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Influence of Ash Substrate Proximity on Growth and Survival of Planted Mixed-Conifer Seedlings

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ABSTRACT

To address uncertainty in the performance of seedlings planted in and around postburn substrates, we systematically planted seedlings in the center of, on the edge of, and outside ash substrate footprints following burning of logging residue piles and monitored growth and survival for a decade. Five species (Douglas-fir [*Pseudotsuga menziesii*], giant sequoia [*Sequoiadendron giganteum*], incense-cedar [*Calocedrus decurrens*], sugar pine [*Pinus lambertiana*], and ponderosa pine [*Pinus ponderosa*]) were planted in a regenerating mixed-conifer stand in the Sierra Nevada range of California. There was a positive effect of ash substrate proximity on growth that was immediate and persisted for 10 years for every species except incense-cedar. Seedlings planted in the centers of ash substrates consistently outgrew (in both height and basal diameter) seedlings that were planted either on the edges of or outside ash substrates. Douglas-fir had the greatest height gain (+47%), followed by giant sequoia (+28%), sugar pine (+23%), and ponderosa pine (+17%). Basal diameter differences were similar. No effect of ash proximity on survival was detected. Planting seedlings in the centers of ash substrates led to exceptionally larger trees by the time the stand had developed enough to apply a precommercial thin, a relevant milestone for managed stands.

Keywords: slash piles, regeneration, repeated measures, site preparation

Ash substrates on forest floors are common following wildfires, prescribed fires, and site preparation activities. The survival and growth of seedlings planted in and around these ash substrates is dependent on a wide variety of environmental factors. The burning of litter and debris changes seedling growing conditions in ways that may either hinder or enhance seedling survival and growth, depending greatly on the intensity of the fire and site-specific soil properties (Certini 2005). Postfire seedling performance may be hindered if soils become deficient in nutrients through volatilization (Ballard 2000, Jimenez Esquilin et al. 2007) or if soils lose microbial biomass (Busse et al. 2005), become hydrophobic (DeBano et al. 1998), or become sites rapidly colonized by competing exotic species (Korb et al. 2004). Alternatively, ash substrates may enhance early growth because of increased nutrient availability (Seymour and Tecle 2005, Thorpe and Timmer 2005) or because of beneficial microclimate changes such as increased growing season temperature (Piatek et al. 2003). Management success of artificial regeneration efforts in and around ash substrates ultimately depends on the net changes in growing conditions and how long-lived effects are.

Planted seedling success is also influenced by methodological choices during planting. The survival and growth of seedlings are dependent on specific planting methods, species used, and the choice of specific planting locations where greater seedling success is more likely. These choices are of particular importance following site preparation techniques that involve the pile and burning of slash residues. Large slash piles can create planting locations where the negative effects of fire on soil properties may be particularly extreme because of high intensity and duration of heat fluxes into the soil profile. Ash beds created by burning a single large burn pile create a steep gradient of soil conditions for seedlings in one small area (Jimenez Esquilin et al. 2007). Choice of planting location in and around these steep gradients is therefore likely to be a key determinant in the ultimate success of postfire planting.

We experimentally tested the outcome of three basic options for planting in and around burn pile ash substrates: planting inside, on the edge of, and adjacent to ash substrates. We relied on repeated measurements of seedling survival and growth over 10 years following planting to find the effect of ash proximity on seedling performance over a time period that was long enough to be relevant for management. Five commercially important species were tested: Douglas-fir (*Pseudotsuga menziesii* [Mirb.] Franco var. menziesii), incense-cedar (*Calocedrus decurrens* Torr.), sugar pine (*Pinus lambertiana* Dougl.), ponderosa pine (*Pinus ponderosa* Dougl. ex Laws.), and giant sequoia (*Sequoiadendron giganteum* [Lindl.] Buchholz). The experiment is empirical in nature: designed to observe, with good power of detection, the effects of alternative practices on meeting regeneration objectives.

Methods

Study Site

Blodgett Forest Research Station (BFRS) is located on the western slope of the central Sierra Nevada mountain range in California (38°52′N, 120°40′W). The study area lies within BFRS at an elevation between 4,002 and 4,298 ft. The climate is montane Mediterranean with dry, warm summers (mean summer temperature, 20°C) and mild winters (mean winter temperature, 5°C). Annual precipitation averages 65 in., most coming from rainfall during fall

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