The Douglas-fir Seed-Source Movement Trial Yields Early Results

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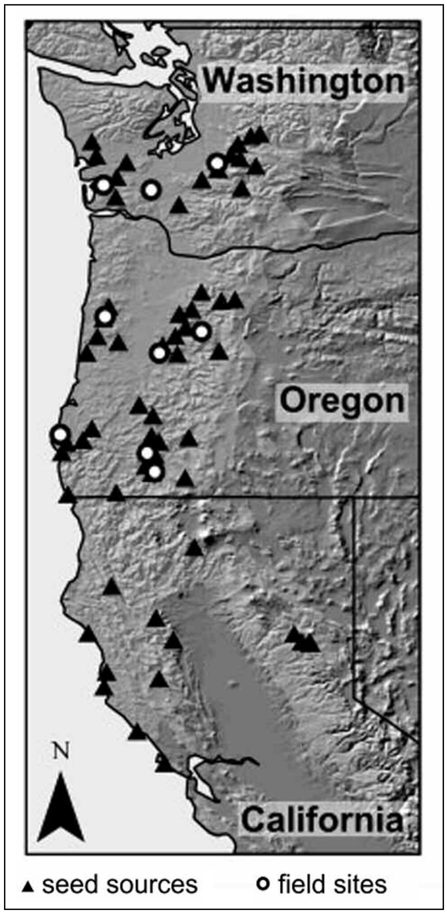
Climate change in the 21st century is likely to dramatically alter the growing conditions that Pacific Northwest tree species experience. It has been suggested that foresters plan for these changes by moving seed sources to locations where the seed-source environment and the future climate will be similar. Some people have called this type of seed-source movement "assisted migration" with the idea that we are helping the plants move to better suited sites faster than they would naturally. But it is important to realize that people have moved seed sources to new locations for centuries without using this term. Think of David Douglas, the early botanist, plant collector, and the one for whom Douglas-fir is named, who sent thousands of seeds back to the British Isles for propagation.

But when it comes to establishing forest stands, rather than ornamental plants or small plantings of exotic species, foresters wonder how far it would be safe to move trees. Should we select seed lots most similar to the current climate, or the climate in 20 years, or the climate in 40 years? After all, if the climate hasn't changed much yet, what would be the benefits or risks in planting seed lots which were adapted to a different climate (say one warmer or drier than the one at the outplanting site) as opposed to local sources?

In 2009, we put out a call to land managers to work with us on a new research trial designed to help answer questions about seed-source movement by providing combinations of seed sources and test sites where we can evaluate various aspects of plant adaptation. We received a great response and currently have 10 organizations involved: Bureau of Land Management, Cascade Timber Consulting, Giustina Land and Timber, Hancock Forest Resources, Lone Rock Timber Company, Port Blakely Tree Farms, Roseburg Resources, Starker Forests, USDA Forest Service Stone Nursery, and Washington Department of Natural Resources. In addition, we have students and faculty from Oregon State University, Evergreen State College, and the University of British Columbia working with us.

