

Range-wide Genetic Variability in Pacific Madrone (*Arbutus menziesii*): Examining Disease Resistance, Growth, and Survival in a Common Garden Study

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Introduction

Pacific madrone (*Arbutus menziesii* Pursh, Ericaceae) is an important evergreen hardwood species in Pacific Northwest (PNW) forests that provides food and habitat for wildlife and has high value in urban environments. Reeves (2007) indicates that Pacific madrone provides habitat for numerous wildlife species, especially cavity-nesting birds. Its evergreen foliage provides browse, especially in the winter, for a number of animals. The berries are an important food for deer, birds, and other small mammals because they are produced in large quantities and may persist on the tree in winter when alternative food sources are limited (Dayton 1931). Reeves (2007) also indicates that it provides excellent erosion control and slope stabilization and is highly prized as an ornamental species for its crooked beauty, colorful bark, showy flowers, and brightly colored fruits. Pacific madrone is relatively drought tolerant, which makes it desirable in urban habitats. Native American tribes have also used various portions of this tree for food, utensils, and medicinal purposes (Arno et al. 1977, Dayton 1931).

The species has been in decline for several decades due to a combination of factors such as climate change, forest management, and several endemic fungal pathogens. Several diseases affect the health of Pacific madrone throughout its range from southern British Columbia (lat. 50 °N) to southern California (lat. 33 °N). These include the endemic canker disease caused by species of *Fusicoccum* (*F. arbuti* and *F. aesculi*), numerous foliar pathogens, and introduced diseases such as *Phytophthora ramorum* and *P. cinnamomi*. Changes in climate over the past 100 years as well as the introduction of *P. ramorum* have resulted in an increase in disease incidence and tree mortality in western North American forests. *Phytophthora ramorum*, *F. arbuti*, and *Phacidiopycnis washingtonensis*, a newly identified potential foliar pathogen, are cool-temperature organisms, having optimum temperatures for growth below 25 °C (Farr et al. 2005, Werres et al. 2001, Xiao et al. 2005). Damage from foliar blight attributed to *P. washingtonensis* was especially severe in 2010, which was a strong La Niña year resulting in extended periods of cool, wet weather in the Pacific Northwest.

Many foliar and canker diseases are more severe during periods of increased wetness and warm temperatures. An example of increased foliar disease due to climate change is the Dothistroma needle blight outbreak on lodgepole pine in Canada (Woods et al. 2005). The higher incidence of observed foliar disease and new canker infections on Pacific madrone may be attributed to the increased frequency of warmer, wetter spring weather during the last half of the 20th century. *Phytophthora cinnamomi*, which causes root disease, is favored by high soil temperatures and has increased in incidence in California forests. The incidence and severity of these diseases is likely to be affected by

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changes in temperature and precipitation and may cause certain populations of Pacific madrone to go extinct under predicted climate change scenarios. A better understanding of the epidemiology of these pathogens on Pacific madrone and the level of genetic resistance among different seed sources is needed to assess this risk.

Very little is known about the range of genetic variability in Pacific madrone. A Canadian study found that genetic diversity was low within populations in the northern part of the range (Beland et al. 2005), and we believe this will be the first common garden study of the species. Establishing field provenance trials of this species over multiple sites will give baseline information on the genetic variation in a range of adaptive traits and will provide guidance for its management under changing climate.

Project Description and Objectives

This project will use a range-wide collection of Pacific madrone to examine genetic variability in a range of traits. Using material from the Washington State University Pacific madrone seed collection (seed collected from 2006 to 2010), common garden plantings consisting of 105 families collected from seven ecoregions were planted in five locations in California, Oregon, and Washington during fall 2011 and winter 2012 (fig. 1). A separate sowing is planned for a planting site in British Columbia. Smaller demonstration plantings with a few trees taken from a range of widely different geographic seed sources, and including other *Arbutus* species from the western states, are planned at other locations to be determined.

Specific objectives include:

- 1) Screen for resistance to multiple pathogens such as *P. ramorum*, *P. cinnamomi*, and endemic canker and foliar pathogens.
- 2) Examine variation in growth and adaptive traits in the nursery and at multiple field sites.
- 3) Identify seed sources or populations that may contain individuals that are best adapted to climate change and for urban and restoration plantings.

Seedling Production

Seed from 125 families of Pacific madrone representing seven ecoregions were cleaned and weighed in lots of 100 seed each prior to sowing in plug trays. Plug trays were watered and placed into a 1.1 °C cooler for stratification in February 2011. Trays were removed from the cooler in April 2011 and placed in a greenhouse. Fertilizer was applied twice a week at the rate of 200 ppm N with Technigro 20-9-20 soluble. Seedling germination data was collected in June 2011. No significant relationship between seed weight and percent germination was seen.

Plugs were transplanted into Treepots with media consisting of 50 percent Specialty Soils standard greenhouse mix + 50 percent fine fir bark + 3 kg/m slow release Plantacote 14-9-15. The seedlings were grown outside until planting (fig. 2). Common garden sites in the United States were planted in fall 2011/winter 2012. Seed was shipped to British Columbia for sowing and planting in fall 2012/winter 2013.

