HSC

annual report 2012

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Hardwood Silviculture Cooperative

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Contents

Highlights of 2012

- Three more 22nd year measurements were collected on the Type 2 installations (variable-density red alder plantation); bringing the total to 4 of the 26 installations.
- Three more Type 2 installations had the 17th year measurement; bringing the total to 22 of the 26 installations.
- 14 of the 26 Type 2 installations have now had all the treatments completed.
- One more Type 3 installation (mixed red alder/Douglas-fir plantation) had its 17th year measurement; bringing the total to 5 of the 7 installations.
- Field data was collected for the collaborative effort between the WA Department of Natural Resources and the HSC investigating volume and stem form effects resulting from thinning natural red alder stands. These data will provide an opportunity to identify these thinning effects and will facilitate the WADNR in fine-tuning their red alder cruise estimates.
- A paper entitled "Climate effects on red alder growth in the Pacific Northwest of North America" has recently been published in Forest Ecology and Management. This paper, co-authored by David and Andrew, is a product of the collaboration of the HSC with multiple Canadian organizations on a large effort titled "Using red alder as an adaptation strategy to reduce environmental, social and economic risks of climate change in coastal BC".

Executive Summary 2012

Established 24 years ago, the Hardwood Silviculture Cooperative (HSC) has led the effort to provide information for foresters interested in the management of red alder either as natural stands or plantations or pure stands or species mixtures. The continued member direction and support has resulted in considerable knowledge and products regarding red alder silviculture and indicates support for the original concept and mission of the HSC. Which got me thinking: Why did the HSC come about? To find out, I pulled from the archives the original HSC Prospectus, written way back in 1986.

Why was the HSC formed in the first place?

When the HSC was formed, virtually nothing was known about managing stands of red alder. Granted, the red alder resource has always been utilized, but changes in the forest industry caused an increase in the number of questions being asked about techniques of reproduction, management, harvesting, processing and marketing. According to the Prospectus, there are "many unaddressed questions still remain(ing) for nursery practices, regeneration, weed control, timing and density of spacing activities, and growth and yield".

What was the original mission of the HSC?

The primary mission was to "conduct high priority silvicultural research on hardwood species and mixed hardwood/softwood stands in the Pacific Northwest, with the goal of providing information that will improve the management of these stands… with red alder being the primary, but not exclusive, interest". Some of the research is designed to meet the immediate needs of foresters, while other studies examine the long-term benefit and impact of certain management practices. The collaboration with the WA DNR on identifying the effects of thinning on stand volume and stem form is an example of the former. The collaboration studying the effects of climate change on the distribution and productivity of red alder and the analysis of red alder Douglas-fir species-mixtures are both examples of the latter. These projects are highlighted in this report.

Why a cooperative?

"A well-run cooperative is an efficient means of developing management information and the communication of results. Cooperatives pool limited resources to carry out research at a modest cost per member. A cooperative can also assure that important research problems are identified, because cooperators help choose the problems to be studied." In other words, the cooperative model works. The changing economy affects companies and organizations differently and it is only through the pooled resources of the cooperatives' members that the HSC has continued to be in the forefront of red alder research for almost 25 years.

What has the HSC accomplished?

The activities of the HSC have resulted in significant gains in the understanding of regeneration and stand management of red alder. The ultimate goal is to be able to tell foresters how to best manage red alder and what volumes and log qualities they will get for that effort. In the years since the first plantation was established, we have learned a great deal about producing quality seedlings, stocking guidelines, identification of appropriate sites, density management guidelines and the effects of spacing on early tree growth and final yield. This report documents some of the HSC activities over the past year.

The current direction of the HSC is to tackle specific short-term projects and continue the long-term mission outlined decades ago.

Thank you members for your original vision, continued patience, and ongoing support,

Andrew Bluhm

History of the HSC

The Hardwood Silviculture Cooperative (HSC) is a multi-faceted research and education program focused on the silviculture of red alder (*Alnus rubra*) and mixes of red alder and Douglas-fir (*Pseutotsuga menziesii*) 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 may 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 through time 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 management on red alder growth and yield, and wood quality and to develop red alder growth and yield models.

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.

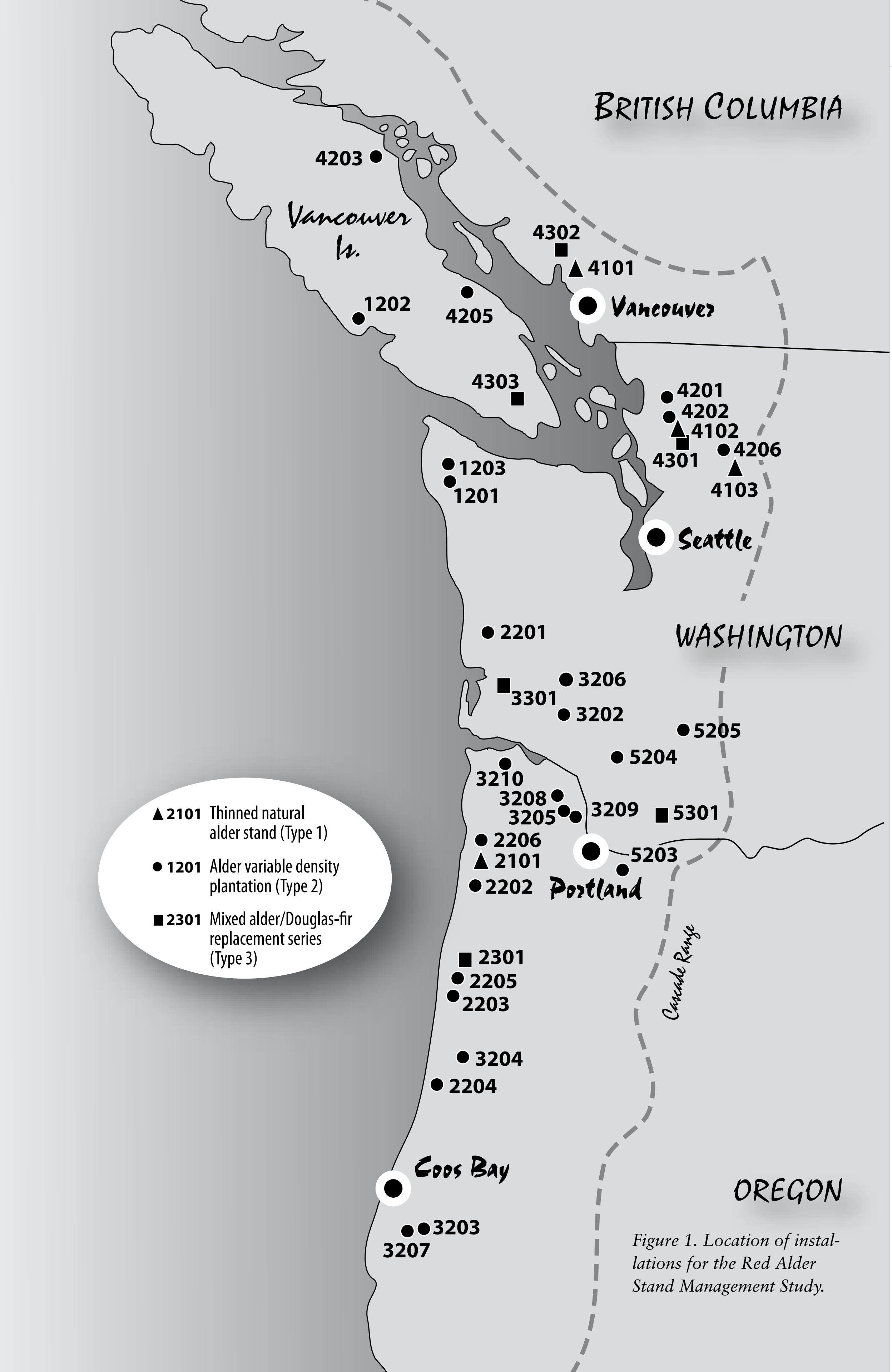

Figure 1. Location of installations for the Red Alder Stand Management Study.

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 100, 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. There are seven Type 3 installations. Please see Appendix 1 for a coomprehensive list of study treatments.

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 quality classes (Table 1).

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

Winter 2011/12 was a typical field season (if you don't take into account of all of the late-season, low-elevation snow!). Measurements and various treatments were completed on 8 of the 37 installations (Table 5). Last year's work included:

- No Type 1 installations had fieldwork.
- Seven Type 2 installations had fieldwork.
  - Three sites- John's River (2201, WHC), Ryderwood (3202, WHC), and Clear Lake Hill (4202, GYN) had their 22nd year measurement.
  - Three sites- Mt. Gauldy (2206, SNF), Scappoose (3209, BLM), Darrington (4206, WADNR) had their 17th year measurement.

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 CAM '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

ANE-ANE Hardwoods.
BCMin-British Columbia Ministry of Forests.
BLM-Bureau of Land Management.
CAM-The Campbell Group
DNR-Washington Department of Natural Resources.
GYN-Goodyear-Nelson.
GPNF-Gifford Pinchot National Forest.
MBSNF-Mt. Baker Snoqualmie National Forest.
ODF-Oregon Department of Forestry.
OSU-Oregon State University Forest Research Laboratory.
SNF-Siuslaw National Forest.
WHC-Washington Hardwood Commission.

