FOREST REGENERATION IN CHANGING ENVIRONMENTS CONFERENCE POSTER ABSTRACTS

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EVALUATING POST-FIRE RESTORATION IN THE MIXED CONIFER FOREST OF THE SIERRA NEVADA USING PLANTATIONS

The fire regime in the mixed conifer forests of the Sierra Nevada has changed in the past century due to fire suppression and logging practices. Historic fires were frequent and low to mixed severity, keeping the forest horizontally heterogeneous and low density. Fire suppression has increased tree density and fuel continuity. This has resulted in much larger, more severe fires that leave large, continuous areas intensely burned. Mixed conifer tree regeneration is often limited after large, high severity fires due to loss of seed source and shrub encroachment. For these reasons plantations are established to aid in restoring the forest. This is what happened after the high severity, 2004 Power Fire in the Eldorado National Forest. Over 2000 hectares of plantations, in several different planting arrangements were planted, including a cluster arrangement consisting of 2-4 trees spaced out 1m from each other with 6.4m between clusters, and evenly spaced trees 3-4.5m from each other. Current sampling efforts are looking at planting arrangement effect on growth, shrub coverage, stomatal conductance, natural recruitment, and soil characteristics. We are comparing thinned and untinned cluster and even plantations as well as natural regenerating stands. Growth rates and fire will be modeled through each stand. Through this research, we hope to inform the management of post fire plantations in their efforts to restore forest structure and function.

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RED SPRUCE IN THE SOUTHERN APPALACHIANS: GENE CONSERVATION, SEED PROPERTIES AND ADAPTIVE TRAITS FOR FUTURE CLIMATES

Red spruce (*Picea rubens*) populations in the southern Appalachians (Tennessee, North Carolina, Virginia) are disjunct from larger northern populations in New York, Vermont, New Hampshire, Maine and Canadian Maritime provinces. Heavy logging followed by severe fires in the early 20th century resulted in a > 90% reduction in spruce-fir forests in the southern Appalachians. The remaining red spruce populations are highly fragmented and restricted to high elevations. Considering their adaptation to cool, humid environs, they have the potential to become maladapted with predicted climate change. To assess existing populations for adaptive traits (phenology, physiology) we collected seed from several populations in North Carolina, Tennessee, and Virginia (half-sib) with the goal of propagating seedlings and identifying phenotypic differences in common garden plantings. Seed was collected from 15 trees in 2015 and 115 trees in 2016 from elevations ranging from 1036 to 1988 m. Red spruce produces seed in large quantities every 3-8 years making seed collection difficult and subject to finds of opportunity. The cones were dried, seeds removed and de-winged manually, heavier seed were removed from debris and cleaned via aspiration. A subset was weighed and counted to yield mean seed mass and 200 seeds were exposed to radiographic imaging to estimate the percent of filled and potentially viable seed. Across all 130 families seed mass ranged from 1.0 to 4.4 mg and averaged 2.6 mg per seed. Seed mass and germination rate increased with elevation across all families and the relationship was strongest in trees in close geographic proximity from different elevations. Percent filled seed generally increased with elevation, but declined at the highest elevations. Surprisingly, estimated percent filled seed did not relate to germination rate. Germination experiments are ongoing to assess whether all families have optimal germination at standard conditions for the genus *Picea* (30C/8hr/light and 20C/16hr/dark). Seedlings are currently being propagated for phenotypic and physiological comparisons (growth, photosynthetic capacity, WUE, bud break, bud set) and will be out planted for continued study. Key findings are that red spruce in the southern Appalachians are producing the largest, most viable seeds the very tops of the mountains and have essentially run out of elevation to migrate towards. We hope to identify and deploy families that are suited to survive and regenerate at lower elevations and warmer conditions to resist losing species range for as long as possible in a warmer future.

