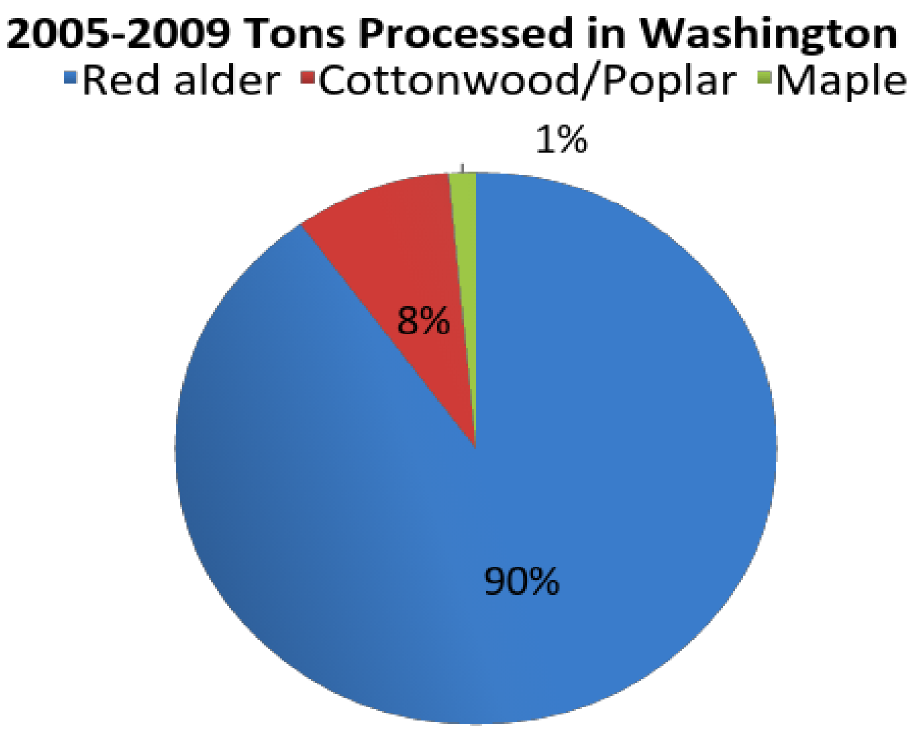
Selecting, Capturing and Producing Superior Alder (*Alnus Rubra*) Clonal Material – an Overview

Introduction

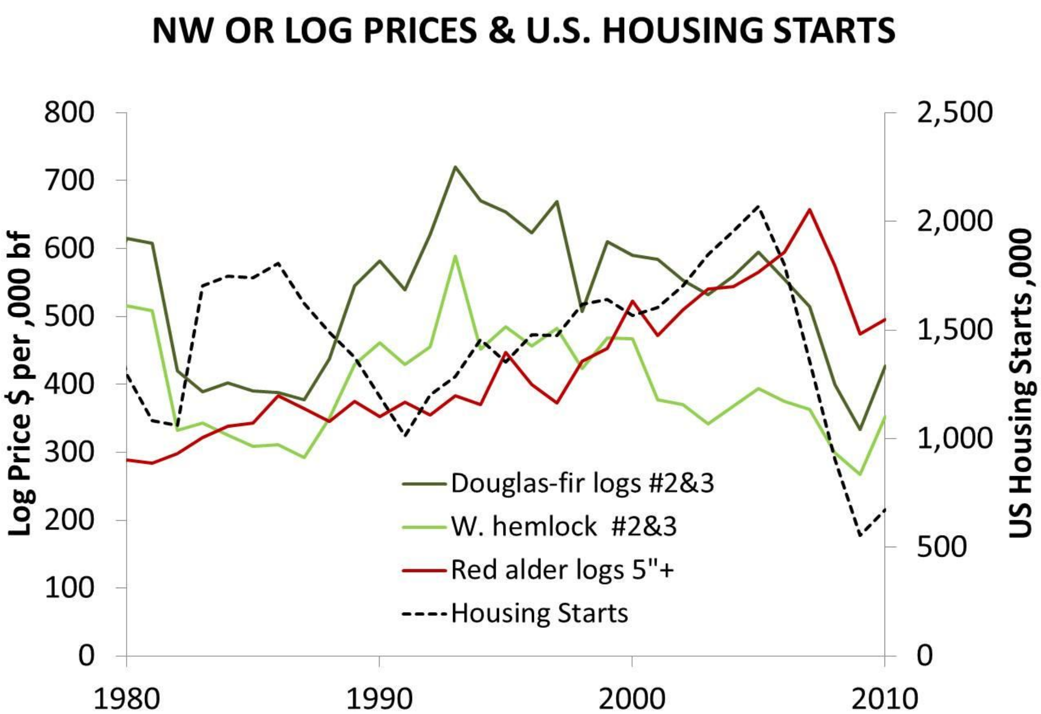
Red Alder (*Alnus Rubra*) is a fast growing hardwood of the Pacific Northwest of the US and Parts of British Columbia and Vancouver Island in Canda. It is also found growing on parts of the South Island of New Zealand around the Nelson area and various provinces in Southern China. It has proved to be a valuable hardwood species for both structural and appearance wood, the Return of Investment (ROI) of 35 year grown red alder is 8.25% versus that of 45 year grown Douglas fir (*Pseudotsuga menziesii*) which has an ROI of 6.99%.

