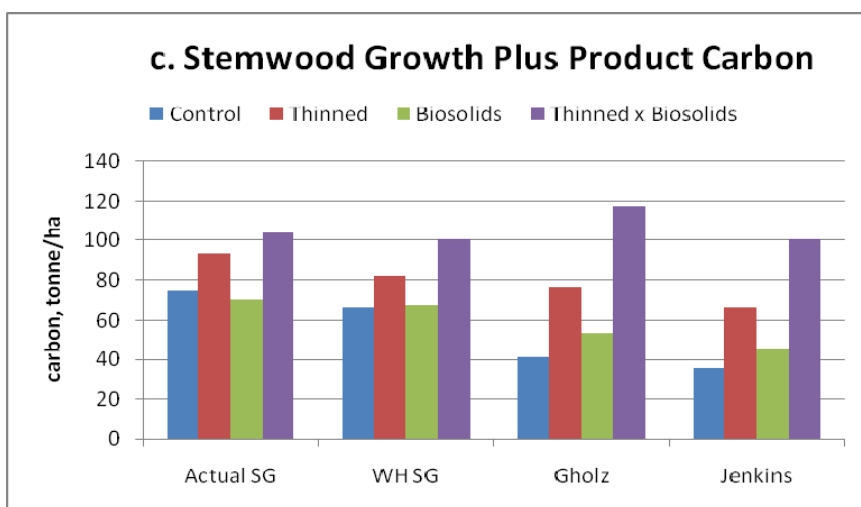
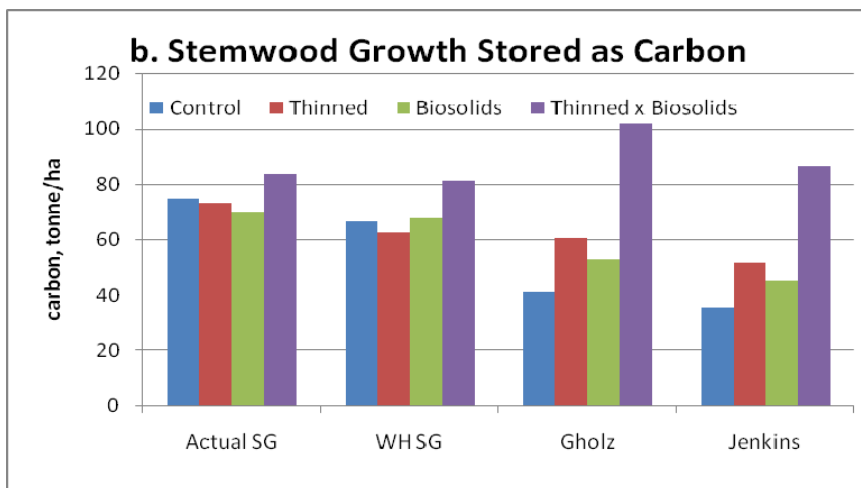
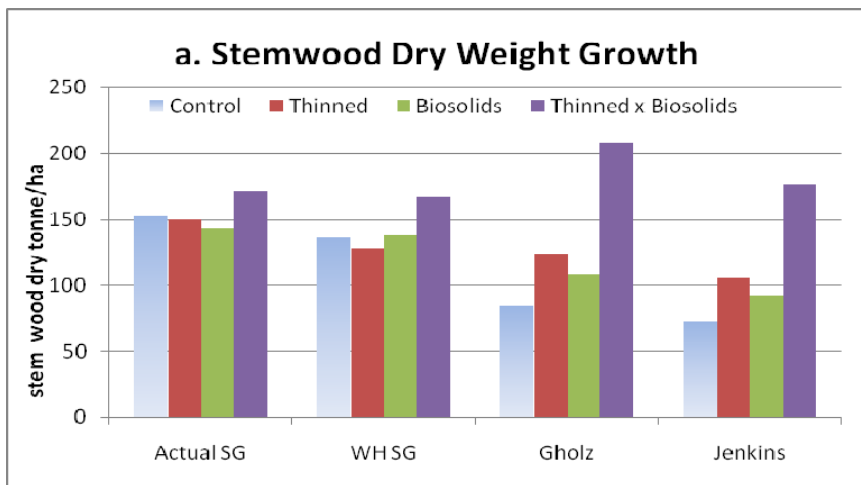
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Figure 1. 20-Year Dry Weight and Carbon Storage, Tonne/Ha, of the Four Management Regimes at the UW Pack Forest Highway Thinning Site: Actual Values vs Average Density and Biomass Equation Estimates



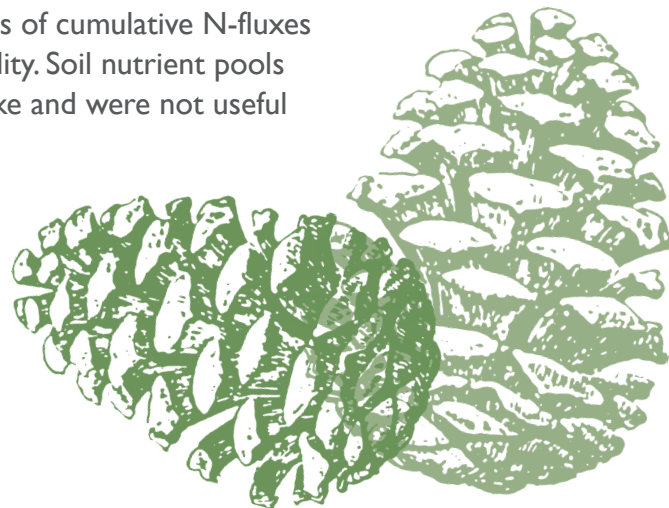
Abstracts and Publications

Wilson, D.S. and D.A. Maguire. Environmental basis of soil–site productivity relationships in ponderosa pine. Ecological Monographs, *in press*.