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DOUGLAS-FIR SEEDLINGS IN THE PACIFIC NORTHWEST: THE GENETICS OF DROUGHT ADAPTATION

Douglas-fir (*Pseudotsuga menziesii*) is a widely distributed, ecologically important, and commercially valuable tree species in North America. However, climate change is expected to adversely impact Douglas-fir trees, and assisted migration may become necessary to lessen the effects of climate change. Because drought stress is one of the projected effects of climate change in the western U.S., it is increasingly important to include drought adaptation traits in breeding programs and in reforestation decisions. In this study, I addressed the following objectives: (1) obtain baseline measurements and climate data to help in the analysis and interpretation of future measurements in the Drought Hardiness Study; (2) characterize the quantitative genetics of drought adaptation traits; and (3) determine whether drought adaptation traits are associated with the climatic origin of Douglas-fir seedlings. To achieve these objectives, data were collected from about 10,000 Douglas-fir seedlings from 429 families from western Oregon and Washington that were planted at two sites (Sprague and Lost Creek) in southern Oregon. Measured variables, which I refer to as drought adaptation traits, included height, second flushing, spring bud flush, damage (foliage, stems, and leaders), and survival. I will discuss the design and results of a study that help increase the understanding about the importance of climatic-driven genetic differences for drought adaptation traits in Douglas-fir. The results of this study will provide useful information for understanding drought, enhancing breeding programs, and potentially adjusting forest management to climate change impacts.

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LONG TERM EFFECTS OF SITE PREPARATION ON GROWTH AND PRODUCTIVITY OF INTERIOR DOUGLAS-FIR AND WESTERN WHITE PINE IN NORTHERN IDAHO

Silvicultural treatments applied prior to regeneration or during early stages of stand development can affect tree and stand productivity throughout the rotation. Most studies rarely extend measurements beyond the first decade after treatment, limiting our ability to properly assess long-term treatment efficacy. This is especially true in forests of the Inland Northwest. In 1982, a study was initiated on the Priest River Experimental Forest in northern Idaho to test the effects of different mechanical and chemical site preparation treatments on regeneration performance of interior Douglas-fir (*Pseudotsuga*

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menziesii var. glauca) and western white pine (*Pinus monticola* Dougl. ex. D. Don) seedlings. The study was replicated at two sites: a high elevation site and a low elevation site. Within each site four treatments were replicated 3 or 4 times per tree species, including (1) organic horizon removal and mineral exposure (scalping), (2) organic soil bedding without competition removal, (3) organic soil bedding with chemical competition control, and (4) an untreated control. The objective of the study is to examine temporal trends in tree growth and growth efficiency to determine if tree productivity was substantially altered by the type of site preparation. Measurements will occur in summer 2017, 35 years after treatment, and 27 years since previous measurements. Trees will be destructively sampled to reconstruct patterns of stem diameter and height growth, and growth efficiency (volume growth increment per unit leaf area). The results of this study will be useful in understanding if site preparation treatments affect site conditions enough to alter changes in tree growth and potential productivity.

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LONG TERM EFFECTS OF VEGETATION MANAGEMENT IN THE PNW: ASSESSMENT OF BIOMASS STOCK AND NET PRIMARY PRODUCTIVITY RESPONSES OF FOUR CONIFEROUS SPECIES

Currently the Vegetation Management Research Cooperative (VMRC) at Oregon State University has two CTP (Critical Period Threshold) studies with 15-16 years of monitoring data on different conifer species (Douglas-fir, western redcedar, western hemlock, and grand fir), in sites located in Coastal range and Piedmont of Cascade Mountains. These studies provide a unique opportunity to evaluate long-term responses to intensive vegetation management treatments, assessing differences across species as well as differences across sites. Even though responses in basal area and volume per acre are well documented for these studies, we do not know the long-term impact of these treatments on total ecosystem productivity and stand sustainability. An effective way to estimate that response is by evaluating aboveground net primary productivity (ANPP, Mg ha-1 year-1) or total biomass stock (including soil, forest floor and competing vegetation biomass). On both sites we measured litterfall, tree biomass, understory biomass, forest floor and soil organic matter in two contrasting VM treatments.

