Partitioning soil respiration: examining the artifacts of the trenching method

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Introduction

Total soil respiration (*Rt*) is a combination of autotrophic (*Ra*) and heterotrophic respiration (*Rh*). Several methods have been developed to tease out the components of *Rt*, such as isotopic analyses, and removing *Ra* input through tree girdling and root exclusion experiments. Trenching involves severing the rooting system surrounding a plot to remove the *Ra* component within the plot. This method has some potential limitations. Reduced water uptake in trenched plots could change soil water content, which is one of the environmental controllers of *Rt* in many ecosystems. Eliminating root inputs could reduce heterotrophic decomposition of SOM via lack of priming. On the other hand, the severed dead roots may temporarily increase available carbon substrate for *Rh*.

***Objective:* To quantified how the artifacts of the trenching method influence estimates of carbon loss from soils.**

Site Description & Methods

Within the footprint of the EMS tower at Harvard forest, automated respiration chambers were utilized in conjunction with the trenching method to partition *Rt* into its components, *Rh* and *Ra*. In the late fall of 2012, a trench was dug (to 1m depth) around a 5x5m area, severing all roots leading into the treatment plot. Plastic tarp was placed along the walls of the trench and then backfilled. Four automated chambers were placed in each of the trenched and un-trenched plot.

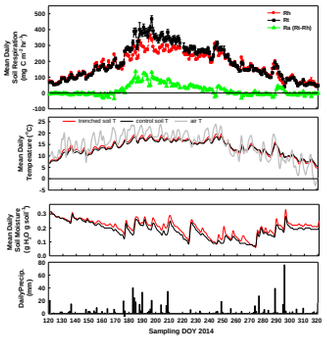
Fluxes, along with soil temperature and moisture, were measured at hourly rates from early spring through late fall of 2013 and 2014. Measurements from the non-trenched plot represent the combined *Rh* and *Ra* components, *Rt*. Fluxes from the trenched plot represent, *Rh* and the difference (*Rt*-*Rh*) represents *Ra*.

Automated chambers in the open position, pre-trenching.

Eighty root decomposition bags were placed in the organic soil horizon of the trenched (40) and un-trenched (40) plots at the time of trenching in 2012 and measured over the course of 2013 and 2014.

Quantifying the artifacts of the trenching method

Changes to soil moisture



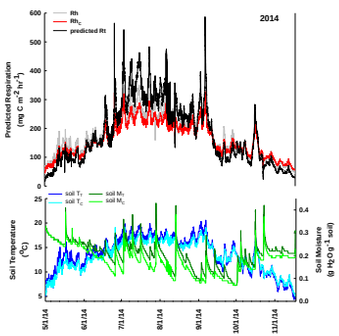
- Mean soil moisture was higher (21%) in the trenched plot then the control plot (18%).
- In early spring, when roots are less active and soils were dry, fluxes in the trenched plot (*Rh*) exceeded the control (*Rt*). During this time period soil moisture between treatments begins to deviate.
- During the summer months, when roots were most active, *Rt* exceeded *Rh,* as expected, even though soil moisture in the trenched plot exceeded the control.
- In the fall, *Rh* exceeded *Rt*, likely due to decreased root activity in the control plot.

Model: $RS = Rref*Q_{10}^{((T-10)/10)} * B^{(WC\ opt-WC)2}$

		2014 (DOY 121-321)	
Trenched- Rh	Ref =	102.6	*(101.2-103.9)*
	Q_{10} =	3.6	*(3.5-3.7)*
	B =	0.89	*(0.88-0.90)*
	FMR^2=	0.47	

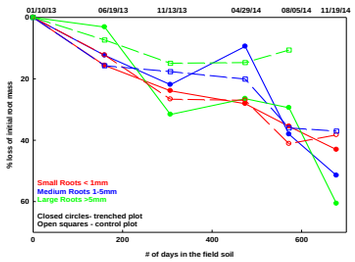
RS- respiration (mg C m^{-2} hr^{-1}), WC_opt- optium water content= 20%, WC – % water content, T – soil temperature at 10cm °C. Model parameter, Rref is Rs at 10°C, Q_{10} is a unitless expression of the increase in Rs for each increase in 10°C, B modifies the shape of the quadratic fit. 95% confidence intervals generated from bootstrapping. FRM^2 Figure of Merit and is akin to an R^2 value.

- *Rh* from the trenched plot was modeled using a soil temperature and moisture function.



- The *Rh* model (*Rh*– gray line) parameters were applied to concurrent temperature and moisture measured in the control plot (*Rhc*- red line in graph)
- Lower predicted *Rhc* was due to lower temperature and moisture in the control plot compared to the trenched plot.
- Integrated over the 2014 sampling season *Rh* is estimated to be 9% lower than observed rates.

Decomposition of severed roots



- Data from the root decomposition bags showed that after two years, roots had lost from 40-60% of their initial mass.

Decay model

$M_t=M_o*\exp^{(-k*t)}$

Where M_t is final root mass (g), M_o is initial root mass (g), t is time in days and k is the decay constant (yr^{-1}). Italics are 95% confidence intervals

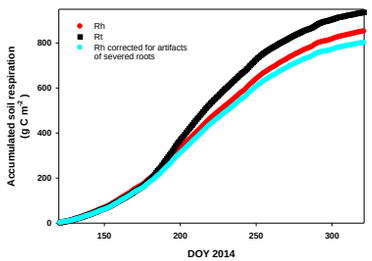
Root decay constant k ($year^{-1}$)	Small	Medium	Large
Trenched	0.29 *(0.25-0.34)*	0.26 *(0.19-0.34)*	0.34 *(0.23-0.45)*
Control	0.29 *(0.26-0.33)*	0.25 *(0.20-0.31)*	0.11 *(0.08-0.16)*

Carbon loss model

$(1-a)*c*M_o(1-e^{-kt})$

Where M_o is initial root mass (g), t is time in days and k is the decay constant in g d^{-1}. C is the initial carbon concentration in root set at 44%, a is the fraction of carbon incorporated into SOM and was set at 0.22. M_o for carbon loss model from R. Abramoff, unpublished data. These models and parameter assumptions are from Epron *et al.* 1999.

- Decay constants were determined for each root class and used to quantify carbon loss due to severed roots in the trenched plot.



- Based on the carbon loss model, we estimated the loss of carbon from the trenched plot attributed to severed roots (blue line in graph).
- For 2014, after roots had been decomposing for >1 year, we estimated carbon loss due to severed roots accounted for 6% of the measured *Rh* from the trenched plot.

Carbon loss for the 2014 season	Harvard Forest (DOY 121-316) kg C m^{-2} $season^{-1}$	*Rh* adjusted for the artifacts of moisture (9%) and severed roots (6%)
Control plot - Rt	0.90	0.90
Trenched plot -Rh	0.81	0.69
Autotrophic Ra = Rt-Rh	0.09	0.21
% contribution over sampling season of Ra to Rt	10%	23%

- **Unadjusted estimates of *Ra* contribution to *Rt* was 10%.**
- **After adjustment for the influence of artifacts, *Ra* contributed 23% to *Rt* over the 2014 sampling period.**

***Conclusions:* Artifacts of the trenching method may have resulted in over-estimation of Rh by 9% due to soil moisture differences and by 6% due to the influence of decomposing severed roots.**

Reference: Epron *et al.* 1999. Soil CO2 efflux in a beech forest: the contribution of root respiration. Annals of Forest Science, Springer Verlag. 56(4), pp289-295.