Abstract

Understanding the environmental basis for soil–site quality relationships requires that we connect the environmental factors important to resource availability to the physiological processes influencing tree productivity. The nitrogen productivity concept provides this link by relating nitrogen uptake rate to plant growth, although the concept has been verified almost exclusively by laboratory experiments on tree seedlings. We tested the nitrogen productivity concept in a field setting by relating foliage production to nitrogen mineralization rate in 19 mature ponderosa pine (*Pinus ponderosa*) stands across a moisture gradient in central Oregon. Models developed following the nitrogen productivity concept predicted annual foliage production precisely, and adequately represented the different influences of nitrogen and water stress. Current-year foliage production was proportional to older foliage nitrogen content ($R^2=0.82$), and a model including a water stress index (stable carbon isotope ratio, $\delta^{13}C$) further explained 95% of the variability.

A direct link between soil nitrogen availability and canopy nutrition was less clear. Annual foliage production was positively, but weakly correlated with soil-estimated N-uptake (estimated *in situ*), likely because annual nitrogen uptake was small relative to nitrogen retained in the canopy. Foliage nitrogen was highly conserved with a mean retention time of 10.5 yrs, which was 2.2 times longer than foliage retention. Annual nitrogen uptake amounted to between 0–11% of total canopy-N. Multi-year estimates of cumulative N-fluxes are needed to adequately assess N-availability. Soil nutrient pools were poorly correlated with nutrient uptake and were not useful for predicting stand productivity.



Abstracts and Publications cont.

Vikram, Vikas. 2009. Stiffness of Douglas-fir lumber: Effects of wood properties and genetics. M.S. Thesis, Oregon State University.

Some of this information was already published in “Cherry, M.L., Vikram, V., Briggs, D., Cress, D., and Howe, G.T. 2008. Genetic variation in direct and indirect measures of wood stiffness in coastal Douglas-fir. *Can. J. For. Res.* 38:2476-2486,” whereas other information is new, including relationships between wood stiffness and knots, microfibril angle, and lumber grade.

Abstract

Wood stiffness is one of the most important properties of lumber and veneer. We studied wood stiffness (modulus of elasticity, MOE), wood density, microfibril angle, and knots in a 25 year-old wind-pollinated progeny test (50 families, ~373 trees) of coastal Douglas-fir to understand the potential for genetically improving wood stiffness. We measured the stress wave MOE of standing trees (MOE-ST) and logs (MOE-HM) using field-based tools (ST300 and HM200) that measure stress wave velocity. We then milled the logs into 2x4s to obtain direct estimates of MOE using bending tests (MOE-bl) and indirect estimates using transverse vibration (MOE-tv) and stress wave (MOE-sw) techniques. On basal wood disks, we measured green (DEN-gd) and dry (DEN-dd) wood density; on 2x4s, we measured lumber density (DEN-dl), sizes of the largest edge (KNT-edg) and center knots (KNT-cnt), number of knots (KNT-tot), and lumber grade; and on small clearwood samples, we measured dry density (DEN-sc), as well as MOE (MOE-sc) and microfibril angle (MFA-sc) using the SilviScan system. MOE-bl had moderate to strong phenotypic (r_p) and additive genetic (r_a) correlations with MOE-HM, MOEST, MOE-tv, and MOEs-w ($r_p = 0.45$ to 0.91 ; $r_a = 0.57$ to 1.03) suggesting that the HM200 and ST300 tools can be used to genetically improve bending stiffness. MOE-bl had moderate to strong genetic correlations with DEN-dl and DEN-dd ($r_a = 0.37$ to 0.91), and weak correlations with KNT-edg and KNT-tot ($r_a = -0.24$ and 0.22). MOE-bl had a strong phenotypic correlation with DEN-sc ($r_p = 0.72$) and moderate negative correlation with MFA-sc ($r_p = 0.42$). Together, DEN-dl, MFA-sc, and KNT-edg explained 49% to 62% of the variance in 2x4 MOE-bl, MOE-tv, and MOE-sw. Compared to MFA-sc and KNT-edg, path analysis suggested that density had the strongest direct effect on MOE-bl. Nonetheless, because density is negatively correlated with growth, and because field-based stress wave tools are now available, there is no great need to measure wood density or MFA to improve wood stiffness. Because the phenotypic and genetic correlations between knot traits and bending MOE are either weak or non-significant, knot traits do not seem to be important to include in breeding programs for structural lumber. The STR lumber grade had a higher MOE-bl and lower KNT-edg than either the S1 or S2 grades.

Upcoming Meetings and Events

May 26 - 29, 2009. 13th Symposium on Systems Analysis in Forest Resources SSA FR09 Announcement and Call for Presentations.

Francis Marion Hotel Charleston, South Carolina.

<http://www.safnet.org/meetings/othermeetings.cfm>

June 21-23, 2009. 2009 Western Mensurationists' Meeting.

Heathman Lodge, Vancouver, WA.

<http://www.westernforestry.org/wmens/>

July 10-17, 2009. IUFRO Working Party 7.03.04: Diseases and Insects in Forest Nurseries. Hilo Hawaiian Hotel - Hilo Hawaii.

<http://www.westernforestry.org>



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