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Patterns of carbon and nitrogen allocation in trees predicted by a model of optimal plant function

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Highlights: Annual carbon allocation to leaves, stems and roots of trees is predicted by a model that simulates canopy photosynthesis and root nitrogen uptake with the overlying hypothesis that annual wood production is maximised.

Keywords: Carbon and nitrogen allocation, forest growth model, Norway spruce, optimisation model, photosynthesis, root nitrogen uptake

Annual carbon (C) allocation belowground in forests can range from 40 % of annual C allocation to wood at fertile, productive sites to 300 % under infertile conditions (Litton et al. 2007; Dybzinski et al. 2011). C allocation is therefore an important determinant of terrestrial C sequestration. However, because the C allocation process is inadequately understood (Franklin et al. 2012), it is a weakness in current ecosystem and earth-system modelling. This paper presents a new theoretical perspective on forest C allocation derived from a model that incorporates the hypothesis that annual wood growth is maximised (Valentine and Mäkelä 2012). The model simulates photosynthesis by a vertically-distributed leaf canopy and nitrogen (N) uptake by a vertically-distributed root system, but does not include a specific C allocation mechanism. It makes predictions of optimal vertical profiles of photosynthetic N-use efficiency *PNUE* of leaves and N-uptake efficiency *NUpE* of roots. Leaf *PNUE* decreases with canopy depth because of light attenuation, and root *NUpE* decreases with soil depth as a consequence of reduced soil N availability at depth. At steady state the model predicts a relationship between *PNUE* of basal leaves and *NUpE* of basal roots that depends on leaf and root longevities and N concentrations. This relationship will be used to determine optimal patterns of annual C and N allocation to leaves, roots and stems in stands of Norway spruce growing at sites with contrasting N fertility (Dewar et al. 2009; McMurtrie and Dewar 2011; Dewar et al. 2012; McMurtrie et al. 2012).

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