The impact of overstory density on tree seedling regeneration and understory shrub cover in a mature mixed-conifer dry forest.

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Abstract

Dry forests of the eastern Cascades are dominated by Pinus ponderosa and Pinus lambertiana. Research associates these species with lower levels of competition for light and nutrients. P. menziesii and P. contorta are associated with higher levels of competition. Ponderosa pine is associated with P. ponderosa. High-grade timber extraction and fire exclusion has altered stand composition with a higher regeneration proportion of P. menziesii in mixed species stands. This study examines the effect of overstory density on tree seedling regeneration and understory shrub cover in a mature mixed-conifer dry forest. The impact of substrate, litter, woody debris, and canopy cover on seedling growth was measured by quantifying substrate, litter, woody debris, and canopy cover. Sampling and sapling presence and count data were collected for each species in addition to understory species richness. This data was compared to basal area measurements for corresponding treatments. Basal area varied among the 40 plots with over 1/3 of the plots containing 31-40 m²/ha with most of the basal area as P. menziesii. Regeneration occurs in stands with less than average stocking, P. menziesii is the majority of regeneration. A positive relationship was found between higher percentages of substrate cover, litter, bare ground, woody debris and regeneration. The vast majority of seedlings were on plots with >40 litter cover. Canopy cover and basal area showed little relationship to species richness, however increased amounts of regeneration was found with increased basal area canopy conditions. Comparing species richness across treatments found increased regeneration with higher species richness. These implied that increased levels of stocking equated to greater counts of P. menziesii, and therefore higher counts of P. menziesii regeneration, which leads to increased competition for P. ponderosa regeneration.

Introduction

Pinus ponderosa/P. menziesii mixed forests in Eastern Washington range from 600 to 1200 meters in elevation in a climate characterized by minimal summer precipitation and an annual precipitation of 35-760mm (mostly comprised of winter snowfall). Fire has historically maintained the grass-dominated understory, reduced litter accumulation, and recycled nutrients while facilitating a park like overstory of drought tolerant conifers (i.e. P. ponderosa and P. menziesii; Lulbridge et al. 1995; Agee 1994; Franklin & Denny 1973). In the absence of fire, or as a result of fire suppression, timber harvests have increased overstory density in driving site composition and structure. As larger trees were removed by selective logging, small canopy gaps were created and later filled by regeneration of heterophytes from the seed bank through seed rain from retained mature trees. Often a secondary result of harvest in the absence of fire is an overstocked stand with more shade tolerant trees, as well as reduced growth rate in the absence of regular thinning or disturbance. Returning these overstocked stands to their historical stand structure has the potential to restore vigor, and possibly allow for the return of a non-stand replacing fire regime (Harrod et al. 1999). Understanding current regeneration dynamics with respect to overstory density would facilitate more informed decision making on silvicultural prescriptions aimed at improving forest vigor. Little is known about the effects of different overstory densities on establishment and early development of natural regeneration (Brodie & DeBell 2013). Relating stocking through basal area measurements with regeneration and understory composition can describe the effect of the overstory on regeneration. The objectives of this study are a) determine basal area in order to assess stocking, then b) determine the effects of stocking on timber species regeneration and understory species richness. Tertiary objectives included evaluating the relationship of slope and aspect on current stocking, regeneration, and species richness.

The study took place on Washington State Department of Natural Resources (DNR) land. The "Elk Heights" site is a 52 acre unit located between Cle Elum and Ellensburg, WA (47°07'49.0"N, 120°49'25.0"W). The study was divided into equal sized plots (Figure 3a.), in order to establish a randomized complete block design for analysis. After removing plots containing roads and landings, 48 plots were used as representative for sampling; being too open due to effects of campsites, roads, or previous landing sites. Sampling consisted of variable radius basal area measurements taken with prisms at the center of each plot. A 20 meter transect was placed at plot center in order to capture the environmental conditions associated with basal area measurements. Aspect, slope, and slope position were collected for each site. Each type of understory species present was listed, as well as species and number of seedlings and saplings for all but 7 plots. Overstory cover was measured in meters of coverage on dripline on the tree for up to two meter away at each site. At a circular plot with a radius of 0.5 meters was surveyed at the 5, 10, 15, 20, and 30 points. Those subplots quantified the percentage of substrate cover, litter, woody debris, and bare ground along with whether the canopy coverage was open, partial, or closed.

P. ponderosa regeneration

Basal Area

All Species Regeneration

P. ponderosa regeneration

P. menziesii regeneration

Methods

These figures illustrate the majoreity of the sampled plots have stocking in the range of 31-40m²/ha. The majority of standing timber per sampled acreage is <40m²/ha; this is most apparent for P. ponderosa.

Results

There is a positive relationship between higher percentages of substrate cover, litter, bare ground, woody debris and the increased number of regeneration. Although not a strong trend, there is a higher frequency of species richness in open canopy, increased basal area in closed canopy, and increased regeneration in partial canopy.

Discussion

Examining basal area, it appears that regeneration occurs mostly in the less than average stocked stands (Figures 2 & 5), as stands with the highest amount of P. menziesii basal in the overstory (Figure 3). With the majority of regeneration as P. menziesii (Figure 6) and low amounts of P. ponderosa (Figure 4), little P. ponderosa regeneration (Figure 7). Low P. ponderosa establishment is likely related to low shade tolerance, although competition and low seed availability cannot be ruled out. Greater P. menziesii seed source and its ability to not only benefit from full overhead light, but also grow in partial shade which can be important for establishment and early development on forest or forest edges (Nelson et al. 2001). At Elk Heights it appears that P. menziesii is more adapted to regenerating in late snow melt areas, where it is utilizing moisture perhaps shortening periods of summer drought.

Increased basal area in these stands not only offer increased seed source but light for the shade intolerant shrub and herb species found in this dry forest. With increased stocking and therefore increased seed rain are demonstrated in the higher frequency of total regeneration that occurs in the higher percentages of substrate cover, litter, woody debris, and bare ground (Figures 8 & 11). Where there is higher basal area, there is a positive correlation with woody debris, litter, and substrate cover. These in turn are likely the factors facilitating increased regeneration immediately after germination (Duguid & Ashton 2013).

In understory species greater resource availability and heterogeneity results from gap creation (Duguid & Ashton 2013). This idea is supported by my findings regarding the relationship between canopy coverage and species richness, where it appears that a greater numbers of species are found primarily in open canopy conditions (Figure 11). Also, it is possible that the shade intolerant shrub and herb species found in this dry forest are increasing competition for P. ponderosa during early regeneration (Lulbridge et al. 1995).

Conclusions

The data reports a transition on this site from a P. ponderosa to P. menziesii dominated overstory due to the ability of P. menziesii to take advantage of mesic and increasingly light limited conditions; as result of past variable harvests, it is outcompeting P. ponderosa. Generally, the data suggests a relationship with relating the current potential organic matter accumulation will facilitate the successful germination of P. menziesii seedlings. This study implies that in the absence of fire or similar disturbance, P. menziesii will become the dominant species on this site.

References


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