HSC

Hardwood Silviculture Cooperative

Annual Report
2006-2007

Oregon State
UNIVERSITY

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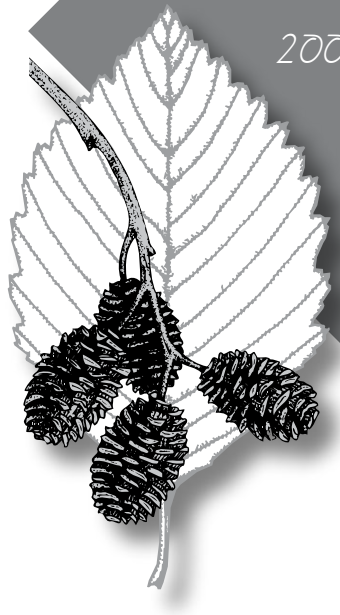


Highlights of 2006-2007

- Dave, Andrew and Sean Garber have published an article in Western Journal of Applied Forestry entitled "Stem Taper and Volume of Managed Red Alder". The taper equation (using DBH and tree height) provides reliable diameter inside bark (dib) and merchantable volume predictions and is an improvement over previous red alder volume and taper equations.

- Andrew and Sean have also submitted a manuscript entitled "Taper Equation and Volume Tables for Plantation-Grown Red Alder" to the USFS to be published as a General Technical Report (GTR). This equation using crown ratio as well as DBH and tree height provides the most accurate predictions of dib (and thus volumes) for red alder grown in plantations. Included in this manuscript are 5 suites of tables: total stem volume, merchantable volume (0.5 ft stump and 5 in diameter outside bark [DOB] top), merchantable height, volume to crown base, and DOB at crown base.

- The modeling effort is underway. The assembled database has been released to all of the cooperators and to the Forest Vegetation Simulator (FVS) Group. In addition, funds have been acquired to develop a growth model in ORGANON. Both of these growth models, when completed, will be available to the general public.

- Three more HSC Type II sites have had their 17th year growth measurements completed (making a total of 4).

- Twenty two of the 26 Type II have had their 12th year growth measurement.

Contents

HSC Executive Summary 2007

The Hardwood Silviculture Cooperative (HSC) is nineteen years old and running strong. First established in 1988 by a small (and visionary) group, the HSC is in the lead providing information for foresters interested in hardwood management. The HSC was formed to learn more about hardwood management in general, and red alder plantation growth, specifically. The HSC's study design includes thirty-six study installations from Coos Bay, Oregon to Vancouver Island, British Columbia divided into three types:

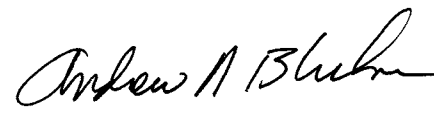
- 4 thinning studies in natural stands
- 7 replacement series studies of red alder/Douglas-fir mixtures
- 26 variable density plantations with thinning and pruning treatments

The data collected from these sites is accumulating rapidly. Massive amounts of data are collected, used in various data analyses, and communicated to the interested public. Many thanks go out to all of the cooperators in getting the data collected and setting research priorities. The database is now large enough to investigate many aspects of red alder stand dynamics. Currently, all of our 26 plantations are at least 9 years old, 22 are at least 12 years old, and 4 have reached the ripe old age of 17. These latter plantations are probably the oldest maintained alder plantations in the region. Included in this report is a preliminary analysis of the 12 year data.

This year, the HSC published two taper equations for plantation-grown alder. These equations provide reliable dib and volume predictions and are improvements over previous red alder volume and taper equations. The first equation (using DBH and height) was used to generate a merchantable volume table. The second equation (using DBH, height and crown ratio) was used to generate 5 suites of tables including 1) total tree volume, 2) merchantable tree volume, 3) merchantable height, 4) stem volume to crown base, and 5) diameter inside bark at crown base.

As agreed upon, the regional alder modeling database has been released to all of the cooperators since modeling efforts are underway. The USFS has agreed to use the database to update their red alder version of the Forest Vegetation Simulator (FVS). Hopefully, the new version will be available within the coming year. Furthermore, funding has been acquired for the proposal to create a new plantation-grown red alder version of ORGANON. Please see last year's annual report for summaries of these efforts.

Unlike yesteryear, managing red alder stands has gained acceptance in the region. Part of this is market driven, but part is due to the efforts of the HSC and all of its members. Whoever would have thought way back in 1988, that the idea of alder management would be so popular today? The vision of a small and dedicated group has made managing red alder no longer a dream but a reality.



History of the HSC

The Hardwood Silviculture Cooperative (HSC) is a multi-faceted research and education program focused on the silviculture red alder (Alnus rubra) and mixes of red alder and Douglas-fir (Pseutotsuga menzeisii) in the Pacific Northwest. The goal of the HSC is improving the understanding, management, and production of red alder. The activities of the HSC have already resulted in significant gains in understanding of regeneration and stand management, and have highlighted the potential of red alder to contribute to both economic and ecological forest management objectives.

The HSC, begun in 1988, is a combination of industry and both federal and state agency members, each with their own reasons for pursuing red alder management. For instance, some want to grow red alder for high-quality saw logs, while others want to manage red alder as a component of bio-diversity. What members have in common is that they all want to grow red alder to meet their specific objectives.

Members invest in many ways to make the HSC a success. They provide direction and funds to administer the Cooperative. They provide the land for research sites and the field crews for planting, thinning, and taking growth measurements.

The HSC's highest priority is to understand the response of red alder to intensive management. To accomplish this, the HSC has installed 26 variable-density plantations extending from Coos Bay, Oregon to Vancouver Island, British Columbia. The majority of plantations are located in the Coast Range, with a few in the Cascade Range. The plantation distribution covers a wide range of geographic conditions and site qualities. At each site, cooperators planted large blocks of red alder at densities of 100, 230, 525, and 1200 trees per acre. Each block is subdivided into several treatment plots covering a range of thinning and pruning options (twelve total treatments per site).

In addition to the 26 variable-density plantations, the HSC has related studies in naturally regenerated stands. Young stands (less than 15 years old) of naturally regenerated red alder, 5 to 10 acres in size, were pursued as a means of short-cutting some of the lag time before meaningful thinning results could be obtained from the variable-density plantations. It came as a surprise to find only four naturally regenerated stands of the right age and size available in the entire Pacific Northwest.

The HSC has also established seven mixed species plantations of red alder and Douglas-fir. They are located on land designated as Douglas-fir site class III or below. Each plantation is planted with 300 trees per acre with five proportions of the two species. The site layout is designed to look at the interactions between the two species. We are finding that in low proportions and when soil nitrogen is limited, red alder can improve the growth of Douglas-fir. This improvement is due to the nitrogen fixing ability of red alder. The management challenge is to find the right proportion of the two species to maintain a beneficial relationship.

Since the HSC was established, we have learned a great deal about seed zone transfer, seedling propagation, stocking guidelines, identification of sites appropriate for red alder, and the effects of spacing on early tree growth (see the HSC web-page http://www.cof.orst.edu/coops/hsc for more information). Furthermore, the data set is now complete enough

to begin analyzing the growth response of red alder after thinning and/or pruning. Our ultimate goal is a better understanding of the effects of stand density on red alder growth and yield, and wood quality and to develop a red alder growth model.

The HSC red alder stand management studies are well designed and replicated on a scale rarely attempted in forestry. Over the next 20 years, we will harvest much from our investment. Our data set on growth of managed stands will make red alder one of the better-understood forest trees of the Pacific Northwest.

1. Location of installations for the Red Alder Stand Management Study.

Red Alder Stand Management Study

The Red Alder Stand Management Study is divided into three specific types of installations. Study installations are predominately located in the coastal mountain ranges of the Pacific Northwest from Coos Bay, Oregon to Vancouver Island, British Columbia (Figure 1). The three types of study installations are as follows:

- Type 1 is a natural red alder stand thinned to 230 and 525 trees per acre. There are four Type 1 installations.
- Type 2 is a variable-density red alder plantation. At each site, red alder is planted in large blocks at densities of 100, 230, 525, and 1200 trees per acre. Each block is subdivided into several thinning and pruning treatments. There are twenty-six Type 2 installations.
- Type 3 is a mixed species plantation of red alder and Douglas-fir. Each site is planted to 300 trees per acre with five proportions of the two species.

The primary focus of the Red Alder Stand Management study continues to be the Type 2 variable-density plantations. Type 2 installations are distributed across a matrix of five ecological regions and three site qualities (Table 1).