In terms of solid wood products, red alder wood is fine grained, pale in color, and is readily worked, whilst taking stain easily. It is in great demand for cabinetry and exports to Asia with seedling demand far in excess of current production availability. Additionally, it is of growing interest among alternative fuel industries as an ultra-short rotation species for biomass to be ultimately used as a potential biofuel source/platform for high value chemicals. Red alder, along with its nitrogen fixing symbiont Frankia (*Frankia alni*), has significant advantages for high value low cost production.



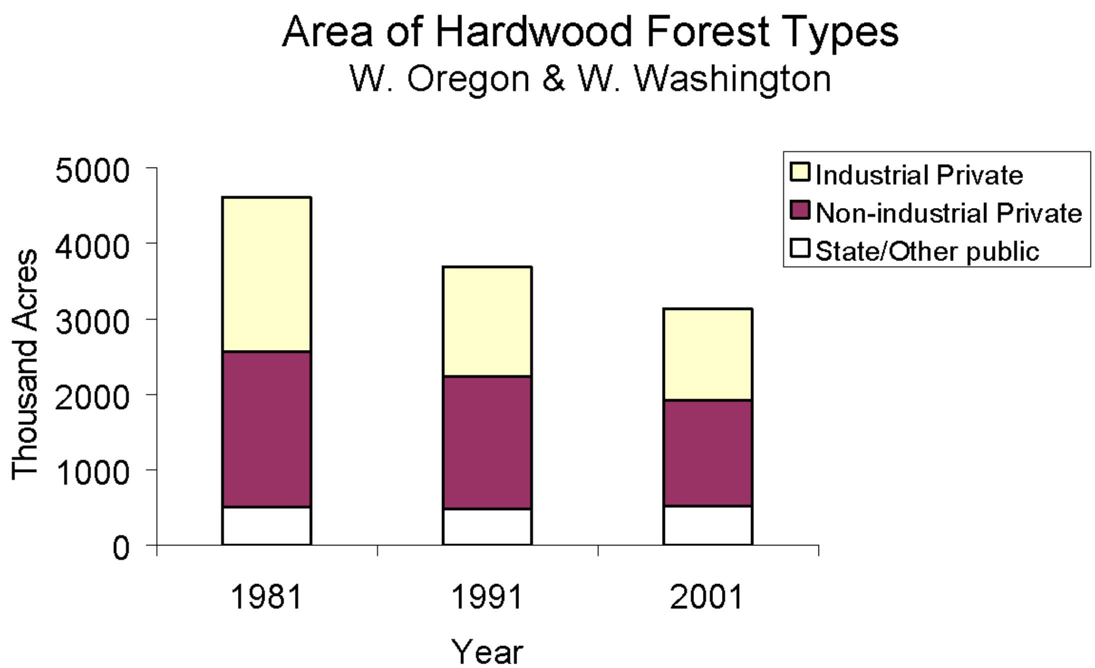
Source: Washington Hardwood Commission Logs Processed Summary from Rasor 2010

Red alder was for many years treated as a weed species and eradicated by many forestry companies and state growers. Thousands of acres of ground were cleared of alder to make way for Douglas fir plantations. Most of this wood went to waste or pulpwood or fire wood giving the species a reputation as a poor quality wood. However, as more alder was processed the value of the wood grew dramatically as did the demand for logs.



