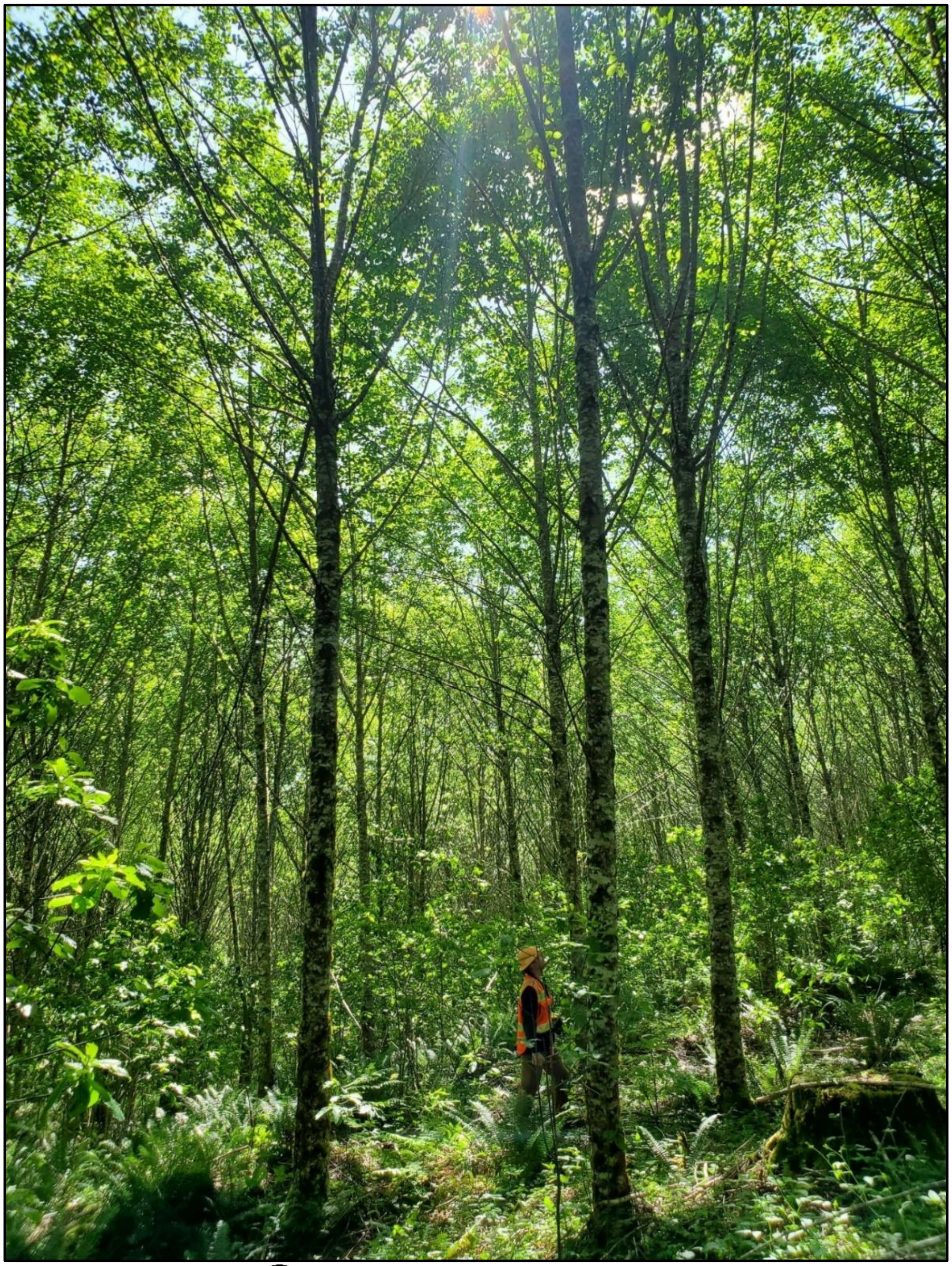
Hardwood Silviculture Cooperative
Annual Report 2021



Oregon State University
College of Forestry

Contents

Hardwood Silviculture Cooperative

Highlights of 2021

- The first 32-year measurement was completed on the Humphrey Hill (#4201) Type 2 installation.

- Five more 27-year measurements were collected on Type 2 installations, bringing the total to 18 of the 25 installations with 27-year data.

- Three more Type 3 installations had the 27th year measurement, bringing the total to 4 of the 7 installations with 27-year data.

- First-year data was collected on a red alder clone field trial at the OSU Blodgett tract.

- The HSC and the Center for Intensive Planted-forest Silviculture (CIPS) continued the update of RAP-ORGANON.

- The HSC participated in numerous continuing education and outreach events including: Clackamas Co. Tree School, the WA Farm Forestry Association (WFFA) Forest Owners Field Day, and the Washington Hardwood Commission (WHC) Annual Symposium.

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 (*Pseudotsuga 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 website http://hsc.forestry.oregonstate.edu 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 10 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.

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).

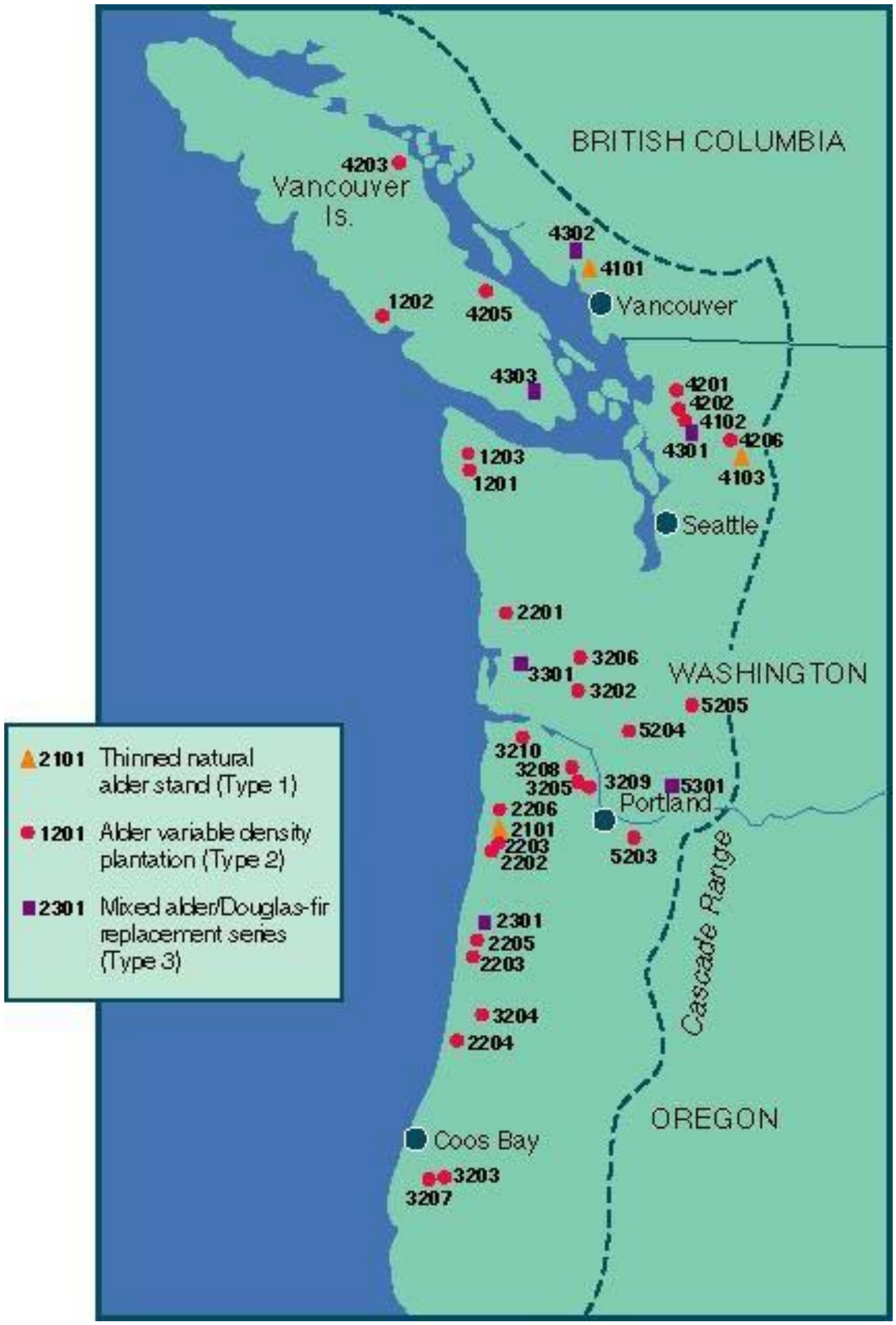


Figure 1. Location of installations for the Red Alder Stand Management Study.

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 approximately 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.

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).

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

	Site Quality		
Region	Low SI50 :23-27 M SI20 :14-17 M	Medium SI50 :28-32 M SI20 :18-20 M	High 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

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.

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	1989	1990	1990	1990	1991	1991	1992	1992	1992	1992	1992	1993	1993
2nd yr Regen	1990	1991	1991	1991	1992	1992	1993	1993	1993	1993	1993	1994	1994
Plot Installation	1991	1992	1992	1992	1993	1993	1994	1994	1994	1994	1994	1995	1995
3rd yr Measure	1991	1992	1992	1992	1993	1993	1994	1994	1994	1994	1994	1995	1995
3-5 yr Thin	1992	1995	1995	1993	1995	1995	1996	1997	1996	1996	1995	1997	1997
Prune Lift 1 6ft	1994	1995	1995	1995	1995	1995	1996	1997	1996	1996	1995	1997	1997
6th yr Measure	1994	1995	1995	1995	1996	1996	1997	1997	1997	1997	1997	1998	1998
15-20' HLC Thin	1994	NA	1998	1995	1998	NA	1999	2000	2000	1999	1999	2001	NA
Prune Lift 2 12ft	1994	2001	1998	1995	2001	1999	1999	2000	1998	1999	1999	2001	2001
9th yr Measure	1997	1998	1998	1998	1999	1999	2000	2000	2000	2000	2000	2001	2001
Prune Lift 3 18ft	1997	2009	2001	1998	2007	2002	2003	2000	2008	2003	2003	2001	2006
12th yr Measure	2000	2001	2001	2001	2002	2002	2003	2003	2003	2003	2003	2004	2004
30-32' HLC Thin	2000	NA	NA	2001	2010	2007	2008	2003	NA	2006	2008	2006	2009
Prune Lift 4 22 ft	2000	NA	2001	2001	2022	2007	2008	2003	2013	2006	2008	2004	2009
17th yr Measure	2005	2006	2006	2006	2007	2007	2008	2008	2008	2008	2008	2009	2009
22nd yr Measure	2010	2011	2011	2011	2012	2012	2013	2013	2013	2013	2013	2014	2014
27th yr Measure	2015	2016	2016	2016	2017	2017	2018	2018	2018	2018	2018	2019	2019
32nd yr Measure	2020	2021	2021	2021	2022	2022	2023	2023	2023	2023	2023	2024	2024

