B31A-0386

Soil respiration following partial stand disturbance by tree girdling rapidly rebounds within a three-year period in a temperate forest

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INTRODUCTION & GOALS

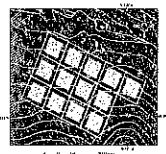
- Soil respiration is the flux of carbon dioxide (CO_2) from the soil surface to the atmosphere. It is produced by autotrophs (plants) and heterotrophs (organisms that get energy by breaking down organic matter).
- The impact of disturbances on land carbon fluxes is poorly understood yet may have important implications for climate[1,2] through a feedback with CO_2
- A key uncertainty is how disturbances impact the timing and magnitude of carbon fluxes within a forest.

GOALS

1)Examine the temporal dynamic of soil respiration shortly after a partial stand disturbance.

2) Reassess the autotrophic contribution to soil respiration based on the second year of observations.

METHODS



Notch Girdling in the summer of 2008

Study Site and Experimental Design

Black Rock Forest, southeastern NY, USA

Forest composition: 67% oak 33% non-oak

Thirteen 75m x 75m plots at three slope positions (C- upper, B- middle, A- lower slope)

Treatments

C- Control

NO - girdling all non-oaks on a plot

O50 - girdling half of the oak trees on a plot

OG - girdling all oak trees on a plot

ALL - girdling all trees on a plot

Soil Respiration (SR)

10 measurements were taken with a LiCor- 6400 gas exchange system in 25m x 25m center sub-plot between 8am and 1pm.

Statistical Analysis: The effect of treatment (*T*), point in the growing season (Julian day, *JulD*), soil temperature($Temp_{soil}$), and slope position (*Slope*) on the measured soil respiration rates was assessed with a linear model. *Flux* = predicted soil CO_2 efflux ($\mu mol\ m^{-2}\ s^{-1}$)

$$Log(Flux) = T + JulD + JulD^2 + Temp_{soil} + Slope$$

RESULTS

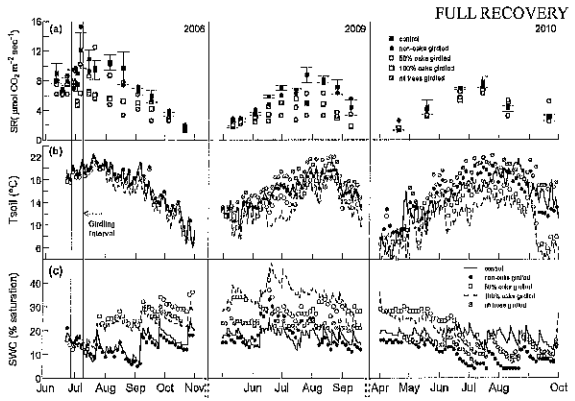


Fig 1. a) Soil respiration (SR) ± one standard error (SE). b) Average daily soil temperature (T_{soil}) at 15 cm depth. c) Average daily soil water content (SWC; % saturation). The measurement interval varied each year; therefore the x-axis is not a continuous. . All data are treatment means. n= 3 for all treatments except for ALL where n=1.

What is the temporal response of soil respiration after a partial stand disturbance?

Soil respiration declined on all plots where at least some oaks were girdled

Full rebounded to control rates within two growing seasons

Changes in soil temperature, soil moisture, and increased growth rates of healthy trees[3] suggest that the processes governing this carbon flux in girdled plots differ from those in undisturbed plots

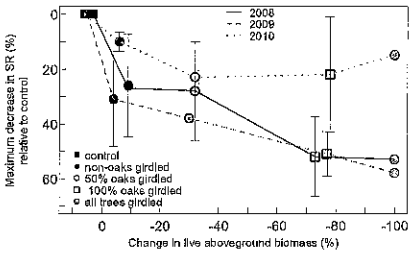


Fig 2. Maximum decline in soil respiration (*SR*) rate from 2008 – 2010 relative to Control plot measurement along a change in the live aboveground biomass (*AGB*) gradient. All data are treatment means ± 1 SE. n= 3 for all treatments except for ALL where n=1.

What proportion of soil respiration comes from autotrophs vs heterotrophs?

The autotrophic component of soil respiration could be up to 58% of total soil respiration (ALL plot in 2009) (Fig. 2)

A larger drop in respiration rate occurred when a small fraction of the canopy was impacted (<10 % AGB loss) than when a larger fraction was impacted (>10 % AGB loss) (Fig. 2)

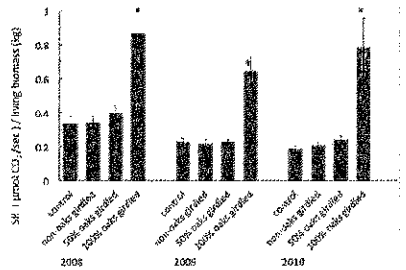


Fig 3. Mean growing season *SR* rate from 2008 – 2010 per unit of living aboveground biomass (kg). * indicates a significant difference, ANOVA analysis. All data are treatment means ± 1 SE. n=3 for all treatments. ALL was assumed to have 100% tree mortality and therefore omitted from this graph.

Do oaks contribute more to soil CO_2 efflux than non-oaks?

Inconclusive.

Direct comparison of respiration rate was complicated by differences in biomass loss between oaks and non oaks

Higher respiration rates on 100% oak girdled vs 50% oak girdled treatment suggest activity of healthy trees was altered in response to the treatment, precluding the ability to distinguish variations in respiratory response resulting from the loss of oaks compared to non-oaks (Fig. 3).

DISCUSSION

- Tree girdling can be used to provide insights into the impact of pest or pathogen disturbances
- The recovery pattern of soil respiration aligns with NEP recovery[4] after a pest or pathogen attack.
- Rapid recovery could be facilitated by compensatory activity of healthy trees[5] and/or resource sharing belowground[6].
- The initial stages of disturbance could have a greater impact on belowground carbon dynamics than later stages of infestation.

CONCLUSIONS

- Full recovery of SR suggests belowground activity is highly resilient to disturbance
- The reduction in soil respiration was not proportional to the degree of canopy loss
- The magnitude of the response for an individual treatment varied interannually
- The autotrophic component of soil respiration could be up to 58%. This aligns with the findings from other tree girdling experiments[7].

REFERENCES & ACKNOWLEDGEMENTS

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We are grateful to the Ernst C. Stiefel Foundation, Black Rock Forest Consortium, and the Chevron Student Initiative fund for funding this research. We thank the entire Black Rock Forest staff for logistical support and Dr. David Madigan for statistical consulting.

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