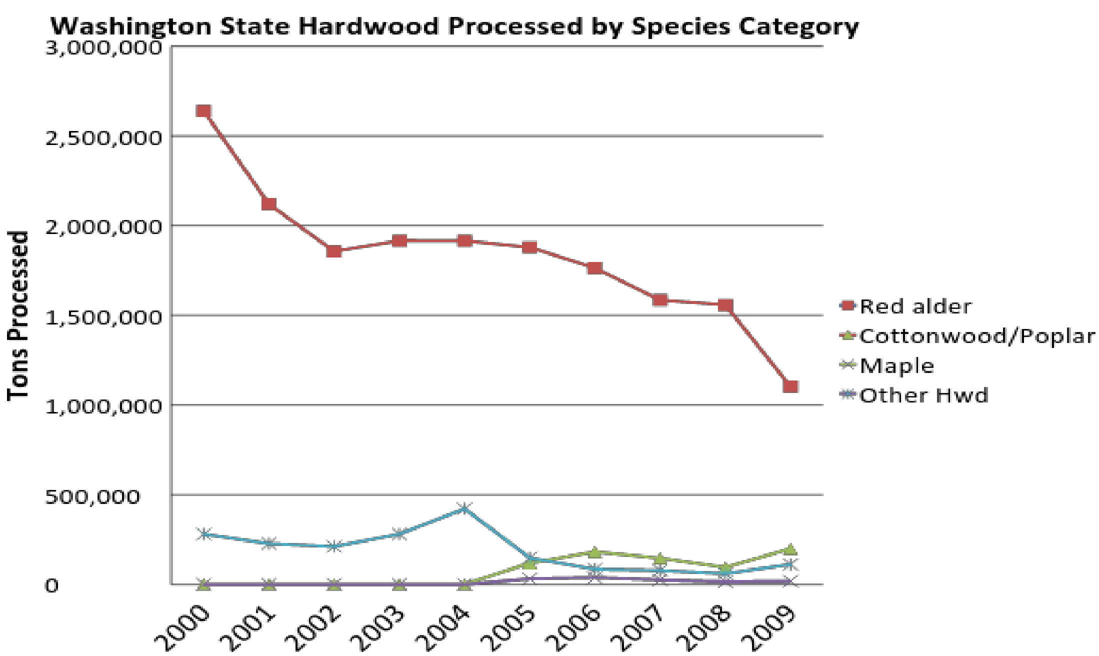
Sources: Glenn Ahrens summary from Housing - NAHB, Logs - ODF NW Oregon

Unfortunately the mass destruction of many standing alder that occurred in earlier years has caused a decrease in availability to the point that the industry is currently in dire need of a reliable source of high quality seedlings. These seedlings will need to have the characteristic of fast growth, but still maintain high industry standards of wood properties, density and stem straightness to improve timber production.



Source: Glenn Ahrens summary of USFS Forest Inventory and Analysis, 2003

This decline in availability of alder logs has been most notable in the large decrease seen in the production of saw timber.



*Non- red alder included in "Other Hwd" pre -2004 from Rasor 2010

Clonal forestry in eucalyptus, poplar and other hardwood species are showing tremendous strides in improving wood properties and shortening rotation times, a red alder clonal program folllowing suit would allow for the production of large numbers of plants that have been selected to exhibit specific wood characteristics coupled to improved growth.

In 1993 Weyerhaeuser Hardwoods (then Northwest Hardwoods) sought to produce a cost effective future supply of red alder saw logs (approximately 150 000 CCF per year) by planting red alder on the best red alder sites not suited for Douglas fir. This new management of red alder allowed for natural regeneration in Douglas fir plantations (with the potential of at least 90 000 cunits of saw-log volume per year coming from managed natural alder) which help to establish a seedling alder plantation program. In 1997 the scope was widened to include a clonal alder program where the goal was to deliver a clonal red alder propagation system to NW Hardwoods by using selected superior field material as the source material. The program was tasked to deliver at least 20 clones with stated criteria of over 1 inch diameter growth per year (based on 5 year selections) and rooting of at least 80%. The future selections had to include parameters on branching, disease resistance, growth, and wood processing characteristics. This project also included work on clonal selections from non traditional Douglas fir sites as well as collecting *Frankia* associated with superior growth alder.

