The Role of Coarse Woody Debris Respiration in a Northern Michigan Hardwood Forest

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Acknowledgements:

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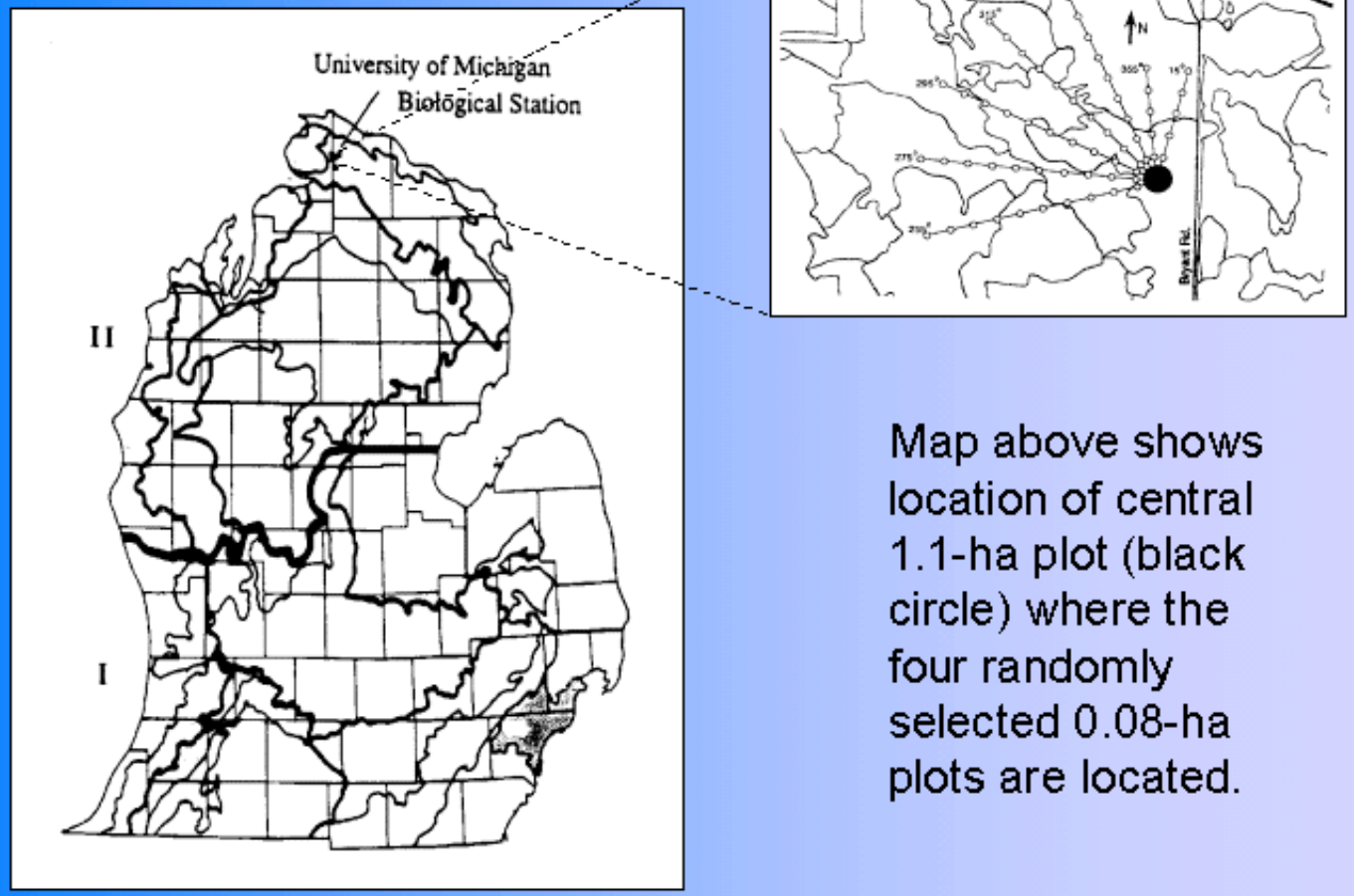
1. Introduction

Concern over global climate change due to rising levels of CO_2 and other trace gases has led to policy negotiations over carbon emissions regulation on an international scale. To better understand the global carbon cycle, researchers are being challenged to define national-level carbon budgets. Understanding forest carbon flux dynamics is central to defining these budgets. Historically, the role of downed wood decomposition has been neglected in hardwood forests. This study attempts to quantify the amount of carbon emitted from coarse woody debris (CWD) defined as downed wood over 10-cm in diameter and to better understand its role within the forest carbon budget.

