

Linking aboveground and belowground responses to chronic soil warming



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In a warming climate . . .

. . . how will the C balance of temperate forests be affected?



Harvard Forest

NSF Long Term Ecological Research Site

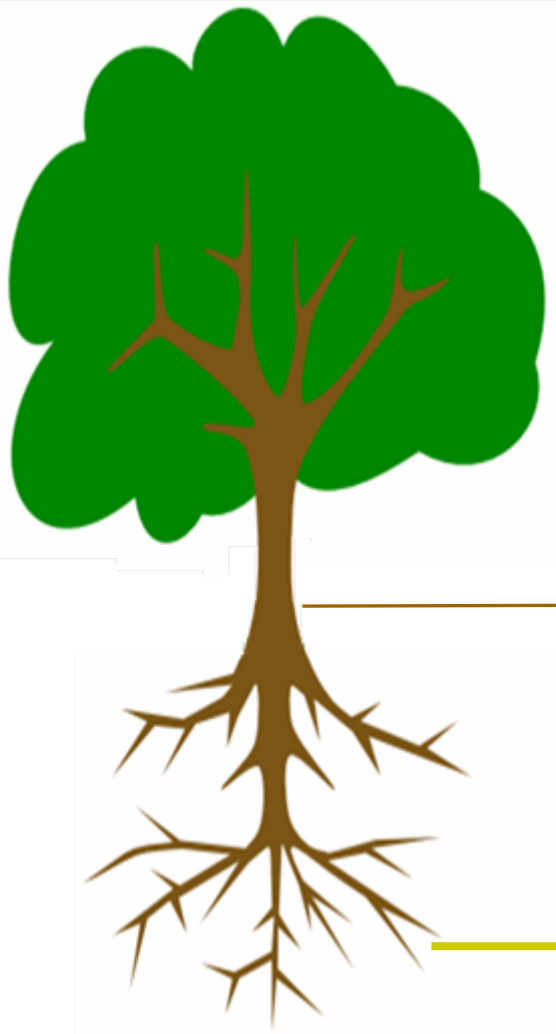


Components of net C balance in terrestrial systems:

- Respiration
- CO₂ sequestration

Two primary responses to soil warming have been observed:

- 1. An increased rate of CO₂ loss from the heated soils.**
- 2. An increased rate of N mineralization**



Current C
(roots & rhizosphere)

Surface litter

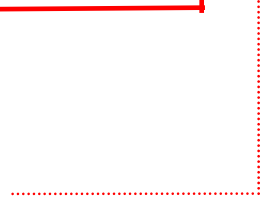
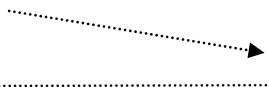
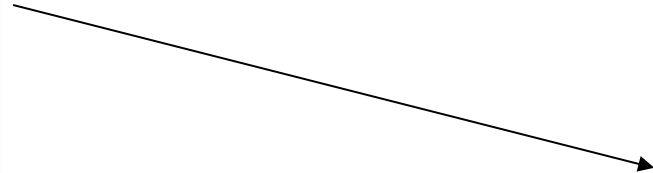
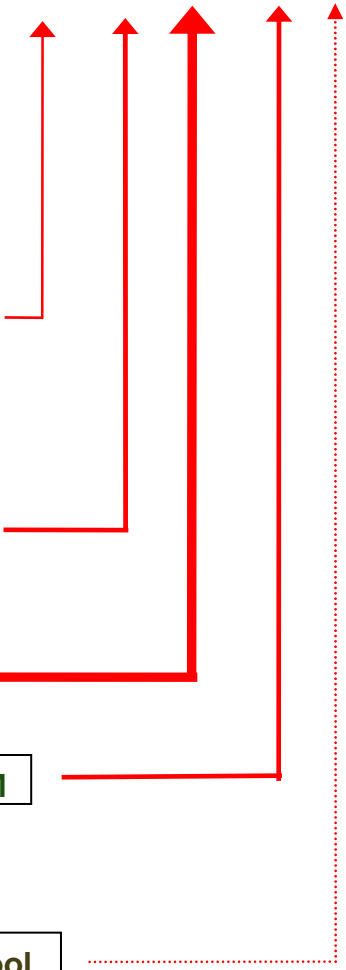
Labile SOM