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	1993	1994	1994	1994	1994	1994	1995	1995	1995	1996	1997	1997	1997
2nd yr Regen	1994	1995	1995	1995	1995	1995	1996	1996	1996	1997	1998	1998	1997
Plot Installation	1995	1996	1996	1996	1995	1995	1996	1997	1996	1997	1999	1999	1999
3rd yr Measure	1995	1996	1996	1996	1996	1996	1997	1997	1997	1998	1999	1999	1999
3-5 yr Thin	1997	1998	1998	1998	1998	1998	2000	1999	NA	2001	2002	NA	NA
Prune Lift 1 6ft	NA	1998	1998	1998	NA	1998	2000	1999	1999	2001	2002	2002	NA
6th yr Measure	1998	1999	1999	1999	1999	1999	2000	2000	2000	2001	2002	2002	2002
15-20' HLC Thin	2001	NA	2005	NA	2002/17	2002	NA	NA	NA	NA	NA	NA	NA
Prune Lift 2 12ft	NA	2005	2002	2002	NA	2002	2003	2003	2001	2004	2008	2005	NA
9th yr Measure	2001	2002	2002	2002	2002	2002	2003	2003	2003	2004	2005	2005	2005
Prune Lift 3 18ft	NA	2015	2012	2010	NA	2005	2011	2009	2003	2010	2011	2010	NA
12th yr Measure	2004	2005	2005	2005	2005	2005	2006	2006	2006	2007	2008	2008	2008
30-32' HLC Thin	2006	NA	2017	2010	NA	NA	2011	2009	2011	2010	2011	2010	NA
Prune Lift 4 22 ft	NA	NA	2017	2020	NA	2013	2016	2009	2006	2017	2013	2013	NA
17th yr Measure	2009	2010	2010	2010	2010	2010	2011	2011	2011	2012	2013	2013	2013
22nd yr Measure	2014	2015	2015	2015	2015	2015	2016	2016	2016	2017	2018	2018	2018
27th yr Measure	2019	2020	2020	2020	2020	2020	2021	2021	2021	2022	2023	2023	2023
32nd yr Measure	2024	2025	2025	2025	2025	2025	2026	2026	2026	2027	2028	2028	2028

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

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	1992	1994	1994	1994	1995	1996	1997
2nd yr Regen Survey	1993	1995	1995	1995	1996	1997	1998
Plot Installation	1993	1995	1995	1995	1997	1998	1999
3rd yr Measurement	1994	1996	1996	1996	1997	1998	1999
6th yr Measurement	1997	1999	1999	1999	2000	2001	2002
9th yr Measurement	2000	2002	2002	2002	2003	2004	2005
12th yr Measurement	2003	2005	2005	2005	2006	2007	2008
17th yr Measurement	2008	2010	2010	2010	2011	2012	2013
22nd yr Measurement	2013	2015	2015	2015	2016	2017	2018
27th yr Measurement	2018	2020	2020	2020	2021	2022	2023
32nd yr Measurement	2023	2025	2025	2025	2026	2027	2028

This last field season (Winter 2020/21) was busy (Table 5). Five Type 2 installations (Lucky Creek, Cape Mtn, Siletz, Dora, and French Creek) needed their 27th year measurement. The Siletz site (2205) had the last pruning lift in addition to collecting taper data on 15 trees. Three Type 3 installations (Monroe-Indian, Turner Creek, and Holt Creek were due for their 27th year measurements. Due to international travel restrictions, the BC Ministry of Forests independently conducted the measurements on their three sites and sent the HSC the electronic data.

Table 5. Hardwood Silviculture Cooperative Field Activities, Fall 2020-Spring 2021

Type	Activity	Installation	Cooperator
Type 1		Completed	
Type 2	4th Pruning lift	2205	NWH- Siletz
	27yr Measure	1202	BCMIN- Lucky Creek
		2204	SNF- Cape Mtn
		2205	NWH- Siletz
		3207	BLM- Dora
		4205	BCMIN- French Creek
	32yr Measure	4201	GYN- Humphrey Hill
Type 3	27yr Measure	2301	NWH- Monroe-Indian
		4301	GYN- Turner Creek
		4303	BCMIN- Holt Creek

So, in the big picture:

- All twenty-five Type 2 installations have now had their 22nd year measurement.
- Eighteen Type 2 sites have their 27th year measurement completed.
- Twenty-four of the twenty-five Type 2 installations have all treatments completed.
- All seven Type 3 installations have had their 22nd year measurement.
- Four of the seven Type 3 installations have had their 27th year measurement.

Field work for the upoming field season (Winter 2021/22) is listed in Table 6. Three Type 2 installations (Mt. Gauldy, Scappoose, and Darrington) will need their 27th year measurement and two Type 2 installations (Ryderwood, and Clear Lake Hill) will need their 32nd year measurement. In addition, only one Type 3 installation (Menlo) is due for their 27th year measurement.

Table 6. Hardwood Silviculture Cooperative Field Activities, Fall 2021-Spring 2022

Type	Activity	Installation	Cooperator
Type 1		Completed	
Type 2	27yr Measure	2206	SNF- Mt. Gauldy
		3209	BLM- Scappoose
		4206	WADNR- Darrington
	32yr Measure	3202	WHC- Ryderwood
		4202	GYN- Clear Lake Hill
Type 3	27yr Measure	3301	WADNR- Menlo

Current HSC Activities

Red Alder Clone Bank

The Hardwood Silviculture Cooperative, with assistance from the Washington Hardwoods Commission and Hancock Forest Management established a red alder clone bank, using material from Washington State University's tree improvement program. This clone bank preserved the improved genetics developed by the program and can provide a source of vegetative material and/or seed for further propagation.

The clone bank was established at the J.E. Schroeder Seed Orchard (ODF). Three ramets each from 20 production clones were planted at an 18' x 12' spacing with randomized planting spots (Figures 2 & 3). Trees were planted in November 2019 and mortality was replaced in April 2020 and April 2021. Despite a very cold Winter in 2020/21, the clones are doing well. In a communication with Don Kaczmarek, Director of the Schroeder Seed Orchard, it was reported:

> "The red alder looks very good. The original trees that were planted in 2019 are growing well and survival looks excellent. A lot of those are 5-6' tall and very vigorous. A few are approaching 8' tall. The replants we planted in 2020 also look good. We may have a couple that have died, but most look good. The extra plants you provided last fall were up potted into 2.5-gallon pots and we will interplant in the field if we have some mortality. We had the ice storm back in February, but here was no damage evident to the young red alder. We also had a series of frosts and freezes here in early April. We were down to about 28F. The red alder were in various stages of budbreak. There was no foliar damage from the freezes. The slight hillslope position seemed to help the trees. There was heavier frost down in the drain but reduced frost on the slope. There were 1 or 2 trees which may have had a little frost damage on the stem, but it seemed to be the new interplants. Overall, I think it looks very good."

Figure 2 & 3. Red alder clonal seedlings and clone trial at the ODF J.E. Schroeder Seed Orchard.

Red Alder Clone Trial

History

As described in the HSC 2020 Annual Report, a red alder clone trial was established on the OSU Blodgett tract (near Mist, OR) to compare the performance of red alder clones with a woods run control.

Study Design

The trial was planted on April 3, 2020 in an unfenced area in the Newton Survivor harvest unit on the Blodgett Forest (46.065472°, -123.344099°). Elevation is 830'-1070'. Aspect is East to Southeast. Slopes are mild, ranging from flat to 20%. Soil type is Scapponia-Braun silt loam and estimated red alder site index (base age 50 years) is 92ft.

The clone trial areas was planted on a 9 x 9' grid (537tpa). Four sources of seedlings were used in this trial: 1) Eighteen clones from the WSU program and grown as PSB 615A plugs, 2) Woods run bare root seedlings from the Weyerhaeuser Aurora nursery, 3) Woods run 615 plugs grown by PRT Hubbard from the 041 seed source (SW WA), bought from WA DNR, and 4) an "Open pollinated" plugs (lot #249) from a WSU clone trial grown as plugs by the WSU program. These four sources are hereafter known as "Clones", "WeyCo", "DNR", and "Hancock".

The study design was a randomized complete block design with four blocks (i.e. replications). Each block contained 21 treatments: 18 clones plus the three comparison sources (WeyCo, DNR, & WSU) included twice to account for its expected higher inter-tree variation (Table 7). Each treatment within each block is represented by an individual-tree plot, with planting locations randomly assigned. Each block had 144 planting spots- six individuals for each of the 18 clones, and 12 individuals for the three comparison sources (Figure 4). The trial was bordered by 5-tree row plots of randomly assigned 20 treatments all of which was surrounded by a red alder operational planting.

Table 7. Planting stock, map code and number of individuals planted in the red alder clone trial.

Clone	Code	Count	Caliper (mm)	Height (cm)
101	A	24	5.0	67.3
114	B	24	3.8	44.2
154	C	24	4.8	72.6
228	D	24	3.6	39.8
242	E	24	4.2	55.8
243	F	24	4.4	55.5
249	G	24	5.2	61.9
250	H	24	4.5	52.5
309	I	24	4.1	47.4
321	J	24	4.1	52.4
426	!K!	24	5.1	64.5
433	L	24	3.9	53.9
602	M	24	4.7	76.8
621	N	24	4.4	67.2
631	O	24	3.7	48.0
633	P	22	3.0	48.2
635	Q	24	4.8	65.1
639	R	24	5.6	96.8
DNR	T	55	4.6	44.1
WSU	S	47	4.1	38.6
Weyco	U	44	5.1	52.5
Total		576	4.4	55.8

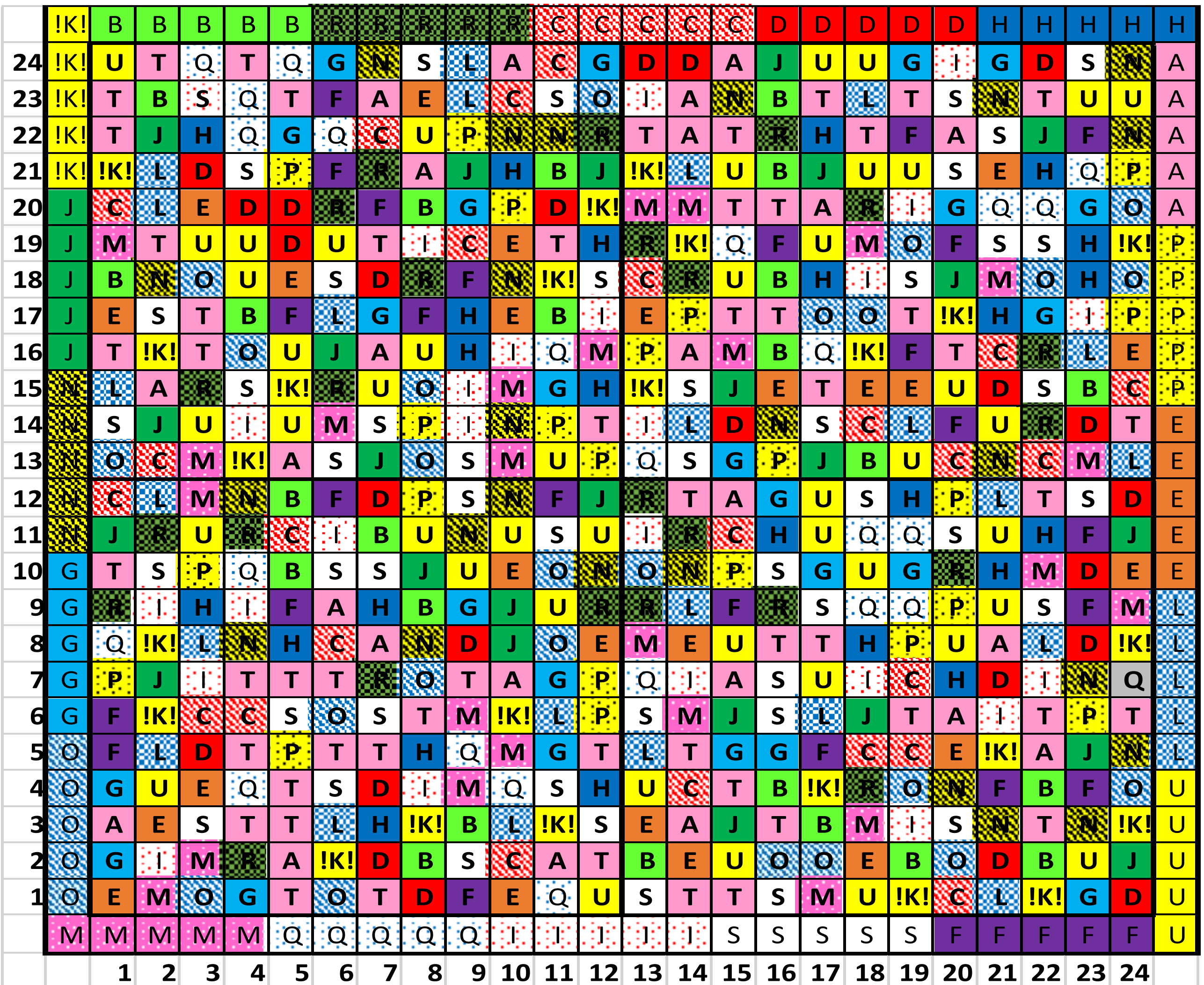


Figure 4. The red alder clone trial experimental design. Each color (and letter) is an individual seedling of a particular clone or seedling source.