2. Study Site

UMBS Ameriflux Tower

- Located at 45º 35'N by 84º 42' W
- Annual precipitation of 750-mm
- Mean annual temperature of 6.2 ºC
- Elevation of 324-m; Flat slope
- Soil is Rubicon Sand formed from glacial outwash
- Dominant tree species of CWD:
  - Paper birch (*Betula papyrifera*)
  - Bigtooth aspen (*Populus grandadentata*)
  - Red maple (*Acer rubrum*)



Map above shows location of central 1.1-ha plot (black circle) where the four randomly selected 0.08-ha plots are located.

3. Methods

- Four 0.08-ha plots were randomly selected within each quadrant of the larger 1.1-ha plot surrounding the tower.
- Decay Classes 1-5 were defined for each species:

Decay Class 1 - Recently downed material - tissue and bark intact throughout

Decay Class 2 - Sapwood beginning to decay but completely present-Bark beginning to crack

Decay Class 3 - Sapwood and bark mostly present-heartwood tissue intact

Decay Class 4 - Sapwood and bark mostly gone with heartwood beginning to decay

Decay Class 5 - Sapwood and bark gone-heartwood decay substantial-original shape spreading but still distinguishable from soil

Based on Marra & Edmonds (1994)

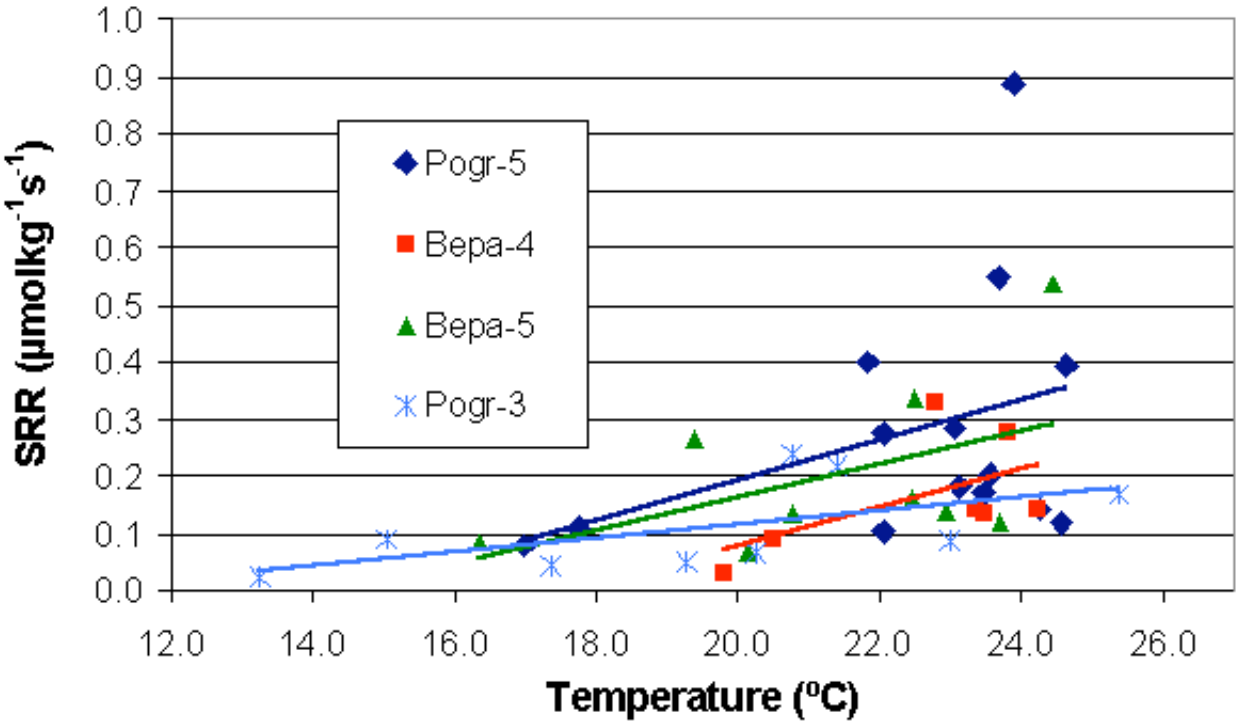
- Within each plot, the species, decay class, length, diameter at base, midpoint and top of each log were recorded. This data was used to calculate the total necromass per hectare across all plots.
- All CWD was also mapped, numbered and tagged for future time-series analyses.
- Densities for each species and decay class were calculated by collecting, drying and weighing samples of known volume from the field.
- PVC collars were mounted on representative logs of each species and decay class with silicone.
- CO_2 efflux ($\mu molm^{-2}s^{-1}$) and CWD temperature were measured using the LI-COR 6400 on 9 days over a two week period.
- The CO_2 efflux was converted to Specific Respiration Rates (SRR) ($\mu molkg^{-1}s^{-1}$) for each species and decay class using the census and density information. The cylindrical area under the collar was assumed to be the area of CO_2 evolution.