The scope of the work included an eventual aim to include options for hybrid alders, a small breeding population, an improved seed production orchard, and establishing a genetic identification and selection mechanism. The Value and Benefits of planting cloned alder are the same as those for planting cloned pine and fir, and have been seen for years in tropical clonal eucalyptus plantations. The alder clones were selected for the best form, growth, and characteristics suited to processing. Clones were tested for disease, frost, and drought tolerance. Much of this work was carried out at Weyerhauser's own facilities and also at facilities through Washington State Univeristy Research and Extension Center (WSU REC) located in Puyallup. In 2011 Weyerhaeuser sold the Hardwoods Division and gifted the Alder Program (under a variety of contractual obligations) to Washington State University Research Foundation (WSURF) in which the work is being carried by the Department of Institute of Biological Sciences where it was also proposed to use the alder for biomass production.

The Program Elements

The selection criteria and initial capture of material from trees selected as the best trees on various sites as used in the clonal alder program is described below. Also discussed are two viable pathways for the bulk up of selected material through either vegatative propagation or tissue culture. This section is an overview of the development of the program to date with an indication of clonal improvement.

Selection of superior material:

The selection criteria listed below are for selection from existing alder plantations on Weyerhaeuser property that were themselves planted from selected seed sources originally collected from wild grown trees. As the forestry practices of the mid 70's and 80's tried to eradicate alder groves from production forests the initial wild types were very much restricted to riparian zones and warm lower slopes of land that were not planted with Douglas Fir. The collection from selected seed sources from these sites has given a slight jump start to the program, although it must be remebered that the selection base is skewed.

To select trees from a particular growing region:

1) Identify red alder trees of seedling origin growing in the selected zone
    a) Age 5-10 years in plantations or naturally growing
    b) Try to locate red alder growing on terrain representative of the site and well within the stand boundaries
    c) Roadside trees are acceptable
    d) Trees growing in riparian areas or draws are acceptable but as a last choice.
    e) Stands where operations did slashing for management of naturally occurring alder would be good areas to sample
2) Tree Characteristics
    a) Disease-free with no visible signs of cankers or damage
    b) Select trees with good growth and good stem form (no forks). We usually select the best looking trees in a 10x10 tree block and then select the best tree for growth conforming to the other criteria. This would be done on 10 blocks in the same site to select 10 trees, the next 10 should come from a new area
    c) Branches should be light and at a steep angle to the stem
    d) Do not select trees growing in old burn piles
3) Identify location of trees
    a) 10 trees from 5 different locations.
    b) Map/bearing and distance
    c) GPS coordinates
4) Mark Trees with flagging and ID number

5) Measurements
   a) Total height (m)
   b) DBH (Diameter at breast height) (mm)
   c) Photograph – show tree and growing environment
6) Sample selection (branch logs)
   a) Select the lowest living branch on the tree showing actively growing tips, buds etc depending on time of year
   b) The branch should be a minimum of ½ inch diameter and up to a maximum of 1 and a ¼ inches. The best branch logs are between ¾ and 1 inch diameter. The section of log cut out of the branch should be 16 to 17 inches long, it should have 1 or 2 active shoots or small branches on it but this is not critical. 2 of the logs should be cut out of 1 branch and then the second lowest branch selected to cut 2 more logs giving 4 logs per selection. The 4 logs should be bundled together and tagged with the collection number
   c) The log bundle should be placed under cold water immediately after it is cut (the water should not be so cold as to damage the stem we have found a handful of ice cubes per gallon of water every now and again through the morning keeps the water chilled but not freezing)
   d) Cut logs need to be placed out under misters in the greenhouse within 24 to 36 hours of cutting

These guide lines allow us to select for the trees with best growth and form that are currently clear of disease and growing actively. Section 6, above, shows the procedure for collecting material that can be used to propagate material that can be used to form parent plants. These parent plants are used to form cuttings that are used for field trials for testing the clone selected. As the initial selection period is 3 years we would generally make more cuttings than needed for trial purposed and the additional plants would be kept for startup production if the clone makes it through all of the selection criteria

The initial selection phase can be represented as the following:

Trees from this selection path are propagated either vegatatively or through tissue culture.