With each passing year, more and more treatments are applied and data collected. Tables 2, 3, and 4 describe the data collection schedules for the three installation types. The shaded areas of the tables indicate what activities have been completed and illustrate the tremendous accomplishments of the HSC to date.

Winter 2007 was another busy year for fieldwork. Measurements and numerous thinning and pruning treatments were completed on 14 sites! Many thanks go out to all of the cooperators for providing crews and special thanks go out to the HSC Management Committee, and the Oregon Department of Forestry for helping out with one of the orphaned sites (Table 5). Work included:

- No Type 1 measurements.
- Three Type 2 sites had their 17th year measurement (John's River, Ryderwood, and Clear Lake). Three others had their 12th year measurement (Mt. Gauldy, Scappoose, Darrington). In addition to measurements, 12 sites had various thinning and pruning treatments.
- One Type 3 installation (Menlo) had its 12th year measurement.

This coming year's fieldwork (Fall 2007- Spring 2008) shows a decrease in the workload. Although only 7 sites need to be measured, up to 12 plots will need to be thinned and 7 plots may need to be pruned. See Table 6 for the list of activities. Work will include:

- Two Type 1 sites, Sauk River and Sechelt, will need their 14th and 19th year measurements, respectively.
- Only one Type 2 site will need its 12th year measurement (Maxfield).
- Two Type 2 sites will need their 17th year measurement (LaPush and Pollard Alder).
- Five sites (including three mentioned above) will also need various thinning and pruning treatments.
- One Type 3 installation (Cedar Hebo) will need its 12th year measurement.
- There are no activities on "orphaned" sites this year.

Table 1. Matrix of Type 2 installations. Each installation identified by number, ownership, and year planted.

	Site Quality		
	Low	Medium	High
Region	SI50 :23-27 M SI20 :14-17 M	SI50 :28-32 M SI20 :18-20 M	SI50 :33+ M SI20 :21+ M
1) Sitka Spruce North	X	1201 DNR '91	1202 BCMin '94 1203 DNR '96
2) Sitka Spruce South	2202 SNF '91 2206 SNF '95	2203 ANE '92 2204 SNF '94	2201 WHC '90 2205 ANE '94
3) Coast Range	3204 SNF '92 3209 BLM '95	3202 WHC '90 3205 ODF '92 3207 BLM '94 3208 ODF '97	3203 MEN '92 3206 WHC '93 3210 OSU '97
4) North Cascades	4205 BCMin '94	4202 GYN '90 4203 BCMin '93 4206 DNR '95	4201 GYN '89
5) South Cascades	5205 GPNF '97	5203 BLM '92 5204 WHC '93	X

Definition of Acronyms

1. ANE-ANE Hardwoods
2. BCMin-British Columbia Ministry of Forests.
3. BLM-Bureau of Land Management.
4. DNR-Washington Department of Natural Resources.
5. GYN-Goodyear-Nelson.
6. GPNF-Gifford Pinchot National Forest.
7. MBSNF-Mt. Baker Snoqualmie National Forest
8. MEN-Menasha
9. ODF-Oregon Department of Forestry.
10. OSU-Oregon State University Forest Research Laboratory.
11. SNF-Siuslaw National Forest.
12. WHC-Washington Hardwood Commission.

Table 2. Data Collection Schedule for Type 2 Installations. Shaded areas indicate completed activities.

TYPE 2	GYN	WHC	WHC	GYN	DNR	SNF	NWH	NWH	SNF	ODF	BLM	WHC	BCmin
Site Number	4201	2201	3202	4202	1201	2202	2203	3203	3204	3205	5203	3206	4203
Site Name	Humphrey	John's R.	Ryderwood	Clear Lake	LaPush	Pollard	Pioneer	Sitkum	Keller-Grass	Shamu	Thompson	Blue Mtn.	Mohun Ck.
Year Planted	1989	1990	1990	1990	1991	1991	1992	1992	1992	1992	1992	1993	1993
1st yr Regen	1990	1991	1991	1991	1992	1992	1993	1993	1993	1993	1993	1994	1994
2nd yr Regen	1991	1992	1992	1992	1993	1993	1994	1994	1994	1994	1994	1995	1995
Plot Installation	1992	1993	1993	1993	1994	1994	1995	1995	1995	1995	1995	1996	1996
3rd yr Measure	1992	1993	1993	1993	1994	1994	1995	1995	1995	1995	1995	1996	1996
3-5 yr Thin	1993	1996	1996	1994	1996	1996	1997	1998	1997	1997	1996	1998	1998
Prune Lift 1 6ft	1995	1996	1996	1996	1996	1996	1997	1998	1997	1997	1996	1998	1998
6th yr Measure	1995	1996	1996	1996	1997	1997	1998	1998	1998	1998	1998	1999	1999
15-20' HLC Thin	1995	1999/07	1999	1996	1999	1999/02	2000	2001	2001	2000	2000	2002	2001/03
Prune Lift 2 12ft	1995	2002	1999	1996	2002	2000	2000	2001	1999	2000	2000	2002	2002
9th yr Measure	1998	1999	1999	1999	2000	2000	2001	2001	2001	2001	2001	2002	2002
Prune Lift 3 18ft	1998	2010?	2002	1999	2010?	2003	2004	2001	2009	2004	2004	2002	2007
12th yr Measure	2001	2002	2002	2002	2003	2003	2004	2004	2004	2004	2004	2005	2005
30-32' HLC Thin	2001	2012?	NA	2002	2008?	2008?	2009	2004	NA	2007	2009	2007	2010?
Prune Lift 4 22 ft	2001	2012?	2002	2002	?	2008?	2009	2004	?	2007	2009	2005	2010?
17th yr Measure	2006	2007	2007	2007	2008	2008	2009	2009	2009	2009	2009	2010	2010
22nd yr Measure	2011	2012	2012	2012	2013	2013	2014	2014	2014	2014	2014	2015	2015

Table 2 continued

TYPE 2	WHC	BCmin	SNF	NWH	BLM	BCmin	SNF	BLM	DNR	DNR	ODF	OSU	GPNF
Site Number	5204	1202	2204	2205	3207	4205	2206	3209	4206	1203	3208	3210	5205
Site Name	Hemlock Ck.	Lucky Ck.	Cape Mtn.	Siletz	Dora	French Ck.	Mt. Gauldy	Scappoose	Darrington	Maxfield	Weebe	Wrongway	Tongue Mtn.
Year Planted	1993	1994	1994	1994	1994	1994	1995	1995	1995	1996	1997	1997	1997
1st yr Regen	1994	1995	1995	1995	1995	1995	1996	1996	1996	1997	1998	1998	1998
2nd yr Regen	1995	1996	1996	1996	1996	1996	1997	1997	1997	1998	1999	1999	1998
Plot Installation	1996	1997	1997	1997	1996	1996	1997	1998	1997	1998	2000	2000	2000
3rd yr Measure	1996	1997	1997	1997	1997	1997	1998	1998	1998	1999	2000	2000	2000
3-5 yr Thin	1998	1999	1999	1999	1999	1999	2001	2000	2000/01	2002	2003	2003/06	2003/07
Prune Lift 1 6ft	NA	1999	1999	1999	NA	1999	2001	2000	2000	2002	2003	2003	NA
6th yr Measure	1999	2000	2000	2000	2000	2000	2001	2001	2001	2002	2003	2003	2003
15-20' HLC Thin	2002	2006/08?	2006	2003/06	2003	2003/11	2004/07	2004/07	2002/07	2005/08	2007/09?	2007/09?	2009?
Prune Lift 2 12ft	NA	2006	2003	2003	NA	2003	2004	2004	2002	2005	2009?	2006	NA
9th yr Measure	2002	2003	2003	2003	2003	2003	2004	2004	2004	2005	2006	2006	2006
Prune Lift 3 18ft	NA	2011?	2011?	2009?	NA	2006	2012	2010	2004	?	2014?	2011?	NA
12th yr Measure	2005	2006	2006	2006	2006	2006	2007	2007	2007	2008	2009	2009	2009
30-32' HLC Thin	2007	?	2011?	2009?	?	2008?	2012?	2010	2012	?	?	?	?
Prune Lift 4 22 ft	NA	?	?	?	NA	2011?	2012?	2012	2007	?	?	?	NA
17th yr Measure	2010	2011	2011	2011	2011	2011	2012	2012	2012	2013	2014	2014	2014
22nd yr Measure	2015	2016	2016	2016	2016	2016	2017	2017	2017	2018	2019	2019	2019

Table 3. Data Collection Schedule for Type 1 Installations. Shaded areas indicate completed activities.

