

# Measuring ecosystem CO<sub>2</sub> 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 CO<sub>2</sub> (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 CO<sub>2</sub> to determine whether forest respiration contains older carbon from soils and trees, or is composed of “young” recently-photosynthesized carbon.

Using radiocarbon (<sup>14</sup>C) measurements we assessed the age of CO<sub>2</sub> 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 CO<sub>2</sub> 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 CO<sub>2</sub>?

## Methodology

Monitor respired CO<sub>2</sub> and <sup>14</sup>CO<sub>2</sub> at nested spatial scales.

Subsurface sampling (4 pits, including a trenched pit, x 7 levels) allow us to partition soil CO<sub>2</sub> production by depth.

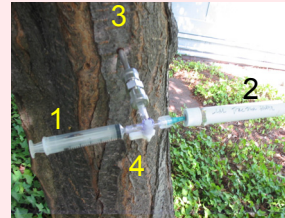
Flask air samples of <sup>14</sup>CO<sub>2</sub> collected at 45 feet in the air at Willow Creek AmeriFlux site in Wisconsin

Tree trunk samples of <sup>14</sup>CO<sub>2</sub> collected using respiration chamber attached to trees.

## Tree Trunk Chamber Design

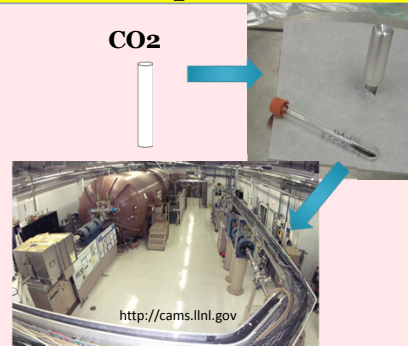
We sampled tree trunk CO<sub>2</sub> based on methods by Muhr et al (2011) and Ubierna et al (2009).

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



## From Gas to Graphite

CO<sub>2</sub> was converted to solid carbon (graphite). By using extremely high temperatures in the presence of hydrogen and an iron catalyst, the CO<sub>2</sub> is reduced to graphite. The graphite is then sent through the Accelerator Mass Spectrometer to determine the carbon isotope ratio.



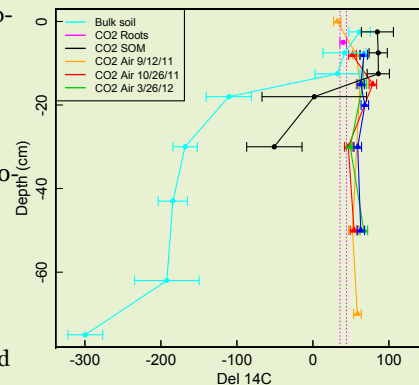
## Results and Discussion

### Soil Emissions

Soil CO<sub>2</sub> has more bomb-C than the present atmosphere suggesting the carbon is years to decades old.

Respired CO<sub>2</sub> is about 50% root respiration and organic matter decomposition.

<sup>14</sup>CO<sub>2</sub> was similar throughout the profile. Deep in the soil, respired CO<sub>2</sub> 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 CO<sub>2</sub> efflux: CO<sub>2</sub> emitted by trees is older than expected. Poster session presented at: 44<sup>th</sup> 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 CO<sub>2</sub> respired by trees: stem CO<sub>2</sub> equilibration. *Functional Ecology*, 2009, 23, 1050–1058 doi: 10.1111/j.1365-2435.2009.01593.

## Tree Trunk Emissions

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

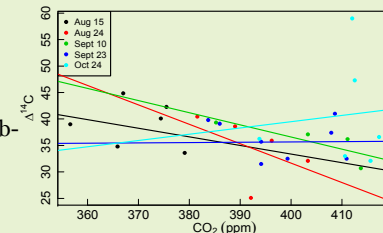
Respiration from tree stems may be a source of bomb-C to the atmosphere.

Species	Common Name	Specimen	D <sup>14</sup> 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

## Canopy Emissions

Impacts of soil on canopy <sup>14</sup>CO<sub>2</sub> not (yet) detected.

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



Currently measuring canopy <sup>14</sup>CO<sub>2</sub> profiles to characterize possible soil influences.

## Conclusions/ Future Research

- CO<sub>2</sub> produced in soils appears to be older than current photosynthesis. This CO<sub>2</sub> contains 30‰ more <sup>14</sup>C than the atmosphere.
- Tree trunk CO<sub>2</sub> 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 <sup>14</sup>CO<sub>2</sub>; however, additional data and method improvements for atmospheric sampling are forthcoming.
- Future research may include more measurements of respired CO<sub>2</sub> from tree trunks, including a larger variety of species.

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