- One site- Weebe Packin (3208, ODF) had its second thinning treatment (when HLC= 15-20ft), its last thinning treatment (when HLC~30ft), and its 3rd pruning lift (to 18ft).
- One site- Mt. Gauldy (2206, SNF) had its 3rd pruning lift.
- One site- Darrington (4206, WADNR) had its last thinning treatment (when HLC~30ft).

- One Type 3 installation had fieldwork.
    - Menlo (3301, WADNR) had its 17th year measurement.

In addition to the measurements and treatments completed above, there was substantial plot maintenance required including: replacing measurement plot corners, retagging trees that outgrew the zipties, refreshing or establishing DBH paint lines, and rouging out invading conifers and/or hardwoods.

Table 2a. 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	2008	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	NA	NA	2002	2011	2008	2009	2004	NA	2007	2009	2007	2010
Prune Lift 4 22 ft	2001	NA	2002	2002	2013	2008	2009	2004	2014	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 2b. Data Collection Schedule for Type 2 Installations. Shaded areas indicate completed activities.

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	2003/16	2004/07	2004/07	2002/07	2005/08	2007/12	2007/09	2009/14
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	2016	2013	2011	NA	2006	2012	2010	2004	2011	2012	2011	NA
12th yr Measure	2005	2006	2006	2006	2006	2006	2007	2007	2007	2008	2009	2009	2009
30-32’ HLC Thin	2007	NA	2016	2011	2016?	2016	2012	2010	2012	2011	2012	2011	2014?
Prune Lift 4 22 ft	NA	2021?	2021?	2016	NA	2016	2017	2010	2007	2013	2014?	2014	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 2011/12

Type	Activity	Installation	Cooperator
Type 1	None		
Type 2	15ft HLC Thin	3208	ODF- Weebe Packin
	3rd Pruning Lift	2206	SNF- Mt. Gauldy
		3208	ODF- Weebe Packin
	17yr Measurement	2206	SNF- Mt. Gauldy
		3209	BLM- Scappoose
		4206	WADNR- Darrington
	30ft HLC Thin	3208	ODF- Weebe Packin
		4206	WADNR- Darrington
	22yr Measurement	2201	WHC- John's River
		3302	WHC- Ryderwood
		4202	GYN- Clear Lake
Type 3	17yr Measurement	3301	WADNR- Menlo

So, in the big picture:

- Four of the twenty-six Type 2 sites have had their 22nd year measurement.
- Twenty two of the twenty-six Type 2 sites have had their 17th year measurement.
- Fourteen of the twenty-six Type 2 sites have all treatments completed.
- Five of the seven Type 3 sites have had their 17th year measurement.

This coming year's fieldwork (Winter 2012/13) will likewise be fairly typical. A total of 8 installations need either a measurement or a treatment. See Table 6 for the list of activities.

Work includes:

- Two Type 1 installations: Sauk River (4103- MBSNF) and Sechelt (4101-BCMIN) need their 19th and 24th year measurements, respectively.
- Five Type 2 installations need fieldwork.
    - Two installations- LaPush (1201, WADNR) and Pollard Alder (2202, SNF) need their 22nd year measurement.
    - One installation- Maxfield (1203, WADNR) needs its 17th year measurement.
    - One installation- Cape Mtn. (2204, SNF) needs its 3rd pruning lift (to 18).
    - Three installations- LaPush (1201, WADNR), Maxfield (1203, WADNR), and French Creek (4205-BCMIN) need their 4th and final pruning lift (to 22ft).
- One Type 3 installation had fieldwork.
    - Cedar Hebo (3202, SNF) needs its 17th year measurement

Of note, the Type 1 installation, Sauk River is an "orphaned" installation withour support for completing the measurements.

Table 6. Hardwood Silviculture Cooperative Field Activities, Winter 2012/13

Type	Activity	Installation	Cooperator
Type 1	19yr Measurement	4103	MBSNF- Sauk River
	24yr Measurement	4101	BCMIN- Sechelt
Type 2	3rd Pruning Lift	2204	SNF- Cape Mtn.
	4th Pruning Lift	1201	DNR- LaPush
		1203	DNR- Maxfield
		4205	BCMIN- French Creek
	17yr Measurement	1203	DNR- Maxfield
	22yr Measurement	1201	DNR- LaPush
		2202	SBF- Pollard Alder
Type 3	17yr Measurement	2302	SNF- Cedar Hebo

Current HSC Activities

Species Mixtures of Red Alder and Douglas-fir: An Analysis

Red alder (*Alnus rubra* Bong.) is a common component of most low-elevation forests in the Pacific Northwest, forming both pure stands and mixed- species stands. Therefore, it is important to identify the effects of species mixtures on growth and stand development. On the one hand, as an early- successional, shade-intolerant species, red alder is often an aggressive competitor with young conifer stands. On the other hand, red alders' nutrient cycling characteristics and nitrogen fixing ability can improve the growth of other conifers on nutrient poor sites. Douglas-fir (*Pseutotsuga menziesii* (Mirb.) Franco) growth in mixed stands is often less than in pure stands because of lower light levels. However, these effects may be offset by red alder's ability to fix atmospheric nitrogen. These processes, competition and facilitation have been the subject of numerous early investigations (Berntsen 1961, Tarrant 1961, Newton et al. 1968, Trappe et al. 1968 (and references within), Miller and Murray 1978, Briggs et al. 1978 (and references within), Tarrant et al. 1983, Hibbs and DeBell 1994).

Understanding both the competitive and beneficial effects of red alder in mixture with Douglas-fir is essential in making certain management decisions. In light of this, the Hardwood Silviculture Cooperative (HSC) established several mixed species plantations throughout the Pacific Northwest (see Figure 1) to improve the understanding of both the competitive and beneficial effects of red alder when grown with Douglas-fir. The design for these sites is a replacement series, with a constant total stand density and changing proportions of each species. All sites were planted with 740 trees per hectare (300 trees per acre) with five proportions of the two species. Each site consisted of one replication of each of the five treatments. The objective of this analysis is to examine the effects of differing species proportions on 1) survival, 2) diameter at breast height (DBH), 3) height (HT), 4) crown ratio (CR), 5) individual tree volume, 6) per acre volume, and 6) relative yields of both red alder and Douglas-fir.

The abovementioned studies of competition between red alder and Douglas-fir have all had various tree ages, treatments, experimental designs, etc. Cole and Newton (1986 & 1987) used a Nelder design, Shainsky & Radosevich (1991 & 1992), Thomas et al. (2005) and Comeau et al. (2007) employed an addition series design, and Chan et al. (2003) used a factorial design. A replacement series design experiment established in 1986 by Oregon State University, has resulted in numerous investigations and publications (D'Amato and Puettman 2004, Grotta et al. 2004 and Radosevich et al. 2006). The latter publication (hereafter referred to as RADFIN) contains specifics on this experimental design, and the results presented therein are used as the primary comparisons for the results presented in this research for three main reasons; 1) same experimental design (replacement series), 2) similar age (14 year and 17 year old results, and 3) similar treatment densities (1110 trees/ha and 740 trees/ha). Furthermore, results from this study will be compared to the two sites from RADFIN: Cascade Head- a fertile site in the Coast Range and HJ Andrews- a relatively infertile site in the Cascade Range.

Methods

Five sites from Oregon, Washington, and British Columbia were used in this analysis. Description of each site can be found in Table 7. The sites were established between 1992 and 1995 following clearcutting and standard site preparation methods and planted with one year old red alder seedlings and two year old Douglas-fir seedlings. At each site there are five treatment blocks planted to an initial target density of 740 trees/ha (300 trees/acre). Each block contains a measurement plot of 0.13 ha or 36.7 m by 36.7 m (0.3 acres or 120.5 ft by 120.5 ft) and a buffer of at least 15 m (50 ft) on all sides. To achieve the desired pattern and density, seedlings were planted in pre-marked planting spots in a 3.7m (12ft) grid (Figure 2). First and second year tree mortality was measured and if stocking fell significantly below the target density, interplanting may have taken place. In addition, all ingrowth of all tree species were removed. Three growing seasons after planting, all trees in the measurement plot were permanently tagged and for every tree, DBH (stem diameter at 1.37m [4.5ft]), stem defect (fork, lean, sweep) and presence or absence of damage (animal, weather, etc.) was recorded. HT and height to live crown (HLC) was measured on a subsample of

40 trees of each species spatially well distributed over the plot that included 10 trees of the smallest DBH, 10 trees of the largest DBH, and 20 mid-range trees (thus, the number of HTs per plot varied by treatment). Missing HTs and CRs (CR=1-HLC/HT) were estimated using the ORGANON growth model DLL (RAP and SMC versions for red alder and Douglas-fir, respectively [Hann 2011]). Measurements were repeated at plantation age 6, 9, 12 and 17 years.