TYPE 1	BCmin	SNF	DNR	MBSNF
Site Number	**4101**	**2101**	**4102**	**4103**
Site Name	**Sechelt**	**Battle Saddle**	**Janicki**	**Sauk River**
Plot Installation	1989	1990	1991	1994
1st yr Measurement	1989	1990	1991	1994
3rd yr Measurement	1992	1993	1994	1997
6th yr Measurement	1995	1996	1997	2000
9th yr Measurement	1998	1999	2000	2003
14th yr Measurement	2003	2004	2005	2008
19th yr Measurement	2008	2009	2010	2013
24th yr Measurement	2013	2014	2015	2018

Table 4. Data Collection Schedule for Type 3 Installations. Shaded areas indicate completed activities.

Owner	BCmin	NWH	GYN	BCmin	DNR	SNF	GPNF
Site Number	4302	2301	4301	4303	3301	2302	5301
Site Name	East Wilson	Monroe-Indian	Turner Creek	Holt Creek	Menlo	Cedar Hebo	Puget
Year Planted	1992	1994	1994	1994	1995	1996	1997
1st yr Regen Survey	1993	1995	1995	1995	1996	1997	1998
2nd yr Regen Survey	1994	1996	1996	1996	1997	1998	1999
Plot Installation	1993	1996	1996	1996	1998	1999	2000
3rd yr Measurement	1995	1997	1997	1997	1998	1999	2000
6th yr Measurement	1998	2000	2000	2000	2001	2002	2003
9th yr Measurement	2001	2003	2003	2003	2004	2005	2006
12th yr Measurement	2004	2006	2006	2006	2007	2008	2009
17th yr Measurement	2009	2011	2011	2011	2012	2013	2014
22nd yr Measurement	2014	2016	2016	2016	2017	2018	2019

Table 5. Hardwood Silviculture Cooperative Field Activities, Winter 2006/07.

Type	Activity	Installation	Cooperator
Type 1		None	
Type 2	15-20ft HLC Thin, Measure & Prune	2201	WHC- Johns River (thin 2 plots, prune?)
		2206	SNF- Mt. Gauldy (thin 1 or 2 plots, prune?)
		3209	BLM-Scappoose (thin 1 plot, prune?)
		4206	WADNR-Darrington (thin 1 plot, prune)
		3208	ODF- Weebe Packin (check status Plot 4 and 7)
		3209	OSU- Wrongway Ck.(thin plots 7 and 8)
		5205	GPNF- Tongue Mtn. (thin 1 plot)
	12yr Measurement	2206	SNF- Mt. Gauldy
		3209	BLM-Scappoose
		4206	WADNR-Darrington
	17yr Measurement	2201	WHC- Johns River
		3202	WHC- Ryderwood
		4202	GYN- Clear Lake
	30ft HLC Thin	3206	WHC- Blue Mtn. (thin 1 plot)
		5204	WHC- Hemlock Ck. (thin 1 plot)
		3205	ODF- Shamu (check HLC status Plot 10)
	4th pruning lift	3205	ODF- Shamu
		4203	BCMin- Mohun Ck. (3rd lift)
Type 3	12yr Measurement	3301	WADNR- Menlo

Table 6. Hardwood Silviculture Cooperative Field Activities, Winter 2007/08.

Type	Activity	Installation	Cooperator
Type 1	14 yr measurement	4103	MBSNF- Sauk River
	19 yr measurement	4101	BCMin- Sechelt
Type 2	15-20ft HLC Thin, Measure & Prune	1202	BCMin-Lucky Ck (check plot 9 HLC)
		1203	WADNR- Maxfield (thin plot 4)
	12yr Measurement	1203	WADNR- Maxfield
	17yr Measurement	1201	WADNR- LaPush
		2202	SNF- Pollard Alder
	30ft HLC Thin	1201	WADNR- LaPush
		2202	SNF- Pollard Alder (check HLC on plot 4)
		4205	BCMin-French Ck. (check HLC on plot 6)
	4th pruning lift	2202	SNF- Pollard Alder
Type 3	12yr Measurement	2302	SNF- Cedar hebo

12th Year Data Summary

Introduction

Plantation management of red alder is in its infancy. However, data on the effects of stand density and thinning from natural stands (eg. Smith, 1978; Hibbs et. al. 1989) may not be applicable to managed plantations. Early data from managed stands exist that both support and contradict many principles derived from natural stands. Therefore, more detailed and coherent information is needed on the effect of planting density and pre-commercial thinning; information that will assist choosing the appropriate silvicultural practices and to predict stand yield. This study is unique in being specifically designed to test long-term growth response of red alder to silvicultural treatments. The following report uses 12 year data from 22 variable-density plantations throughout the Pacific Northwest. This manuscript describes the diameter, height and volume growth responses from four planting densities and four pre-commercial thinning treatments.

Methods

The data in this analysis came from 22 plantations of pure red alder in western Oregon (OR), western Washington (WA), and southwestern British Columbia (BC) (121.7-125.4°W, 43.1-50.7°N). Five plantations were in the OR Coast Range, one in the OR Cascade Mountains, two in the Puget Trough of WA, and one on Vancouver Island, BC. (see Fig. 1). The climate is maritime and characterized by wet, mild winters, and cool, dry summers. Soil types included silty loams, clay loams, gravelly loams, and cobbly loams. Elevation ranged from 91 to 375 m, slopes ranged from 5% to 35%, and annual precipitation ranged from 115 to 330 cm.

Plantations were established on previously harvested sites of at least 6 hectares (ha) and reasonably uniform ground conditions. Site preparation methods were the standard operating methods for the region at the time and included normal competition reduction practices. Climatic (annual and growing season precipitation, length of growing season) and soils information was determined and site index was estimated using the soil-site method of Harrington (1986). Mean site index (base age 50 years) was 30 m.

Sites were planted between 1989 and 1995 using operational planting crews. At each site, blocks of local red alder nursery stock (inoculated with *Frankia* spp.) were planted to target densities of 250, 570, 1300, and 2950 trees per hectare (tph). Planting blocks were randomly assigned and within each planting block, control plots and various thinning and pruning treatment plots were randomly assigned. Treatment plots are 0.5 ha and contain a 0.13 ac measurement plot; the remaining area serving as a

buffer. Treatment activities and data collection are administered by the Hardwood Silviculture Cooperative (HSC), Forest Science Department, Oregon State University, Corvallis, OR. A full description of site locations, plot layouts, treatments, etc. can be found at www.cof.orst.edu/coops/hsc/.

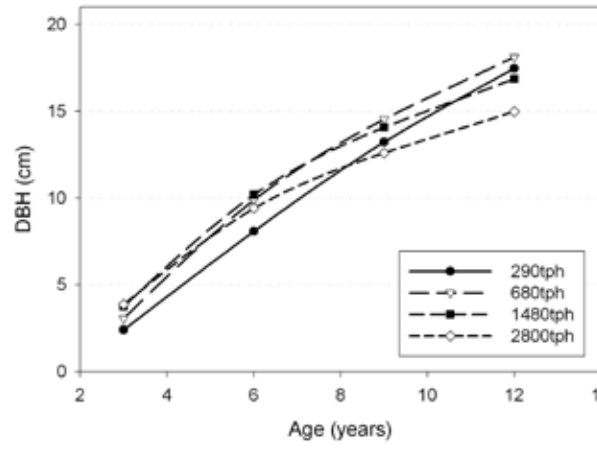
Two thinning treatments were performed on the two highest planting densities (1300 and 2950 tph). The first treatment was thinning when the tree crowns closed and lower branch mortality commenced (occurring around age 6). The second thinning treatment was thinning when the average height to the live crown was between 4.5 and 6.0 m (occurring around age 9). Residual target density for all thinning treatments was 570 tph.

At age 3, 6, 9, and 12, data was collected on permanently tagged individual trees. For every tree, stem diameter at 1.37 m (DBH), stem defect (fork, lean, sweep) and presence or absence of damage (animal, weather, etc) was recorded. Height was measured on a subsample of 40 trees that included the 10 trees of smallest diameter the 10 of largest diameter, and 20 mid-range trees (based on diameter). Mean tree diameter was calculated as quadratic mean diameter. Plot means were calculated for diameter, height, and height to live crown for 1) the sample of trees on the plot that would represent the 247 trees per hectare with the largest diameter (used for initial planting density comparisons), or 2) all the trees on the plot (used for thinned versus unthinned comparisons). Merchantable tree volume (DBH greater than 15 cm, 10 cm top) was calculated using the equation in Hibbs, et al. (2007).