The branch logs are generally collected in October or November when the trees are in dormancy or early in spring just before the first flush. Once these branch logs are brought into the greenhouse from the field they are immediately placed in trays of vermiculite that have been wetted down under the misters.

These branch logs are then misted for a week at 76F every 15 minutes for 15 seconds. The misters are then turned off and allowed to dry at the surface for 20 minutes in which the logs are then sprayed with a mix of BAP and STEM nutrients. The logs sit with the spray solution for 40 minutes longer with no misting. After this treatment the misters are turned back on the logs are misted again at 15 minute intervals for 15 seconds. The misters are very low volume Delevan misters with an 8gph flow rate and a particle size of 10 microns running at 60psi.

In approximately 2 weeks the axils on the stem surface should start to break and the new growth can be seen on most of the logs.

These are allowed to grow to at least 2.5cm or longer.

Once the stems are 2.5cm or longer, small cuttings are taken of the new growth which are then rooted in a 50:50 mix of vermiculite and perlite as per previous publication.

As soon as these cuttings are rooted and growing in 20cm pots and there are more than one copy of the plant in hand, the testing for further clonal selection is started.

These small potted and rooted plants become the parents for further testing. This is the first testing step; the parent plant is topped and allowed to form a bushy top with four or five main primary branches. Cuttings are then taken from the secondary and tertiary branches on these parents to be tested for rooting efficiency. The cuttings were initially rooted in a known mix of 50:50 perlite:vermiculite. This was later changed to a pre-packed rooting mix from Earthpot.

Initial rooting had to reach a minimum of 70% for the clone to be considered for trials. As this was testing for the eventual aim to produce commercially viable numbers of trees whilst this step may well cut out some excellent clones if they cannot be produced in commercial numbers – easily – they will not make viable production clones.

These rooted cuttings were then placed out in replicated trials over multiple sites and over at least 3 separate years to assess the growth and form potentials of the clone. Initial trials were 4 replications of 10 tree x 5 row plots. These were very expensive to maintain and in land use when clones failed so these were replaced with single tree plots with 20 replications. The statistical power of the tests was improved by moving to the new design layout.

Once the plants for field testing were removed, remaining plants were potted up and used for cold tolerance and disease tolerance testing. Cold tolerance testing was carried out at WSU by traditional methods of chilling at various temperatures and testing for ethylene production. Disease tolerance testing was more difficult as Alder has very few field diseases that can be cultured to provide a pure inoculum to use in under bark testing as has been done for eucalyptus.

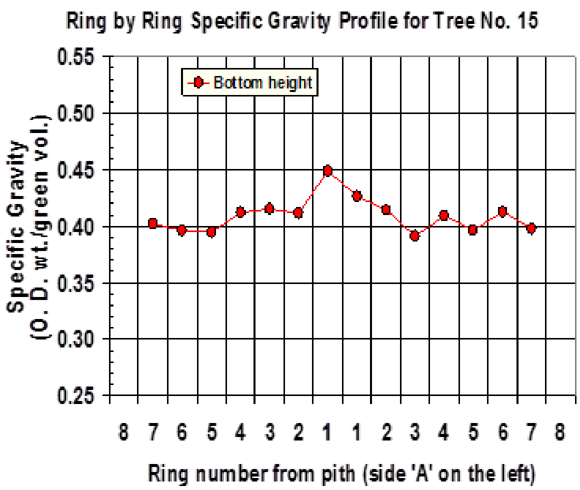
In the field however one of more damaging diseases of alder is *Nectria ditisima* – this forms large cankers and the tree is then infected by multiple secondary diseases. In order to test for tolerance to this disease and the associated diseases infected 4 inch logs from the field were suspended in the irrigation tanks used to water the alder parent plants. Any plants showing infection over a growing season were removed from the program. The *Nectria* presented as a light apricot colored growth on the stem of susceptible plants.