Year 0 Data

Immediately after planting, initial tree size (height and caliper) was measured on all 576 trees. As seen in Table 7, mean caliper was 4.4mm (range 3.0mm to 5.6mm) and mean height was 55.8cm (range 38.6cm to 96.8cm). Grouping all clones together revealed small (but statistically significant) differences in caliper between the clone group and the comparison sources. The caliper of the WeyCo source was significantly greater than the caliper of the Clone group and the WSU source. Regarding height, the Clone group was taller than the DNR and the WSU source, and the WeyCo source was taller than the WSU source.

Figure 5. Measuring year one growth at the HSC clone trial.

Year 1 Data

In the Fall of 2020, all trees were remeasured to quantify year 1 mortality, caliper and height (Figure 5). Overall, survival was very good- averaging 89.7% and ranging from a low of 63.6% to a high of 100% (Figure 6). The survival of the non-clonal sources (WeyCo, DNR, Hancock) was very high (93.2%- 97.9%)- statistically greater than the average for all the clonal sources combined (88.7%).

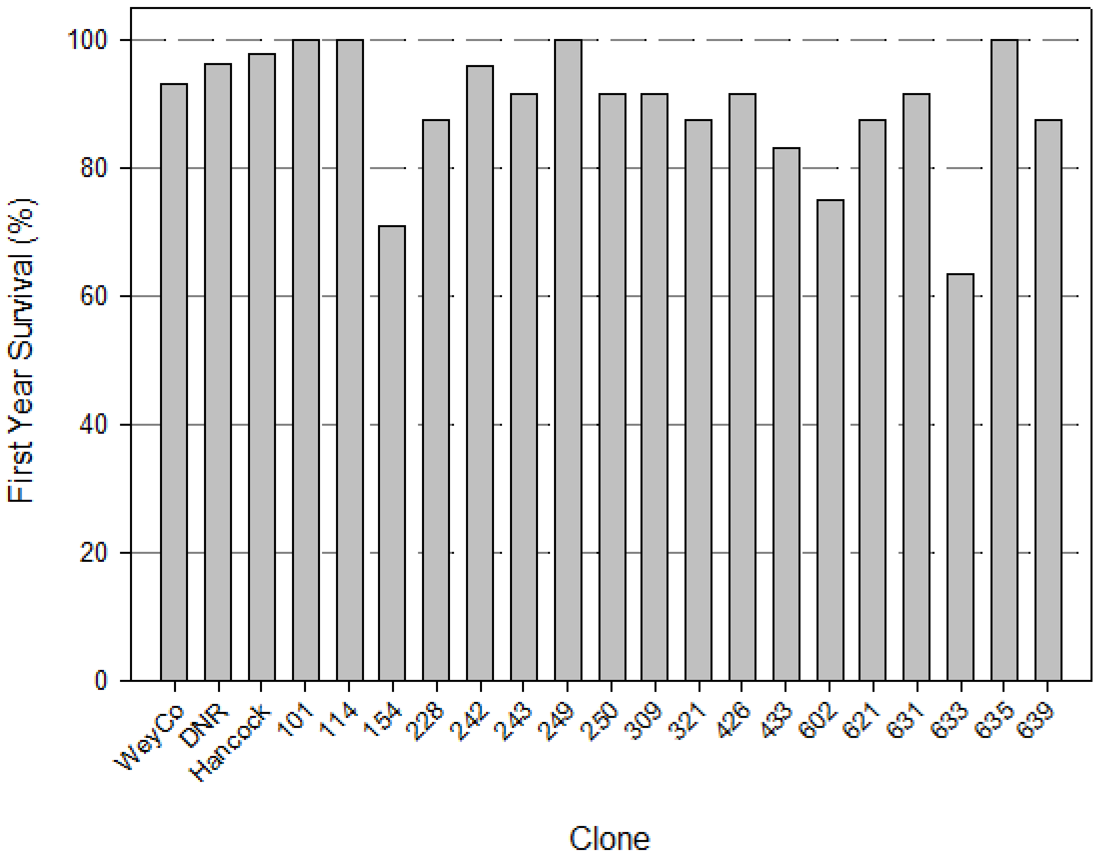


Figure 6. Year 1 survival by source type.

Overall, mean caliper was 10.8mm and ranged from a low of 7.4mm to a high of 13.1 (Fig. 7). There were no statistical difference in mean caliper between the non-clonal sources (11.0mm) and all the clonal sources combined (10.7mm). The greatest observed differences among sources was seen in year one height (Fig. 7). Mean height was 91.2cm and ranged from 66.8cm to 121.7cm. Unlike caliper, the clonal sources were significantly taller (94.7cm) than the non-clonal sources (77.9cm). However, considerable variation existed in year one height among individual clones.

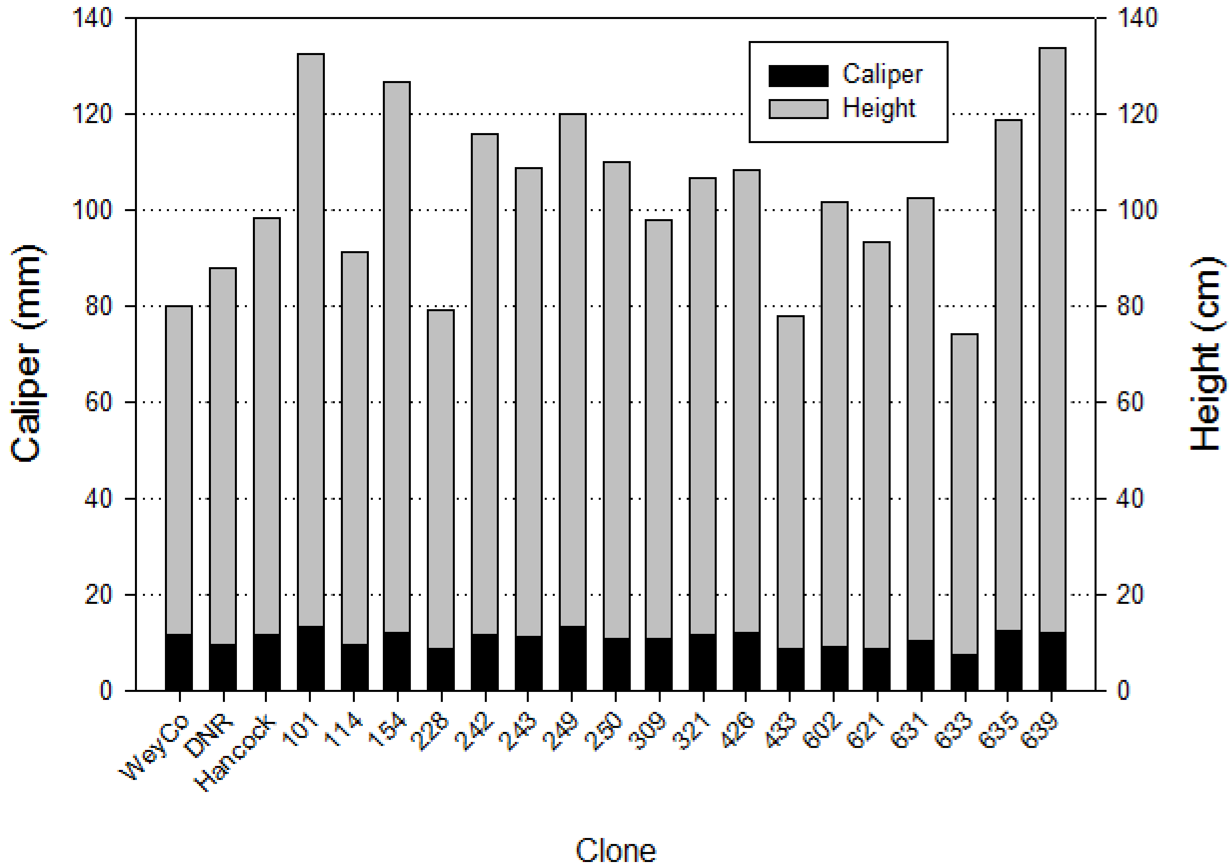


Figure 7. Year 1 caliper (mm) and height (cm) by source type.

Despite the fruitlessness of drawing conclusions of this clone trial from one year of growth, a couple observations are warranted:

- The performance of the non-clonal sources was consistent. Little variation was observed between the three sources in terms of survival, caliper and height.
- With the exception of 2 clones, clonal survival was above 75%.
- Little variation in caliper was observed either between non-clonal and clonal sources or across individual clones.
- As a group, year one height for the clones was greater than that of the non-clones. In fact, only five of the eighteen clones were shorter than the non-clones and two clones were approximately half again as tall as the non-clones.

Updates to the ORGANON Red Alder Plantation (RAP) equations

Introduction

When the original red alder plantation version of ORGANON (RAP) was first produced in 2011, the oldest measured data from red alder plantations were 18 years total age, so the initial version of the model was envisioned to provide suitably accurate extrapolations of trees and stands simulated out to 30 years, especially given the early peak of alder diameter and height growth. Comparison of RAP model projections to measured plot data from the Hardwood Silviculture Cooperative (HSC) network of plots has found some inconsistencies, most notably significant underestimates of diameter in thinned stands, and overestimates of mortality in unthinned stands.

A refit of alder equations with updated datasets was begun in 2017, when two of the installations had been measured at 28 years total age. Since that time, all installations (25) have been measured at age 23, an additional 2 have received a 25-year measurement, and 13 have received a 28-year measurement, providing data applicable to trees and stands near an appropriate rotation age.

CIPS allied with the HSC to refit the equations using the existing model forms, or, if necessary, with some simple alteration to existing equations. This report provides a short description of the modeling dataset, provides results from refitting the equations, and compares the original equations to the equations presented here.

Dataset

Although the original RAP equations were based on a combined dataset of measurements from Weyerhaeuser and HSC plantations, differences in early plantation development within the two datasets (Fig. 8) and their adverse influence on some of the equations, resulted in the decision to base the updated equations on HSC data only. Thus, the dataset for this refitting work came from 25 HSC Type 2 variable density plantations, as well as the 100% red alder planting from 7 Type 3 mixed red alder-Douglas-fir plantations. The dataset of untreated plots contained nearly 200,000 individual tree measurements. Planting density ranged from a low of 70 tpa (trees per acre) to a high of 1749 tpa, with a medium of 801 tpa.