Results

Planting Density

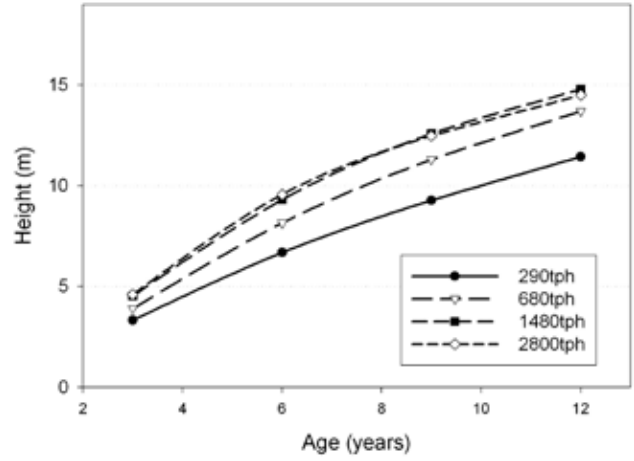
At age 3, crop tree DBH increased with increasing density (Figure 2). After age 3 and continuing through age 12, reduction of diameter with increasing density was observed (i.e. crossover effect) with the highest densities "crossing over" (i.e. becoming less than) the next lowest density. At age 12, crop tree DBH of the three lowest densities was surprisingly similar. Only the 2800 tph plot showed significant reduction in DBH (17% less than the maximum DBH). Annual increment peaked near age 4 for all densities and then gradually declined. Mean annual DBH in-



2. Comparison of diameter at breast height (DBH) by initial planting density for the 247 largest trees per hectare (crop trees). Data is derived from 22 HSC red alder plantation with a site index of 30 m (base age 50 years) calculated from Harrington (1986).

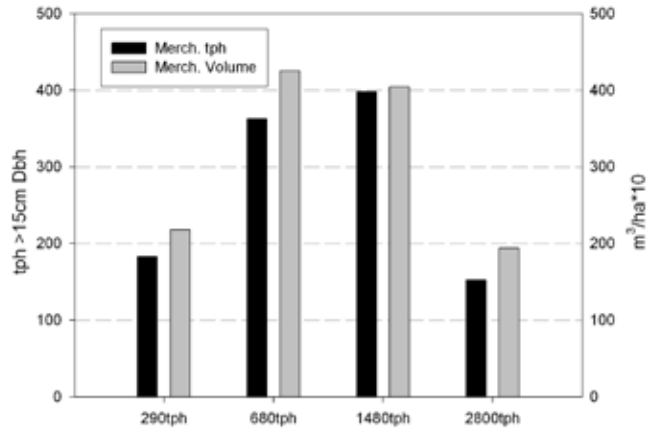
crement ranged from 1.2 cm/yr to 1.5 cm/yr. Periodic annual DBH increment from age 9 through 12 decreased with increasing density and ranged from 0.8 cm/yr to 1.4 cm/yr.

Like DBH, crop tree height increased with increasing density (Figure 3) yet this effect was much more persistent. "Crossing-over" didn't occur until about age 8 and only for the highest density. At age 12, tree heights were similar between the 2800 tph and the 1480 tph densities. Height growth reductions of 7% and 23% were observed for the 680 tph and the 290 tph densities, respectively. For every measurement date, the lowest two densities had the shortest trees. Mean annual height increment ranged from 0.9 m/yr to 1.2 m/yr. Periodic annual height increment from age 9 through 12 ranged from 0.7 m/yr to 0.8 m/yr.



3. Comparison of total tree height by initial planting density for the 247 largest trees per hectare (crop trees). Data is derived from one HSC red alder plantation with a site index of 30 m (base age 50 years) calculated from Harrington (1986).

Merchantable tree volume per hectare was greatest for the 680tph and 1480 tph densities (42.5 m^3/ha and 40.4 m^3/ha, respectively). Volumes in the 290 tph and 2800tph were approximately one-half that of the two intermediate densities. The number of merchantable tph closely mirrored that of total volume indicating similar individual tree volume (data not shown). The number of merchantable trees per hectare (tph) was greatest for the 1480 tph density (397 tph), followed by the 680 tph (362 tph), the 290 tph (182 tph) and the 2800 tph (152 tph, Figure 4). Although the 1480 tph density had the greatest



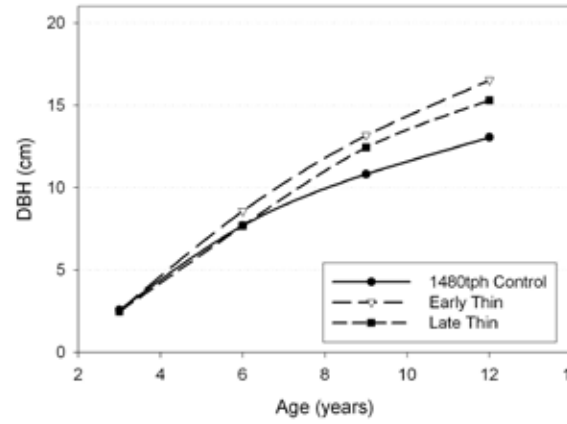
*4. Comparison of 12 year merchantable tph (Dbh>15 cm, 10 cm dib top) and merchantable volume ((m³/ha)*10) by initial planting density. Data comes from 22 HSC red alder plantations with a site index of 30 m (base age 50 years) calculated from Harrington (1986). Volume estimates come from Hibbs, et al. (2007) "Stem taper and volume of managed red alder. Western Journal of Applied Forestry 22(1): 61-66.*

number of merchantable trees, the 680 tph density had the greatest volume, indicating the latter density had larger mean individual tree volumes. The percentage of merchantable trees to total trees declined with increasing density and ranged from 6% for the highest density to 66% for the lowest density.

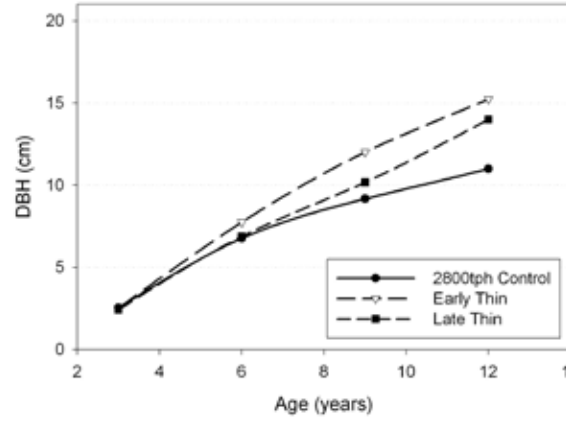
Thinning

Unlike the above control plot comparisons (which used the dominant, or crop trees) the following thinning comparisons use all of the trees on the plots with the intent of comparing the stand-level effects of thinning treatments.

In all cases, thinning increased tree diameter as compared to the control plot. The greatest increases in diameter occurred when thinning was done at age six (i.e. early thin) compared to when thinning was done at age nine (Figures 5 and 6). At age 12, diameters in the early thinned plot were 3.4 cm and 4.2 cm greater than the control for the 1480 tph and the 2800 tph densities. This corresponds to a 21% and a 28% increase. Thinning at age nine (i.e. late thin) also resulted in diameter improvement for the 1480 tph plot (2.2 cm and 15%) with greater diameter improvement for the 2800 tph plot (3.0 cm and 22%). Mean annual DBH increment for the 1480 tph density were 1.1 cm/yr, 1.4 cm/yr and 1.3 cm/yr for the control, early thin, and late



5. Comparison of diameter at breast height (DBH) for unthinned (control) trees, "early thinned" trees (appx. age 6) and "late thinned" trees (appx. age 9). All plots were planted at approximately 1480 trees per hectare (tph) and thinned to approximately 580 tph. Data comes from 22 HSC red alder plantations with a site index of 30 m (base age 50 years) calculated from Harrington (1986).