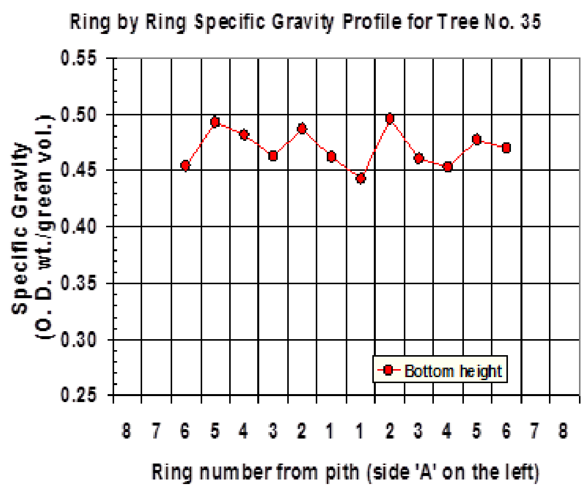
Once the trials were planted and there were multiple parental clones in pots so the genetic material could not be lost, the parent trees from which the original selections were captured were felled and tested for wood properties. The main stem of the 7 to 9 year old trees, taken from just above diameter at breast height (DBH), were taken for milling at the Northwest Hardwoods Centralia Saw Mill in which several disks were taken from the base of the tree and at DBH for xray analysis of wood density gradients and strength testing.

The saw milling analysis was carried out by the commercial graders on the mill line and all of the trees tested to date have passed the graders inspection for color and quality (obviously with unpruned trees knots are present).

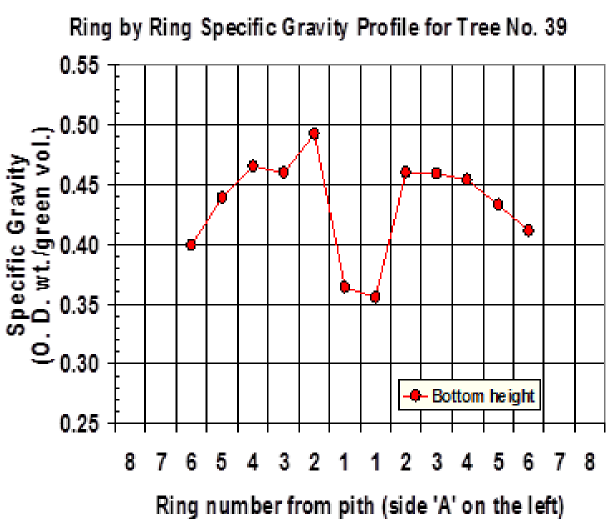
The density gradient work was carried out at the Weyerhaeuser Technology Center wood properties lab using small sticks cut across the stem from edge to edge through the pith.

In the selection process we found that the larger the ring to ring discrepancy the higher the probability of warping occurring when drying the timber after processing. Density gradients across the stem could not vary by more than 50 points total and variation between rings was preferably kept below 30 points. Using these criteria we were able to further reduce the number of clones from which we could select production trees. We were also able to place the clones into two acceptable wood density classes, one from 400 – 450 KG/m3 and one at 450 – 500kg/m3. Examples are shown below for a selected high density tree and a low density tree.