Table 7. HSC replacement series site descriptions

Site Name	East Wilson	Monroe-Indian	Turner Creek	Holt Creek	Menlo
Site Number	4302	2301	4301	4303	3301
Year Planted	1992	1994	1994	1994	1995
Longitude	123.67° W	123.83° W	122.20° W	123.86° W	123.69° W
Latitude	49.46° W	44.74° W	48.45° W	48.76° W	46.58° W
Elevation (m)	276	137	259	173	333
Slope (°)	0-10	0-5	20-30	10	0-10
Aspect	South	Flat- Southeast	South	North	Flat-North
Soil Parent Material (USA)/Biogeoclimatic Zone (CA)	Costal Western Hemlock Dry Maritime[1] Dystric	Sedimentary colluvium Blachly silty	Volcanic ash and loess over glacial drift Tokul	Costal Western Hemlock Very Dry Maritime[1] Humo-Ferric	Basaltic residuum Boistfort
Soil Type	Brunisol[2]	clay loam	gravelly loam	Podzol[2]	silt loam
Annual Precipitation (cm)	163	231	136	169	260
Growing Season Precipitation (cm)	45.9	45.6	41.8	34.3	57.7
Avg. Minimum Temperature (°C)	1.9	5.2	2.5	2.7	3.7
Avg. Maximum Temperature (°C)	16.9	16.4	16.1	16.5	15.3
Growing Season (days)	183	185	166	176	165
Site Class/Douglas-fir Site Index(ft)[3]	IV/82	III/106	III/97	III/109	III/98
Site Index Red alder/Douglas-fir (ft)[4]	52.6/73.7	63.6/92.3	64.9/90.6	48.9/96.6	61.8/87.5

[1]Based on the Biogeoclimatic Ecosystem Classification (Pojar et al. 1987)

[2]Based on the Canadian System of Soil Classification (Soil Classification Working Group 1998)

[3]Site Class and Site Index (base age 50 years) based on Bruce (1981)

[4]Red alder site index (base age 20 years) based on Weiskittel et al. (2009), Douglas-fir site index (base age 30 years) based on Flewelling et al. (2001)

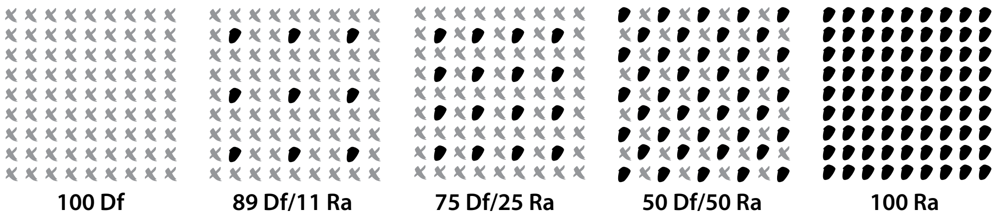

Figure 2. Type 3 species mixture patterns for different proportions of Douglas-fir and red alder. Df = Douglas-fir ( ), Ra = red alder ( ).

Statistical Analysis

The total number of trees used in the analysis was 679 for red alder and 1128 for Douglas-fir. Survival was calculated as the number of living trees in each treatment at each measurement divided by the number of living trees at age three. DBH was calculated as the treatment quadratic mean diameter. For trees with a HT less than 1.37m (4.5ft), a DBH of 0.1 cm was assigned. HT and CR was calculated as the treatment arithmetic mean. Individual tree stem volume index (SVI) was calculated as DBH^2(m)*HT(m), SVI/ac was calculated by summing individual tree SVI for each species/treatment combination multiplied by the plot expansion factor and was then used to calculate relative yield (RY) defined as species mixture yields relative to yields in pure species treatments (Harper 1977). Effects on RY were examined using the same two methods as found in RADFIN. Total relative yield (RYT) = (the yield of Douglas-fir in mixture + the yield of red alder in the mixture)/ (the yield of Douglas-fir in pure stand + the yield of red alder in pure stand) and relative land output (RLO) = (the yield of Douglas-fir in mixture + the yield of red alder in the mixture)/ (the equivalent fraction of Douglas-fir in pure stand + the equivalent fraction of red alder in pure stand).

All statistical analyses were performed in SAS. Analysis of variance was used to determine the effects of treatment (species proportion) on survival, DBH, HT, CR, and individual tree SVI by species and for total SVI per acre, RYT and RLO. Significant differences in treatment means were determined using mean separation tests. An alpha=0.05 was used in all comparisons.

Results and Discussion

Survival

By age 17, the range of survival for both species was nearly identical. Red alder survival ranged from 78% to 96% and Douglas-fir survival ranged from 76% to 94% (Figure 3a and Figure 3b) consistent with values reported in RADFIN. Survival of all species and treatment combinations was greater than 90% through age 12. Treatment had little effect on the variation in survival of both red alder (R-square=0.28) and Douglas-fir (R-square=0.16). However, the pattern of survival differed by species. Red alder survival increased with increasing red alder percentage. Douglas-fir survival decreased at the two highest red alder percentages (50% and 25%), but was greatest at the 11% red alder treatment (Figure 4).

The high rate of survival (>95% through age 8) early in stand development (also reported by RADFIN) is unexpected because of the low planting densities (and thus increased competition from understory vegetation) but was obviously mitigated by interplanting in both studies. Early effects of competing vegetation on survival could be investigated using existing first and second year data (individual tree survival and competing vegetation type and cover) but was not done for this analysis.

By age 17, overall mortality was similar in this study (15% or less in 14 of the 24 plots) to mortality at age 14 for

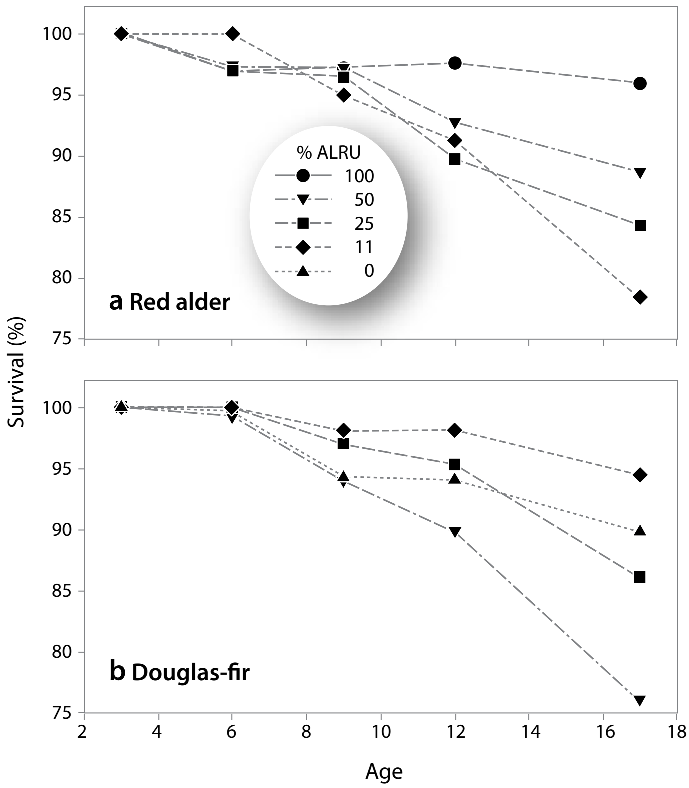

Figure 3. Red alder (a) and Douglas-fir (b) survival for 5 HSC Type 3 installations. Survival is calculated as the percentage of year three density.

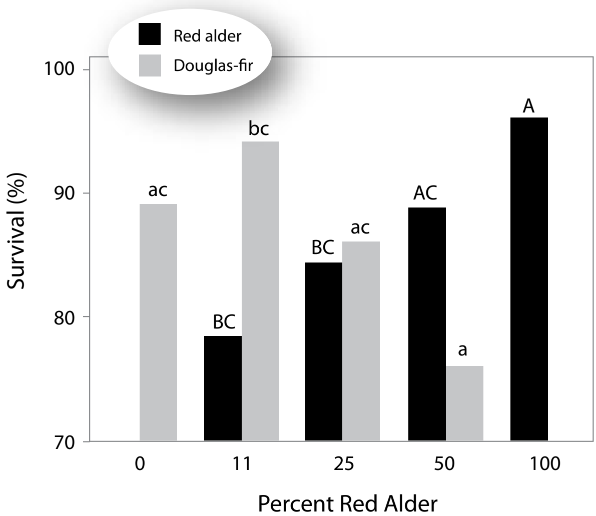

Figure 4. Mean year 17 survival (%) for red alder and Douglas-fir for 5 HSC Type 3 installations. Different upper- and lower-case letters indicate significant differences ($p< 0.05$) among treatments for red alder and Douglas-fir, respectively.

RADFIN (15% or less in 108 of the 132 plots). Yet the strong positive relationship of red alder survival with red alder percentage in this study is surprising and opposite of that reported by RADFIN. By this age, red alder trees were generally larger than Douglas-fir trees regardless of species proportion and it has been shown that larger absolute (Shainsky and Radosevich 1991) and relative (D'Amato and Puettman 2204) tree sizes have a greater competitive effect. Therefore it was expected that, for a given individual red alder tree, intraspecific competition would be greater than interspecific, and therefore total competition (and its effect on survival) would be greatest as red alder percentages increased.