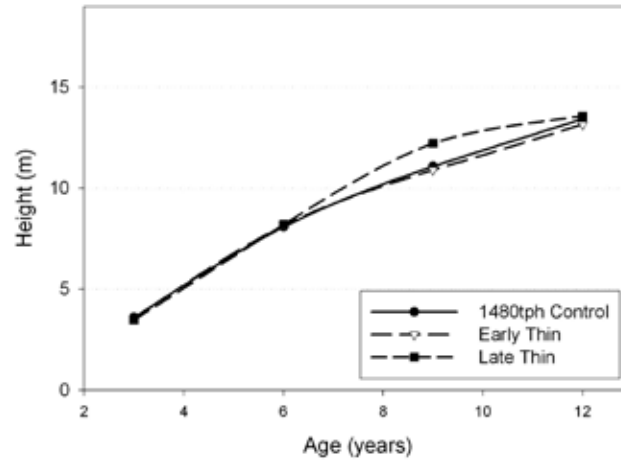
6. Comparison of diameter at breast height (DBH) for unthinned (control) trees, "early thinned" trees (appx. age 6) and "late thinned" trees (appx. age 9). All plots were planted at approximately 2800 trees per hectare (tph) and thinned to approximately 580 tph. Data comes from 22 HSC red alder plantations with a site index of 30 m (base age 50 years) calculated from Harrington (1986).

thin respectively. Correspondingly, periodic annual DBH increment from age 9 through 12 was 0.7 cm/yr, 1.1 cm/yr, and 1.0 cm/yr, respectively. Mean annual DBH increment for the 2800 tph density were 0.9 cm/yr, 1.3 cm/yr and 1.2 cm/yr for the control, early thin, and late thin respectively. Correspondingly, periodic annual DBH increment from age 9 through 12 was 0.6 cm/yr, 1.1 cm/yr, and 1.3 cm/yr, respectively.

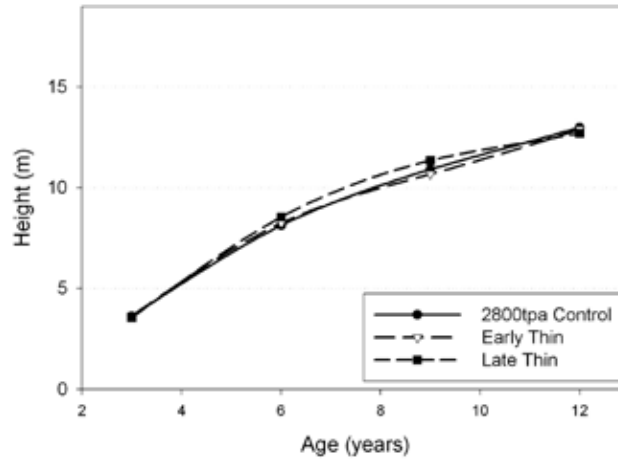
There was no effect of thinning on tree height for any density or timing of thin (Figure 7 and 8).

Although thinning reduces the total number of trees, it had almost no effect on the number of merchantable trees in the 1480 tph plots (Figure 9). There were 397 tph of merchantable size in the unthinned (control) plot as compared to 384 tph in the early thin and 343 tph in the late thin; the latter only a 14% reduction. However, in the 2800 tph plots, thinning increased the number of merchantable trees. There were 152 tph of merchantable size in the control plot as compared to 317 tph in the early thin and 220 tph in the late thin; the former about a 52% increase (Figure 10).

Thinning resulted in slight or no differences in volume per hectare for both densities. In both cases, the early



7. Comparison of total tree height (m) for unthinned (control) trees, "early thinned" trees (appx. age 6) and "late thinned" trees (appx. age 9). All plots were planted at approximately 1480 trees per hectare (tph) and thinned to approximately 580 tph. Data comes from 22 HSC red alder plantations with a site index of 30 m (base age 50 years) calculated from Harrington (1986).



8. Comparison of total tree height (m) for unthinned (control) trees, "early thinned" trees (appx. age 6) and "late thinned" trees (appx. age 9). All plots were planted at approximately 2800 trees per hectare (tph) and thinned to approximately 580 tph. Data comes from 22 HSC red alder plantations with a site index of 30 m (base age 50 years) calculated from Harrington (1986).

thinned plots had the greatest volume (47.3 m^3/ha for the 1480 tph and 37.8 m^3/ha for the 2800 tph). This corresponded to a 14% and a 49% increase in volume, respectively. Thinning late had almost no effect on volume for the 1480 tph plot (less than 1% difference) and a positive effect on volume for the 2800 tph plot (a 22% increase).

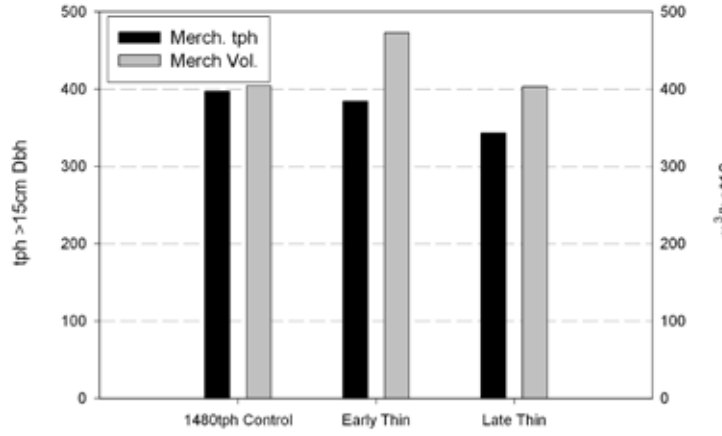
Pruning

Pruning had virtually no effect on diameter and height. At age 12, pruned trees averaged 15.5 cm DBH, while unpruned trees averaged 15.6 cm DBH. Likewise with height; pruned trees averaged 12.6 m in height, while unpruned trees averaged 12.8 m (data not shown).

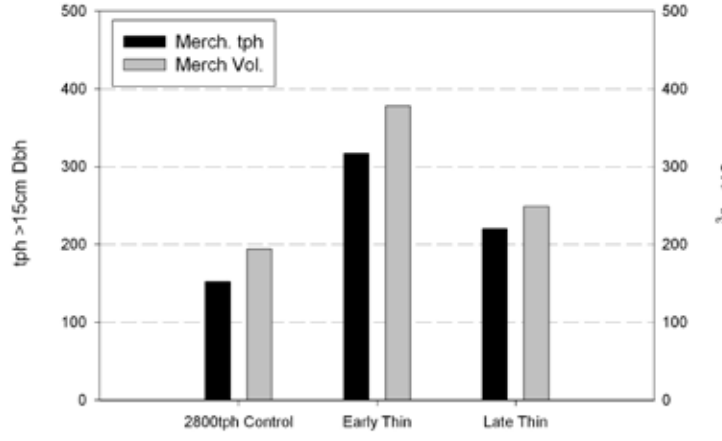
Discussion

Planting Density

Early diameter and height increased with stand density. Up through age 4,



*9. Comparison of 12 year merchantable tph (Dbh>15 cm, 10 cm dib top) and merchantable volume ((m³/ha)*10) for the 1480 tph unthinned (control) and thinned plots. Data comes from 22 HSC red alder plantations with a site index of 30 m (base age 50 years) calculated from Harrington (1986).Volume estimates come from Hibbs, et al. (2006) "Stem taper and volume of managed red alder. Western Journal of Applied Forestry 22(1): 61-66.*



*10. Comparison of 12 year merchantable tph (Dbh>15 cm, 10 cm dib top) and merchantable volume ((m³/ha)*10) for the 2800 tph unthinned (control) and thinned plots. Data comes from 22 HSC red alder plantations with a site index of 30 m (base age 50 years) calculated from Harrington (1986).Volume estimates come from Hibbs, et al. (2006) "Stem taper and volume of managed red alder. Western Journal of Applied Forestry 22(1): 61-66.*

diameter growth increased with density until a crossover effect ensued. Optimal diameter growth was maximized in the intermediate densities through about 11 years of age, after that, optimal diameter growth shifted to the lowest density (290 tph). Only by age 13 was the pattern of decreasing diameter with increasing density observed. It could be argued that these results are not unique at all since the typical relationship of diameter and density is occurring and (most likely) will continue and intensify as the stands age. However, these early differences are important for at least three reasons. First, due to the short rotation ages predicted, 10 years old is about half to a third of a rotation. Second, since thinning can maintain diameter growth rates, one could possibly continue to build off of these increased growth rates. Third, since a huge improvement in tree form occurs with increasing density, log quality and thus value is maximized.