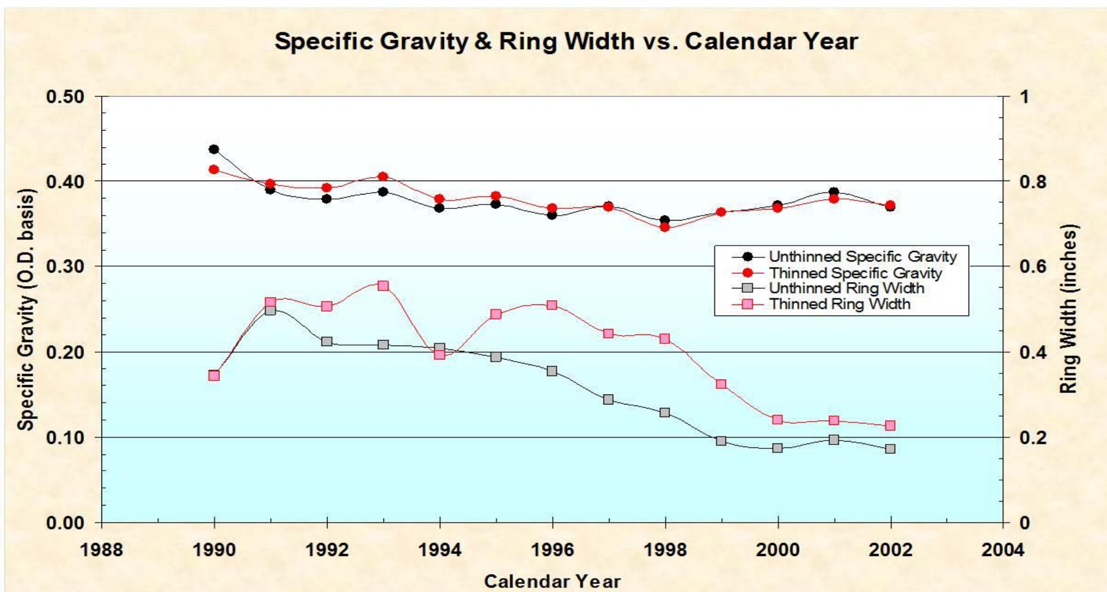
And a tree that was rejected for the large variations between rings.



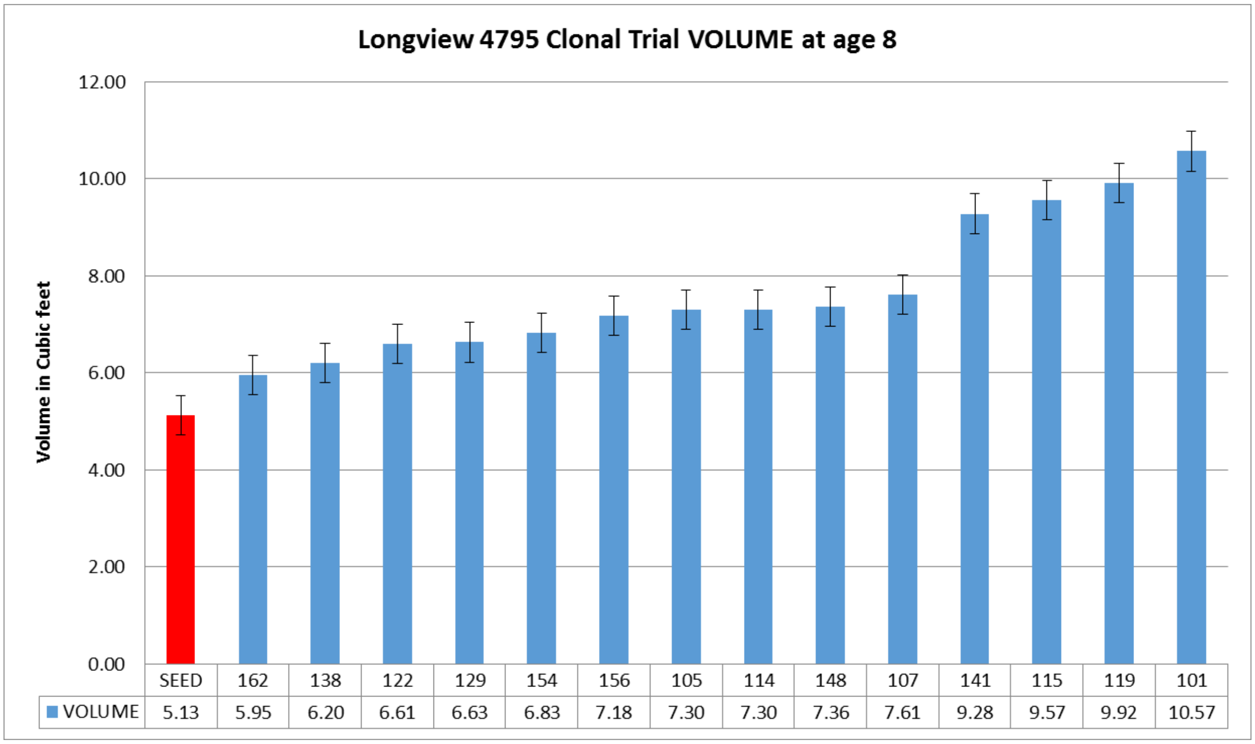
The graph of Modulus of Elasticity (MOE) and Modulus or Rupture (MOR) is appended but all of the selected clones surpassed the minimum MOE of 1 million psi (+/-0.5%)

