Oxford Journals Life Sciences Tree Physiology Volume 18, Issue 12 Pp. 785-793.

Tree Physiology
treephys.oxfordjournals.org

Tree Physiol (1998) 18 (12): 785-793. doi: 10.1093/treephys/18.12.785

Net ecosystem productivity, net primary productivity and ecosystem carbon sequestration in a *Pinus radiata* plantation subject to soil water deficit

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Received March 2, 1998.

Abstract

Tree carbon (C) uptake (net primary productivity excluding fine root turnover, NPP′) in a New Zealand *Pinus radiata* D. Don plantation (42°52′ S, 172°45′ E) growing in a region subject to summer soil water deficit was investigated jointly with canopy assimilation (A_c) and ecosystem–atmosphere C exchange rate (net ecosystem productivity, NEP). Net primary productivity was derived from biweekly stem diameter growth measurements using allometric relations, established after selective tree harvesting, and a litterfall model. Estimates of A_c and NEP were used to drive a biochemically based and environmentally constrained model validated by seasonal eddy covariance measurements. Over three years with variable rainfall, NPP′ varied between 8.8 and 10.6 Mg C ha^{-1} $year^{-1}$, whereas A_c and NEP were 16.9 to 18.4 Mg C ha^{-1} $year^{-1}$ and 5.0–7.2 Mg C ha^{-1} $year^{-1}$, respectively. At the end of the growing season, C was mostly allocated to wood, with nearly half (47%) to stems and 27% to coarse roots. On an annual basis, the ratio of NEP to stand stem volume growth rate was 0.24 ± 0.02 Mg C m^{-3}. The conservative nature of this ratio suggests that annual NEP can be estimated from forest yield tables.

On a biweekly basis, NPP′ repeatedly lagged A_c, suggesting the occurrence of intermediate C storage. Seasonal NPP′/A_c thus varied between nearly zero and one. On an annual basis, however, NPP′/A_c was 0.54 ± 0.03, indicating a conservative allocation of C to autotrophic respiration. In the water-limited environment, variation in C sequestration rate was largely accounted for by a parameter integrative for changes in soil water content. The combination of mensurational data with canopy and ecosystem C fluxes yielded an estimate of heterotrophic respiration (NPP′ – NEP) approximately 30% of NPP′ and approximately 50% of NEP. The estimation of fine-root turnover rate is discussed.

Key words canopy assimilation eddy covariance interannual variability model respiration water stress

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Online ISSN 1758-4469 - Print ISSN 0829-318X