Mean annual diameter growth rates reported here (1.1 cm/yr, averaged across all control densities) compare favorably to those reported in DeBell and Harrington (2002). They report annual diameter growth rates of 1.2 and 1.0 cm/yr for 20 year old trees grown in a plantation on a comparable site. Across their lowest density plots (within the range of densities presented here and potential operational planting densities), the similar pattern of decreasing diameter increment with increasing density was detected. In a review of density management studies, Puettman (1994) reported annual diameter growth rates between 0.6 and 1.2 cm/yr. He then extrapolates that under optimal management regimes "good" sites could average trees 38 cm in diameter in approximately 27 years. Using the most recent periodic increment observed here, final rotation age would be between 27 years (for the 290 tph plot) and 41 years (for the 2800 tph plot).

Height increased with stand density through age 12 except at extremely high densities. Tree heights in the 2800 tph plot "crossed over" the next lowest density (1480 tph) at about age 8.

Individual crop tree volumes reported here (0.12 m^3, averaged across all densities) were comparable to those reported by Hibbs et al. (1989) for 14-year-old trees found in a natural stand (0.15 m^3). Individual merchantable tree volume decreased with increasing density but differences were slight. Total merchantable volume per hectare was closely linked to the number of merchantable trees. The number of merchantable trees varied considerably, mainly as a function of the absolute number of trees and minimum merchantability limits. Trees in the lowest densities were generally larger in diameter than the other densities and therefore had a very large percentage (but not number) of merchantable trees. Conversely, the densest plots had lots of trees but few exceeding the merchantable diameter limit. At this time, the best balance between tree size and number was found in the intermediate densities (680 tph and 1480 tph). The volume per hectare estimates reported here are slightly lower than those reported for 12 year old stands of equivalent site index (Peterson, et.al. 1996). The average per hectare volume in this study (approx. 31.0 m^3/ha) was similar to that predicted by Worthington et al. (1960) using interpolation to adjust for site index and age (41.1 m^3/ha).

Thinning

Two main factors affect tree and stand response to thinning; the timing and the intensity of thinning. For DBH, thinning early resulted in an increased level of growth response; and this pattern was observed for both planting densities (i.e. thinning intensities).

Thinning elevated diameter increment levels and thinning early resulted in greater diameter increment when compared to thinning later. At age 12, the mean diameter of plots thinned at age six (on average) was 1.2 cm greater than plots thinned at age nine.

Again, using the above example (growing trees to 38 cm in DBH) and current periodic annual increment, one can calculate the expected rotation length. For the 1480 tph plots, the control plot would reach rotation at age 48, while the early thin and late thin would reach rotation at ages 32 and 35, respectively. For the 2800 tph plots, the early and late thin would reach a rotation age at 33 and 31 years, respectively, while the control would take 57 years. However, this estimate is extremely conservative since it includes all of the trees (not just the dominant or "crop trees") and the associated reduced DBH growth rates of the suppressed trees, both currently and in the future.

Thinning in alder plantations increased individual tree diameter with minimal effect on height growth. Volume data at age 12 indicated that the reduction in stand density through thinning is offset by the increased diameter growth rates associated with thinning. Furthermore, the accelerated diameter growth rates would result in shorter rotations because the remaining trees would reach commercial size sooner. Therefore, as with all species, the goal of thinning is to balance the maintenance of vigorous individual tree growth with overall stand growth and, more exclusively with alder, optimal stem quality.

Conclusion

This case study supports the conclusions made previously using data from younger stands, enables further comparisons between the possible growth benefits of plantations versus natural stands, and provides a much needed data point to extrapolate rotation ages, diameters, and volumes. However, it is prudent to be cautious when projecting this data into the future or to other sites.

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Direction for 2008

The specific goals for 2008 are both continuations of our long-term objectives and two new projects:

- Continue treatments and measurements of Red Alder Stand Management Study installations.
- Keep the HSC website updated and current.
- Continue efforts to recruit new members.
- Continue working with the USFS to develop an updated version of Forest Vegetation Simulator (FVS) model.
- Commence the ORGANON modeling project. This project has two parts. First, using the pure red alder plantation data from the database, create a new version of ORGANON. This version of ORGANON will be called the "red alder plantation" version of ORGANON (RAP-ORGANON). Second, using the natural stand red alder data from the database, re-calibrate the existing red alder equations currently found in the southwest Oregon, Northwest Oregon and SMC versions of ORGANON.

Appendix 1

Summary of Red Alder Stand Management Study Treatments

Type 1- Thinned Natural Red Alder Stands

1. Control- measure only, stand left at existing density
2. 230 trees/acre (tpa) re-spacing density in year 3 to 5
3. 525 tpa re-spacing density in year 3 to 5
4. 230 tpa re-spacing density when height to live crown (HLC) is 15 to 20 feet
5. 525 tpa re-spacing density when HLC is 15 to 20 feet
6. Control- measure only, stand left at existing density
7. 100 tpa re-spacing density when HLC is 30 feet
8. 230 tpa re-spacing density when HLC is 30 feet
9. Control- measure only, stand left at existing density

Type 2- Red Alder Variable Density Plantations

1. 100 tpa control- measure only
2. 230 tpa control-measure only
3. 230 tpa pruned to 6 ft. lift, 12 ft lift, 18 ft lift, 24 ft lift
4. 525 tpa control -measure only
5. 525 tpa thin to 230 tpa in year 3 to 5
6. 525 tpa thin to 230 tpa when HLC is 15 to 20 feet
7. 525 tpa thin to 230 tpa when HLC is 30 to 32 feet
8. 1200 tpa control- measure only
9. 1200 tpa thin to 230 tpa in year 3 to 5
10. 1200 tpa thin to 230 tpa when HLC is 15 to 20 feet
12. 1200 tpa thin to 100 tpa when HLC is 15 to 20 feet
13. 525 tpa thin to 100 tpa when HLC is 15 to 20 feet

Type 3- Mixed Red Alder Douglas-fir Plantations

1. 100% red alder planted at 300 tpa density
2. 50% red alder and 50% Douglas-fir planted at 300 tpa density
3. 25% red alder and 75% Douglas-fir planted at 300 tpa density
4. 11% red alder and 89% Douglas-fir planted at 300 tpa density
5. 100% Douglas-fir planted at 300 tpa density

HSC Management Committee Meeting Minutes

Summer Management Committee Meeting Minutes

Wednesday July 12, 2006:

Attendees: Andrew Bluhm- OSU; Jeannette Griese- BLM; Robert Deal- PNW, Portland, OR; Buck Tanner and Russell Brewer- BC Forest Service; Paul Courtin, Kevin Hardy, and Craig Wickland- BC Ministry of Forests; Bob Carl- Carlwood Lumber Ltd.; Nathaniel Stoffelsuma- Arbutus Grove Nursery; Andrew Brown- Western Forest Products

The day started out wet and rainy at 8:20am at the Subway in Gibsons, BC. After a short drive we reached the first stop of the tour- Roberts Creek Study Forest. Here, Brian D'Anjou, gave a very good presentation about an experiment designed to evaluate and develop a range of alternative systems with the potential to meet a variety of biological, social, and economic objectives. Local management issues consisted of water availability and quality, mushroom harvests, aesthetics, and mountain biking potential. This is a co-operative project demonstrating and studying different methods for harvesting and forest management. Please see the handout for more details and results. Or see http://www.for.gov.bc.ca/rco/research/projects/RCSF/RCSF.htm

The next stop was a BC Ministry of Forests addition series experiment- Gough Creek. This experiment was established in 1992 and replicated at three locations. Here, Douglas-fir and western redcedar were planted at a total density of 1100 trees per hectare (tph) with one of five alder densities (from 0 to 400 tph) added or superimposed over the conifers. Due to the heavy rain and the thick brush we visited only plot 4, which consisted of the 200 tph of alder. Of all treatments, this one had the greatest heights and diameters for all species, illustrating the potential beneficial effects of red alder on site productivity. More results are included in the handout or can be found at http://www.for.gov.bc.ca/hfd/pubs/Docs/En/En76.pdf.

