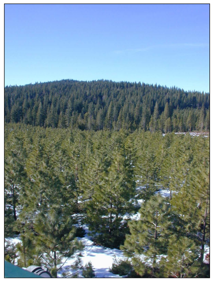

Controls of Canopy Activities on Roots and Soil Carbon Dynamics in a Young Ponderosa Pine Forest

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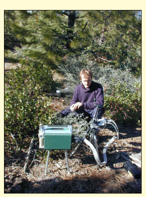
Introduction

Globally, belowground CO_2 fluxes in forest ecosystems constitute a major link between atmospheric CO_2 and the soil CO_2 pools. However, a lack of understanding of belowground carbon fluxes in forest ecosystems in general, and specifically the role of roots in belowground CO_2 dynamics is one of the primary limitations in our ability to assess the contribution of forests in the global carbon balance. Our research at the Blodgett Forest Ameriflux site in the Sierra Nevada Mountains of California addresses the issue of aboveground controls on root turnover and soil carbon sequestration in a mid-elevation, young ponderosa pine (*Pinus ponderosa*) plantation with an understory of shrubs (*Arctostaphylos* spp. and *Ceanothus* spp.).

Experimental Design

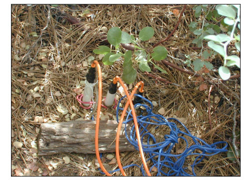
Site Description

Measurements were made in a young ponderosa pine plantation, located adjacent to the Blodgett Forest Research Station, on the western slope of the Sierra Nevada, CA, at 1315 m elevation. The site is characterized by a Mediterranean climate, with warm dry summers and cold wet winter. Annual precipitation has averaged 163 cm, with the majority of precipitation falling between September and May, and almost no rain in the summer.



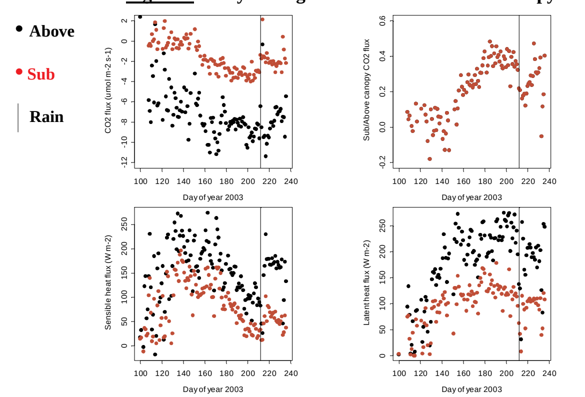
Measurements

Our measurements included: **1/** Canopy scale measurements of CO_2 and energy fluxes at two levels by the eddy covariance method, **2/** Meterological variables (above-, sub-canopy, and vertical gradient), **3/** Root dynamics, demography and biomass, **4/** Stem, leaf, and shoot growth, **5/** Ecosystem respiration chamber measurements, **6/** Soil CO_2 gradient profile and continuous soil CO_2 efflux, **7/** Leaf gas exchange.



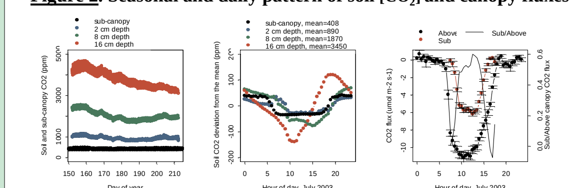
Results I: Canopy Scale Flux Measurements

Figure 1. Daily average fluxes above- and sub-canopy



During the 2003 vegetation period the leaf area index of Ponderosa pine increased from ~3.0 to ~3.5, while the shrubs leaf area index increased from ~0.70 to ~1.2. The photosynthetic capacity of the shrubs was 2 (winter) to 5 times (summer) higher than Ponderosa pine per unit leaf area. Both above- and sub-canopy daily flux integrals of CO_2 showed significant uptake of carbon from the atmosphere (Figure 1). The daily sub-canopy CO_2 uptake was 10% of the above canopy in spring and up to 50% in mid-summer. During summer, around 60% of the outgoing energy flux was from the sub-canopy level. The seasonality of ecosystem NEE was principally controlled by the sub-canopy level. The CO_2 concentration gradient from 16 cm soil depth to the air at sub-canopy level drove the soil CO_2 efflux, both daily and seasonally (Figure 2).

Figure 2. Seasonal and daily pattern of soil $[CO_2]$ and canopy fluxes



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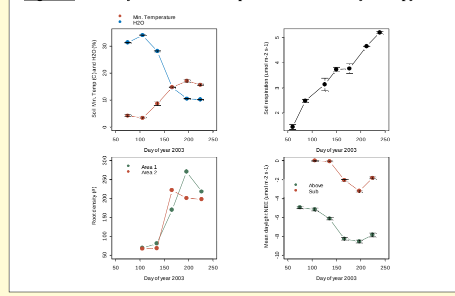
Results II: Soil respiration and Root Growth

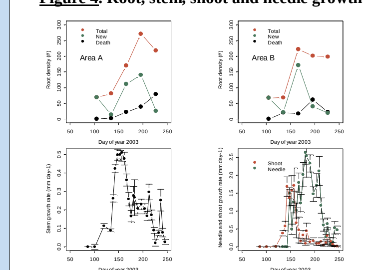
Figure 3. Monthly soil t°, water, respiration, root density, canopy fluxes



Soil respiration was driven by temperature and soil moisture (Figure 3). No significant increases of soil CO_2 efflux was detected during the most active period of root growth. At this stage of the research, it has not been demonstrated that root dynamics exert a major control over the seasonal patterns of the soil surface CO_2 efflux.

Results III: Carbon Allocation

Figure 4. Root, stem, shoot and needle growth



Tree stems started to expand at the beginning of May, and shoots to elongate in mid-May (Figure 4). The roots didn't exhibit substantial growth until mid-June, probably because the soil was too cold. Needle elongation followed root growth closely. Root death was observed primarily in the first month after emergence. Overwintering of fine roots appears to be minimal. The root dynamics in this plantation was decoupled from photosynthetic activity in the short-term, but probably strongly linked with photosynthesis in the medium-term via regulating root demography and biomass.