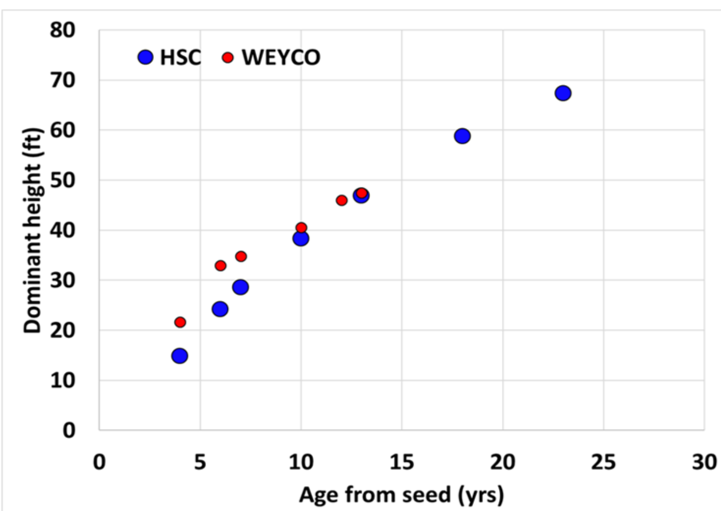


Figure 8. Dominant height over time in comparable plots of the Weyerhaeuser and HSC datasets.

Equations

Site index and planting density correction factor

When combined with the planting density correction factor (PDEN), the site index equation is employed to calculate the appropriate SI for input tree lists, and is also used to estimate potential height growth. Data for fitting this equation requires estimates of dominant height (H40) for each stand age (A) measured on a plot. H40 at each age was calculated as the mean height of the 40 largest trees per acre (based on diameter) that did not have height damage or other severe damage for each measurement period. The following GADA model form for the Schumacher equation was fit to the non-overlapping forward difference data structure of the modeling data using nonlinear regression:

[1] $H40_2 = H40_1 \cdot e^{b_1 ({A_2}^{b_2} - {A_1}^{b_2})}$

Where,

$H40_1$ = Measured H40 (i.e., top height) in feet at the start of the growth period
$H40_2$ = Measured H40 (i.e., top height) in feet at the end of the growth period
A_1 = Measured total stand age from seed at the start of the growth period
A_2 = Measured total stand age from seed at the end of the growth period

The resulting parameter estimates and their standard errors are found in Table 9.

Table 9. Regression parameters for the red alder site index equation [2].

Parameter	Estimate	Standard Error
b_1	-5.269144	0.04703208
b_2	-0.586430	0.01768175

Equation [1] can be transformed to predict site index, uncorrected for PDEN, using:

[2] $SI_P = H40_M \cdot e^{b_1 (20.0^{b_2} - {A_M}^{b_2})}$

Where,

SI_P = Predicted site index (H40 at a total stand age from seed of 20 years) in feet and uncorrected for planting density
$H40_M$ = Measured H40 (i.e., top height) in feet
A_M = Measured total stand age from seed

It was found that the equations for height to crown base (HCB), diameter increment, mortality rate, etc. are more highly correlated to values of SI that have been corrected for PDEN. Therefore, the predictions from Equation [2] must be corrected for PDEN values under approximately 500 tpa. To do this first requires the development of an equation that predicts relative site index (*RSI*) using the following model form:

[3] $RSI = 1.0 - b_3 e^{(b_4 \times PDEN^{1.5})}$

Where,

RSI = The SI of the plot divided by the average SI for those plots on the installation with PDEN greater than 500 tpa.

The equation's parameters and their standard errors are found in Table 10.

Table 10. Regression parameters, and their standard errors, for the relative site index correction Equation [3].

Parameter	Estimate	Standard Error
b_3	0.23951149	0.03984259
b_4	-0.00024883	0.00004880

Height increment

Height growth was modeled as a function of potential height growth as represented by the top height or site tree component of the stand. Potential height increment (PHI) for a given tree was estimated by algebraically isolating age in the above equation to determine its growth effective age (GEA), algebraically isolating HT40 to determine the implied potential height of that tree at its GEA, and taking the difference between that height and the height of the tree at age (GEA +1).

Height increment for each tree was then estimated by modifying this potential dominant height increment by accounting for relative dominance using the same model form as the original RAP ORGANON equation:

[4] $HtI = PHG \cdot MOD$

Where

[5] $MOD = b_0(e^{b_1+b_2CCH} + (e^{b_3CCH^{0.5}} - e^{b_1+b_2CCH})e^{-(1.0-CR)^2}e^{b_4CCH^{0.5}})$

where *HtI* was predicted annual height increment (ft), *CCH* was crown closure at the height of the subject tree (expressed as a percentage), *CR* was crown ratio (expressed as a proportion), and b_0- b_4 were parameters estimated from the data. Parameter estimates and standard errors are provided in Table 11.

Table 11. Regression parameters for the red alder height increment equation [5].

Parameter	Estimate	Standard Error
b_0	1.0974352	0.0044486
b_1	-0.3938138	0.0305215
b_2	-0.0097719	0.0010941
b_3	-0.0294643	0.0013658
b_4	0.1452722	0.0137987

DBH increment

DBH increment was modeled with a function that potentially peaked over initial DBH. Similarly, variables representing the effects of stand density, relative stand (social) position, and site quality were included as predictors, specifically stand-level basal area, basal area in larger trees, crown ratio, and 20-yr site index ([1]). The following model was identified as the best predictor of diameter growth:

$$[6]\ DI = exp(b_0 + b_1 \cdot ln(DBH+1) + b_2 \cdot DBH + b_3 \cdot \ln\left(\frac{CR+0.2}{1.2}\right) + b_4 \cdot ln(SI_{20} - 4.5) + b_5 \cdot \left(\frac{BAL}{log(DBH+1)}\right) + b_6 \cdot BA^{0.5})$$

where *DI* was predicted annual diameter increment (inches), *DBH* was initial diameter at breast height (inches), SI_{20} was the plot-level site index (ft at 20 years; equation [1]), *BAL* was basal area in larger trees (ft^2/ac), *BA* was total stand basal area (ft^2/ac), b_0-b_6 were parameters estimated from the data (Table 12), and all other variables defined above.

Table 12. Regression parameters for the diameter increment equation [6].

Parameter	Estimate	Standard Error
b_0	-4.2678111	0.0442179
b_1	0.5926127	0.0146110
b_2	-0.1608185	0.0029914
b_3	1.2023668	0.0170500
b_4	0.9628269	0.0105937
b_5	-0.0181369	0.0002761
b_6	-0.0200355	0.0015492

Mortality

Parameters for an equation to predict the probability of mortality were annualized with a compound interest formula that was implemented iteratively. Predictor variables were set equal to their value at the beginning of the measurement period for each iteration. The iterative estimation process was run in SAS PROC NLIN and was allowed to continue until further changes in the parameter estimates resulted in no significant improvement in minimization of the negative log likelihood.

After exploring numerous options with independent variables which included DBH, CR, BAL, SI, BA, SDI, $DBH^{0.5}$, kurtosis, and skewness, the final fitted model remained unchanged from the original RAP form:

$$[7]\ PM = \exp(Y)/(1+\exp(Y))$$

$$[8]\ Y = (c_0 + c_1 \cdot DBH + c_2 \cdot CR + c_3 \cdot BAL + c_4 \cdot SI_{20})$$

Table 13. Regression parameters for the mortality equation [8].

Parameter	Estimate	Standard Error
c_0	-2.7597948	0.0599281
c_1	-0.4883743	0.0049895
c_2	-3.9428757	0.0712963
c_3	0.0228031	0.0003592
c_4	0.0195756	0.0007389

where *PM* was predicted annual probability of mortality, c_0-c_4 were parameters estimated from the data (Table 13), and all other variables defined above.

Alternative models were assessed by comparing actual mortality rates to predicted rates in systematic subclasses of each of the independent variables using the χ^2 goodness of fit statistic. The interactive behavior of the alternative mortality model forms with the diameter and height increment equations were assessed by projecting treelists for each density (100, 225, 500, and 1000 TPA) from low, moderate and high site index installations, and observing the estimated SDI over time. The expectation would be for SDI to approach a constant maximum value and then remain at that value as age increases. However, there was a tendency for SDI to peak early in stand development, with the age of the peak negatively associated with density and site index. The final chosen model form minimized this early peaking behavior.

Height to crown base

A static equation was constructed to update height to crown base over successive growth periods. The model was fitted using data from only those trees measured for both total height and height to crown base. The final model for undamaged trees, altered from the original model form to remove the bias shown for trees with large HCB, was as follows:

[9] $HCB = (HT - 1.7) / (X + 1.7)$

[10] $X = (1 + exp(d_0 + d_1 \cdot HT + d_2 \cdot CCFL + d_3 \cdot ln(BA) + d_4 \cdot ln(DBH / HT) + d_5 \cdot ln(SI_{20} - 4.5)))$

Table 14. Regression parameters for the height to crown base equation [10].

Parameter	Estimate	Standard Error
d_0	4.31170878	0.03570994
d_1	-1.05143537	0.21984467
d_2	-0.11890137	0.02149907
d_3	-1.19088510	0.00820792
d_4	6.45529850	0.08044905
d_5	1.61303631	0.0755043

where *HCB* was predicted height to live crown base (ft), *CCFL* was crown competition factor in trees larger than the subject tree, d_0-d_5 were parameters estimated from the data (Table 14), and all other variables defined above.

Thinning modifiers

Modifying equations are used within ORGANON to adjust individual tree growth in thinned stands to account for the differences in growth between those observed and those expected simply from reductions in stand density in unthinned stands. This effect of thinning that cannot be explained by the effect of lowering initial stand density proportional to the thinning is referred to as the direct effect of thinning. Final efforts to estimate the effects of thinning on diameter and height increment and mortality are still being pursued.

Results and Discussion

The equation forms for each of the equations described in this report were unchanged from the original RAP ORGANON. A comparison of stand level output from the original RAP ORGANON and the new equations was made by projecting 4-yr old treelists to age 30 using two different initial densities and three different site indices; results are shown in Figures 9-16. The initial densities were 265 TPA and 570 TPA, and the sites indices covered the range found in the modeling dataset, with the low SI_{20}=40.1 ft, moderate SI_{20}=63.5 ft, and the high SI_{20}=82.3 ft.

The new equations predict greater mortality than the original equations at older ages, with increasing divergence as the projections approach a typical rotation age (Figs. 9-10). The original RAP-ORGANON modeling dataset was limited to stands of 18 years of age, with projections beyond this age constituting an extrapolation. At 18 years of age, these plantations had not experienced a great deal of mortality. The updated mortality equation is based on significantly greater recorded mortality, so its greater predictions of mortality might be expected. The increase in mortality has enabled development of an equation describing the maximum stand density trajectory. Although this equation is not provided here, its use is an option within the compiled source code, and restricts stand development in a manner that keeps the stand on or below the maximum size-density trajectory as it develops over time.

For the two densities and three site indices, projections indicate that juvenile quadratic mean diameter development is relatively similar for the two sets of equations (Figs. 11-12), and their divergence coincides with the predicted divergence of surviving trees (Figs. 9-10). This fact results in larger predicted diameters at older ages when using the new equations, and underscores the importance of accounting for the interactivity of all the equations during any assessment.

Basal area development is very similar for the two sets of equations for moderate and high site indices, though at lower site indices, the new equations predict greater stand basal area (Figs. 13-14). These graphs, and our understanding of the rapid juvenile growth of alder and its much slower growth in maturity, hint at what might be expected for maximal standing basal area. The greatest measured basal area within the 28-year old dataset was ~170 ft^2/ac. Numerous plots had exceeded 150 ft^2/ac, and some had lower stand BA at age 28 years than they'd had at age 23 years.

Scribner volume is predicted to be greater for both densities and all site indices at age 30 years (Figs 9-10). The difference between the predictions for the original and new equations is found to be greater at the higher density. Nonetheless, although the Scribner volume for a given site index is estimated to be greater at the higher density, (Fig. 16 vs. Fig. 15), the importance of piece size for red alder value means that a log-level valuation would provide a better comparison which of the two densities is most financially beneficial.