- Linear regression analysis comparing temperature and SRR was completed for all species and decay classes (Graph 1).
- For those classes found to be temperature-dependent, SRR was modeled over a two-month period using temperature data from July and August of 1999 (Graph 2).
- For the temperature-independent classes, the mean SRR values were used from the collected field data.
- SRR values for both temperature-dependent and independent data were then converted to $\mu molkg^{-1}$.
- Using the necromass data from the field, the total kilograms of carbon lost were calculated for the two-month period of July to August 1999 (Table 1).

4. Results

- Based on linear regression analysis, temperature differences were found to explain the following variation in SRR:
  - 31.8% for Bepa-4 (*B. papyrifera*)
  - 24.4% for Bepa-5
  - 33.2% for Pogr-3 (*P. grandadentata*)
  - 13.6% for Pogr-5
- With a p-value of less than 0.20, these classes were found to be temperature-dependent (Graph 1).
- For these classes, SRR data was modeled using the temperature data from July and August of 1999 (Graph 2):
- Using the mean SRR values for the temperature-independent classes, the total kilograms of carbon lost from the forest for the two-month period from July to August of 1999 was calculated (Table 1):

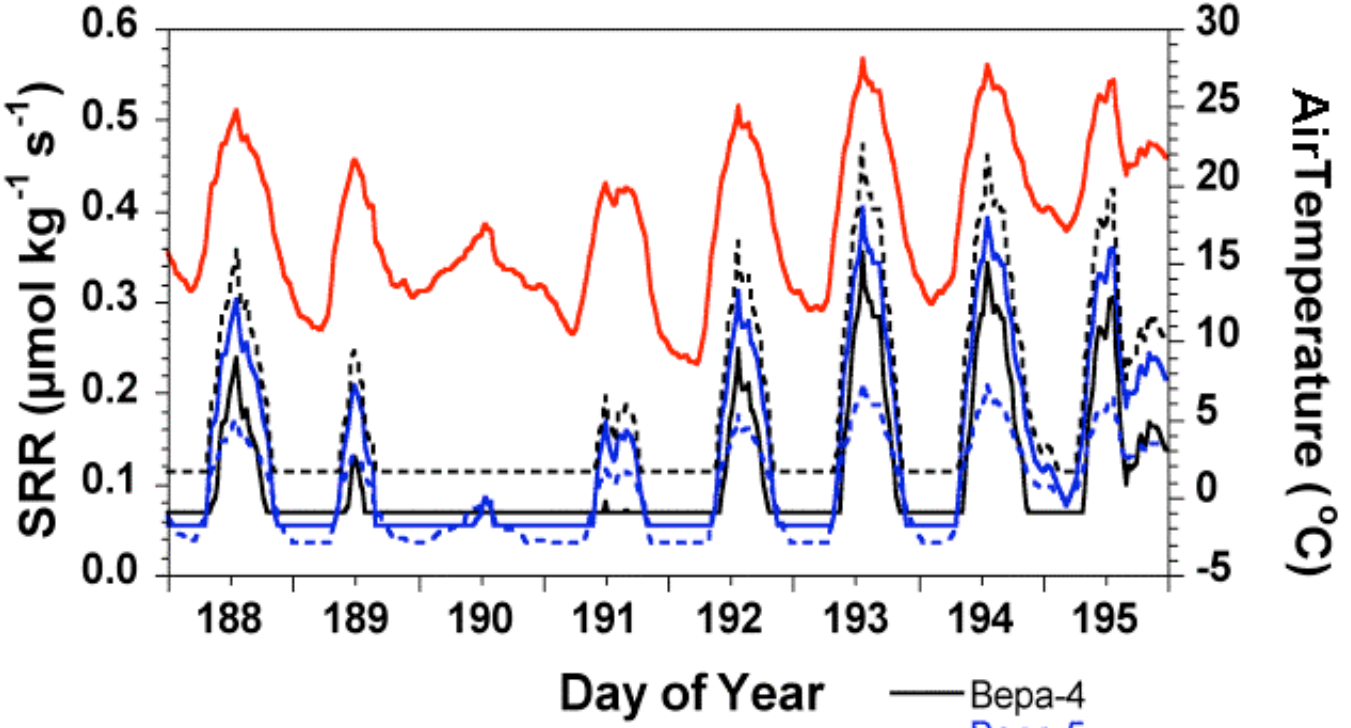
Graph 1 CWD Temperature Vs. Specific Respiration Rate



Four of 10 classes were found to be temperature-depended based on the above linear regression analysis and a p-value of 0.20.

Graph 2

Specific Respiration Rate over Time



Here the modeled SRRs are shown for the temperature-dependent classes over 7 days of the 2-month period.

Table 1

Total Carbon Lost from CWD Respiration July-August 1999