Next we visited a BC Ministry of Forests replacement series experiment- East Wilson Creek. This experiment was established in 1992 using the protocol of the HSC and is in the HSC database. Here, instead of increasing densities like Gough Creek, the density is held constant and the proportion of species changes. Douglas-fir and red alder were planted at a total density of 742 tph with one of five proportions (0, 11%, 25%, 50%, and 100% red alder). At the first plot (25% alder) the alder dominated the Douglas-fir and had had large branches nearly to the ground. However, at the second plot (11% red alder), the Douglas-fir shared dominance. The third plot (50% red alder) was essentially a red alder stand with a small component of Douglas-fir. It was interesting to note that the height and diameter of both species increased with increas-

ing red alder. Discussions centered around 1) the large branch sizes of red alder with decreasing red alder proportions, 2) the infeasibility of using species mixtures with the objective of managing alder, but 3) the advantage and feasibility of using species mixtures with the objective of managing Douglas-fir. In fact, the difference in Douglas-fir size, crown size, needle length, and needle color was strikingly better when there was 11% alder versus pure Douglas-fir. More results are included in the handout or can be found at http://www.for.gov.bc.ca/hfd/pubs/Docs/En/En76.pdf.

After lunch at Davis Bay, we visited the last tour stop of the day- Sechelt. This site is a 35 year old natural stand of red alder thinned to two different densities (247 tph and 568 tph) in 1989 (at age 18). Current data consists of diameters, heights, volumes, and relative densities 14 years following thinning. For site characteristics and 9 year post-thinning results please see the HSC 2004 annual report (http://www.cof.orst.edu/coops/hsc/report/Report04.pdf). Results presented here (and included in the handout) are consistent with previous results in regards to diameter (diameter increases with increasing thinning intensity) and height (relatively insensitive to thinning intensity). Thinning substantially increased individual tree volume but reduced the number of merchantable trees per hectare. The increase in individual tree volume was overshadowed by the decrease in the number of merchantable trees following thinning; Total volume per hectare decreased with increasing thinning intensity. A key factor is that when thinning alder to get big sawlog sizes, you lose volume when you thin that may not be recoverable in short rotations. Please see the handout for detailed results.

Discussion then shifted to the problems and difficulties of using projected volumes to determine economic profit and the choice of which silvicultural treatment maximizes said profit. Although he was unable to attend, Glenn Ahrens with Oregon State Extension Service, provided a handout exploring these volume estimates and economic comparisons. In this Sechelt example, although he used different assumptions, volume equations, and log volumes instead of whole tree volumes both examples predicted surprisingly similar per hectare volumes. However, more importantly, Ahrens analysis took into account the differences in log sizes. So although the unthinned plot had the greater total volume, it had only 23 to 31% the number of logs greater than 20cm scaling diameter.

The last part of his handout then took these projected volumes by log sizes a step further by factoring in log prices and logging costs. This analysis was performed on a 36 year old thinned natural stand in Northwestern Oregon thinned at age 14. Once again the control had more volume than 3 of the 4 thinning treatments, but much less net value than all of the 4 thinning treatments. Please see the handout for detailed results.

Glenn also noted some of the key points to consider in any discussion of expectations for gains in yield and value from thinning.

- For any thin vs. not thin comparison - Gains in crop tree diameter are hard to interpret until you look at actual volume by log size-classes that are meaninful to buyer.
- Value of thinned vs not thinned - this is very dependent on price structure you choose for 6,8,10,& 12-inch logs.
- Result can be big differences in net return - especially for higher logging costs that

eat up all the profits with lots of small trees in the not-thinned.

- Accurate characterization of taper is very important for estimating yield in meaningful size-classes.
- As we get closer to reality with alder yield projections, it is increasingly important to clarify what log rules and conventions are being used in any numbers presented - best if they match common practice of buyers and sellers (or are easily converted to common practice).
- Differences between log-rules can be dramatic.

Thursday July 13, 2006:

Attendees: Andrew Bluhm- OSU; Jeannette Griese- BLM; Robert Deal- PNW, Portland, OR; Paul Courtin, Kevin Hardy, and Craig Wickland- BC Ministry of Forests; Bob Carl- Carlwood Lumber Ltd.; Nathaniel Stoffelsuma- Arbutus Grove Nursery; Andrew Brown- Western Forest Products; Kevin Brown- KR Brown and Associates; Stan Wheat- Stan Wheat Reforest Consulting

The morning meeting was held in the local BC Forest Service office in Powell River. After welcomes and introductions, Andrew reviewed the last year and the coming year measurements.

Winter 2006 (last year) was a very busy year for fieldwork. Measurements and numerous thinning and pruning treatments were completed on 13 sites! Many thanks go out to all of the cooperators for providing crews and special thanks go out to the HSC Management Committee, the Siuslaw National Forest Hebo District, and Oregon Department of Forestry for helping out with the three orphaned sites (Table 5). Work included:

- No Type 1 measurements.
- Eight Type 2's had fieldwork. Three installations were the last to have their 9th year measurement. Five installations had their 12th year measurements. Humphrey Hill (GYN), our oldest site, had its 17th year measurement. A total of seven plots were thinned and three plots were pruned.
- One Type 3 installation (Cedar Hebo) had the 9th year measurement.

This coming year's fieldwork (Fall 2006- Spring 2007) will be another busy year. Although only 7 sites need to be measured, up to 12 plots will need to be thinned and 7 plots may need to be pruned. Work will include:

- No Type 1 measurements.
- Three Type 2's will need their 12th year measurement.
- Three Type 2's will need their 17th year measurement.
- One Type 3 installation (Cedar Hebo) will need its 12th year measurement.
- Only one site (Wrongway Creek) is "orphaned".

Next, Andrew updated the group on the HSC's two main "side projects"; the regional growth model effort and the taper equation effort. Once again, these are both described in the annual report.

The first step towards building a new alder model is the compilation of a regional alder data base, a project managed by the Stand Management Cooperative. Data was submitted from natural and plantation plots in Oregon, Washington and British Columbia in the fall of 2005. Database compilation was largely completed a year ago but small problems have delayed its release. Two alder modeling efforts are being organized. First, Barri Herman of Weyerhaeuser has been working with the US Forest Service to facilitate their work in FVS. This is a public domain modeling system used by a variety of public agencies and private companies. Second, the HSC is beginning work in the summer of 2006 on two new versions of ORGANON, one for natural alder stands and one for alder plantations. The time line for completion is about 2 years.

Last year, the HSC partnered up with the USFS PNW Research Station to develop taper equations for alder plantations. A taper equation and an associated volume table are currently in press with the Western Journal of Applied Forestry. In addition to this manuscript the HSC is currently investigating the effect of various tree crown characteristics (mainly the live crown ratio) and their effects on stem shape. Preliminary analysis does suggest that trees (of a given DBH/HT) with deep, long crowns and trees with smaller, shorter crowns differ in stem form. We intend to publish these results in a Forest Service General Technical Report as various suites of tables including 1) total tree volume, 2) merchantable (6 inch stump and 5 inch dib top) tree volume, 3) merchantable height in feet (5 inch dib top), 4) stem volume to crown base, and 5) diameter inside bark (dib) at crown base.

When this project is completed, we will commence specifically and statistically testing the effects of various silvicultural treatments (initial planting density, pruning, and thinning) on stem form. Current research has shown treatment effects in conifers, but no work has been done on hardwoods. This dataset/project provides a great opportunity to test these effects.

Next, the topic turned to the HSC budget. Because every member paid their full dues in FY 2006, the HSC had a new member, and there was a little carryover from FY 2005, the HSC had enough income to fund Andrew for 10 months instead of 9 months. All other expenses were less than expected. This resulted in another carryover going into FY 2007. However, because one member has indicated that they may not be able to pay their dues next year, Andrews time may have to be reduced back to 9 months. Andrew is currently looking to procure additional funds to pay for his salary.

Kevin Brown then gave a presentation titled "Update on fertilization studies with young red alder in South Coastal BC". Some of his results have been previously presented at the "Red Alder- A State of Knowledge" symposium (see http://www.treesearch.fs.fed.us/pubs/22325). However, he has now started a plot-level, operational field study looking at the effects of adding Phosphorous in repeated applications and increasing levels on both moderately-dry sites and moist sites. Essentially, height, diameter, volume, and foliar N increased with increasing P applications up to a certain level. However, please see the handout for more detailed results.

Andrew then presented preliminary results of his analysis of 17 year old data collected from Humphrey Hill. The data gathered is extremely valuable because 1) it is one of (if not the) oldest continually measured alder plantations established with nursery stock and is over half the expected rotation age, and 2) conclusions about the effect of silvicultural treatments (i.e. planting density, thinning intensity and timing, and pruning) should be more robust because the trees have had a long time to "respond". What follows is a summary of Humphrey Hill's 17th year measurement. Please see the handout ans the 2006 annual report for more information. However, it is important to note that that since this is only one site, the results should be interpreted with a great deal of caution.