However, competition occurs when adjacent trees are forced to share the sites limited resources. This reduces growth, and eventually may cause tree mortality. The relationship between tree size and stand density is called the self-thinning line and is often expressed in stand density diagrams (Puettman et al. 1993a). For red alder, the self-thinning (i.e. mortality) line occurs at a relative density of 0.65 and mortality starts at a relative density of 0.44 (Puettman et al. 1993b). The 100% red alder treatment had a relative density of 0.41, with decreasing relative densities for the other species proportions (data not shown). Therefore, any decrease in survival for red alder is most likely not due to self-thinning.

Because young red alder can rapidly overtop juvenile conifers (Newton et al. 1968), Douglas-fir mortality was expected to increase with increasing red alder percentage as reported by RADFIN. Douglas-fir survival did decline with increasing red alder percentage with the exception of the 11% red alder treatment, which exhibited the highest Douglas-fir survival. It has often been hypothesized that at low percentages red alder has potential facilitative effects on Douglas-fir growth and yield, mainly through nitrogen fixation (Tarrant 1961, Newton et al. 1968, Binkley et al. 1994. Evidence here suggests it has positive effects on survival as well.

Differential mortality by tree species, treatment and site caused a difference in actual versus planted densities through time. Nevertheless, the original planted percentages were used for all subsequent analyses.

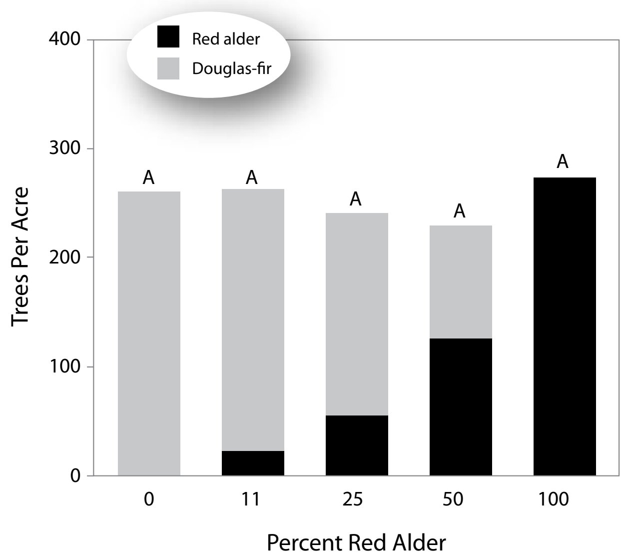

Figure 5. Red alder, Douglas-fir, and total 17 year density for 5 HSC Type 3 installations. Different upper-case letters indicate significant differences (p< 0.05) among treatments in total density..

Treatment densities at age 17 are shown in Figure 5. Combined species mean densities by treatment ranged from 565 trees /ha to 674trees/ha (229 trees/ac to 273 trees/ac) due to initial plot-level differences and subsequent mortality patterns. There were no significant differences in 17 year total density by treatment.

Diameter (DBH)

By age 17, DBH ranged from 18.3cm to 24.0cm (7.2in to 9.4in) for red alder and from 15.6cm to 17.6cm (6.1in to 6.9in) for Douglas-fir (Figure 6a and Figure 6b). Treatment differences in diameter for red alder were minimal through age 9 but by age 17, DBH was greatest in the two intermediate red alder percentages (Figure 6a and Figure 7) with treatment explaining 47% of the variation. RADFIN reported this slight (though not significant) peaking pattern on red alder DBH for the HJ Andrews site and a very strong negative effect of increasing red alder percentage on red alder DBH for the Cascade Head site.

The reduction of red alder DBH at the extreme red alder percentages could be due to different types of competition. As mentioned earlier, the 100% red alder treatment is approaching the self-thinning line and should be experiencing accompanying reductions in DBH growth (Puettman et al. 1993a). These growth reductions are caused by intraspecific competition. At the lowest red alder treatment (11% red alder) DBH reductions could be the effect of intraspecific competition with

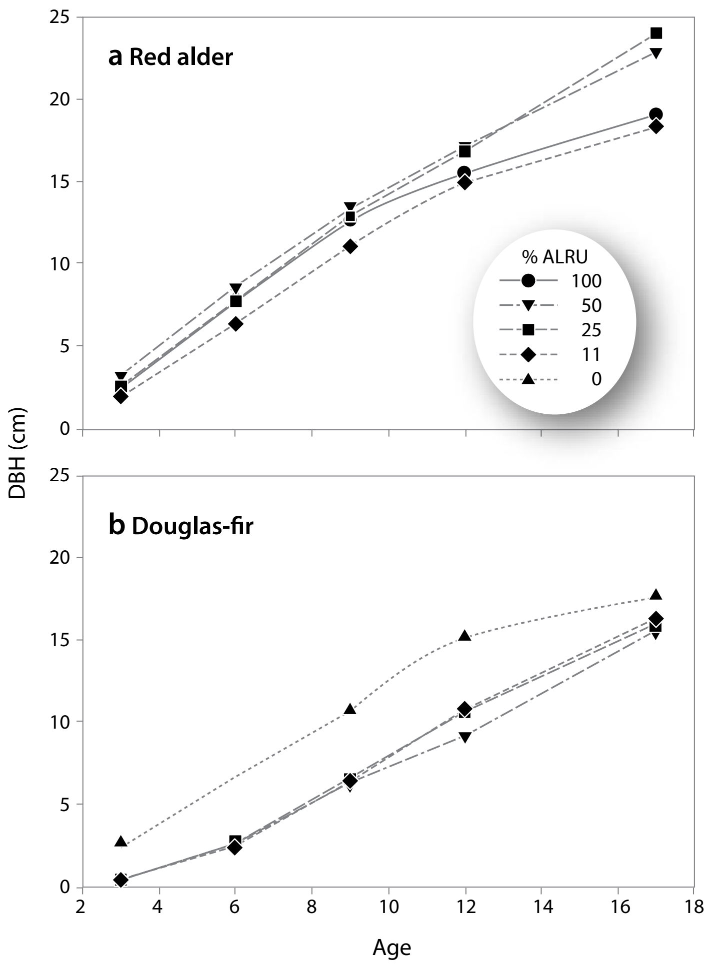

Figure 6. Red alder (a) and Douglas-fir (b) DBH for 5 HSC Type 3 installations. DBH is calculated as treatment mean quadratic mean diameter.

the Douglas-fir in the form of competition for available water (Chan et al. 2003). It has been shown that red alder seedlings die at levels of soil drought that Douglas-fir can endure (Shainsky & Radosevich 1992, Shainsky et al. 1994).

For Douglas-fir, treatment differences in DBH were only observed for the pure Douglas-fir treatment through age 17 (Figure 6b and Figure 7); DBH was greatest in the 0% red alder treatment. Douglas-fir DBH declined slightly with increasing red alder percentage (Figure 7) although significant differences were minimal (treatment explained only 17% of the variation in Douglas-fir DBH).

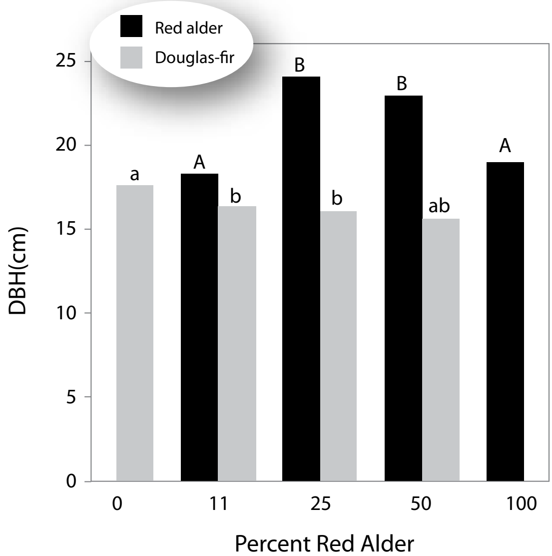

Figure 7. Mean year 17 DBH (cm) for red alder and Douglas-fir for 5 HSC Type 3 installations. Different upper- and lower-case letters indicate significant differences ($p < 0.05$) among treatments for red alder and Douglas-fir, respectively.

This relative independence of Douglas-fir DBH with red alder percentage has been reported by RADFIN for HJ Andrews but the authors also reported a very strong negative relationship of Douglas-fir DBH with increasing red alder percentage for Cascade Head.

Suppression of Douglas-fir should increase both with the increasing amount/percentage of red alder as well as with stand development. Within the first five years of stand development Cole and Newton (1987) observed increasing red alder competition and thus greater reductions in Douglas-fir growth with time. However, the shape of the Douglas-fir DBH growth curves in Figure 6b indicate a strong linear relationship with time instead of a slowly decreasing function. In fact, the only treatment displaying decreasing DBH growth rates is the 0% red alder treatment; the treatment with no overtopping of red alder. A possible reason why Douglas-fir DBH does not significantly decrease with red alder percentage could be that the density (i.e. competitive influence) of red alder is below some critical threshold. Hibbs and DeBell (1994) recommend no more than 250 red alder trees/ha (100 trees/ac) to ensure that the associated conifers would receive some sunlight, minimizing mortality and promoting the conifers eventual dominance. In this study, the red alder percentages in the mixed species treatments (11%, 25%, and 50%) correspond with 81 trees/ha, (33trees/acre), 185 trees/ha (75trees/acre), and 370 trees/ha (150trees/acre) of red alder; possibly resulting in competition levels too low to cause a reduction in Douglas-fir DBH growth.