Data collected on these seedlings prior to planting included height, stem diameter, leaf area, and leaf color (fig. 3). Preliminary data collected on a subset of the seedlings in August 2011 and on seedlings from a 2008 sowing of some of the same families indicates that there is some variability in these traits within and among families.

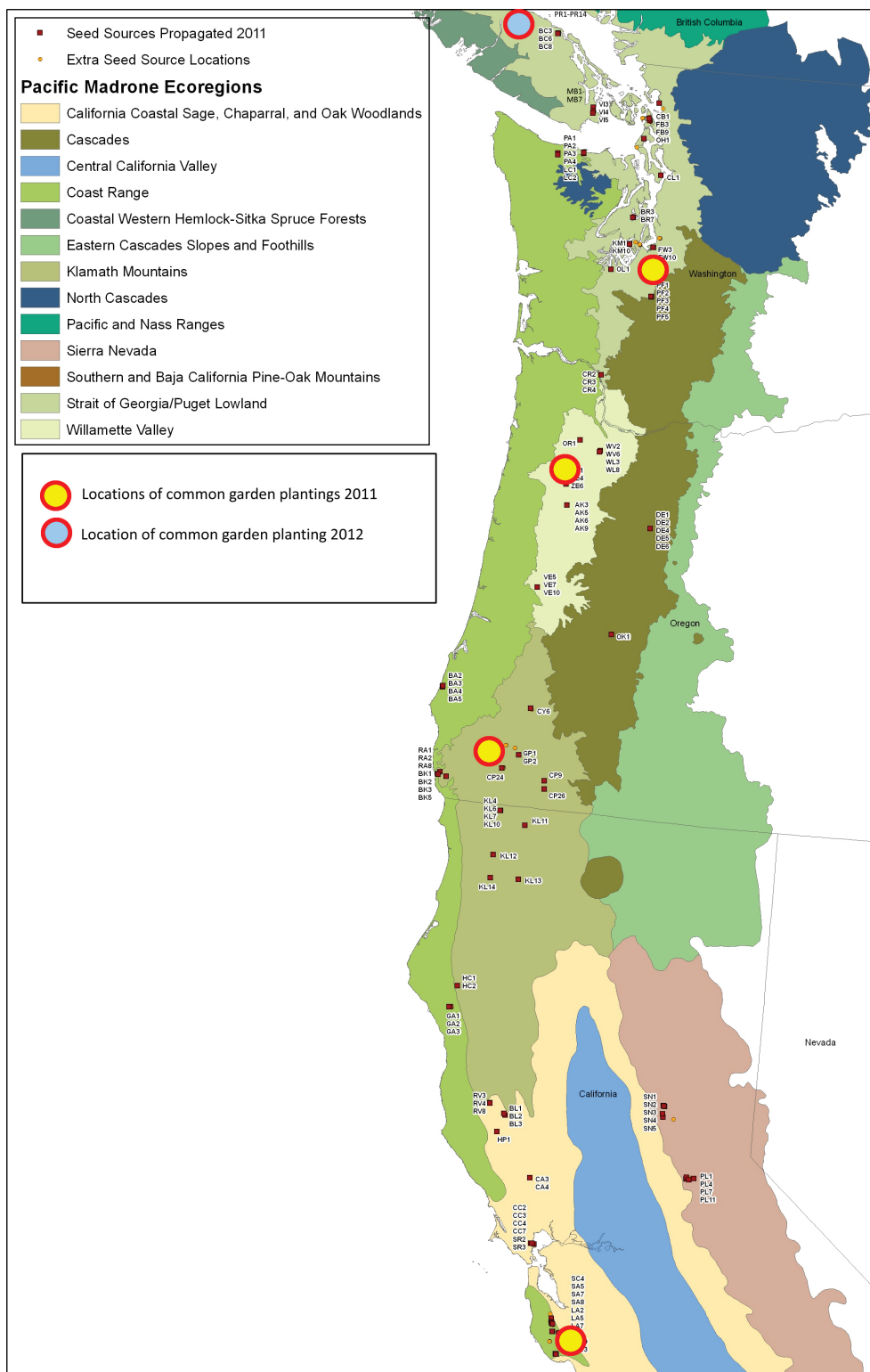


Figure 1—Map showing Pacific madrone range, ecoregions, seed collection sites, and locations for common garden plantings in western North America. The range of Pacific madrone extends to San Diego County, California, but the species occurs rarely in the far southern portion of the range.



Figure 2—Madrone seedlings in the container nursery at WSU-Puyallup after transplanting from plug trays. These seedlings were planted in the common garden sites in the United States in winter 2011.



Figure 3—Differences in leaf color in Pacific madrone seedlings. The seedlings on the left have more red pigment than those on the right. Quantitative differences in color were measured using a Minolta CR200b Chroma Meter.