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CONTROL OF *SAMBUCUS RACEMOSA* ON FOREST REGENERATION SITES

The widespread of red elderberry (*Sambucus racemosa*) has increased considerably in recent years and the species are troublesome especially on forest regeneration sites. Sufficient seedling establishment of new forest are important both for the forest owner and to achieve the role of forest related to climate change (IPCC 2014). Dense stands with red elderberry are one of the main reasons for use of glyphosate on forest regeneration sites in Norway. The measure is controversial, and there is therefore a need for documentation on the effect of the measure compared with alternative control methods. Natural spread of the species occurs mainly by birds who willingly eat the juicy fruits. In the risk assessment to "Norwegian Black 2012» red elderberry was categorized as "high risk" because species with its rich fruit setting and juicy fruits can affect the spread of our domestic shrubs with juicy fruits. Experimental plots were established on three sites in Eastern Norway in 2013 to provide a better knowledge on control methods. The experiment consists of the following treatments 1) cutting in June or (2) October; 3) cutting in June and stump treatment with glyphosate; 4) leaf spraying with glyphosate June or 5) August; 6) cutting in June and spraying with glyphosate on regrowth in August; 7) control. There was a high level of regrowth following cutting, and this methods had only limited effect on the height of the shrub. There was a significant correlation between stem diameter before cutting and height and number of re-sprouting stem and branches two growing seasons after cutting. Spraying in August showed markedly reduced plant height in all three fields. Spraying in June was effective in two of three sites. Stump treatment was not as effective as leaf spraying, probably because it is too small stumps and therefore less uptake of glyphosate.

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PHOTOPERIOD REDUCTION INFLUENCES WESTERN LARCH (*LARIX OCCIDENTALIS* NUTT.) SEEDLING DEVELOPMENT

Western larch seedlings grown in a greenhouse were subject to short day treatments that resulted in differences in seedling morphology and physiological status. Once seedlings reached 10 cm in height growth, treatments were induced that resulted in reduction of photoperiod from ambient to 8 hours for durations of 7, 14, 21, or 28 days (a 0-day control was also maintained). A 5mm blackout polyfilm cloth was positioned above the containers to eliminate photosynthetically active radiation from reaching the seedlings. Height, root collar diameter, bud formation, outplanting survival rates, and seedling net photosynthetic assimilation were assessed. The objectives of this study were to (1) determine the morphological and physiological effects of mid-summer photoperiod reduction of differing durations on western larch seedlings and (2) compare growth and survival between fall- and spring-planted seedlings subjected to these short-day treatments. It is hypothesized that short-day treatments, particularly those of a longer duration, will induce dormancy (as measured by cessation of height growth, initiation of bud-set, and decreased rates of photosynthesis) and will result in greater fall outplanting success, as measured by seedling survival. If the duration of short day treatments can be minimized while still producing the desired dormancy induction, effort towards applying blackout cloth can be minimized within nursery operations.

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USING AGE-SHIFT METHOD TO ESTIMATE LONG-TERM GAINS OF VEGETATION MANAGEMENT

Age shift (or time gain) is an alternative method for analyzing long-term responses to silvicultural treatments that focuses on determining the number of years of advancement in growth realized at a given age. We analyzed 4 studies with long-term responses of planted conifer stands to vegetation management treatments using the age-shift approach. For the 4 conifer species tested (Douglas-fir, western hemlock, western redcedar and grand fir), the age-shift response ranged between 0 to 8 years, depending on site and vegetation management treatment applied. When compared at the same site, western red cedar was more responsive to treatments and had age-shifts that were 2-6 years larger than Douglas-fir. One year of spring release showed

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no effect on Douglas-fir and western hemlock. Age-shift analysis can be used to support decision making about thinning and rotation length making it a useful tool in economic analysis.