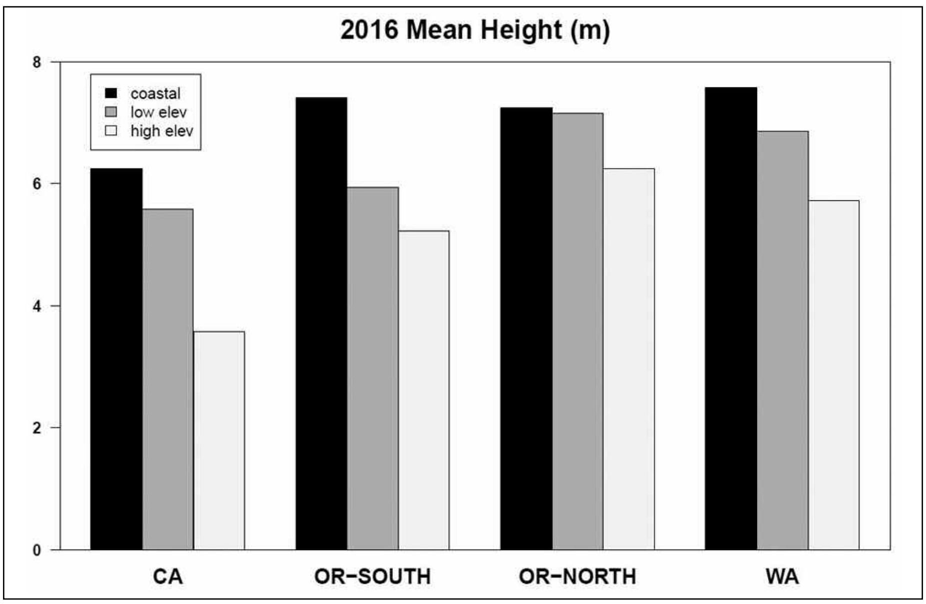
We collected from 60 diverse populations selected from natural stands in California, Oregon, and Washington (see Figure 1); these were from coastal and inland sites and represented a range in elevations. We planted the seedlings on nine sites in Washington and Oregon in the fall of 2008 or spring of 2009. All the sites were fenced to prevent browsing by deer and elk and were treated operationally (site preparation or vegetation control treatments) by our partners prior to or after planting.

The seed sources cover 12 geographic regions: three in California, three in southern Oregon, three in central



SOURCE: C. HARRINGTON

Figure 1. Locations of the seed sources and outplanting sites in the Douglas-fir Seed-Source Movement Trial.



SOURCE: C. HARRINGTON

Figure 2. Height by geographic source eight years after planting at the Nortons site on Starker Forests land west of Philomath, Ore. In general, trees from the coastal families in each latitudinal band grew better than those from inland low elevations sources or high elevation sources.

Oregon, and three in Washington. The outplanting sites along three general latitudinal bands include a coastal site, a low-elevation inland site, and a higher elevation inland site. Each site includes 48 plots—four blocks with each of the 12 regions planted in each block. Each site has a weather station and some additional environmental sensors.

The sites have been visited many times for different types of assessments. We measure the usual things like height and diameter, and record mortality and tree condition. We have also assessed the timing of vegetative budburst in the spring and the presence of foliage diseases such as Swiss needle cast and Rhabdocline on all sites. And on some sites we have collected additional information related to cold or drought hardiness, flowering, and timing of height and diameter growth.

So, what have we learned?

First, the most important thing we have learned (or reinforced from other trials) is that we need to focus on "climate space" and not "geographic space." That is, it is important to specify how far we move something in terms of the differences between the climate at the seed source site and the climate at the planting site and **not** in terms of miles the crow flew or the mountain goat climbed in elevation. The most important variables describe how cold the winters are (e.g., minimum winter temperature) and how dry the summers are (e.g., summer precipitation or some measure of evapotranspiration or aridity). We can move trees fairly long distances as long as the climate variables don't change much (for examples on how to use this concept to select seedlots to plant or where to deploy seedlots you have, check out the Seedlot Selection Tool online https://seedlotselectiontool.org/). Be reassured, we are not suggesting moving trees from the California coast to the Washington Cascades, but rather you might consider some small seedlot movements in a climate-smart manner. Moving trees too far can result in mortality, top dieback, and increased susceptibility to some insects and diseases.

Plants from coastal environments generally are faster growers than those from inland sources, and those from higher elevation sources grow less than those from lower elevation sources (see Figure 2). This conclusion has been reported many times from other studies, but it's good to see it repeated in our current trial.

Sometimes mild sites are not the best. For example, the sites that had cool weather in the fall had less cold damage to artificial cold events than the site which had mild weather in the fall as trees on the milder site did not get the "slow down" signals of temperatures close to freezing before they experienced a freeze event.