Height (HT)

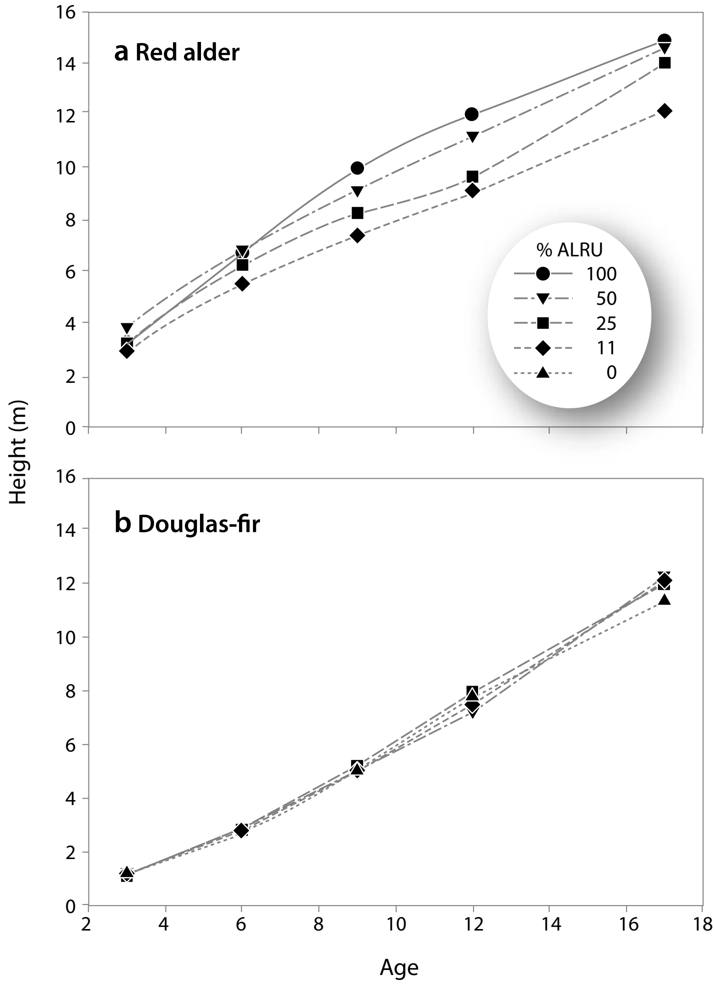

Figure 8. Red alder (a) and Douglas-fir (b) height for 5 HSC Type 3 installations. Missing heights were estimated using localized height-diameter equations in the RAP version of ORGANON for red alder and the SMC version of ORGANON for Douglas-fir.

Regardless of age or treatment, red alder always overtopped Douglas-fir but the degree of overtopping decreased with age. At age three, red alder HT was on average 2.7 times greater than that of Douglas-fir. By age 17 the difference decreased to 1.1. These values are consistent with that reported by RADFIN for HJ Andrews but considerably lower than that for Cascade Head. Cole and Newton (1987) report red alder overtopping of Douglas-fir increasing through age five in a Nelder-type experimental design.

By age 17, total tree HT was relatively similar for both species and across treatments. HT ranged from 11.8m to 14.4m (38.7ft to 47.2ft) for red alder and from 11.3m to 12.3m (37.1ft to 40.3ft) for Douglas-fir (Figure 8a and Figure 8b). Differences in HT for red alder, by treatment, were manifested by age 9 and continued through age 17 at which time red alder HT increased with increasing red alder percentage (Figure 9) with treatment explaining 58% of the variation. This is in disagreement with RADFIN, which reported that red alder HT was insensitive to species proportion for both sites.

For Douglas-fir, treatment had little effect on HT until age 17 when a slight (R-square=0.12) decrease in HT with increasing red alder percentage was detected (Figure 9). Douglas-fir HT in pure stands was always greater (albeit slightly) than in species mixtures, regardless of red alder percentage. RADFIN reported no effect of species proportion on Douglas-fir HT at HJ Andrews but a strong negative relationship at Cascade Head. This strong negative effect of red alder on Douglas-fir HT has been reported for other studies as well (Newton et al. 1968, Cole and Newton 1986 & 1987).

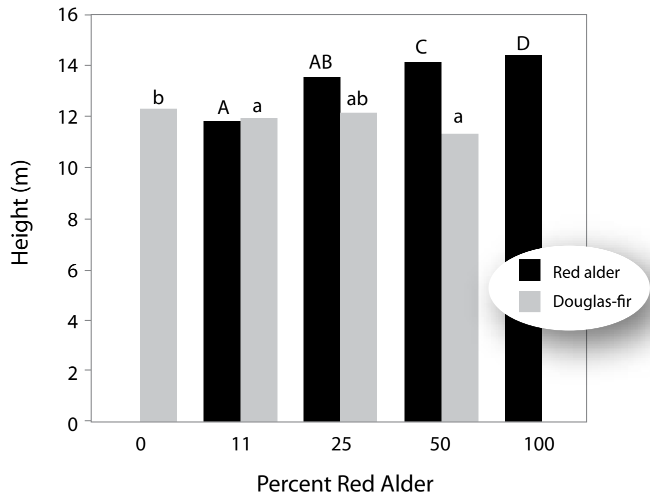

Figure 9. Mean year 17 height (m) for red alder and Douglas-fir for 5 HSC Type 3 installations. Different upper- and lower-case letters indicate significant differences ($p < 0.05$) among treatments for red alder and Douglas-fir, respectively.

Crown Ratio (CR)

As expected, CR for red alder declined with age and with increasing red alder percentage (Figure 10a), with the earliest and most severe reductions occurring at the highest red alder percentages. By age 17, CR ranged from 0.53 to 0.75 for red alder, differing significantly by treatment (Figure 11) with treatment explaining 39% of the variation. The pattern of CR across treatments was the same as the pattern of DBH across treatments, peaking at the 25% red alder treatment and decreasing rapidly at the higher red alder percentages with the pure red alder treatment having the lowest CR. RADFIN also found that the pure red alder treatment had significantly lower CR than the species mixtures at HJ Andrews. At Cascade Head, red alder CR decreased with increasing red alder percentage.

For Douglas-fir, CR varied little with age and with increasing red alder percentage (Figure 10b). By age 17, CR hardly dropped and ranged from 0.75 to 0.79. Treatment had little absolute effect on CR yet explained 51% of the variation. Douglas-fir CR was significantly greater at the lowest (0% and 11%) red alder treatment (Figure 11). This negative relationship between CR and red alder percentage was also observed by RADFIN at Cascade Head (no relationship was observed at HJ Andrews).

Stem Volume Index (SVI)

Individual tree SVI

In this analysis, SVI was used as a substitute for tree volume to account for different volume equation model forms, and thus, to standardize results. SVI does not accurately represent actual tree volumes (which will not be reported here), but does allow for comparing treatment effects. SVI was calculated only at age 17. Red alder SVI was significantly greater at the two intermediate red alder percentages; with SVI values almost double that of the 11% and 100% red alder treatments (Figure 12). SVI

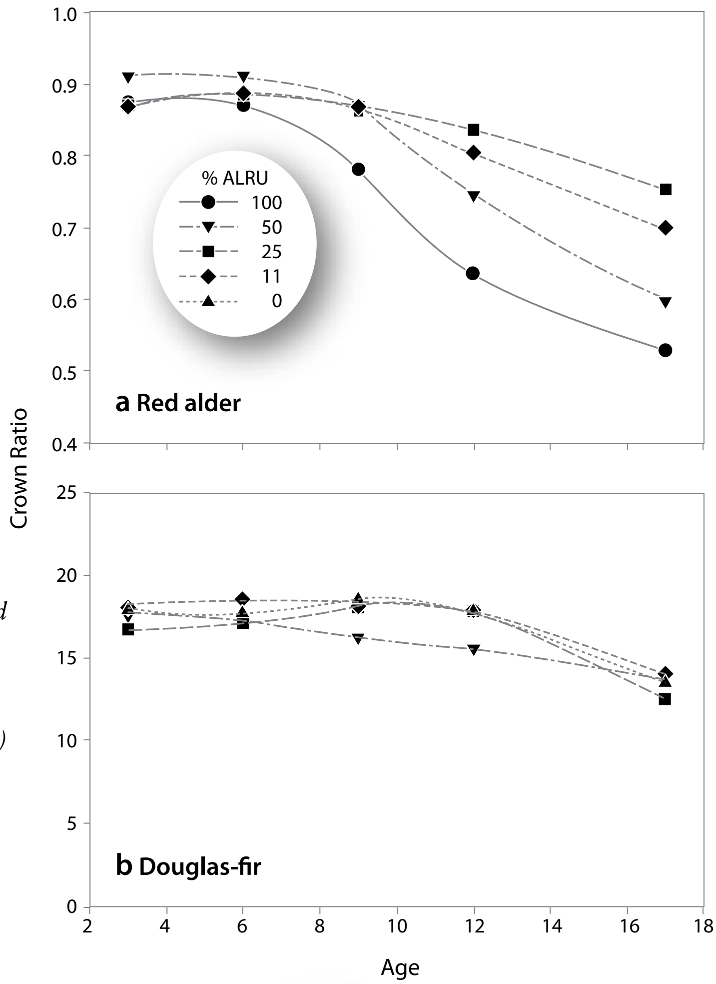

Figure 10. Red alder (a) and Douglas-fir (b) crown ratio for 5 HSC Type 3 installations. Missing heights and height to crown base (HCB) were estimated using localized height-diameter and HCB equations in the RAP version of ORGANON for red alder and the SMC version of ORGANON for Douglas-fir.

