AN ABSTRACT OF THE DISSERTATION OF

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Title: Characterizing Early-Seral Competitive Mechanisms Influencing Douglas-fir Seedling Growth, Vegetation Community Development, and Physiology of Selected Weedy Plant Species

Abstract approved: ______________________________________

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Three studies were conducted to characterize and present early-seral competition between Douglas-fir seedlings and the surrounding vegetation communities during Pacific Northwest forest establishment. The first experiment served as the foundation for this dissertation and was designed to quantify tradeoffs associated with delaying forest establishment activities by introducing a fallow year in order to provide longer-term management of competing vegetation. A range of six operationally relevant treatments were applied over two growing seasons that included in the first (1) a no-action control, (2) a spring release only, (3) a fall site preparation without sulfometuron methyl followed by a spring release, as well as (4) a fall site preparation with sulfometuron methyl and a spring release. In the second year, there was (5) a fall site preparation without sulfometuron methyl followed by a spring release and also in the second year (6) a fall site preparation with sulfometuron methyl and a spring release. Treatments 5 and 6 were left fallow without planting during the first year. These treatments were applied in two replicated experiments within the Oregon Coast Range.

After adjusting for initial seedling size, year-3 results indicated that plantation establishment and competition control immediately after harvest (i.e. no fallow period) enabled seedlings to be physically larger than those planted after a one year delay. At the Boot study site, limiting vegetation below 20% for the first growing season improved year-3 Douglas-fir seedling stem volume over 273 cm^3. Delaying establishment activities

one year and reducing competing vegetation below 11% enabled seedling volume after two years to be statistically the same as three year old seedlings in the no-action control, a volume range of between 148 to 166 cm^3. Delaying forest establishment at Jackson Mast improved seedling survivorship over 88% when a spring heat event reduced survivorship of trees planted a year earlier to less than 69%. The combined effect of applying a fall site preparation and spring release was necessary to reduce competitive cover below 10% in the year following treatment and provided longer-lasting control of woody/semi-woody plants. Less intense control measures (i.e. no-action control and treatment 2) were not able to restrain woody/semi-woody plant cover which grew to nearly 40% at Boot and over 24% at Jackson Mast in three years. No treatment regime provided multi-year control of herbaceous species. Including sulfometuron methyl in the fall site preparation tank-mix did not have a negative effect on seedling growth or provide significant reductions in plant community abundance in the year following application when compared to similar regimes that did not include the chemical. Delaying establishment lengthened the amount of time associated with forest regeneration except on a site that accentuated a spring heat event.

In the second study, horizontal distance and azimuth readings provided by a ground-based laser were used to stem map seedling locations and experimental unit features at Boot. These data were used to create a relative Cartesian coordinate system that defined spatially explicit polygons enabling, for the first time, the ability to collect positional data on competing forest vegetation within an entire experimental unit. Deemed “vixels” or vegetation pixels, these polygons were assessed for measures of total cover and cover of the top three most abundance species during the initial three years of establishment. An alternate validity check of research protocols was provided when total cover resulting from this vixel technique was compared to a more traditional survey of four randomly located subplots. The resulting linear regression equation had an adjusted R^2 of 0.90 between these two techniques of assessing total cover. When compared within a treatment and year, total cover differed by less than 12 percentage points between the two techniques. Analysis of year-3 woody/semi-woody plant cover produced by the techniques led to identical treatment differences. Two treatments resulted in woody/semi-woody cover of approximately 1500 ft^2 by the vixel method and nearly 40%

cover by the subplot method while the remaining four treatments were grouped below 600 ft^2 or 20% cover, respectively. With continued refinement, these techniques could visually present forest development through all phases and provide long-term information used to bolster growth and yield models, measures of site productivity, as well as community ecology research.

The third study evaluated the season-long gas exchange and biomass partitioning of four weedy plant species capable of rapidly colonizing Pacific Northwest regenerating forests. *Cirsium arvense*, *Cirsium vulgare*, *Rubus ursinus* and *Senecio sylvaticus* were studied at two sites. A greenhouse was used to introduce two levels of irrigation (well-watered and droughty). These species were also studied while growing among a larger vegetation community at a field site. Irrigation treatments had little impact on gas exchange rates. Species achieved maximum photosynthetic rates of 30, 20, 15 and 25 $\mu mol\ CO_2\ m^{-2}\ s^{-1}$ (respectively) prior to mid-July coinciding with an active phase of vegetative growth. As the season progressed, photosynthetic rates declined in spite of well-watered conditions while transpiration rates remained relatively consistent even when soil water decreased below 0.25 $m^3\ H_20/m^3$ soil. Water use efficiency was high until late-July for all study species, after which time it decreased below 5 $\mu mol\ CO_2 \cdot mmol\ H_2O^{-1}$. Multi-leaf gas exchange measurements as well as biomass data provided a holistic view of plant-level mechanisms used to shunt activity toward developing tissues. Herbaceous species had assimilation rates that differed vertically (within each species) by as much as 10 to 20 $\mu mol\ CO_2\ m^{-2}\ s^{-1}$ from July to September as lower leaves senesced in favor of those higher on study plants. Specific leaf area was greatest in June for all species then declined indicating species placed little effort into sacrificial early season leaves when compared to those higher on the plant that could continue to support flowering or vegetative growth. The study of seasonal gas exchange in the presence of declining water availability has helped to describe competitive mechanisms at work during forest regeneration as well as provide physiologic support for the application of vegetation management regimes.