It has been reported for several horticultural plants that warmer winters result in earlier dates of flowering or budburst. However, coastal sites in southern Oregon and California do not currently experience many chilling hours in the winter and Douglas-fir has an obligate chilling requirement; thus, warmer winters in the future on sites with currently mild winters could result in no advancement in date of budburst or even delays in budburst as the trees wouldn't experience enough cool temperatures to burst bud promptly in the spring.

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Early Provenance Trials Lead to Contrasting Conclusions

BY KEITH JS JAYAWICKRAMA

Compared to Europe, where many resources were invested in studying provenance variation in forest trees, little was done in the Pacific Northwest through the heyday of forest tree improvement in the 20th century. Just two Douglas-fir trials were established, one trial for ponderosa pine was established, and none for western hemlock, western redcedar or noble fir west of the Cascades in Oregon and Washington. The low emphasis on provenance trials was partly due to lack of interest in importing and testing species from outside the PNW, and partly due to a strong commitment on the part of foresters and tree improvers to emphasize local seed sources.

The 1912 Douglas-fir Heredity Study was one of the first forestry provenance tests in the USA, and was established by Thornton T. Munger. In 1915 and 1916, progeny from 120 parents from 13 provenances were planted at six sites. Measurements were taken over the next 100 years (with credit for later measurements to Roy Silen); the trial was last measured in 2013. The original objectives were to determine the best type of tree to be used for seed collections for artificial reforestation and for seed trees, as well as to determine the influence of provenance on tree growth. Munger was primarily interested in how progeny differed between sound versus infected, old versus young, and low- versus high-elevation parents; thus, the study became known as the Heredity Study, although later emphasis switched more to provenance variation. The trial was used in the 1960s to make the case for a large-scale tree improvement program for Douglas-fir and to argue for small breeding zones for this species.

The other Douglas-fir trial was coordinated by Kim Ching at Oregon State University. Seeds were collected in 1954-1956 from 16 provenances from southern Oregon to northern Vancouver Island. Fourteen to 89 parent trees were chosen at random at each location for seed collection. The 16 seed lots were outplanted in 1959 on 16 sites (located in the vicinity of seed collections) in a reciprocal design where one provenance is native to each site. Each planting site was within a 40 km radius and 60 m in elevation of a seed collection site. Many sites were abandoned due to damage caused by frost, browse, drought, and fire. The sites were measured on a regular schedule through age 25. Close to rotation (46-52 years from seed), total height and DBH were measured at six of the 16 sites (on 7,600 trees). Trial data were used for many publications; in contrast to the Douglas-fir Heredity Study, the case for small seed zones was not compelling. ◆

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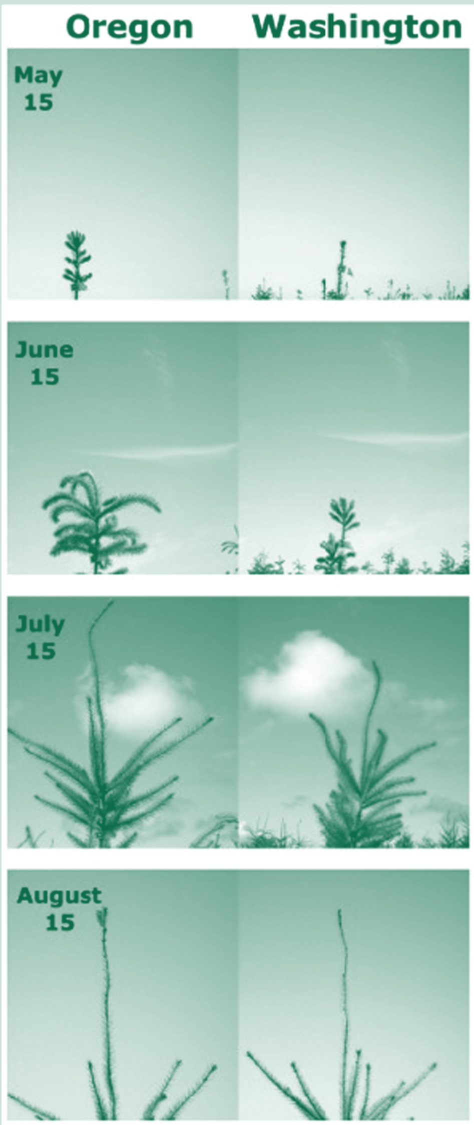
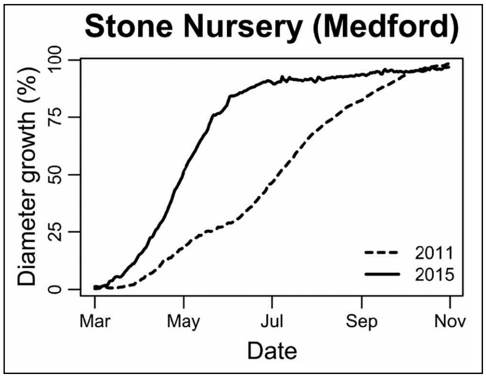
Tracking Changes through Time-lapse Cameras