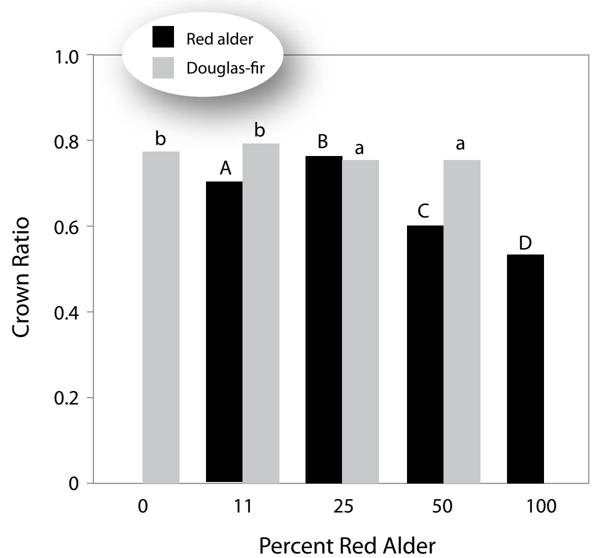

Figure 11. Mean year 17 crown ratio (1-Hlc/Ht) for red alder and Douglas-fir for 5 HSC Type 3 installations. Different upper- and lower-case letters indicate significant differences ($p< 0.05$) among treatments for red alder and Douglas-fir, respectively.

values of these latter treatment only differed by 10%. This pattern was driven by the larger diameters in these intermediate percentages. Overall, treatment explained 47% of the variation of red alder SVI.

For Douglas-fir, pure stands had a substantially greater SVI (18%) than any of the species mixture treatments (Figure 12) indicating that red alder at any percentage reduced Douglas-fir SVI. SVI was greatest in the pure Douglas-fir treatment due to the larger DBH and HT of these trees. Within the species mixture treatments (11%, 25%, and 50% red alder), percentage of red alder had little effect on Douglas-fir SVI (8% difference at most). Overall, treatment explained 17% of the variation of Douglas-fir SVI across treatments.

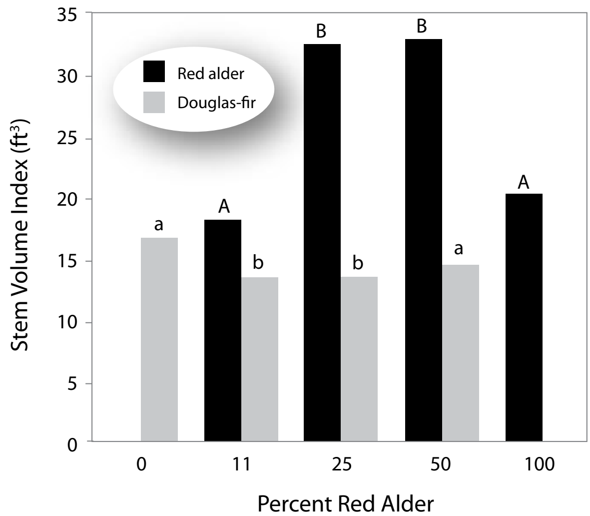

Figure 12. Mean year 17 individual tree stem volume index ($Dbh[ft]^2 * Ht[ft]$) for red alder and Douglas-fir for 5 HSC Type 3 installations. Different upper- and lower-case letters indicate significant differences ($p< 0.05$) among treatments for red alder and Douglas-fir, respectively.

SVI/acre

Summing the mean individual tree SVI values with the plot expansion factor for each species/treatment combination yields a land based value (per acre) useful for comparisons of productivity/yield for pure stands and species mixture treatments. Figure 13 shows that SVI/acre was greatest for the 50% and 100% red alder treatments, followed by the 25% and 0% treatments, and lowest for the 11% treatment. Although SVI/acre is not a measure of true volume (total or merchantable), it was used to facilitate comparisons with the results from RADFIN presented in the next section.

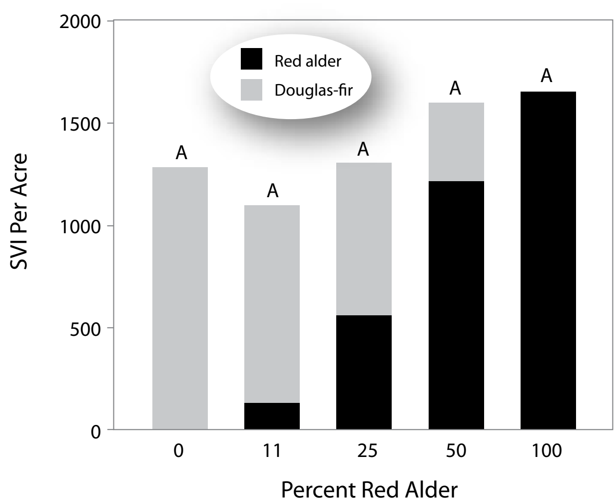

Figure 13. Red alder, Douglas-fir, and total 17 year stem volume index per acre ($ft^3/acre$) for 5 HSC Type 3 installations. Different upper-case letters indicate significant differences ($p< 0.05$) among treatments in total SVI/acre.

Relative yield and land output

A key hypothesis of studies focusing on intra- and inter-specific competition of red alder and Douglas-fir is that gradients of resource availability can be created by gradients of species densities (Chan et al. 2003). These relative densities can result in changes in tree size and yield over time (Grotta et al. 2004). Relative yield, defined as the average yield of mixed species stands relative to that of pure stands (Harper 1977), can be used as a measure of productivity. Two measures of relative yield, RYT and RLO, are measures of production enhancement (facilitation) or production penalty (competition) of species mixtures when the value is either greater than, or less than one, respectively.

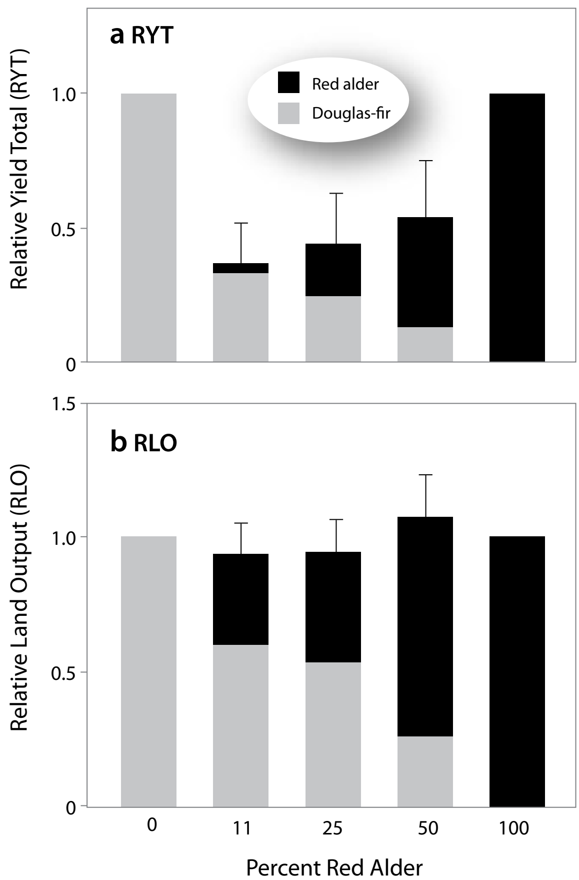

Figure 14. Red alder, Douglas-fir, and total 17 year relative yield total (a) and relative land output (b) for 5 HSC Type 3 installations. Error bars are one standard deviation of the total relative yield total (RYT) and total relative land output (RLO), respectively.

In this study, all species mixtures had RYT values less than one (Figure 14a), indicating reduced production/yield in these treatments compared to pure stands of either species. RADFIN also reported a negative effect on mixed species RYT for any site or treatment combination. In this study, RYT varied considerably by site which resulted in no significant differences in RYT by treatment (data not shown).

RLO is another measure of mixed species stand productivity where the percentage of each species in mixtures is compared with the equal percentage in pure stands of each species. In this study, a positive effect (>1) in RLO was observed for only the 50% species mixture (Figure 14b). Like RYT, RLO varied considerably by site resulting in no significant differences in RLO by treatment (data not shown).

Although RLO values presented in RADFIN varied considerably by site and species percentage, RLO values greater than one were reported for five of the eight site times species mixture combinations. The values of RLO reported here are similar to those found at Cascade Head but generally much lower than those found at HJ Andrews.

