

# Growth and development of ponderosa pine on sites of contrasting productivities: relative importance of stand density and shrub competition effects<sup>1</sup>

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**Abstract:** Effects of stand density and shrub competition on growth and development were compared across a gradient of study sites. Challenge, the most productive site, is located in the foothills of the Sierra Nevada, northern California. Pringle Falls is of intermediate productivity in the rain shadow of the central Oregon Cascades. Trough Springs Ridge is the poorest site with minimally developed soils in California's North Coast Range. Treatments included a minimum of four stand densities, from 150 to 2700 trees ha, in combination with at least no or full shrub removal. Challenge produced almost twice as much tree volume as Pringle Falls, and about three times the volume of Trough Springs Ridge. Regardless of site quality, growth was significantly greater in full shrub removal plots for stand densities <2000 trees-ha<sup>-1</sup>. After 26-36 years, stand volumes were 25-67 m<sup>3</sup>•ha<sup>-1</sup> (11%-38%) greater at Challenge, 30-33 m<sup>3</sup>•ha<sup>-1</sup> (25%-52%) greater at Pringle Falls, and 27-4 m<sup>3</sup>•ha<sup>-1</sup> (115%-326%) greater at Trough Springs Ridge when shrubs were removed. Periodic volume growth declined substantially during the last 10 years at Challenge and Pringle Falls, regardless of treatment, because of confounding effects of mortality, drought, inter-tree competition, and insect defoliation. Further, the importance of shrub control on growth increment was not evident during the last 10 years at both sites, as tree-shrub competition likely switched to tree-tree competition. On the low quality site, shrub control is critical for stand development.

**Resume :** Les effets de la densite du peuplement et de la competition des arbustes sur la croissance et le developpement ont ete compares le long d'un gradient de stations experimentales. Challenge, la station la plus productive, est situee dans les contreforts de la Sierra Nevada, dans le nord de la Californie. Pringle Falls dont la productivite est intermediaire est situee dans l'ombre pluviometrique des Cascades, dans le centre de l'Oregon. Trough Springs Ridge, qui est la station la plus pauvre avec des sols a peine developpes, est situee dans la partie nord de la chaine catierne en Californie. Les traitements incluait au moins quatre densites de peuplement, de 150 a 2700 tiges•ha<sup>-1</sup>, combinees avec au moins l'elimination complete ou non des arbustes. A Challenge, le volume des arbres etait presque deux fois plus eleve qu'a Pringle Falls et environ trois fois plus eleve qu'a Trough Springs Ridge. Peu importe la qualite de la station, la croissance etait significativement plus forte dans les parcelles avec une densite de moins de 2000 tiges•ha<sup>-1</sup> ou les arbustes avaient ete completement amines. Apres 26-36 ans, le volume du peuplement etait 25-67 m<sup>3</sup>•ha<sup>-1</sup> (11 % - 38 %) plus eleve a Challenge, 30-33 m<sup>3</sup>•ha<sup>-1</sup> (115 % - 326 %) plus eleve a Trough Springs Ridge. Le volume en volume a diminue de facon importante au cours du traitement, a cause de la confusion creee par la mortalite, la secheresse et les insectes. De plus, l'importance de n'etait pas evidente durant les 10 dernieres annees de l'etude, car la competition entre arbres et les arbustes ont probablement ete remplacee par la competition entre arbres pour le developpement du peuplement dans la si

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## Introduction

The successful establishment of plantations depends on a wide variety of factors including sufficient site preparation

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