

Measuring ecosystem CO₂ emission sources in a northern hardwood forest

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Introduction

Forests represent an important carbon sink that partially offsets rising levels of atmospheric CO₂ (Goodale et al., 2002). However, carbon that is stored in forest trees and soil is vulnerable to loss, and could potentially return to the atmosphere through respiration. We investigated the age of respired CO₂ to determine whether forest respiration contains older carbon from soils and trees, or is composed of “young” recently-photosynthesized carbon.

Using radiocarbon (14C) measurements we assessed the age of CO₂ respired from soils, tree trunks, and the whole forest canopy, to see whether any of these sources emitted older, stored carbon.

Research Questions:

- 1) How old is CO₂ respired from soil??
- 2) Do tree trunks respire recently-fixed carbon, or older “bomb” carbon from reserves?
- 3) Can “bomb” carbon from soils or tree trunks be detected in canopy CO₂?

Methodology

Monitor respired CO₂ and ¹⁴CO₂ at nested spatial scales.



Subsurface sampling (4 pits, including a trenched pit, x 7 levels) allow us to partition soil CO₂ production by depth.



Tree trunk samples of ¹⁴CO₂ collected using respiration chamber attached to trees.

Flask air samples of ¹⁴CO₂ collected at 45 feet in the air at Willow Creek AmeriFlux site in Wisconsin



Tree Trunk Chamber Design

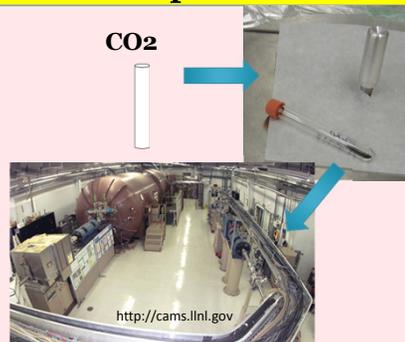
We sampled tree trunk CO₂ based on methods by Muhr et al (2011) and Ubierna et al (2009).

1. Syringe was used to create a vacuum
2. A pre-evacuated collection tube was used to collect CO₂
3. Stainless steel tube and fitting to connect collection tube to tree
4. Valve to allow CO₂ to enter vial



From Gas to Graphite

CO₂ was converted to solid carbon (graphite). By using extremely high temperatures in the presence of hydrogen and an iron catalyst, the CO₂ is reduced to graphite. The graphite is then sent through the Accelerator Mass Spectrometer to determine the carbon isotope ratio.



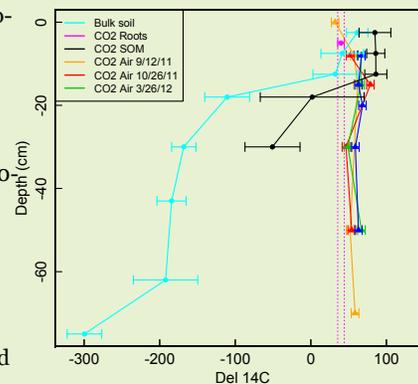
Results and Discussion

Soil Emissions

Soil CO₂ has more bomb-C than the present atmosphere suggesting the carbon is years to decades old.

Respired CO₂ is about 50% root respiration and organic matter decomposition.

¹⁴CO₂ was similar throughout the profile. Deep in the soil, respired CO₂ was much younger than solid bulk soil.



References

- Goodale, C. et al., Forest Carbon Sinks in the Northern Hemisphere. *Ecological Applications*, 2002,12(3), 891–899 by the Ecological Society of America.
 Muhr, J. et al., Radiocarbon in tree stem CO₂ efflux: CO₂ emitted by trees is older than expected. Poster session presented at: 44th Annual American Geological Union Fall Meeting: 2011 December 5-9, San Francisco, CA.
 Ubierna, N. et al., A new method to measure carbon isotope composition of CO₂ respired by trees: stem CO₂ equilibration. *Functional Ecology*, 2009, 23, 1050–1058 doi: 10.1111/j.1365-2435.2009.01593.

Tree Trunk Emissions

Tree trunk emissions had amounts of 14C intermediate between soil respiration and the background atmosphere.

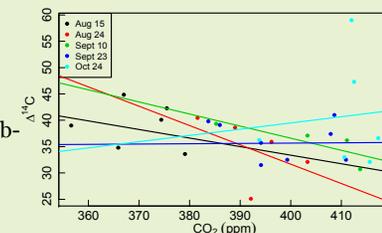
Species	Common Name	Specimen	D ¹⁴ C (‰)
<i>Acer saccharum</i> Marsh.	Sugar maple	1	28.0 ± 4.6
<i>Acer saccharum</i> Marsh.	Sugar maple	2	43.9 ± 6.7
<i>Acer saccharum</i> Marsh.	Sugar maple	3	36.9 ± 5.3
<i>Tilia americana</i> L.	Basswood	1	41.9 ± 5.5
<i>Fraxinus americana</i> L.	White ash	1	56.6 ± 8.2

Respiration from tree stems may be a source of bomb-C to the atmosphere.

Canopy Emissions

Impacts of soil on canopy ¹⁴CO₂ not (yet) detected.

Canopy 14C was highly variable, and there was no obvious contributions of bomb-C from soil or trees.



Currently measuring canopy ¹⁴CO₂ profiles to characterize possible soil influences.

Conclusions/ Future Research

- CO₂ produced in soils appears to be older than current photosynthesis. This CO₂ contains 30% more ¹⁴C than the atmosphere.
- Tree trunk CO₂ were also slightly older than current photosynthesis.
- We found no clear evidence of bomb carbon from soil or tree trunk respiration in whole-ecosystem respired ¹⁴CO₂; however, additional data and method improvements for atmospheric sampling are forthcoming.
- Future research may include more measurements of respired CO₂ from tree trunks, including a larger variety of species.

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