AGRICULTURAL RESEARCH FOUNDATION
FINAL REPORT
FUNDING CYCLE 2020 – 2022

TITLE: Investigating thinning intensity impacts on tradeoffs between drought adaptation, stand productivity, and understory tree growth in Douglas-fir plantations

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EXECUTIVE SUMMARY:

Projected increases in drought frequency and severity are expected to have significant impacts on forest productivity, health, and structure in the Pacific Northwest. Concerns about how increasing drought activity will affect timber production, wildlife habitat, and a range of other ecosystem services have prompted calls for developing forest management strategies that increase the resistance and resilience of forests to drought and other climate change impacts. Thinning treatments are one of the most commonly suggested approaches to increasing drought resistance and resilience in forests, but forest managers lack key information about how tradeoffs between drought resistance, drought resilience, and other management goals such as wood production and biodiversity conservation shift as thinning intensity varies and time since thinning increases. In this project, we are assessing the impacts of different thinning intensities on the tradeoffs among drought adaptation, stand-scale wood production, and the development of understory tree layers, which are a critical contributor to the development of high-quality, late-successional wildlife habitat in forests of the Pacific Northwest.

OBJECTIVES:

1. Characterize the effects of thinning intensity on residual overstory tree resistance and resilience to drought events, and how these responses change between drought events occurring in the near-term after thinning (within five years) and in the medium-term after thinning (15-20 years).
2. Characterize the effects of thinning intensity on the drought resistance, resilience, and growth rates of understory western hemlock and western redcedar trees.
3. Quantify the tradeoffs between overstory tree drought resistance, drought resilience, stand-scale volume growth, and understory tree growth rates.

PROCEDURES:

Due to Covid-related restrictions on field housing at our originally planned field sites, we relocated the field sites for this project to Oregon State University's McDonald-Dunn Research Forest. We sampled overstory and understory trees across thinning treatments in the Mature Forest Study, a long-term thinning and underplanting trial established in 1993. The study sites included 24, 2.4-ha treatment units established within Douglas-fir plantations that were planted around 1940 and thinned to four different residual density levels in two spatial patterns

(uniform thinning and thinning with gaps), resulting in three replicates of each thinning intensity x spatial pattern combination. The study sites were thinned in 1993 and underplanted in January, 1994 using a 3 m x 3 m grid consisting an even mix of Douglas-fir (*Pseudotsuga menziessi*), grand fir (*Abies grandis*), western hemlock (*Tsuga heterophylla*) and western redcedar (*Thuja plicata*) seedlings.

We sampled stand structure and collected increment cores from both oversotry and understory trees at five sampling points in each treatment unit. We recorded the diameter at breast height (1.37 m) and species of every tree $\geq$ 10 cm dbh within a circular, 0.1-ha plot around each sampling point to characterize local stand density. We collected increment cores (i.e., tree cores) from the nearest 2-3 overstory trees and the nearest 1-2 understory western redcedar and western hemlock at each sampling point. Understory Douglas-fir and grand fir were not sampled due to poor survival since planting over the 26 years since planting. We measured the total height, diameter at breast height, and live crown ratio of each cored tree.

We mounted and sanded each increment core, measured the widths of their annual rings, and are currently in the process of cross-dating the cores to assign years to each annual ring width measurement. We will calculate annual stem volume growth from the annual radial growth measurements using regionally-derived, species-specific volume equations based on tree diameter. We calculated stand-scale metrics of drought resistance and resilience based on annual basal area growth for drought events in 2001 and 2015-2016 following D'Amato et al (2013) as:

$$\text{Resistance} = GI_D/GI_{Pre} \qquad \text{Resilience} = GI_{Post}/GI_{Pre}$$

where GI_D is the mean basal area growth during the year or years of a drought event, GI_{Pre} is the mean growth for the three years immediately prior to the drought event, and GI_{Post} is the mean growth for the three years immediately following the drought event.

We used the tree ring measurements and volume calculates to generate estimates of drought resistance and resilience for overstory trees, understory hemlock, and understory redcedar. We assessed tradeoffs between drought resistance, drought resilience, overstory productivity, and understory tree growth using the normalized benefit approach described by Bradford and D'Amato (2012). Differences in drought resistance, drought resilience, periodic volume increment, and all two-way tradeoffs between these factors were analyzed using linear mixed models.

SIGNIFICANT ACCOMPLISHMENTS TO DATE:

We completed field data collection for this project in September, 2020, completed the processing and measurement of tree cores in December, 2021, and completed data analysis in December 2022. The results are currently being written up as part of a M.S. thesis.

BENEFITS & IMPACT: Drought frequency and magnitude are projected to increase across the Pacific Northwest by the end of this century, leading to calls from forest managers and stakeholders to identify adaptation actions. This study will inform efforts to promote resistance and resilience to increasing drought activity by providing managers with information about how the impacts of thinning intensity and the spatial pattern of thinning affect drought responses over a circa two-decade post-treatment period. Importantly, our study also provides information about tradeoffs between managing for drought adaptation and managing for wood production, which will allow managers to assess the feasibility of thinning as an drought adaptation action relative to commercial wood production and/or revenue goals.

ADDITIONAL FUNDING RECEIVED DURING PROJECT TERM: $92,497 was secured for this project prior to the active award period for this ARF grant.

FUTURE FUNDING POSSIBILITIES: We plan to use results from this study as preliminary data in a larger, USDA NIFA AFRI grant proposal focused on assessing drought risk and evaluating potential drought adaptation strategies across a series of long-term study sites that span the western Cascades and coastal ranges of Oregon and Washington.