These updated equations are currently being used within R- and Excel-based programs which call DLLs for their application. Though the entire system is as of yet incomplete, with more work to be done on thinning modifiers and optional addition of variation to diameter and height increment estimates, it is useful for estimating the growth and yield of untreated stands.

As to other future work, observations were made of relatively high mortality rates with uncharacteristic mortality patterns—relatively even across the diameter distribution—on some of the denser plots of specific installations at age 28 yrs. Whether this observation will constitute a trend or an anomaly makes the next remeasurement at age 33 highly anticipated.

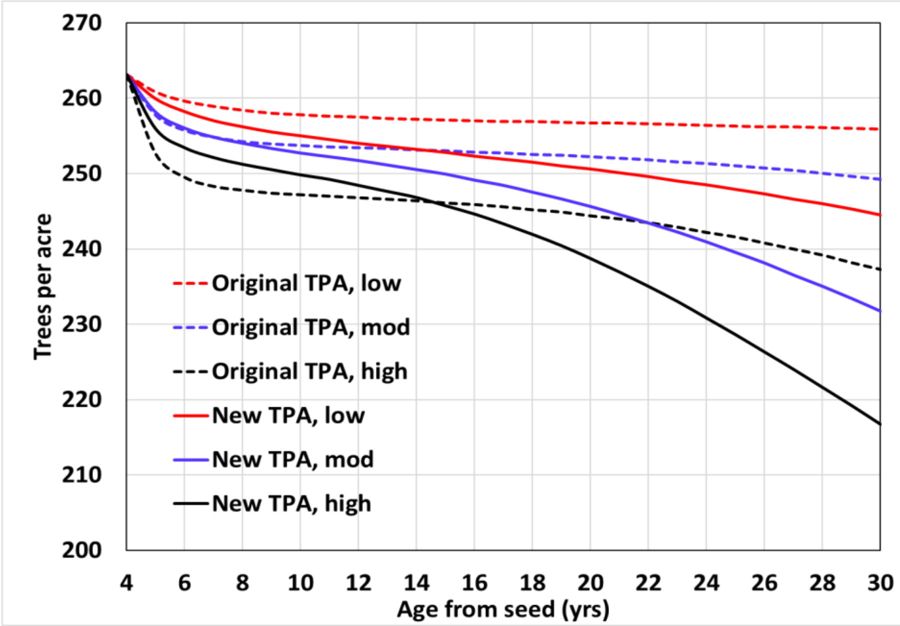


Figure 9. Projected TPA for an initial density of 265 TPA using the original RAP equations and the updated equations at low, moderate, and high site indices.

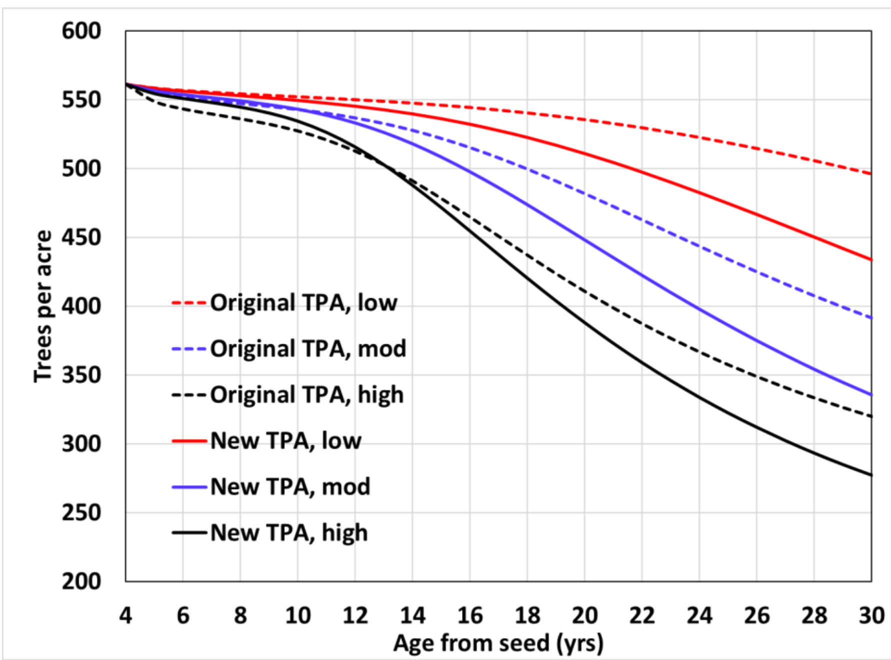


Figure 10. Projected TPA for an initial density of 570 TPA using the original RAP equations and the updated equations at low, moderate, and high site indices.

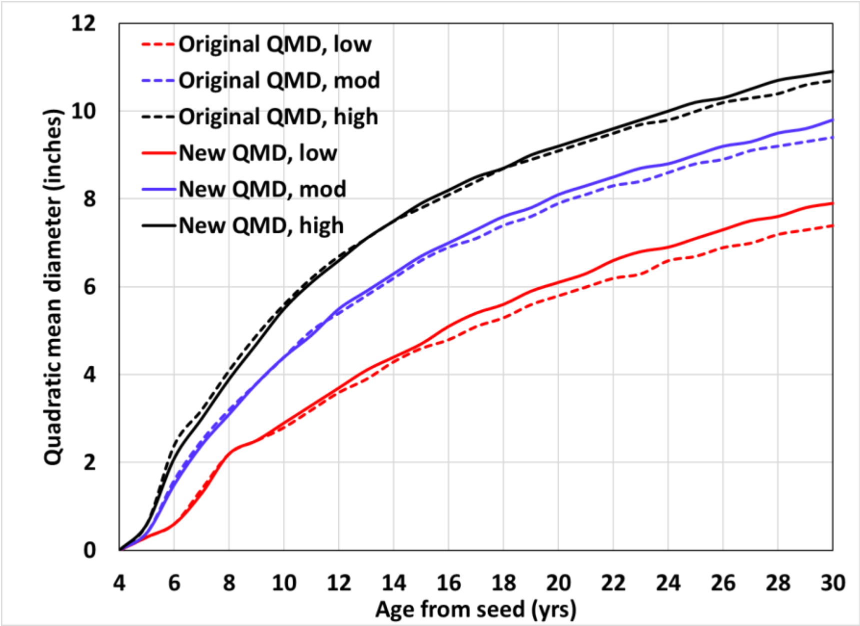


Figure 11. Projected QMD for an initial density of 265 TPA using the original RAP equations and the updated equations at low, moderate, and high site indices.

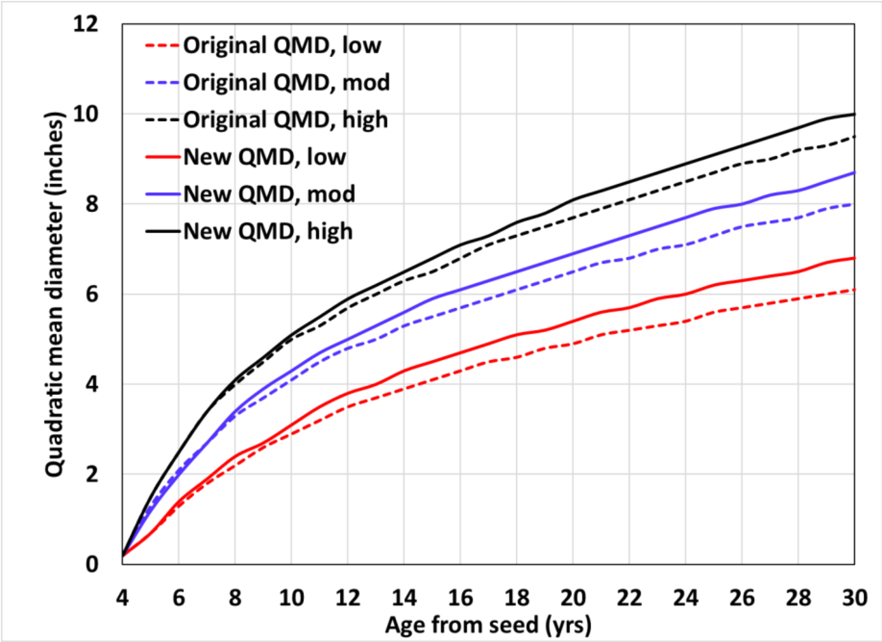


Figure 12. Projected QMD for an initial density of 570 TPA using the original RAP equations and the updated equations at low, moderate, and high site indices.

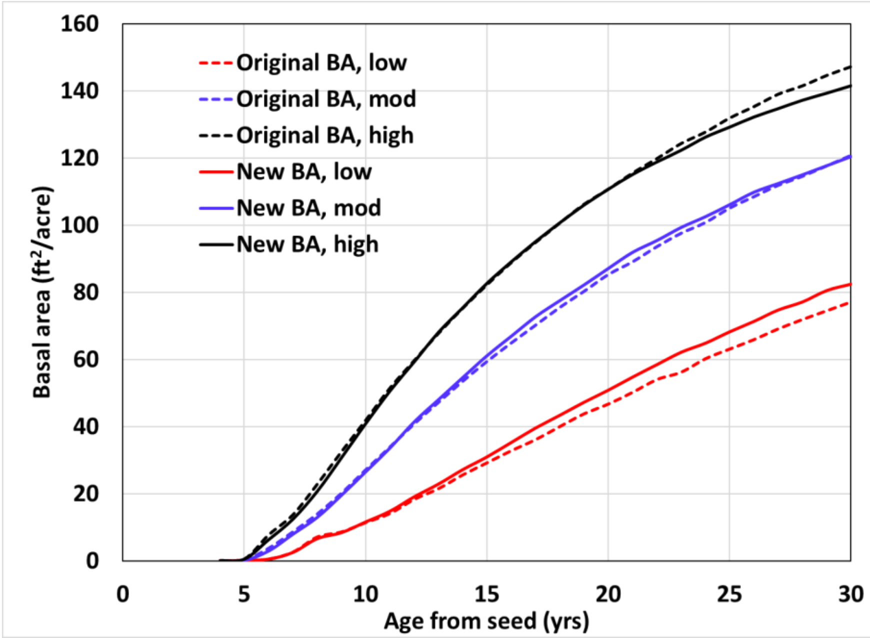


Figure 13. Projected basal area per acre for an initial density of 265 TPA using the original RAP equations and the updated equations at low, moderate, and high site indices.

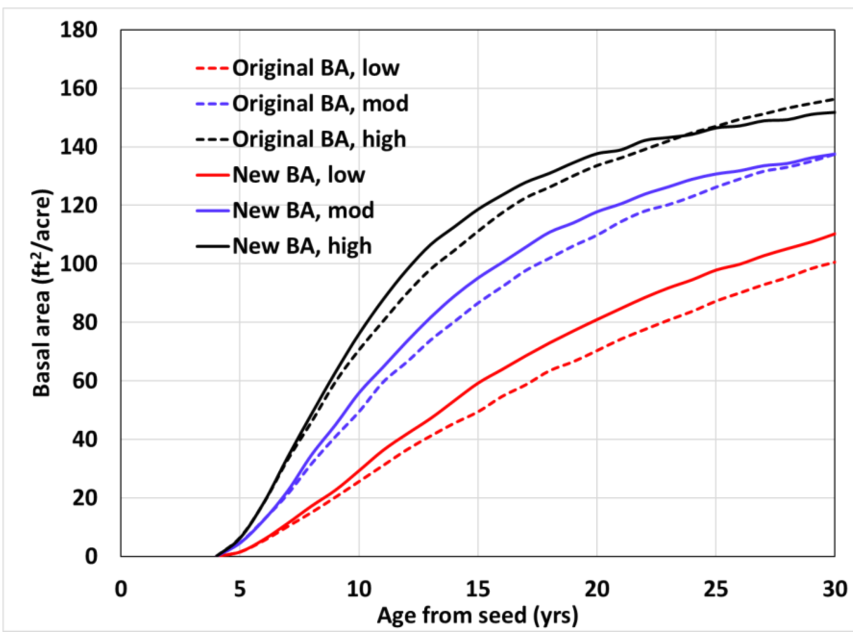


Figure 14. Projected basal area per acre for an initial density of 570 TPA using the original RAP equations and the updated equations at low, moderate, and high site indices.

