Abstract #
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Soil Carbon Budget During Establishment of Short Rotation Woody Crops

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INTRODUCTION: Soil carbon fluxes are among the largest in forest ecosystems. Even though autotrophic inputs and heterotrophic effluxes are large, our understanding of management and environmental effects is extremely limited because of problems accessing soil organisms in place. The need for accurate accounting of soil carbon budgets is critical for assessing management impacts and determining carbon sequestration potential. We have measured the major processes of the soil carbon cycle and assembled a budget that quantifies important pools and fluxes during establishment of forest plantations.

OBJECTIVE: Measure soil carbon pools and fluxes during forest stand development to estimate changes in carbon stocks.

METHODS: Soil carbon pools and fluxes were estimated for loblolly pine and cottonwood stands growing with irrigation and fertilization at the Savannah River Site near Aiken, South Carolina. Figures 1 to 5 illustrate techniques used. Soil carbon budgets are presented in Figure 6. Soil carbon pools are expressed as g C m^{-2} and fluxes are expressed as g C m^{-2} yr^{-1}. Published values of specific root respiration (Pregitzer et al. 1998) are used to estimate total root respiration based on root biomass. Carbon transported to symbionts, root exudates and dissolved C leached in runoff are not estimated. The latter two fluxes are assumed to be minimal. Positive net carbon gain represents soil carbon sequestration; negative values represent loss of soil carbon (Table 1).

Soil Carbon

Figure 1. We sampled and analyzed soil carbon from the plantation prior to establishment.

Litter Fall

Figure 3. Litter baskets of known area collect leaf and branch litter during autumn leaf fall. Litter was analyzed for carbon content.

Biomass sampling

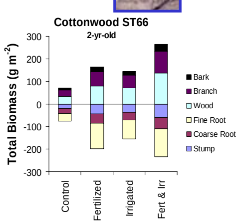

Figure 2. Above and belowground biomass harvest. Fine and coarse root fractions were analyzed for carbon content.

Fine Root Turnover Estimate :

Minirhizotrons were used for measuring fine-root turnover

Turnover Ratio (TOR, year^{-1})

$$TOR = \frac{(\text{Annual Production} + \text{Annual Mortality})/2}{\text{Average Annual Standing Crop}}$$

Fine-root turnover on carbon basis (TO$_C$, g m^{-2} C yr^{-1}):

$$TO_C = TOR \times C_{fr}$$

where (C_{fr}) is the carbon content of live fine-root biomass.

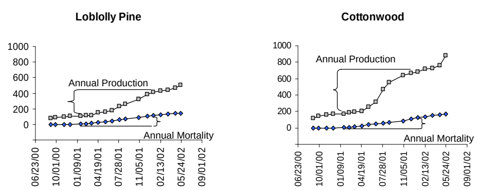

Figure 4. Fine root turnover is estimated from the average of annual production and mortality. Biomass from coring date is scaled proportionally using annual changes observed with minirhizotrons (Coleman et al. 2000).

Soil CO_2 Efflux

Estimate Annual Soil CO_2 Efflux as a function of hourly soil temperature.

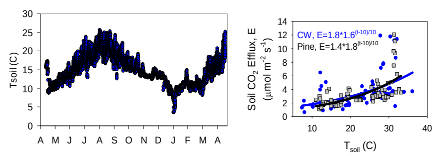

Figure 5. Mid-day monthly soil respiration measurements (Coleman et al. 2000) are scaled to an annual basis (g C m^{-2} yr^{-1}) by summing cumulative hourly fluxes estimated from the hourly temperature trace and soil respiration as a function of soil temperature. Rates are comparable to those reported by Raich and Schlesinger (1992).

References:

Coleman, M.D., R.E. Dickson and J.G. Isebrands. 2000. Contrasting fine-root production, survival and soil CO_2 efflux in pine and poplar plantations. Plant Soil 225:129-139.

Raich, J.W. and W.H. Schlesinger. 1992. The global carbon dioxide flux in soil respiration and its relationship to vegetation and climate. Tellus 44B:81-99.

Pregitzer, K.S., M.J. Laskowski, A.J. Burton, V.C. Lessard and D.R. Zak 1998. Variation in sugar maple respiration with root diameter and soil depth. Tree Physiology 18:665-670.

