Collecting tree seed in hot, dry places: do progeny of these trees have drought tolerance and water-use efficiency needed for restoration of harsh sites?

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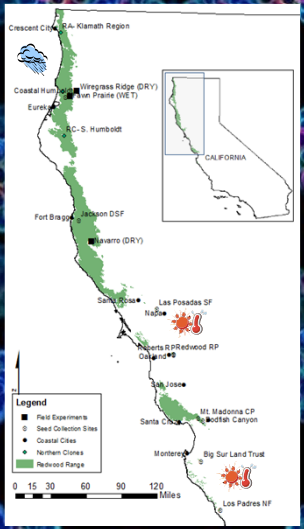
Abstract

Trees growing in the hottest/driest parts of their natural range may be better-adapted to hot, dry conditions and hold promise for restoration and resistance to climate change.

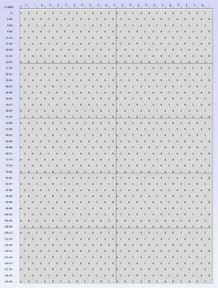
If drought tolerance and water-use efficiency were heritable traits, we could select for these characteristics and raise seedlings for reforestation on marginal sites or in areas where adverse changes in climate were forecast.

We sought to quantify heritability of these traits in coast redwood, a species with limited range and thought to be dependent on moist soils and mild summer temperatures moderated by coastal fog. The species is threatened by declining fog and warming trends at the drier extremes of its range, inland and to the south. We collected seed on dry ridges and upper slopes from the southernmost populations and inland locations where redwood experiences the hottest summertime temperatures. Our expectation was that - when planted on drier sites - their offspring would outperform seedlings from moister, more northern, coastal locations. Conversely, we expected seedlings adapted to moister locales to outperform the 'dry site' redwoods when planted on moister northern sites.

Coast redwood seedlings from southern/dry sites (from Monterey to Napa Counties), central sites (Mendocino County), and northern sites (Humboldt County) were outplanted in a replicated interlocking hexagonal experimental design, at a cool, wet northern coastal site and a hot, dry, high-elevation site (outside of redwood's natural range) in Humboldt County, and at a hot, dry site in Mendocino County, California. A total of almost 3000 seedlings were planted by Humboldt State University students in 2010 and 2011. Seedling health status and height have been measured repeatedly. The experiment will continue to provide insights into outcomes of reclamation and "assisted migration" forest conservation/restoration strategies and the impact of climate change on regional sub-populations better- or worse-adapted to the new climate. A portion of the seed collected from each tree is in long-term storage at the state seed bank in Davis, California, to conserve their genes. This will allow for future tree breeding or restoration of vulnerable, isolated, small populations at the fringes of their natural range. This poster describes the seed collection procedure and field experiment design, and shows how hundreds of students studying forestry and ecological restoration have been actively involved in this long-term study.



Experimental Design



Design features:

(i) Hexagonal design gave even spacing between neighbors, and allowed for two future thinnings (each removing a complete replicate).

(ii) Border trees (experimental buffer; row plots) surround the experiment: two rows of seedlots with too few individuals (not enough replicates) to be included in experiment.

1.2ha (2.7ac) per site

980 seedlings/site

10 replicate blocks, with 3 replicates per block (A,B,C)

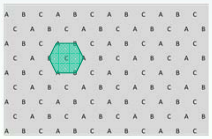
34 different seedlots

3.5m (11.5ft) spacing in triangles

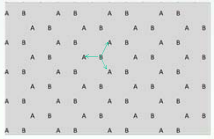
Interlocking hexagonal layout (Bill Libby, UC Berkeley)

Students surveying site, install a colored pinflag where each seedling is to be planted

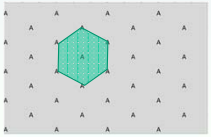
Planting: seedlings have 6 evenly-spaced neighbors, so competition is equal



First Thinning: remove 'C' trees. Every tree now has 3 evenly-spaced neighbors



Second Thinning: remove 'B' trees. Every tree now has 6 evenly-spaced neighbors



Field Sites

Three field experiment sites:

Site 1: Foggy, moist coastal site at northern latitude (Humboldt County)

Site 2: Dry, exposed, harsh site at high elevation, northern latitude (Humboldt County)

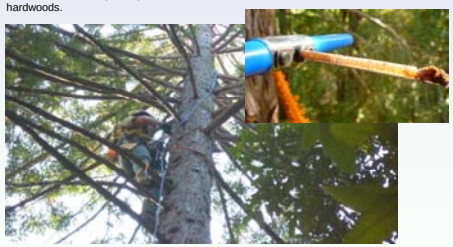
Site 3: Dry, harsh site at mid-latitude in Mendocino County

Cone Collection

Southern redwoods growing in the driest/hottest locations, mixed with shrubs or hardwoods.

Characteristics of southern redwoods: thick, flaking bark, and sparse crowns.

Cones were concentrated at the tops of the trees. Pruners provided the extra reach needed to clip the branches.



Criteria for tree selection was based on crown position (dominant or co-dominant), growth (fast), heartwood color, stem form (straight, without ramicorns or excessive forking), and branching (small, horizontal).

Small branches loaded with cones were dropped to the ground and then collected in buckets.

Seed Processing & Propagation

Cones have to be clipped from branches and kept clean before processing at CALFIRE.

Individual trees yielded 1-5 gallons of cones.

Each cone can have up to 50 seeds!

Seed processing and testing at CALFIRE L.A. Moran Reforestation Center

Seedlings raised in commercial nursery in hot, dry location (outside redwoods natural range).

Seedlots (separate seedlot for each parent tree) were tested for germination rate, cold stratified for one month, then planted at rate of four seeds per container in Styro-15s.

Data Collection & Future Studies

Students actively involved in research.

Assessment of health status and height growth.

Future: Trees can be instrumented for sapflow, water potential, etc. Trees cut at each thinning will be tested for wood properties.

Acknowledgments

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