Transplanting Madrone Seedlings

Pacific madrone has a reputation for being difficult to transplant since its roots react poorly to disturbance. Before transplanting into the common garden sites, a study was undertaken to determine the best methods for planting madrone seedlings. Two-year-old seedlings from three families were subjected to five treatments based on methods used in Hummel et al. (2008) and planted in December 2010. Seedlings were examined in May 2011. Treatments that involved washing the roots resulted in the most seedling mortality (fig. 4). Seedling mortality was between 5 and 10 percent in the unwashed treatments and 30 to 50 percent in the two treatments that involved washing the roots. Resprouting was observed on some seedlings that had died back, indicating that the root system may still be functioning. Total mortality and final measurements of height, stem diameter, and dry weight will be taken after two growing seasons.

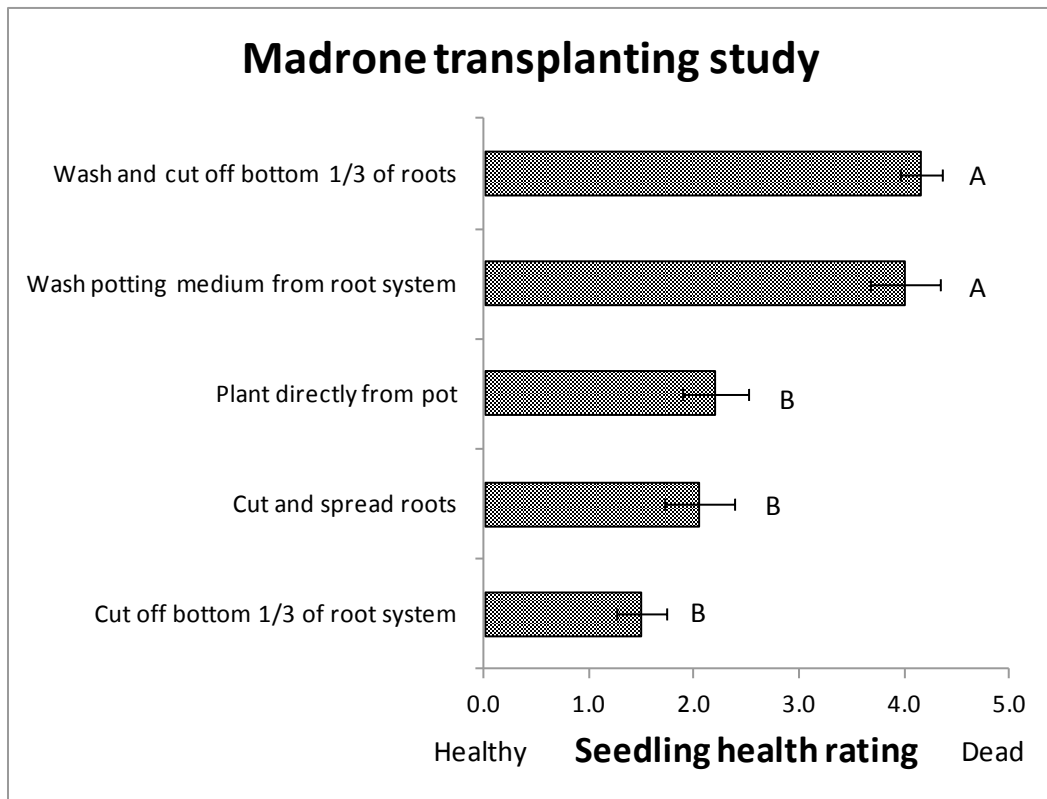


Figure 4—Effects of several transplanting methods on the growth of two-year-old Pacific madrone seedlings. Bars with different letters are significantly different at $p = 0.05$, Kruskal-Wallis test with Dunn's multiple comparisons.

Summary

We believe this project represents the first common garden study involving a range-wide collection of Pacific madrone. This project will provide baseline information on the genetic variation in a range of adaptive traits and will provide guidance for the management of this species under changing climatic conditions. Preliminary data on the seedlings grown for the common garden study indicates that variability is present in a number of plant characteristics. Other studies to assess the range of resistance to various pathogens, such as *P. cinnamomi* and *P. ramorum*, have been conducted in the greenhouse and biocontainment facilities at WSU Puyallup.

In addition to the common garden field plots, a series of long-term disease monitoring plots in naturally occurring stands of Pacific madrone near the common garden test sites are planned to determine which pathogens are present near these sites. These plots will be monitored at several intervals to observe changes in pathogen populations and disease severity due to fluctuations in climate or other factors. For example, it is known that *P. ramorum* and *P. cinnamomi* have been detected in the vicinity of the California site. Damage attributed to the foliar pathogen *P. washingtonensis* and others has been observed throughout the range of the species. This provides an opportunity to formally document portions of the range and the incidence of these pathogens and to study field resistance to several important pathogens of Pacific madrone.

The potential for many projects including molecular phylogenetic studies of Pacific madrone exists and we invite other scientists with an interest in working on special assessments from these tests to contact us. More information and updates on the project will be available on the website: <http://www.puyallup.wsu.edu/ppo/madrone/>.

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