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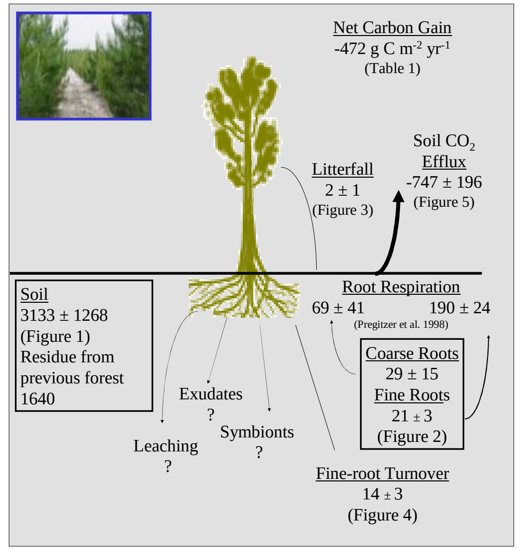
Figure 6. SOIL CARBON BUDGETS for loblolly pine and cottonwood. Soil carbon standing crops (g C m^{-2}) are included in boxes. Soil carbon fluxes (g C m^{-2} yr^{-1}) are shown with arrows. Citations for each pool or flux in the budget indicate the data source. Figures present more detail on measurements and calculations.

Loblolly Pine 2-year-old



Cottonwood 2-year-old

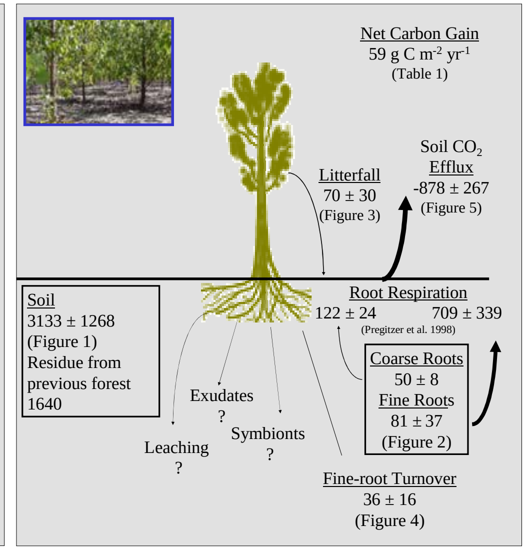


Table 1. Carbon budget for pine and cottonwood grown with irrigation and fertilization treatments. Net carbon gain is the difference between efflux and inputs. Loss of carbon from site does not occur with highest productivity.

	Pine					Cottonwood				
	Control	Irrigated	Fertilized	Irr & Fert	Average	Control	Irrigated	Fertilized	Irr & Fert	Average
Standing crop										
coarse root biomass	5 a	8 a	31 a	20 a	29	36 a	27 a	25 a	34 a	50
fine-root biomass	17 b	21 ab	20 ab	25 a	21	30 b	93 ab	85 ab	117 a	81
Inputs										
litterfall	1 a	2 a	3 a	3 a	2	27 b	81 ab	74 ab	97 a	70
fine root turnover	14 ab	13 ab	11 b	18 a	14	14 b	44 ab	35 ab	51 a	36
root respiration	176 a	214 a	253 a	267 a	259	341 a	867 ab	776 ab	1150 a	831
Total	190	228	268	288	275	382	992	885	1297	937
Efflux	-961 a	-781 a	-749 a	-751 a	-747	-704 a	-826 a	-720 a	-883 a	-878
Net Carbon gain	-771	-553	-482	-463	-472	-322	166	165	414	59

CONCLUSIONS:

❖Soil CO_2 efflux is equivalent to combined inputs from fine-root turnover, litterfall and root respiration in cottonwood, but CO_2 efflux exceeds inputs in loblolly pine.

❖Management that improves biomass production (irrigation & fertilization with cottonwood) reverses net loss of site carbon stocks.

❖Unaccounted efflux may be either due to symbionts, exudation, or leaching loss, or it may be due to loss of soil organic carbon.

❖Dynamic soil carbon content changes are expected during stand establishment due to high respiration rates and low detrital inputs.