Control plot summary:

DBH

- Early DBH increased with density until age 6
- "Crossover" occurred between ages 7 and 13
- At age 17, ranged from 22-29 cm
- Mean annual DBH increment ranged from 1.3-1.7 cm/year, slightly better than reported elsewhere (DeBell 2002, Puettman 1994)
- Rotation age to a mean DBH of 38 cm (15 in) would range between about 24 and 45 years, increasing with increasing density

Height

- Increased with density except for highest density
- Ranged from 17-22 m
- Mean annual HT increment ranged from 1.0-1.3 m/year
- However, current MAI has slowed considerably (0.3-0.6 m/yr)
- Observed HT< Expected HT (~26m)

Individual Tree Volume

- Individual merch tree volume decreased with increasing density
- Merch volume ranged from 0.22 m^3/tree to 0.33 m^3/tree
- However, the absolute difference by density was slight

Number of Merchantable trees

- The number of merch tph was greatest for the 1760 tph, followed by the 3320 tph, the 590 tph, and the 270 tph
- The % of merch trees to total trees declined with increasing density and ranged from 48% to 99%

Stand Volume Estimates

- Stand volume is a product of the size and number of merch trees
- Here the densities with the greatest number of merch tph had the greatest volumes

- Volume per hectare for the three densest plots was 157 m^3/ha and 178 m^3/ha and 138 m^3/ha, respectively (83 m^3/ha for the lowest density)
- The best balance between tree size and number was found in the intermediate densities (590 tph and 1760 tph)
- The mean value (approx. 157 m^3/ha) is slightly lower than reported for 20 year old stands of equivalent site index (Peterson 1996) but greater than what would be predicted from Worthington (1960) using interpolation to adjust for site index and age (133 m^3/ha)

Stand Volume Projections

- Projected merch volume was greatest for the intermediate densities
- At age 25, projected volumes by increasing density would be 2000, 3800, 4100, and 3200 ft^3/acre
- Assuming 4 bf/ft^3, for this stand to reach 20 mbf would take 54, 31, 29, and 35 years, by increasing density
- Can not reach the "mythical" 20 mbf in 25 year target by planting alone

Thin plot summary

DBH

- DBHs in the early thinned plots were just over 4 cm greater than the corresponding control, corresponding to a 21% and a 14% increase
- Thinning at age six resulted in DBH improvements of 6% for the 1760 tph plot (1.2 cm) and 18% for the 3320 tph plot (3.2 cm)
- On average, DBH was 2.1 cm greater for the early thin versus late thin
- Thinning slightly increased mean annual DBH increment however, this is misleading (comparing stand BA would be more proper)
- Rotation age to a mean DBH of 38 cm (15 in) would be at age 76 for the 1760 tph control, 40 years for the early thin and 59 years for the late thin
- For the 3320 tph plots both the early and late thin would reach a rotation age of 44 years, less than half the time it would take for the control
- However, this estimate is extremely conservative since it includes all of the trees (not just the dominant or "crop trees") and the associated reduced DBH growth rates (and mortality) of the suppressed trees

Height

- The effect of thinning on tree height differed by planting density and timing of thinning
- Thinning in the 1760 tph density resulted in somewhat severe height reductions for the late thin treatment
- Thinning had no appreciable effect on height when applied to the 3320 tph density

- However, before sweeping generalizations are made, more research should be done testing specific residual densities, thinning intensities, timings (precommercial or commercial), and single or repeated entries

Individual Tree Volume

- Thinning substantially increased individual tree volume
- For the 1760 tph plots, individual tree volume was increased by 57% and 9% for early and late thinned plots respectively
- For the 3320 tph plots, individual tree volume was increased by 50% and 40% for early and late thinned plots respectively

Number of Merchantable trees

- Thinning reduced the number of merchantable trees per hectare
- There was a 30% reduction and a 18% in the number of merch tph for the 1760 tph and the 3320 tph densities, respectively

Stand Volume Estimates

- The increase in individual tree volume coupled with the decrease in the number of merch tph resulted in only slight differences in volume
- More importantly, the control trees in both densities had small trees, but many of them, whereas trees in the early thin had larger trees but fewer of them
- For both densities, the early thinned plots had the greatest volume (186 m^3/ha for the 1760 tph and 152 m3/ha for the 3320 tph) corresponding to a 14% and a 16% increase in volume, respectively
- The 3320 tph plot that was thinned early followed the same pattern as above (an 18% increase), whereas the 1760 tph plot thinned late had less volume than the control due to both fewer trees as well as smaller trees (a 22% reduction in volume)

Stand Volume Projections

- Projected merch volume was greater for the thinned vs. unthinned plots
- For the 1760 tph density, thinning early increased volume at age 25 from 4100 to 4800 ft^3/acre (very close to the "20 mbf in 25 year target")
- For the 3320 tph density, both thinnings increased volume at age 25 from 3200 to about 3800 ft^3/acre
- These results are only a snapshot during stand development

This case study supports the conclusions made previously using data from younger stands, enables further comparisons between the possible growth benefits of plantations versus natural stands, and provides a much needed data point to extrapolate rotation ages, diameters, and volumes. However, using these results to estimate/project/predict is unwise for multiple reasons

- This is only one site and is not representative of all the alder growing sites in the region

- Diameter and height growth rates, and mortality rates differ by treatment and are difficult to accurately account for
- Not accounted for are the trees just below the merchantable DBH limit
- Stand growth will be affected by any environmental or stochastic changes that occur

With that, the group loaded up to visit a few experimental and operational alder activities with Neil Hughes, an employee with Northwest Hardwoods, and a strong advocate for red alder management in British Columbia.

The first stop was a stock-type trial established last year. Four sizes of plugs and plug ½'s were planted at three sites to investigate growth and mortality. Neil has had luck with both plugs and plug ½'s but prefers the latter due to their larger caliper and fuller lateral roots. This experiment should provide more information on the differences in growth and frost mortality between sizes and types of red alder stock.

The next stop (where we ate lunch) was a young plantation (2 growing seasons) that was chemically treated after harvest, successfully regenerated, and now is experiencing intensive competition from salmonberry and elderberry. Neil was interested in the groups opinion whether or not to brush out the competition or not. The advantage of brushing is that it would allow the alder crowns to expand and close canopy sooner. The disadvantage, obviously, is the cost. Members of the group were split over whether to brush or not.

The next stop was near Duck Lake where Neil put in a site preparation trial. The plantation is 3 and ½ years old and the site preparation methods included 1) piling the slash and burning the piles, 2) piling followed by scarifying the site, and 3) piling and mounding the site. In all cases, height and diameter were greatest for the piling and mounding treatment. However, the exact reasons for that were discussed but no consensus was found. Possible suggestions included, that there really was not a treatment difference at all, just site variability, changes in nutrient cycling and/or changes in soil water holding capacity due to mounding. The plantation looked great- especially the trees growing in the burn piles.

The last stop of the tour was at another one of Neils operational red alder plantations. This plantation, one of the oldest in BC, was planted eight years ago at 1600 sph, experienced prolific ingrowth from natural red alder, and at the time of thinning had a density of approximately 300 sph. Thinning occurred last year and had three residual densities of approximately 600, 800, and 1000 sph. Results of the HSC study recommend densities close to 600 sph but the group liked the look of the 800 sph. The trees had a little more support from their neighbors, and planning against post-thinning mortality, will hopefully reach acceptable density levels.

The tour ended there and many thanks go out to Paul Courtin and Neil Hughes for their planning and logistic help and to Glenn Ahrens, Kevin Brown, and Keith Thomas for their materials and presentations.

Finally, since so few HSC members attended, Andrew decided that he will contact the group at a later time to schedule the next HSC winter meeting. If we do have a winter meeting it will be near Longview, WA so we can measure an "orphaned site" located near there. Stay tuned for more information.

Appendix 3

Financial Support for 2006-2007

Cooperator	Support
BC Ministry of Forests	$8,500
Bureau of Land Management	$8,500
Goodyear-Nelson Hardwood Lumber Company	$4,500
Oregon Department of Forestry	$8,500
Siuslaw National Forest	$8,500
Trillium Corporation	$8,500
USDA Forest Service PNW Station	In kind
Washington Department of Natural Resources	$8,500
Subtotal	$55,500
Forestry Research Laboratory	$47,332
Total	$102,832


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