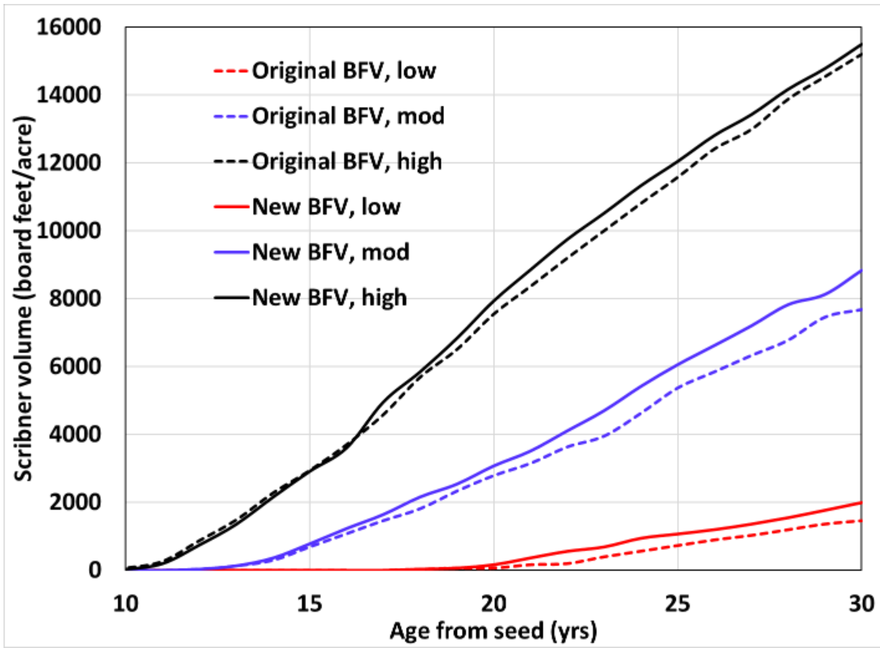


Figure 15. Projected board feet per acre for an initial density of 265 TPA using the original RAP equations and the updated equations at low, moderate, and high site indices.

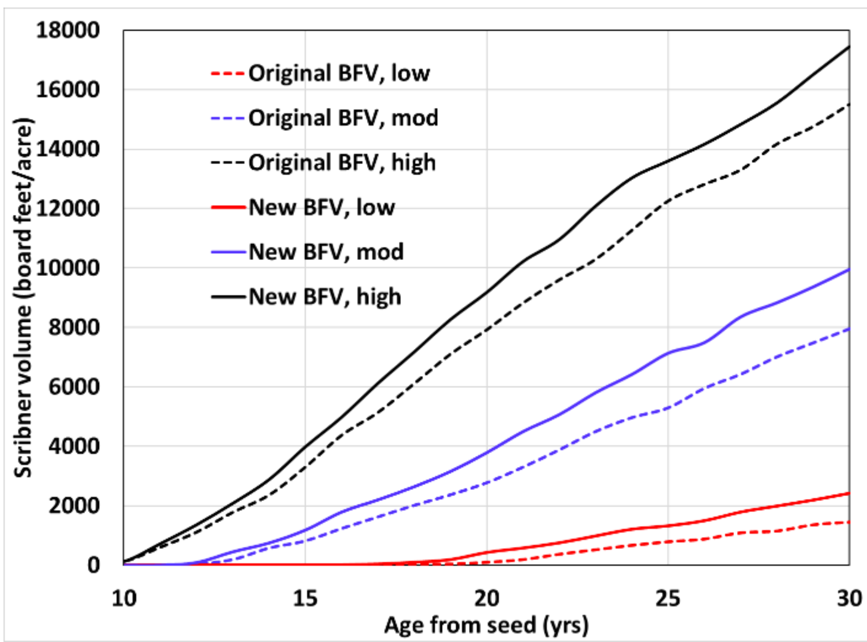


Figure 16. Projected board feet per acre for an initial density of 570 TPA using the original RAP equations and the updated equations at low, moderate, and high site indices.

Red Alder Yield Tables

The goal of the HSC is to improve the understanding, management, and production of red alder and specifically to understand of the effects of stand density management on red alder growth and yield. Then to take this knowledge and to create red alder growth and yield tools for forecasting future yields of managed red alder stands.

There is currently a large amount of 22- and 27-year-old data. This additional data offers potential for the improvement or creation of stand tables to project yield from managed, even-aged, pure alder stands across the range of site productivity for a series of likely plantation management scenarios. These yield tables would be a welcome new tool for forest managers.

An updated growth and yield model (see above) is the first step in achieving this goal. Once the updated growth model is available, the HSC is intent on publishing a suite of red alder stand volume tables. Until then, however, the HSC presented preliminary growth and yield data and yield tables at the 2021 Washington Hardwoods Commission 2021 Annual Symposium on June 10th, 2021.

Andrew presented "NPV/IRR for Red Alder vs Doug Fir" and Glenn presented "Growth & Yield". A recording of the presentation can be found online at:
https://www.youtube.com/watch?v=VtB0i6U8Sfs

Glenn used 22 and 27 year-old HSC data and projected future yields using the interim CIPSANON red alder growth model, by site productivity class. Those tables are presented in Tables 15 and 16.

Table 15. Red alder yield (MBF/ac = 1,000 BF Scribner/acre (30 ft target log length, 5-inch min. top) from high productivity sites.

Plantation Age	Plant 525tpa PCT 230 age 7	Plant 250 tpa	Plant 525 tpa
20	9.3	10.8	13.6
25	13.5	15.2	17.0
30	16.6	18.1	19.6
35	19.2	20.8	21.8
40	21.5	23.1	24.1
45	23.7	25.4	26.1

Table 16. Red alder yield (MBF/ac = 1,000 BF Scribner/acre (30 ft target log length, 5-inch min. top) from medium productivity sites.

Plantation Age	Plant 525tpa PCT 230 age 7	Plant 250 tpa	Plant 525 tpa
20	7.7	7.4	9.9
25	10.4	10.4	12.8
30	12.6	12.9	15.0
35	14.8	15.2	17.3
40	16.8	17.4	19.3
45	18.6	19.2	21.1

Red Alder Lumber Recovery Study

Introduction

With the increasing reliance on short-rotation plantation forestry, log sizes continue to decline. Research has previously shown that Douglas-fir trees harvested at younger ages do not produce the same log and lumber grade yields as those harvested from older stands (Barbour & Parry 2001, Weiskittel et al 2006). However, only a limited amount of research has been done on the influence of intensive management activities such as vegetation control, precommercial thinning, and fertilizer application on wood quality characteristics (Sonne et al. 2004; Gartner 2005) with no existing studies on red alder. It has been shown that silvicultural activities associated with short-rotation plantation management increases juvenile wood content and knot size (Fahey et al. 1991; Gartner 2005). However, gains in lumber yield may possibly outweigh any negative consequences for log or product quality (Sonne et al. 2004). Some important individual tree attributes that are sensitive to stand condition and influence lumber quality are stem form (i.e. taper), proportion of juvenile wood, and branching characteristics (number and size). This study will test the influence of intensive management on red alder log quality and lumber recovery.

Very few, if any red alder plantations have been commercially harvested. In addition, managed plantations (of all species) differ in rotation ages, harvest volume, lumber recovery, etc. from natural, unmanaged plantations. Therefore, given that many red alder plantations are approaching harvest, the HSC and Cascade Hardwood Group have initiated a project to obtain information relative to the recoverable volumes and grade yields of lumber from managed stands of red alder in the Pacific Northwest. Cascade Hardwood Group is an ideal cooperator since they have undertaken numerous mill/lumber recovery studies. Currently, there is no information available on the volume, grade recovery, and product value of logs from managed stands of red alder.

Objectives

The goal of this study is to provide valuable information for land managers and for mill owners on the recoverable volumes and grade yields of lumber from managed plantations of red alder. The specific objectives of this project are:

1) Describe characteristics of trees and logs from red alder plantations with various silvicultural regimes (varying planting density, pruning, and precommercial thinning).
2) Estimate total lumber volume recovery rates, grade recovery percentages, overrun percentage, cubic recovery ratio (CRR), lumber recovery factor (LRF), and lumber grade recovery percentages for the different silvicultural treatments.
3) Compare estimates of lumber recovery variables for managed stands with "woods-run" or industry averages for unmanaged, natural stands.
4) Assess the applicability of current red alder log grades and buyer specifications for use on logs from managed stands. How well do log grades/log buyer specs predict lumber recovery for alder logs from managed stands?

Previous Volume and Yield Estimates

In contrast to softwood species, few studies have been conducted on product (or lumber) recovery from western hardwood species. The only available information on growth and volume characteristics for red alder is based on material from unmanaged, natural stands. Volume tables have been developed based on Scribner and International log rules and cubic volume (Chambers 1986, Johnson et al. 1949, Worthington et al. 1960). This study should provide accurate volume information as it pertains to silvicultural treatments (i.e. management regimes).

Previous recovery studies do exist from unmanaged, natural stands of red alder. Pfeiffer and Wollin (1954) conducted a recovery study based on data from 472 red alder logs harvested in Oregon. The logs processed in this study were 8 feet long with top diameters ranging from 10 to 24 inches dbh. Plank et al. (1990) conducted a study based on a sample of 159 red alder trees in the coastal range of northwest Oregon. These trees ranged in size from 12 to 28 inches dbh and were from 49 to 116 feet tall. Average age was 66 years with individual stems varying from 31 to 102 years. The LRF (ratio of board feet of lumber tally per net cubic foot of log input) for logs in the 9-inch-and-larger diameter class ranged from 4.3 to 4.4 board feet. Regression equations were developed to calculate grade recovery (percentage of recovery values) as a function of log diameters. In this study, it was estimated that recovery of the two highest grades of lumber (Select and No. 1 Shop) increased from 4 percent for 7-inch logs to 88 percent for 23-inch logs. Plank and Willits (1994) also conducted a second study using 153 red alder trees that were harvested from Northwest Washington. These trees were slightly younger, but of a similar diameter range. Slightly higher grade recovery values were obtained in the Washington study.

More recently, Brackley et al (2009) quantified the recovery of lumber from a 46 year-old natural stand of red alder from Southeast Alaska. The study compared red alder in southeast Alaska to other regions of the Pacific Northwest and provided information useful for inventory, forest management, and appraisal purposes. The study specifically provided information on the characteristics of trees and logs, compared volume and grade recovery with yields from other studies and compared overrun percentage, cubic recovery ratio (CRR) and lumber recovery factor (LRF) from the Alaska material with reported values from other regions. They determined that there were no significant differences in material between that log resource and other regions in the Pacific Northwest. As can be seen from these studies, the trees used were much older and larger than trees (i.e. logs) expected to be produced from short-rotation, managed plantations.

Site Selection

Two sites are potential candidates for this study. Both are in NW Washington, owned by Swaner Hardwoods (Goodyear-Nelson). These sites are two of the first HSC Type II installations established. The first, Humphrey Hill (#4201) was established in 1989 and the second, Clear Lake Hill (#4202) was established in 1990. Table 17 describes the site characteristics.

Table 17. Characteristics for the candidate sites to be used in this study.