Conclusion

Early tree mortality was extremely low, mainly due to interplanting. Successive tree mortality was also low, most likely because of the low initial planting densities and thus, little intra- or inter-species competition as seen by low relative densities of all the treatments. Surprisingly, red alder survival increased with red alder percentage. Not surprisingly, Douglas-fir survival generally decreased with increasing red alder percentage. By age 17, total tree density was similar across all treatments indicating there was no effect on species dominance through differential survival/mortality patterns due to competition pressures.

Mean DBH of both species across all treatments were surprisingly similar through age 17 at which time red alder DBH was greatest in the intermediate red alder percentages, and Douglas-fir DBH showed a slight (but insignificant) decrease with increasing red alder percentage. As with mortality, the lack of a DBH response across treatments suggests low levels of both inter- and intra-species competition. However, Douglas-fir DBH was greatest in the pure Douglas-fir treatment, indicating that Douglas-fir DBH growth did not benefit from any potential facilitative effects of red alder at any percentage level.

Predictably, regardless of age or treatment, red alder always overtopped Douglas-fir with the degree of overtopping decreasing with age. In fact, the most recent Douglas-fir HT growth increment is greater than red alder in all treatments except one, indicating that Douglas-fir will soon be taller than red alder for most treatments. For red alder, HT increased with increasing red alder percentage. This is in contrast with RADFIN, which reported that red alder HT was insensitive to species percentage for both sites. Douglas-fir HT followed the same patterns as seen for DBH in this study; treatment had little effect on HT yet HT was greatest in the pure Douglas-fir treatment compared to any mixture with red alder.

Treatment had a significant effect on red alder CR. The pattern of red alder CR was similar to that of DBH. It peaked at the 25% red alder treatment and decreased with increasing red alder percentage. If, as assumed, crown recession (and thus, by extension, CR) is in response to light interception (i.e. shading) by neighbors, that would account for the low CR values at high red alder percentages, but does not explain why red alder CR in the 25% treatment was greater than the 11% red alder treatment, since there were no differences in the associated Douglas-fir (i.e. the neighbors) HT for those treatments. Douglas-fir CR did not change with age or treatment. This indicates that shading from neighbors (either other Douglas-fir or red alder) was inadequate to trigger crown recession.

SVI per tree was directly correlated with DBH and followed the same pattern across treatments, for both species. However, SVI per acre (a substitute for stem volume and a useful measure of productivity) was greatest in the 50% and 100% red alder treatments, although the high levels of site variability, resulted in substantial treatment differences, and made interpretation of these results difficult.

RYT & RLO, various measures of species-mixture stand yield in comparison to pure stands, indicate that there are benefits in mixed-species total wood productivity, especially as the percentage of red alder increases.

In general, red alder individual tree growth increased with increasing red alder percentages, while the presence of red alder at any percentage either did not affect, or had little effect on Douglas-fir individual tree growth. These muted individual tree responses could be the result of limited inter- or intra-tree competition as a result of the low initial planting density and the corresponding low values of relative density. On a stand level, species- mixtures may result in positive yields but depend on the type of calculation and experimentation used (Jolliffe 1997). Planning for, and managing mixed-species stands could be used to as a method of improving individual tree and stand yields (Chan et al. 2003), but clearly, more must be understood before applying experimental results in operational settings.

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Thinned Natural Red Alder Stand Volume and Stem Form

As previously reported in last years annual report, the HSC and the WA Department of Natural Resources are investigating the effects of thinning on stem form and tree and stand volume. Please see last year's annual report describing the project rationale and objectives. As is often the case, procedures described in a research proposal are modified when the actual measurements are taking place. Due to these modifications, the actual field sampling methods are listed below.

When the trees were harvested, multiple measurements along the entire stem of selected trees were taken. The location for these measurements were chosen to facilitate the WADNR in fine-tuning their red alder cruise estimates and to help improve existing (or create new) red alder volume/taper equations. For the former objective, measurements of diameter outer bark (DOB) and double bark thickness (DBT) were taken at DBH (4.5ft or 1.37m), at the WADNR form factor point (16.5ft or 5.0m), at 40% of the DOB of WADNR form factor point (e.g. if DOB at 16.5ft=8.7in, then at a DOB of 3.5in), and at DOB=5in (12.7cm). For the 40% of the form factor point and the 5in top, the distance from breast height was also recorded. To achieve the latter, DOB and DBT were taken at 20cm and 65cm above groundline, breast height, and 20%, 40%, 60%, and 80% of the length between breast height and total tree height. In addition, DOB, DBT, and height above breast height were taken at crown base.

The field procedure was as follows: Before falling, DBH and sample number were permanently marked on ten trees per plot (due to time limitations only six trees (instead of 10) were sampled from the unthinned/control plot) for a total of 26 sample trees. After falling, sample tree breast height was located and stem diameter (and DBT) was measured at breast height, 20cm and 60cm. Once these measurements were completed a nail was driven into the tree at breast height, a tape was stretched to the top of the tree and total tree height and height to live crown (from breast height) was determined. DOB and DBT at the above sample locations were measured. An example of the datasheet is illustrated in Figure 15.

There are no new results to date. The data has been entered and analysis is proceeding.

Red Alder Upper Stem Measurement Project

Date:	Data Recorder:
Site: 4102	Plot:
Tree #	Sample #:

Sample Points	Dist from DBH	DOB (cm)	DBT (cm)
H100%		XXX	XXX
H80%			
H60%			
H40%			
H20%			
DBH (1.37m)	XXX		
H65cm	-70cm		
H20cm	-120cm		
Form Factor (FF)	370cm		
Olney FF	840cm		
40% of FF DOB			
5in DOB Top		12.7cm	
HCB			

Comments:

Figure 15. Sample datasheet for the Thinned Natural Red Alder Stand Volume and Stem Form Study

Red Alder and Climate Change

As mentioned in previous annual reports, the HSC has collaborated with multiple Canadian organizations on a project titled "Using red alder as an adaptation strategy to reduce environmental, social and economic risks of climate change in coastal BC". The idea behind the project is that because the range of red alder is expected to increase with climate change, and it is a short rotation high value crop providing a diversity of wood products, and improving long-term site productivity and ecosystem resiliency, the increased use of red alder is an adaptation strategy that could reduce environmental, social and economic risks of climate change in coastal B.C. The HSC is involved in the environmental (biological) component through its network of long-term research installations.

The HSC has provided geographic and tree growth information and has collected soils data and foliage data to accurately characterize the installations. In May 2010, the HSC collected soil samples from all of the replacement and additive installations in the US. In December 2010, the HSC also collected Douglas-fir foliage from the same installations. A description of the project in its entirety, the projects that are underway or completed, and more information can be found at the FFESC (Future Forest Ecosystems Scientific Council) website: www.for.gov.bc.ca/hts/future_forests/council/index.htm.

A paper from this effort entitled “Climate effects on red alder growth in the Pacific Northwest of North America” has recently been published in Forest Ecology and Management. The citation is as follows: Cortini, F., P.G. Comeau, T. Wang, D.E. Hibbs, and A.A. Bluhm. 2012. Climate effects on red alder growth in the Pacific Northwest of North America. For. Ecol. Mgnt. 277: 98-106.

The full article can be found electronically at the Forest Ecology and Management or by contacting one of the authors. Below is a copy of the abstract:

We investigated the effects of climate on the growth of red alder across a broad latitudinal gradient and over a wide range of growing conditions in the Pacific Northwest of North America (PNW). Data for this study came from a study established in 1988 that includes 31 research installations located between the Pacific Coast and the Cascade Mountains in Oregon, Washington, and British Columbia. The growth-climate model developed includes: summer heat moisture index (SHM), mean warmest month temperature (MWMT), spring precipitation (PPTsp), and initial height; and captures 78% of the variation in red alder volume increment. Based on this model, estimates of potential future growth were generated for three climate scenarios (i.e., cccma_cgcm3_A2-run4 'warm and wet' of the Canadian Centre for Climate Modeling and Analysis; and ukmo_hadcm3_B1-run1 'cool and moist' and ukmo_HadGEM1_A1B-run1 'hot and dry' of the Hadley Centre for Climate Prediction and Research). These projections indicate a potential increase in volume increment of up-to 12% by the 2080s. Range-wide maps were generated for the volume increment potential (VIP) for the reference normal period 1961-1990, for the 'warm and wet' climate scenario, and the 2050s time period, suggesting that climate change may cause a substantial shift in the range and productivity of red alder in the PNW. In addition, maps of the predicted VIP of red alder for the Campbell River District in BC were generated and indicate an overall increase in projected growth of red alder. This study provides evidence that climate change will likely lead to expansion of the range and potential increases in growth for red alder in conjunction with assisted migration of provenance in the PNW. While these results indicate potential increased opportunities for extension of the range of red alder and opportunities for its management, care must be taken to avoid planting alder on sites with high risk of damaging agents such as cold outflow winds, frost, or drought.

Direction for 2013

As always, the specific goals for 2013 are both continuations of our long-term objectives and new projects:

- Continue efforts to recruit new members.
- Continue HSC treatments, measurements and data tasks.
- Keep the HSC website updated and current.
- Continue efforts in outreach and education.
- Continue working with and analyzing the HSC data.
- Continue growth and yield modeling efforts; primarily to continue testing RAP-ORGANON outputs/predictions.

