AN ABSTRACT OF THE THESIS OF

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in Forest Science presented on _____

Title: NITROGEN FIXATION BY SCOTCH BROOM (CYTISUS SCOPARIUS L.) AND RED ALDER (ALNUS RUBRA BONG.) PLANTED UNDER PRECOMMERCIALLY THINNED DOUGLAS-FIR (PSEUDOTSUGA MENZIESII (MIRB.) FRANCO)

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Red alder (Alnus rubra Bong.), scotch broom (Cytisus scoparius L.) and snowbrush (Ceanothus velutinus Dougl.) were planted under precommercially thinned Douglas-fir (Pseudotsuga menziesii Mirb. Franco) in the central Oregon Cascades. Plug grown red alder had significantly greater survival than all wildling propagules except for the second broom planting. Browsing was strongly positively correlated with mortality for snowbrush. Survival was somewhat correlated with Douglas-fir basal area (BA) and cover but not with available light.

Nitrogen fixation in underplanted alder and broom and naturally occurring alder, broom and snowbrush was measured by acetylene reduction. Plant moisture stress (PMS) appeared to exert a stronger control on nitrogen fixation through the season than soil temperature. Nitrogen fixation did not appear to be related to available light or Douglas-fir BA or cover. On single dates neither PMS nor soil temperature appeared to be related to nitrogen fixation.

Averaged over the season, broom had significantly greater nitrogen fixation per unit nodule weight than alder but on a per plant basis the species were nearly equal. For underplanted alder, leaf area may have a higher immediate priority for photosynthate than nitrogen fixation as indicated by negative correlations between percent foliar nitrogen and leaf/top and leaf/nodule dry weight ratios. Nitrogen fixation ability keeps apace with leaf development as seen by the positive correlations between leaf and stem total nitrogen values with nodule weights; leaf and nodule dry weights; and leaf weights and nitrogen fixation. For all species, total foliar nitrogen (leaf dry weight x percent nitrogen) was better correlated to nitrogen fixation than percent foliar nitrogen. A greater leaf/nodule ratio for underplanted alder compared to naturally occurring may have resulted from lowered light levels in the thinned stands. In late February, all broom had strong nitrogenase activity compared to sporadic weak activity for alder and no activity for snowbrush. This may suggest that fixation on broom is much less controlled by dormancy. Red alder plugs offer the best potential for nitrogen fixation because of their higher survival, potentially greater growth and fixation, ease of planting, and lesser weed potential.

Given seasonal estimates of nodule fixation rates and the proportion of alder mass as active nodules, nitrogen fixation for alder can be estimated over time from its expected growth under the Douglas-fir. The termination of alder growth is likely set by crown closure of the Douglas-fir. This in turn depends on the number of Douglas-fir left

after precommercial thinning and the radial growth rate of their crowns.

A probability tree can organize and display the uncertainties of future growth and nitrogen fixation from underplanted alder. It displays possible paths of growth that individual alder may follow and allows calculation of an expected or mean value for cumulative nitrogen fixation. For an example 15 year period, the expected cumulative fixation for an individual underplanted alder is about 0.668 kg. For comparison, a fully stocked alder stand with this rate of accretion averages 121 kg $ha^{-1}yr^{-1}$ of nitrogen. The initial cost of 224 kg N ha^{-1} from underplanted alder accrued over a 15 year period is about double the current cost of applying an equivalent amount of urea. The longer recovery period for the underplanting costs further magnify the difference.