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Influence of nutrient supply and water vapour pressure on root architecture of Douglas-fir and western hemlock seedlings

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Abstract. Root growth responses of Douglas-fir *[Pseudotsuga menziesii* (Mirb.) Franco] and western hemlock *(Tsuga heterophylla* Raf. Sarg.) seedlings to three nutrient concentrations and two shoot vapour pressure deficits were measured. Both species gained dry mass at high and medium nutrient treatments throughout the experiment, but not at low nutrition. Low nutrition gave highest ratios of projected leaf surface area to total root length in both species. Douglas-fir geometry differed from that of hemlock, with longer interior link lengths, particularly at the lowest nutrition. Douglas-fir showed greater numbers of exterior–interior links than hemlock. More links were observed at medium and high nutrition than at low nutrition for both species. Exterior–interior links increased over time for the two highest nutrient treatments. Significant topological differences were observed between species, the lowest and two highest nutrient treatments, and high and low vapour pressure deficits. Both species showed herring-bone root architecture at the lowest nutrition. This architectural configuration became more pronounced in hemlock seedlings grown under higher vapour pressure deficits. Faster-growing Douglas-fir had a dichotomous architecture at medium and high nutrition that was not influenced by increased vapour pressure deficits. Douglas-fir topology appears to be adapted to exploit soil nutrient patches while hemlock appears to rely on efficient exploitation of soil volume.

Keywords: architecture, geometry, nutrition, *Pseudotsuga menziesii,* root, topology, *Tsuga heterophylla.*

Introduction

The need to develop a method for describing the root systems of trees has been recognised at least since Busgen and Munch (1931) differentiated between feeder and sinker roots. Traditionally, plant scientists have measured the dry mass of root systems and used root : shoot ratios to determine the response of trees to environmental conditions. However, the root : shoot ratio provides only minimal information about root response to environment. Root surface area is an important factor in nutrient uptake (Barber and Silberbush 1984), and hence for roots of similar diameter, length is an important physiological measurement. In large trees, the biomass of the coarse root system is a relatively constant proportion of the stem biomass unless the tree experiences flexing (Stokes *et al.* 1 997), but the fine root system is variable, with increases in length and longevity apparently benefiting growth (McKay and Coutts 1989). The architecture of the root system is also of interest because it is influenced by environmental conditions, such as soil type and depth (Eis 1974), site preparation (Coutts *et al.* 1990), soil compaction (Wass and Smith 1994), drought (Berntson and Woodward 1992; Berntson 1994) and mineral nutrition (Crabtree and Bernston 1994).

Abbreviations used: a, root system altitude; HVPD, high vapour pressure deficit; LRRAT, projected leaf surface area to total root length ratio; LVPD, low vapour pressure deficit; p_c, total exterior pathlength; root system magnitude.

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