**PROJECT ID:** CAFS.20.85

**YEAR:** 2of 3

**PROJECT TITLE:** Variation in productivity, wood quality and soil carbon of ten conifer species across a gradient in water deficit

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| **PROJECT DESCRIPTION:**  In the Pacific Northwest (PNW), climate change is expected to increase average temperatures and shift precipitation regimes, contributing to more severe and widespread disturbances. The higher evapotranspiration demands and the potential increase in water deficit can be detrimental to the growth and survival of tree species in the PNW. Understanding how commercially and ecologically valuable species are sensitive to water balance deficits can help to guide species selection and management decisions for reforestation purposes to enhance stand resistance and resilience to projected climate changes.  In an effort to evaluate the relative growth between conifer species in western Oregon as well as improve the understanding of species sensitivity to climate variability, a species comparison study was implemented in 1996. Ten native and non-native conifer species were planted in three sites along a water deficit gradient from the western Coast Range to the Willamette Valley of western Oregon. These species include ponderosa pine, Port-Orford cedar, Douglas-fir, grand fir, western hemlock, western redcedar, giant sequoia, Leyland cypress, Sitka spruce, and western white pine. An additional unplanted (naturally-regenerated plot was included on each site, as all the seedlings of the originally planted species (Japanese larch) died during the first growing season.  The overall objective of this proposal is to better inform species selection for reforestation efforts. We will compare productivity, wood quality, and the sensitivity of the ten conifer species to varying environmental conditions as well as investigate variations in wood density, above ground biomass and soil organic matter and soil nutrient pools. |
| **HYPOTHESES or OBJECTIVES:**   1. Measure and compare the cumulative, annual, and intra-annual growth and wood density of the ten species across the water deficit gradient. 2. Measure and compare LAI, aboveground biomass and net primary productivity (NPP) of the ten species (including overstory, midstory and understory) across the water deficit gradient. 3. Measure and compare soil organic matter and nutrient pools of the ten species across the water deficit gradient. 4. Correlate environmental factors with NPP, intercepted radiation, LAI, and soil OM. |
| **METHODS:**  This study focuses on three sites distributed from Oregon’s Coastal Range to the Willamette Valley, with an average annual precipitation ranging between 1300 to 2000 mm. In 1996-1998, ten 0.5-acre plots were planted at each site, with each plot containing one of ten conifer species: ponderosa pine, Port-Orford cedar, Douglas-fir, grand fir, western hemlock, western redcedar, giant sequoia, Leyland cypress, Sitka spruce, and western white pine. No prior data have been collected on these sites.  In the winter of 2021, weather stations were installed at each site and a measurement plot containing 100 trees was implemented within each species’ plot. Height and DBH measurements as well as percent mortality were recorded in the winters of 2021, 2022, and 2023 to determine the cumulative and annual volume, basal area, and biomass growth for each species at each site. Total and aboveground biomass, including overstory, midstory, understory, and forest floor biomass, were also determined using species-specific biomass functions and direct measurements. In the summer of 2022, samples were taken on forest floor and in mineral soil to a depth of 1 m (0-15, 15-30, 30-50, 50-100 cm) within each plot in order to describe the organic matter composition of the soil. In April 2022, Plant Root Simulator probes were installed in all plots in order to quantify differences in soil nutrient availability across species and sites. Bi-monthly since the winter of 2021, litterfall from five litterfall traps per plot were collected and used in conjunction with biomass data to determine NPP for each species at each site. Bi-monthly since the winter of 2021, LAI at each plot was measured with a ceptometer and LAI-2200c canopy analyzer, which was then combined with NPP data to assess growth efficiency for each species at each site. In the winter of 2021, dendrometer bands were installed on ten trees per plot and are measured monthly to determine intra-annual diameter growth rate as well as the timing and length of the growing season. Wood increment cores were extracted from the ten banded trees during the winter of 2022 to measure total wood density as well as annual basal area increment and latewood percentage.  Additional measurements on mineral soil (2 more points per plot at 4 depts), as well as overstory inventory, midstory DBH and understory cover and height will be performed during year 2023 in order to improve the accuracy and expand the outreach of the estimates. Measurements on dendrometer bands will continue until December 2023 in order to capture more climatic variability into the drivers of dimeter growth of each species. |
| **MAJOR FINDINGS:**  From initial observations, assuming productivity is reflected by measurements of volume, biomass, NPP, and basal area increment over time, it is determined that there are differences in the growth-climate sensitivity and productivity between species under different levels of water deficit. Some species such as Douglas-fir appear to have consistent productivity across sites and were therefore less sensitive to differences in climate and water deficit. Other species, such as grand fir and giant sequoia, showed remarkable productivity on wet site and had progressively reduced productivity under higher levels of water deficit. In contrast, the productivity of ponderosa pine and western white pine was reduced under higher levels of water availability.  Further, significant differences were found in the timing of diameter growth initiation and cessation, which were typically driven by temperature rather than water deficit, across species and sites. Annual BAI, annual latewood BAI, and latewood percentage as derived from tree ring measurements significantly differed between species and across sites over time while wood basic density significantly differed between species and across sites. The annual BAI and annual latewood BAI for most species were influenced by climate conditions associated with water supply and evaporative demand while the annual latewood percentage for most species were only influenced by water supply.  Both aboveground and belowground biomass across most species tended to progressively reduce under higher levels of water deficit, and differences between species and sites were also reflected in the amount of various soil macronutrients and micronutrients. However, in terms of growth efficiency, there is an opposite trend, increasing from the wet to dry site. As for the slope of the relationships between BA/LAI and ANPPT (crop tree) /ANPPM (midstory), while there is a positive sigmoidal relationship between BA/LAI and ANPPCT, there is a negative power relationship between BA/LAI and ANPPM.  When comparing biomass stock on naturally-regenerated against planted plots, the naturally regenerated plots showed similar or even larger soil organic matter, but less that 1/10 of aboveground biomass stock. |
| **DELIVERABLES:**  Two MS students were graduated on this project (Emily Von Blon in in summer 2022 and Erkan Babat in spring 2023). Two oral presentations were performed at the annual meeting of the Vegetation Management Research Cooperative (winter 2022 and 2023). Manuscripts for peer-review journals are in process. |
| **MEMBER COMPANY BENEFITS:**  This project would ultimately allow for a better understanding of the sensitivity of 10 commercially and ecologically valuable species in the PNW, in term of productivity and wood properties, to water deficit and climate variability. This information becomes relevant in light of climate change and the projected increase in water deficits across the region. Understanding the growth-climate relationship for many alternative species, as well as its impact on wood quality, will help management decisions on species selection for reforestation purposes. It can also contribute to the enhancement of stand productivity, which can improve resistance and resilience to projected climate changes while serving as a mitigation tactic through increased carbon sequestration. |