Soil CO_2 Efflux and Tree Carbon Relations in a Loblolly Pine Plantation

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Introduction

- A major goal of the Pine Integrated Network: Education, Mitigation and Adaptation Project (PINEMAP) is to increase carbon (C) sequestration in planted southern pine forests.
- Storage of C in the soil depends on the rate of litter inputs and the rate of decay of existing C pools.
- Soil carbon dioxide (CO_2) efflux can be partitioned into autotrophic and heterotrophic components to establish the amount of gross primary productivity (GPP) allocated to roots and the rate of decay of old soil carbon.
- Understanding how trees alter their allocation of C to storage - particularly underground in the roots – in response to water and/or nutrient stress is also useful for predicting soil carbon storage.
- We are addressing two research questions at a young loblolly pine plantation in Washington, Georgia (a Tier III site).
- First, what are the relative contributions of heterotrophic and autotrophic respiration to soil respiration?
- This question will be approached at this, and other Tier III sites within the natural range of loblolly pine using precipitation and nutrient treatments.
- Our second research question focuses specifically on the Washington, Georgia site: do trees experiencing water and/or nutrient stress increase partitioning of carbon to storage or allocation of carbon to root growth?
- These measurements will be used to test the functional equilibrium hypothesis.

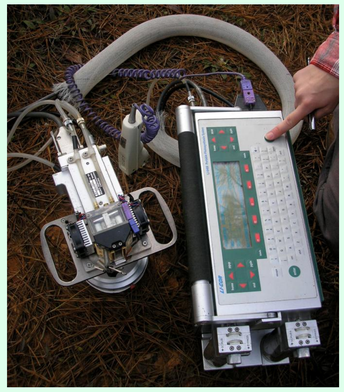


Figure 1: Li-6400 with soil chamber.

Soil CO_2 Efflux Partitioning

- Our first aim is to characterize treatment effects and seasonal patterns of soil CO_2 efflux and partition soil CO_2 efflux into autotrophic and heterotrophic components.
- Total soil CO_2 efflux will be measured using a Li-Cor LI-6400 Portable Photosynthesis System with a soil chamber attachment (***Figure 1***).
- Modified root exclusion cores will be used to cut off the influx of carbohydrates from parent trees.
- Carbon dioxide efflux measured above these cores comprises the heterotrophic respiration component.
- Subtraction yields the autotrophic respiration component.
- Preliminary total soil CO_2 efflux measurements were taken on February 9 & 23, 2012 at the Washington, Georgia Tier III site (***Table 1***).

Table 1: CO_2 efflux (μmol m^{-2} s^{-1})

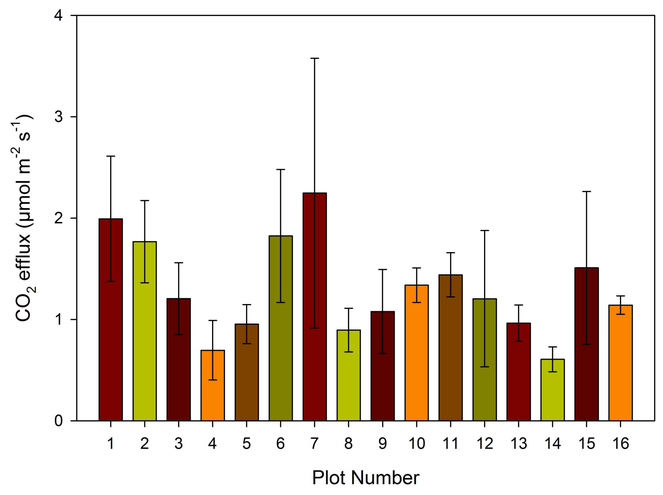
Block	Plot	Plot Mean ± SD	Block Mean ± SD
1	9	1.078 ± 0.414	1.265 ± 0.421 **b***
1	10	1.338 ± 0.170	
1	11	1.440 ± 0.217	
1	12	1.204 ± 0.672	
2	4	0.696 ± 0.293	1.106 ± 0.509 **b***
2	8	0.895 ± 0.215	
2	13	0.962 ± 0.180	
2	15	1.509 ± 0.754	
3	3	1.205 ± 0.354	1.253 ± 0.909 **b***
3	5	0.954 ± 0.192	
3	7	2.246 ± 1.331	
3	14	0.607 ± 0.123	
4	1	1.993 ± 0.618	1.681 ± 0.574 **a***
4	2	1.768 ± 0.406	
4	6	1.824 ± 0.656	
4	16	1.141 ± 0.091	