Site Name	Humphrey Hill	Clear Lake Hill
Establishment date	1989	1990
Latitude	48.58	48.47
Longitidue	122.18	123.03
Elev (ft)	400	500
Slope (%)	5	35
SI(50) (ft)[a]	115	105
SI(20) (ft)[b]	75	65

[a]Calculated pre-establishment using the Site Selection Method from Harrington (1986)
[b]Calculated from control treatment tree top heights using the equation in Weiskittel et al (2009)

Each site is composed of 10 different silvicultural treatments of approximately one acre each (Figures 17 & 18). Within each silvicultural treatment is a 1/3 acre measurement plot where diameter, height, and height to live crown has been measured for individually tagged trees at least seven times up to age 27.

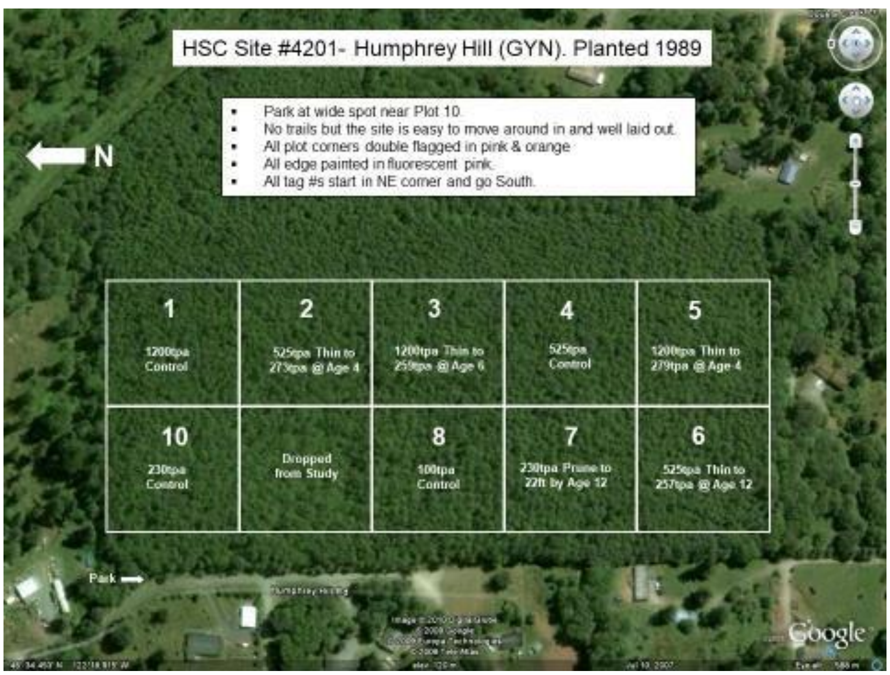


Figure 17. Site map for Humphrey Hill showing silvicultural treatments.

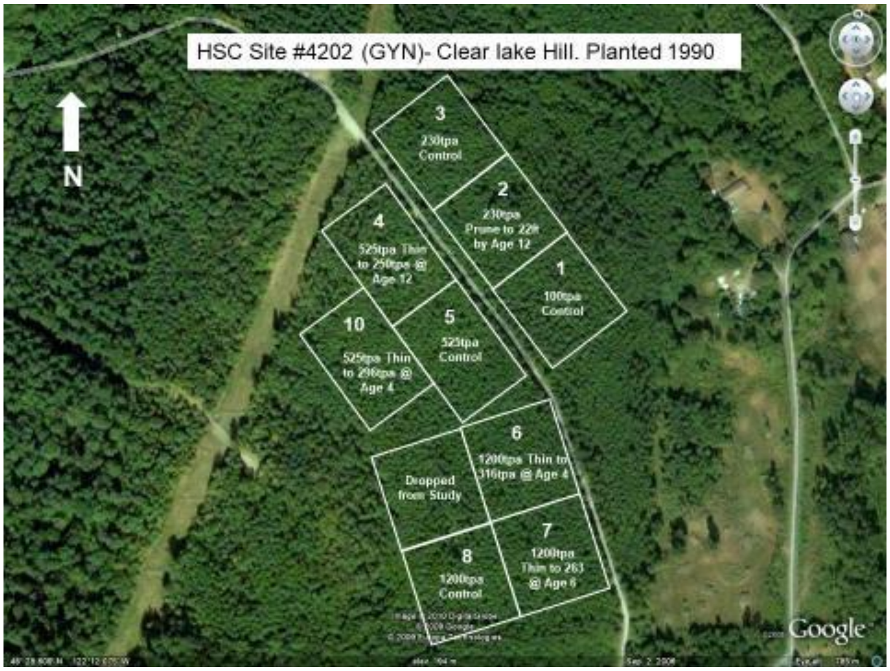


Figure 18. Site map for Clear Lake Hill showing silvicultural treatments.

Timing

The proposed timing of this study is during the Fall 2021/Spring 2022 winter after Humphrey Hill has had its 32-year measurements and when the harvesting plan has been approved by Swaner Hardwoods. It has been proposed that only one site will be used in this study. Then, if there is interest, lumber recovery from the Clear Lake Hill site could be assessed in the future.

Harvest and Logging Plan

The sale of the timber and all associated logging, trucking and milling costs will be negotiated between the HSC, Cascade Hardwood, and Swaner Hardwoods. Harvesting will be done using ground-based equipment with the specific logistics determined by Cascade Hardwood staff and conveyed to the logging contractor. Likewise, the log tracking methods will be determined by Cascade Hardwoods.

Log Selection

The number of trees from each treatment that will be selected for this study will be determined by HSC and Cascade Hardwood staff. The number of logs used in this study will also be determined by the bucking methods used. Two options currently being considered are 1) landowner preferred- 20ft lengths, or 2) mill preferred length for butt log then cut to a 5 or 6 inch small-end diameter. The delivered logs will be unloaded and placed on bunk logs in the wood yard at a Cascade Hardwood Group mill. All logs will be scaled according to the standard methods used by Cascade Hardwood. Additional scaling methods could include:

- Cubic content using the National forest cubic scaling handbook (USDA FS 1991).
- Stem analysis methods where diameter outside bark will be taken at multiple locations along the log (locations TBD). Volume would then be calculated for each section and total stem volume would be based on the sum of the section volumes. The bark thickness equation from

Bluhm et al (2007) will be used to convert outside bark measurements to bark-free measurements.

Once the long-length sections are scaled and measured, all material will be bucked into mill-length logs in accordance with current industry practices.

Log and Lumber Processing and Lumber Grading

The critical aspects of log and lumber processing and lumber grading will be handled by the experts at Cascade Hardwood.

Deliverables

Stand and tree mensuration statistics, by treatment, will be determined by current HSC data. Standard timber cruise methods used by hardwood log buyers may also be employed for each treatment.

This study would also be an excellent opportunity to collect taper data on merchantable- sized trees, branches, and tree crown widths. The taper data would improve RAP-ORGANONs volume estimation routine, the branch data might be important since red alder lumber grade is based primarily on the presence of knots and the crown width data, although having little relation to this study, is an important variable in RAP-ORGANON model but very hard to come by.

In addition, merchantable board foot volume by log diameter class and treatment will projected using the HSC data and RAP-ORGANON. These estimates can then be compared with gross volume estimates from cruise data. Figure 19 is an example of projected volume estimates by log diameter class, treatment, and site.

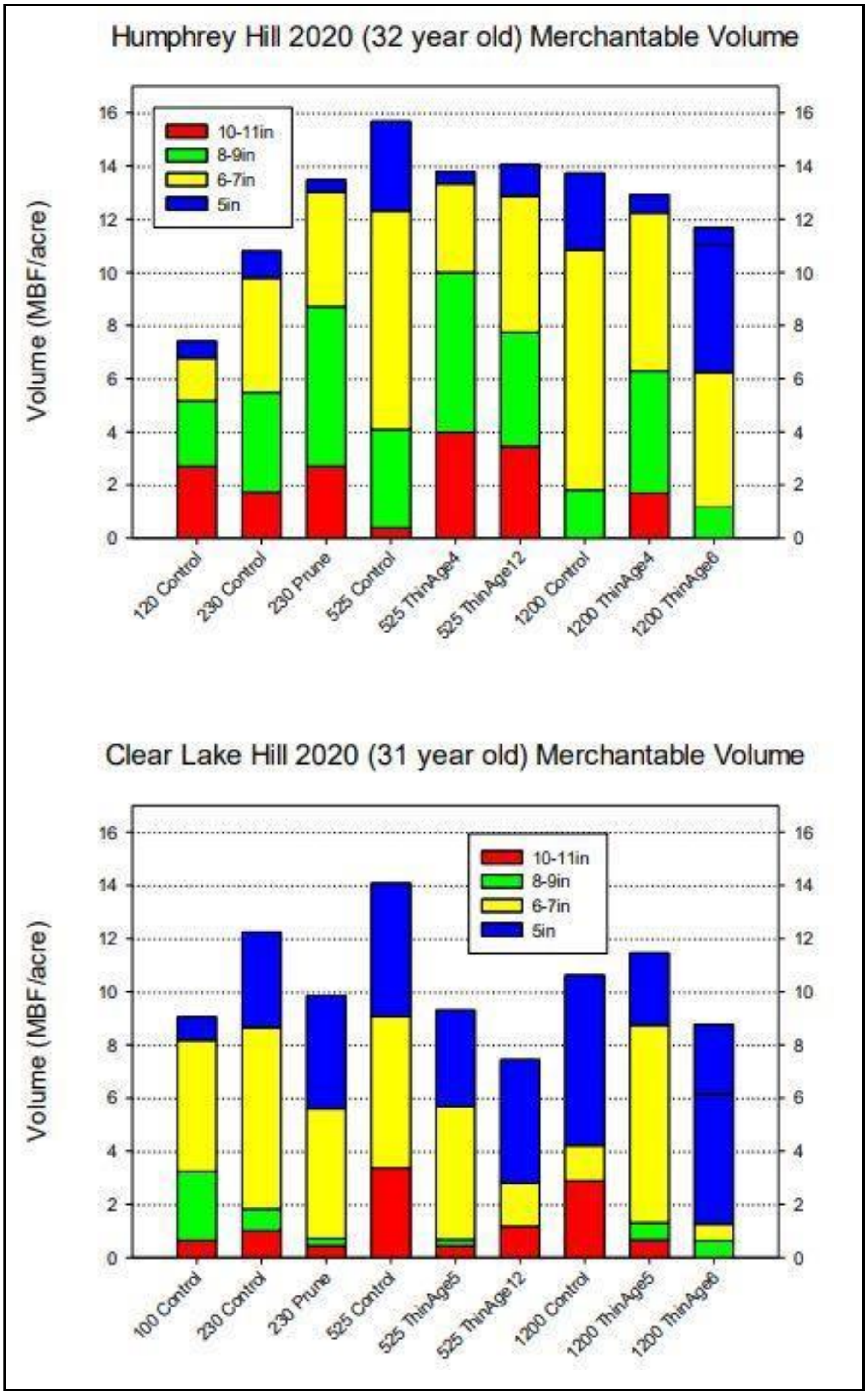


Figure 19. Projected volumes by treatment and log diameter class for a) Humphrey Hill, and b) Clear Lake Hill.

Log Sample Measurements

Stem characteristics by treatment and log diameter class will be determined. Characteristics from logs may include:

- Stem length
- Top diameter
- Gross and net Scribner board foot scale volume
- Gross and net cubic scale volume
- Gross cubic volume from the stem analysis measurements

Lumber yield and quality would be calculated for each silvicultural treatment, summarized and used to calculate:

- Total lumber volume
- Cubic lumber recovery (ratio of recovered lumber volume to actual log volume)
- Lumber recovery factor
- Lumber recovery percentage by grade
- Volume weighted grade average
- Estimated value based on current prices.