Species & Decay Class	Mean SRR ($\mu molkg^{-1}s^{-1}$)	($\mu molkg^{-1}$)	Mean Necromass	Lost Carbon $kgCha^{-1}$
Acru-3	0.213	1,143,292.2	70.7	0.970
Bepa-2	0.027	146,030.2	61.6	0.108
Bepa-3	0.214	1,144,492.9	58.9	0.809
Bepa-4*		663911.0*	15.0	0.119
Bepa-5*		848796.4*	39.0	0.398
Pogr-1	0.087	468,158.5	455.2	2.557
Pogr-2	0.077	414,563.8	155.4	0.773
Pogr-3*		560815.6*	147.0	0.989
Pogr-4	0.135	725,366.7	2.5	0.022
Pogr-5*		1095750.7*	0.6	0.008
Total Lost Carbon				**6.754**

*Temperature-dependent class

5. Conclusions

- While some degree of temperature-dependency was exhibited by the sampled CWD, the relationship was not as strong as has been observed within plant and soil respiration.
- Because CWD respiration, like that of soil, is heterotrophic, it is likely that it is also dependent on moisture levels.
- For this reason, it is probable that dry conditions this summer negatively affected the temperature relationship.
- CWD moisture could not be measured with confidence based on the instrumentation but would be an interesting topic for future studies.
- Because soil respiration is the major component by which carbon leaves the system, comparing it with CWD respiration yields a good understanding of the relative fluxes.

- Over the same two-month period, soil respiration was 4,621.0 $kgCha^{-1}$ (Curtis pers. comm.).
- CWD respiration was found to make up less than 0.14% of soil respiration.
- Based on this comparison, CWD appears not to be a significant contributor to the amount of carbon lost overall from the forest ecosystem.

Works Cited

Marra, James L. and Robert E. Edmonds. 1994. Coarse woody debris and forest floor respiration in an old-growth coniferous forest on the Olympic Peninsula, Washington, USA, Can. J. For. Res. 24: 1811-1817.