Time-lapse cameras can be used to document differences in budburst and the timing of height growth. In this example, we followed trees from two seed sources (southern Oregon Coast and Washington Coast) planted in the Buckhorn2 common garden outplanting site on Port Blakely Tree Farms land near Chehalis, Wash. In this example, the tree on the left started growing much earlier in the year than the one on the right, but the one on the right caught up later in the year. However, which source will do best in a particular year on a specific site would depend on the seed source and the weather conditions during the spring and summer. A video clip of the full season of time-lapse images is available at http://bit.ly/2ev7xbr. ◆



Our two dry sites in southern Oregon did not have needle diseases when surveyed in 2015. On the other seven sites, all the trees had Swiss needle cast—but some seed sources seemed to tolerate it and grew well. On the other hand, there was a big difference in the frequency of Rhabdocline (another needle cast disease) by seed source with the sources which burst bud early most impacted by Rhabdocline. We suspect that the disadvantage of having new foliage available during the time period when many of the fungal spores are dispersing could be a reason why trees from some cool, wet geographic areas—such as the Washington coast—have evolved to burst bud late in the spring.



SOURCE: C. HARRINGTON

Figure 3. Diameter growth at some sites was monitored hourly using electronic dendrometers. In 2011, a fairly typical year, diameter growth on our outplanting site near Medford, Ore., started in late March or early April and continued until late October or early November. In 2015, a year with a warm spring and hot summer, diameter growth on that same site started in early March and ceased for the season by July 1.

We learned different things each year. For example, the very hot early summer in 2015 changed the pattern of diameter growth (see Figure 3). In most years diameter growth occurs throughout the year from spring through fall. But in 2015 at our J. Herbert Stone Nursery site near Medford, Ore., many of the trees that were hosting our electronic dendrometers showed the trees stopped diameter growth in late June and didn't start again until the following spring. This would have not only reduced the total amount of diameter growth for the year, but also reduced the percentage latewood produced (which could impact drought hardiness and wood quality). Sometimes people ask us what future date or climate projection we would suggest they use to plan for the future. An easy answer at this point is to suggest you plan for the conditions we experienced in 2015 (no models needed!).

We also learned that these sites are great for field visits and tours—and not just ones led by scientists. The differences in survival, growth, or susceptibility to insects or diseases are striking and both we and our collaborators have used these sites for many formal tours and informal visits. Foresters can take interested folks (shareholders and board members from the participating companies, regulators, other researchers, and natural resource professionals) to the sites and SHOW them why we do this and related research projects on evaluating and moving seed sources and understanding tree responses to their growing environments. A picture may be worth a thousand words, but a field demonstration is worth a whole lot more than that!

We plan to continue this study for as long as our cooperators will host our sites. The specific types of factors we can study will change over time. We have enjoyed taking detailed measurements on young trees, but also look forward to taking measurements on older trees of other variables that foresters are also interested in (such as branching, wood quality, stem taper). If you would be interested in working with us, or just in suggesting topics we might consider for evaluation in the future, please contact either of us. ◆

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