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ESTABLISHING AND MONITORING BLISTER RUST RESISTANCE, PATHOGEN VIRULENCE, AND GENETIC ADAPTABILITY OF WESTERN WHITE PINE IN WASHINGTON

Western white pine (WWP, *Pinus monticola* Dougl.) is a wide-ranging forest tree species of high economic and ecological value. However, due to several factors, including the inadvertent introduction of the non-native fungal pathogen *Cronartium ribicola* Fisch. (cause of white pine blister rust (WPBR) disease) around 1910, there has been extreme levels of mortality in many natural populations of WWP, and a greater reluctance to use this species in reforestation. The Washington Department of Natural Resources and the USDA Forest Service's Dorena Genetic Resource Center have partnered to undertake a series of field trials to evaluate disease resistant WWP. Trials recently planted in western Oregon and eastern Washington, complementing another test series planted in 2006/2007 in western Washington, will provide key information on the efficacy of rust resistance over time, as well as the adaptability of different seed sources of WWP in a changing climate. These trials include both the most advanced seed orchard lots currently available, as well as seedlings from parents spanning the full range of resistance types currently known for WWP. The parent trees for this trial originate from Oregon, Washington, Idaho and British Columbia. A This series of trials will provide information on genetic resistance to white pine blister rust, on adaptability of seedlots from different geographic sources in these locations, and serve as sentinel plantings to monitor impacts of pathogens and insects or impacts from abiotic events associated with a changing climate. Nine years after planting the western Washington trials, the level of blister rust infection varies dramatically among the six sites assessed in 2015, from 6.9 % to 61.9%. Sites in western Washington vary dramatically in their apparent rust hazard, according to our data, and different management strategies (level of resistance, pruning, spacing, etc.) may be utilized across the region.

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ACHIEVING ADEQUATE OAK REGENERATION THROUGH SHELTERWOOD CUTTINGS IN MISSISSIPPI

Bottomland hardwood sites have some of the most productive forest soils, and correspondingly high species richness ratings found in North America. However, inherently fertile soils often lead to increased vegetative competition and difficulty establishing oak species in total harvest operations across the southeastern U.S. Shelterwood harvesting is often prescribed as a viable regeneration option in these systems with a basal area target of 11.48m2/ha. Six, 8.1 hectare study areas representing typical bottomland hardwood sites were selected in Mississippi. Stands selected averaged 83 years, possessed overstory canopies comprised of 67.5 percent oak, and initial basal area ranging between 21.12m2/ha and 28.01m2/ha. Six overstory removal treatments (16.07m2/ha, 13.77m2/ha, 11.48m2/ha, 9.14m2/ha, 6.89m2/ha, and untreated) and midstory removal were tested to determine which residual basal area created appropriate light and competition conditions to maximize regeneration density. Six year results are presented with a wider range of treatments than typically prescribed in regeneration efforts of this forest type. While, the 11.48m2/ha basal area treatment yielded the greatest seedling densities, seedling density in other treatments was excellent as well. It is entirely possible that land managers may target a wider, more flexible basal area range than typically prescribed in these systems.

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COLLABORATIVE RESEARCH FOR SUSTAINABLE MANAGEMENT OF SOUTHWESTERN WHITE PINE

A collaborative team of researchers from the United States (U.S.) and Mexico have begun an exciting new research project funded by The National Science Foundation's Macrosystems Biology program. The project is to study ecological and evolutionary processes affecting the distribution of southwestern white pine, an important tree species of mixed conifer forests in the southwest U.S. and Mexico. Southwestern white pine (*Pinus strobiformis*) sustainability is threatened by changing climate, and a non-native tree disease, white pine blister rust. White pine blister rust causes extensive tree decline and mortality where it occurs in North America, including where it overlaps with southwestern white pine, an ever-expanding area. Climate may change too rapidly for southwestern white pine to adapt. The dual threats of climate change and an invasive species make forecasting future tree distributions across continental scales an urgent challenge. The goal is to determine how gene movement among populations, adaptation to disease and drought, heritable changes beyond DNA mutations, and a changing environment interact to govern the success of southwestern white pine. This project will develop tools to help forecast and manage the future of the species, including genomics, common gardens, disease resistance testing, engineering, and technology innovation to measure drought tolerance, and computer modeling in landscape ecology and genomics. The research team is using the Southwest Experimental Garden Array, set of common gardens, that allows scientists to quantify the ecological and evolutionary responses of species to changing climate conditions. We will present an overview of the project, an update on status and preliminary results, and potential management applications focused on regeneration of southwestern white pine.

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