Lumber Volume and Grade Recovery would be summarized for each silvicultural treatment. The basic characteristics and resulting tally of lumber by grade for each log diameter class would be reported. These characteristics may include:

- Board feet by grade and scaling diameter
- Lumber recovery by grade and scaling diameter
- Percent grade for each scaling class
- Overrun of net log scale
- Cubic recovery ratio (CRR)
- Lumber recovery factor (LRF)
- Average recovery ($) by gross scale class
- Value lumber tally from log
- Value/mbf of tally from log

Comparison of Yields With Natural Stands

Recognizing the differences that exist between sample characteristics, production systems, products, and applied grading rules, the lumber recover results from this study (e.g. CRR and LRF) will be compared to the results of previous studies from unmanaged, natural red alder stands. This study would provide information that can be used for inventory, forest management, and appraisal purposes and provide information for mill owners and entrepreneurs interested in producing lumber products.

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Outreach and Education

Tree School Online

Instead of the traditional, in-person, one day Tree School, OSU Extension Service put together a multi-session webinar for 2020. Andrew gave a talk on "Red Alder Management: From Silviculture to marketing" on July 28th, 2020.

WA Family Forest Field Day

Washington State University hosted an online Forest Owners' Winter School hosted by Washington State University on February 27th, 2021.

Andrew presented on "Red Alder Management". A recording of the presentation can be found online at: https://www.youtube.com/watch?v=P0K_ErFL0YY.

Glenn presented "Hardwood Management" His recording can be found at: https://www.youtube.com/watch?v=6oDaMtCyUyg

Washington Hardwoods Commission 2021 Annual Symposium

The Washington Hardwoods Commission hosted an online version of their 2021 Annual Symposium on June 10th, 2021. Andrew presented "NPV/IRR for Red Alder vs Doug Fir" and Glenn presented "Red Alder Growth & Yield". A recording of the presentation can be found online at: https://www.youtube.com/watch?v=VtB0i6U8Sfs

HSC 2020 Committee Meeting Minutes

July 16, 2020 Zoom

Attendees: Andrew Bluhm, Glenn Ahrens- OSU; Gary Swaner- Swaner Hardwoods; Bob Deal- PNW Research Station; Randy Bartelt- Port Angeles Hardwood; George McFadden, Bureau of Land Management; Brian Morris- WA DNR; Dave Sweitzer- Washington Hardwoods Commission; Alvin Yanchuk, Kwadwo Omari, Neil Hughes- BC Ministry of Forests

The meeting started at 9:00 AM on Zoom with a welcome from the HSC program leader, Glenn Ahrens. After introductions, Glenn gave a tribute to the late Paul Kriegal,, a long-time supporter and key member of the HSC.

Following that, Andrew Bluhm moved on to HSC business with a review of last years' fieldwork, the coming years' fieldwork and an overview of the data collection schedule for all three installation types.

Last year (Winter 2019/20) was a very light year.

- Three Type 2 installations (Blue Mtn., Mohun Creek, and Hemlock Creek) had their 27th year measurement.
- There were no thinning or pruning treatments required.
- Since the Washington Hardwoods Commission (WHC) could not support the measurements at Blue Mtn. and Hemlock Creek, the WA DNR graciously stepped in and provided personnel to get those measurements completed.

Next year (Winter 2020/21) will be a busy year.

- One Type 2 installation (Humphrey Hill) will have its 32nd year measurement.
- Five Type 2 installations (Lucky Ck., French Ck., Cape Mtn., Siletz, and Dora) will have their 27th year measurement.
- Three Type 3 installation (Monroe-Indian, Turner Ck., and Holt Ck.) will have their 27th year measurement.
- One Type 2 installation (Siletz) will require the 4th pruning treatments required.
- Unfortunately, three of the ten installations were "orphaned" making it difficult to get the measurements completed.

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

Andrew then gave a summary of the latest refitting of the RAP-ORGANON growth and yield model. Key points were:

- When the original alder plantation version of ORGANON (RAP1) was first produced in 2011, the oldest measured data from alder plantations were 18 years total age.
- Comparison of model projections (using RAP1) to measured plot data from the HSC network found some inconsistencies, most notably significant underestimates of diameter in thinned stands, and overestimates of mortality in unthinned stands.
- A refit of updated, older datasets was done by David Hann and CIPS (Center for Intensive Planted-forest Silviculture) allied with the HSC.
- The new dataset included over 70,000 more measurements than the dataset used for RAP1 fit.
- The new dataset included only HSC data, it was found that the early growth in trees between the HSC dataset and the WeyCo dataset were significantly different from one another as to make model fitting improbable.
- All equation forms in the model were to be refit and if not significant, reparameterized.

- This refitting should lead to better individual tree and stand level predictions.

Glenn then discussed the ongoing effort to produce alder plantation growth and yield tables. These yield tables would be generated with predictions from the updated growth model. Glenn used the intermediary growth model produced by CIPS to generate a preliminary set of growth and yield tables.
Methods:

- HSC Type 2 sites were classified into three productivity classes- high, medium, and low
- Seventeen or 22 year-old data from three sites from each productivity class was selected
- After deciding on merchantability standards ((30 ft target log length, 5-inch min. top, 8-inch trim), the original version of RAP-ORGANON was used to generate Scribner volume estimates in 5 year intervals for the following three treatments:
    - Plant at 250tpa
    - Plant at 525tpa
    - Plant at 525tpa and PCT to 230tpa at age 7

Preliminary results included:

- Volume estimates on Medium to High Productivity sites are 25% to 50% higher than "normal yield" from natural stands.
- Thinning increases yield of larger log sizes (>8 inch scaling dia), but it reduces total yield somewhat (>5 inch dia).
- The economic benefit of thinning depends on price premiums for larger logs.
- Thinning has a greater impact on medium productivity sites compared to high productivity sites.

Once the updated growth model is available, the HSC is intent on publishing a suite of red alder stand tables. Until then, however, the HSC would like further input from regional foresters as to what information should be presented and how the stand tables would be structured. For instance, creating vilume tables using metric units would be of interest to British Columbia foresters.

The next topic, alder genetics, was presented by Andrew. This general topic was broken down into three components- an alder clone bank, an alder clone trial, and the future of alder tree improvement.
Clone bank (for a full description please see the 2020 HSC Annual Report):

- The HSC, WHC, and Hancock Forest Management launched an effort to establish an alder clone bank, using material from WSU's tree improvement program.
- The ODF Schroeder facility was chosen for the clone bank. Details of the clone bank are as follows:
    - 20 WSU production clones were used
    - 3 one-year-old plants per clone
    - 12ft x 18ft spacing
    - 0.3 acre (plus more if needed)
    - Planted late Fall 2019
    - All mortality was replaced with reserve trees
    - FY20 Costs (site prep & establishment): =$2500
    - FY21 Costs (veg control & watering): =$3000

Clone Trial (for a full description please see the 2020 HSC Annual Report): Therefore, the objective of this study was to establish a clone trial on public land (OSU Blodgett tract) to compare the performance of red alder clones with a woods run controls.
Study Design:

- The trial was planted on April 3, 2020 in an unfenced area in the Newton Survivor harvest unit on the Blodgett Forest.

- The Newton Survivor unit was harvested in December 2018, and hand sprayed in the summer of 2019. Nine acres were planted in Douglas-fir in February 2020, leaving twelve acres available for red alder. Of that acreage, ~1 acre was designated for the trial and cleared of any slash piles (and subsequent burn piles). The remaining acreage was an operational planting with a mixture of the red alder clones.
- The trial area was planted on a 9 x 9' grid (537tpa).
- Four sources of seedlings were used in this trial: 1) Eighteen clones from the WSU program and grown as PSB 615A plugs, 2) Woods run bare root seedlings from the Weyerhaeuser Aurora nursery, 3) Woods run 615 plugs grown by PRT Hubbard from the 041 seed source (SW WA), bought from WA DNR, and 4) an "Open pollinated" plugs (lot #249) from a WSU clone trial grown as plugs by the WSU program (hereafter known as "Clones", "WeyCo", "DNR", and "WSU")
- The study design was a randomized complete block design with four blocks (i.e. replications).
- Each treatment within each block is represented by an individual-tree plot, with planting locations randomly assigned.
- Each block (rep) contained 21 treatments:
    - 18 clones
    - The three comparison sources (WeyCo, DNR, & WSU) included twice (to account for its expected higher inter-tree variation).
- Each block had 144 planting spots- six individuals for each of the 18 clones, and 12 individuals for the three comparison sources.
- The trial was bordered by 5-tree row plots of randomly assigned 20 treatments (DNR source not included) all of which was surrounded by the operational planting.
- Immediately after planting, initial tree size (height and caliper) was measured on all 576 trees (not including the row plot borders)
    - Mean caliper was 4.4mm
    - Mean height was 55.8cm (22in)
- Grouping all clones together revealed small (but statistically significant) differences in caliper and height
- Tree size and survival measurements will be made in years 1, 2, 3

Glenn then described the proposed lumber recovery project between the HSC and Cascade Hardwood. The main objective of this study would be to provide valuable information for land managers and for mill owners interested in red alder by obtaining information on the recoverable volumes and grade yields of lumber from managed plantations of red alder. The specific objectives of this project are (subject to change):

1) Provide characteristics of trees and logs from a red alder plantation with various silvicultural regimes (varying planting density, pruning, and thinning).
2) Calculate total lumber volume recovery rates and grade recovery percentages for different silvicultural treatments.
3) Compare overrun percentage, cubic recovery ratio (CRR) and lumber recovery factor (LRF) across treatments.
4) Compare lumber volume recovery rates and grade recovery percentages to "woods-run" or industry averages (i.e. unmanaged, natural stands)?
5) Determine how well log grades/log buyer specs predict lumber recovery.

Two sites are potential candidates for this study. Both are in NW Washington, near Mt. Vernon, owned by Swaner Hardwoods and managed by Goodyear-Nelson. These sites are two of the first HSC Type II installations established. Many of the specifics/details still need to be worked out, including:

- Timing
- Harvest Plan
- Treatment, tree, and log selection
- Log and lumber processing
- Lumber grading
- Cost structure

Next, Andrew presented the HSC budget. Please see the handouts included in the meeting folder. Highlights included:

- Dues received in fiscal year 2020 were $55,500.
- Actual FY2020 costs were greater than what was projected for FY2020.
- Andrew’s time decreased from 0.40 to 0.35FTE.
- The HSC will be carrying appx. $24,000 into FY2021.

<u>Direction for 2022</u>

- Complete an updated version of the red alder growth and yield model RAP-ORGANON.
- Complete development of red alder stand tables from the updated RAP-ORGANON growth and yield model.
- Continue treatments, measurements and data tasks on HSC installations.
- Continue adding content and updating the HSC website.
- Continue efforts in outreach and education.
- Continue assisting HSC members with their specific red alder management needs and projects.
- Determine level of interest and support for maintaining the alder clone bank at Schroeder Seed Orchard.
- Continue measurements on the red alder clone trial at the OSU Blodgett tract.
- Continue efforts to recruit new members.

In order to sustain or grow the HSC, new members and collaborators along with additional funding are needed. We need to pursue new opportunities and funding for hardwood research on priority topics.

Hardwood Silviculture Cooperative

HSC Financial Support 2021

Cooperator	Support
BC Ministry of Forests	$8,500
Bureau of Land Management	$8,500
Cascade hardwood LLC	$8,500
Goodyear-Nelson Hardwood Lumber Company	$4,500
Hancock Natural Resource Group	$8,500
Oregon Department of Forestry	------
Port Angeles Hardwood	$8,500
Siuslaw National Forest	------
Washington Department of Natural Resources	$8,500
Washington Hardwood Commission	------
Subtotal	$55,500
Oregon State University	$16,514
Total	$72,014

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