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

3 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

Appendix 2

HSC Management Committee Meeting Minutes

Summer Management Committee Meeting Minutes

Wednesday July 13, 2011

Attendees: Andrew Bluhm, David Hibbs- OSU; Florian Deisenhofer- WA DNR; Jeanette Griese, Clint Gregory- BLM; Glenn Ahrens, Amy Grotta- OSU Extension Service; Mitch Taylo, Ashley Letara, Kevin Barry- Oregon Department of Forestry; Mark McKelvie- Forest Capital.

Please refer to the associated handouts for further information.

We started the meeting at 8:30 at the OSU Extension Service Office in St. Helens, OR and traveled to the BLM/HSC Type 2 site #3209 (Scappoose). This site is a 16 year old variable density plantation of mid- to low site quality.

Here we first looked at Plot 7, treatment 207. This treatment was planted at 630tpa and thinned to approximately 230tpa at age 15. RAP-ORGANON was used to calculate plot statistics at the time of thinning and to calculate gross revenue. Please see the handout for more details.

The main results included:

- Thinning removed 67% of the trees, 60% of the basal area, 54% of the cubic foot volume, 43% board foot volume, and reduced relative density to 0.21.
- QMD went from 5.8 in to 6.3 in. QMD of the removed trees was 5.5 in.
- 423 trees were removed, yielding 3.159 MBF/acre of sawtimber and pulp and grossing $1,335 (or $1,706 for camp run).

Then RAP-ORGANON was used to project the growth of all the treatments out to age 30. The main results were as follows:

- Control plots:
  - DBH ranged from 6.4 in to 10.9 inches with DBH increasing with decreasing density.
  - Height of the 40 largest trees per acre (H40) was between 60 ft and 65 ft for all plots except the 105tpa density which was considerably shorter (43 ft).

    - At age 30, merchantable volumes of the two intermediate control plot densities (330tpa and 650tpa) were approximately 10MBF/acre. The lowest and the highest densities had considerably lower volumes.
    - When current log prices were used, the gross revenue for the two intermediate densities was approximately $5000/acre.

- 650tpa Thinned plots:
    - Thinning at any age resulted in a DBH increase of just over one inch (14%).
    - Age of thinning had little effect on H40 except the plot thinned at age 6, which was considerably shorter due to post-thinning damage.
    - At age 30, merchantable volumes were approximately 6MBF/acre, 7MBF/acre, and 8MBF/acre for the plots thinned at age 6, 13, and 16, respectively.
    - At age 30, gross revenue was approximately $3,400/acre, $3,800/acre, and $4,400/acre for the plots thinned at age 6, 13, and 16, respectively.
    - Without discounting, the revenue for the plot thinned at age 16 (~$1,500/acre) added to the final revenue ($4,400MBF/acre) was approximately equal to that of the unthinned (control) plot ($5,300/acre).

Next, we traveled to a mixed-species stand of natural origin on BLM property. Here, Clint Gregory, the Tillamook Resource Area silviculturist led the conversation about various issues concerning the harvest of the current red alder resource.

The main topics were as follows:

- Extent/amount of alder resource base on BLM lands
    - Mixed stands
    - Pure Stands
    - Age classes

- Extent/amount of alder resource base in BLM timber sales
- BLM timber sale regulations/restrictions
    - Leave tree
    - Riparian
    - Other (i.e lawsuits)

- How do these regulations/restrictions affect alder management in these sales?
- Alder management prescriptions
    - Historic, current, future
    - Basis of prescriptions (i.e. "Just the way we've always done it.", science-based, policy based, any lack of knowledge, etc.)

- Multiple-use (conflicting) issues effecting prescriptions
    - Riparian
    - Wildlife
    - Diversity
    - Public perception

Due to the pouring rain, the group relocated back to the OSU Extension Office for lunch instead of visiting the last tour and lunch stop, Scapponia Columbia County Park.

After lunch we heard 4 presentations, as follows:

- Ownership, Location and Supply Issues for the Hardwood Industry-Glenn Ahrens
- Climate Effects on Red Alder and Douglas-fir Growth in the Pacific Northwest-Andrew Bluhm
- Unveiling the New Alder Growth and Yield Model-The Economics of Growing Alder-David Hibbs
- RAP-ORGANON Model Validation Example- Andrew Bluhm

Please see the attached handouts for the entire presentations.

The floor was then opened for a discussion/question and answer session of various hardwood related management issues. Topics touched upon were:

- Improving the GIS-based site selection model created by Florian Deisenhofer, WA DNR. As it currently works, the site index estimate is placed into 4 classes, and not on a continuous scale.
- Creating a tool based on the one above for the state of Oregon. Dave and Andrew would pursue the feasibility of such an effort and coordinate the efforts/resources of Forest Capital, BLM, and WA DNR in creating such a tool.

Andrew then proceeded with a review of last years' fieldwork, the coming years' fieldwork and an overview of the data collection schedule for all three installation types.

Winter 2010/11 was an extremely busy field season. Measurements and various treatments were completed on 12 of the 37 installations. Work included:

- No Type 1 installations had fieldwork.
- Nine Type 2 installations had fieldwork.
    - One site- Humphrey Hill (4201, GYN) had its 22nd year measurement.
    - Four sites- Lucky Creek (1202, BCMIN), Cape Mtn. (2204, SNF), Dora (3207, BLM), and French Creek (4205, BCMIN) had their 17th year measurement.
    - One site- Siletz (2205, ForCap) had its 17th year measurement, its 3rd pruning lift and the last thinning treatment (when HLC~30ft).
    - Two sites- Maxfield (1203, WADNR) and Wrongway Creek (3210, OSU) had their 3rd pruning lift and the last thinning treatment (when HLC~30ft).
    - One site- LaPush (1201, WADNR) had its last thinning treatment (when HLC~30ft).Three Type 3 installations had fieldwork.
    - Three sites- Monroe-Indian (2301, ForCap), Turner Creek (4301, GYN), and Holt Creek (4303, BCMIN) all had their 17th year measurement.
    - Three Type 3 installations had fieldwork.
    - Three sites- Monroe-Indian (2301, ForCap), Turner Creek (4301, GYN), and Holt Creek (4303, BCMIN) all had their 17th year measurement.

So, in the big picture:

- Three of the four Type 1 sites have had their 19^{th} year measurement.

- One of the twenty-six Type 2 sites has had its 22nd year measurement.
- Nineteen of the twenty-six Type 2 sites have had their 17th year measurement.
- Twelve of the twenty-six Type 2 sites have all treatments completed.
- Four of the seven Type 3 sites have had their 17th year measurement.

This coming year's fieldwork (Winter 2011/12) will be on a total of 8 installations. Work includes:

- No Type 1 installations need fieldwork.
- Six Type 2 installations need fieldwork.
    - Three installations- John's River (2201, WHC), Ryderwood (3202, WHC), and Clear Lake Hill (4202, GYN) need their 22nd year measurement.
    - One installation- Scappoose (3209, BLM) needs its 17th year measurement.
    - One installation- Darrington (4206, WADNR) needs its 17th year measurement and the last thinning treatment (when HLC~30ft).
    - One installation- Mt. Gauldy (2206, SNF) needs its 17th year measurement, the last thinning treatment (when HLC~30ft), and the 3rd pruning lift.
    - One installation- Weebe Packin (3208, ODF) needs its second thinning treatment (when HLC~15-20ft), and the 3rd pruning lift.
- One Type 3 installation needs fieldwork.
    - Menlo (3301, WADNR) needs its 17th year measurement

Of note, there are no "orphaned" installations to be measured/treated this coming year.

As fall approaches, Andrew will contact each HSC member to provide specific on the activities and schedule the fieldwork.

Next, the topic turned to the HSC budget. Just like in FY2010, in FY 2011, dues received were less than expected. This allowed the HSC enough income to fund Andrew for only 3 months at 1.0 FTE instead of the expected 4 months and still resulted in the HSC carrying a debt of ~ $4,700 into the next fiscal year.

For FY 2012, the dues will likely increase due to the joining of Cascade Hardwood Group. This will allow the HSC enough income to fund Andrew for only 3.5 months at 0.8FTE in addition to balancing the budget.

To help identify what Andrew has time for and conversely what he is not able to accomplish with his reduced time, Dave and Andrew assembled a list of deliverables- what's being done, and what is not.

Please see the associated handouts for the specifics on the budget and future directions.

Many thanks go out to Clint Gregory (BLM) and Glenn Ahrens and Amy Grotta (OSU Extension Service) for their help in the logistics and the planning of the meeting.

As a reminder, there will be a Winter 2010/11 winter meeting. Potential dates are the 2nd or 3rd week of January. If you have any preference as to the dates, please contact the HSC.

Appendix 3

Financial Support Received in 2011-2012

Cooperator	Support
BC Ministry of Forests	$6,354
Bureau of Land Management	$8,500
Forest Capital	$8,500
Goodyear-Nelson Hardwood Lumber Company	$4,500
Oregon Department of Forestry	$4,250
Siuslaw National Forest	------
Trillium Corporation	------
Washington Department of Natural Resources	$4,250
Washington Hardwood Commission	------
Subtotal	$36,354
Forestry Research Laboratory	$24,700
Total	$61,054

www.cof.orst.edu/coops/hsc/