We were also able to show from previous Weyerhaeuser work that the density of the growing tree is almost totally insensitive to rate of growth so as the growth rings increase in size the density of the wood remains essentially unchanged.

Effects of Silviculture on Wood Formation



The final step in the process is to make selections on growth – primarily volume at year 3 and then at year 5 in the field trials. One makes the initial cut at year 3 and starts to propagate up those parent plants that are in the top quartile, 2 years later when the 5 year volumes are measured there may be some changes in ranking but in all cases to date the top 10% at year 5 have been in the top quartile at year 3. As the top quartile were started in the propagation process at year 3 this means that at year 5 as soon as the results come in the parents are ready for commercial production.



These "good" clones planted on good sites can grow very fast with the top clones reaching 8 to 10 inches diameter at 10 years of age (Planted June 2004 WSU Goss Farm).

Percentage gain at 9 yrs in the top 20 clonal alder				
shown as a percent gain				
Clone	dbh gain	ht gain		
115	42	48		
634	34	16		
101	33	41		
110	33	18		
635	30	20		
637	29	19		
109	25	14		
141	24	39	top 10 clones	
228	23	14	dbh gain	ht gain
639	23	14	29.60%	24.30%
243	21	-2		
309	19	16		
631	16	1		
107	16	36		
433	16	17		
132	13	21		
156	13	26		
154	12	20	top 20 clones	
114	5	23	dbh gain	ht gain
129	4	33	21.50%	21.60%

This program has been implemented for 16+ years with results of 30+ commercially viable selected alder clones with excellent wood quality characteristics and growth 20 to 40% above those of seedling alder measured on the top (Df 130 and DF 140 site index) sites. The success of these clones on even marginal sites is directly related to the *frankia* symbiont with which they are initially inoculated and the quality of the planting stock produced by the nursery. Work at WSU continues to produce novel clones and there is now a small breeding program in place to supplement clone selection. These coupled to marker studies and phenomics will hopefully lead to faster selection and thus to faster production turn around.

Conclusions

The alder clonal program was based on similar clonal programs used for eucalyptus initially started by Aracruz Forestal in Brazil. This model has been successfully copied in several other countries by multiple forestry organizations.

The initial steps in making nursery production an initial cut off point is unique to this program as most of the hardwoods commercially grown from clonal selections are far easier to root than red alder. This step couples to a very strong set of both collection and selection criteria have provided a very robust clonal system. The rooting system has been tested in four commercial nurseries (Weyerhaeuser Rochester – Grand Mound WA, DeGoede - Sumner WA, Briggs – Porter WA, Greenwood – Westport OR) over six years and the lowest rooting and transplanting survival achieved was just over 60% and the best overall rooting achieved was just over 90% in very different environmental and management conditions.

There are currently over 35,000 clonal trees planted in 36 replicated trials over the last 10 years on very good forestry sites and agricultural sites to some very marginal coastal and inland arid sites. The 30+ clones selected for production to date have exceeded seedling growth on all sites by at least 20% and in many cases have survived where the seedling controls have died and we were forced to compare against seedlings in trials on less stressful sites. One of the conditions when the program was gifted to WSU was the commercialization of these clones and the production of new clones. WSU has developed a commercialization plan and these clones will become available to the commercial growers on the West Coast. We still have some way to go but now that we have our breeding orchard in place the pace will pick up again.

If you are interested in purchasing clones please contact Norman Lewis the CEO of Ealasid at lewis@ealasid.com for all other questions please contact myself, Barri Herman, or Randi Peterson at WSU Puyallup REC barri.herman@wsu.edu or luchtera@wsu.edu

Barri Herman and Randi Peterson WSU Puyallup REC