*Different letters indicate a significant difference at the α=0.05 level.

Results

- Efflux from the soil varied from 0.372 to 4.47 μmol m^{-2} s^{-1} CO_2 with a mean of 1.30 ± 0.668 μmol m^{-2} s^{-1} CO_2.
- Block 4 had significantly (α=0.05) higher rates of soil CO_2 efflux than the other blocks.
- Many plots had significantly (α=0.05) different rates of soil CO_2 efflux (***Figure 2***).

Figure 2: Washington, GA Tier III Site CO_2 Efflux



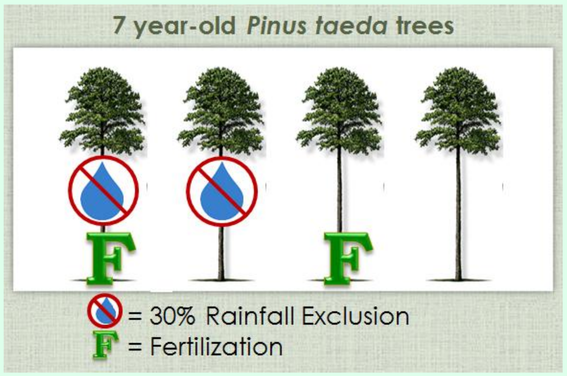


Figure 3: Treatments applied to Tier III sites.

Tree Carbon Allocation and Partitioning

- Our second aim is to determine the effects of rainfall exclusion and fertilization on carbon allocation and storage in young loblolly pine trees.
- We hypothesize that trees under nutrient and/or water stress will allocate more carbon to storage and – in accordance with the functional equilibrium hypothesis – to root growth.
- We are establishing a 2 × 2 factorial treatment of natural rainfall and 30% rainfall exclusion combined with low and high nutrient application (***Figure 3***).
- This study will be conducted at a Tier III PINEMAP site in Washington, Georgia with 16 plots segregated into 4 blocks (***Figure 4***).
- Samples of current and one-year-old needles and xylem of branch, root, and stem tissues will be taken every two months for one year.
- Samples will be analyzed for total carbon as well as carbohydrate and lipid content.
- Growth rate of stems, aboveground biomass, and belowground biomass will be quantified.
- SAS software (Cary, NC) will be used to analyze the data to detect differences using factorial and repeated measures ANOVA and the chi-squared test.

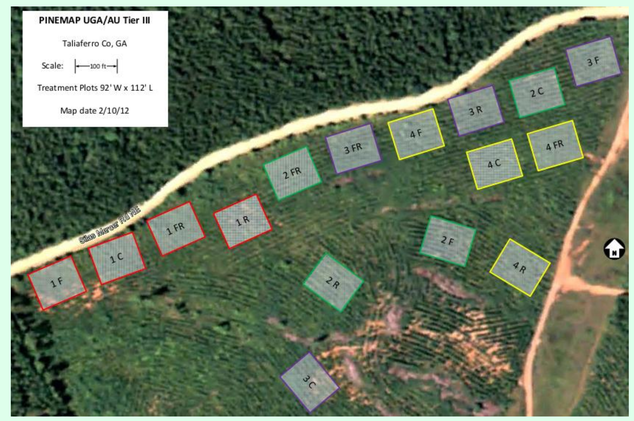


Figure 4: Map of Washington, GA Tier III site treatments.