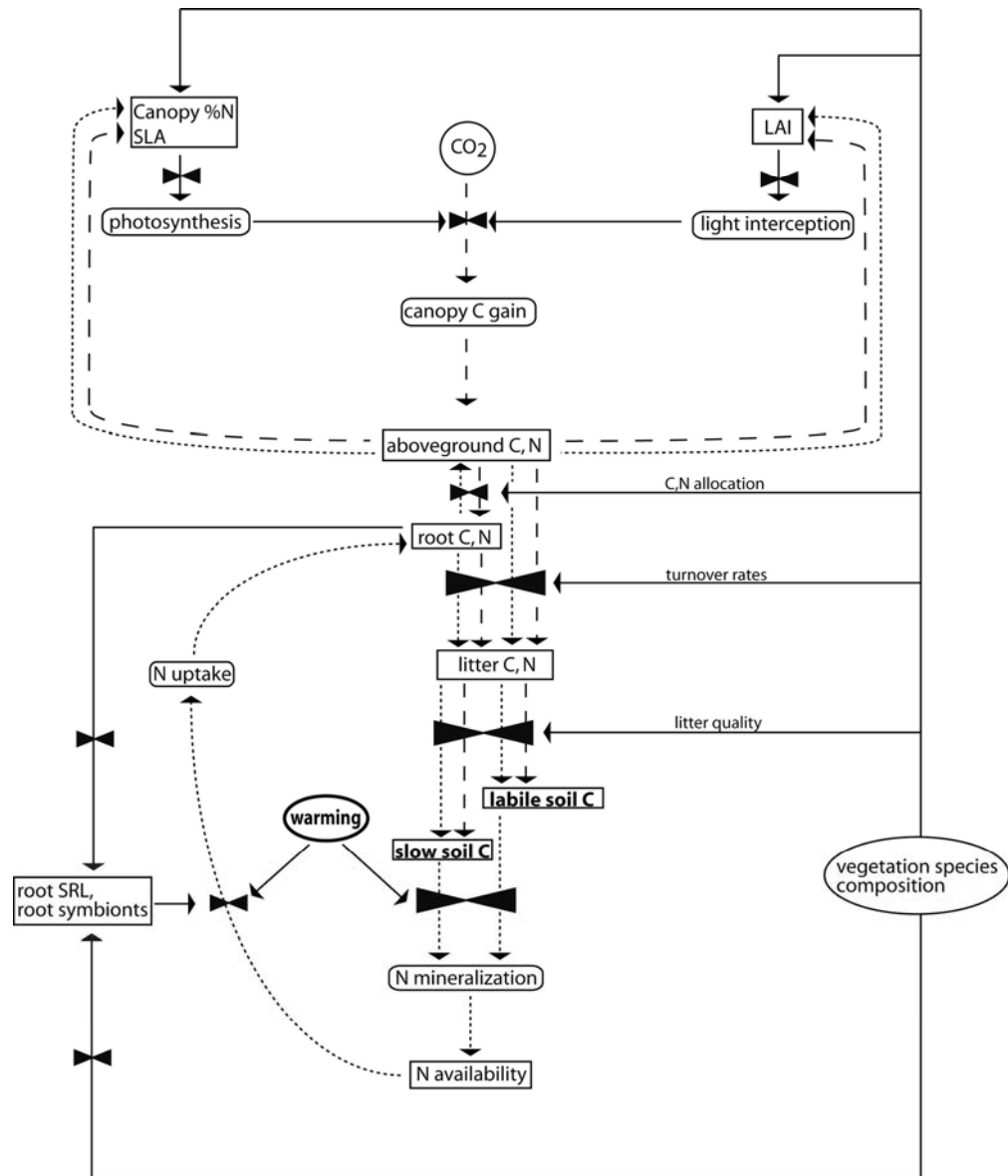
Intermediate SOM

Slow decay C pool

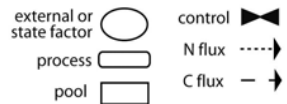
CO₂

root death & exudation





The above diagram represents a simplified hypothetical model of the effects of soil warming on interacting biogeochemical and vegetative processes. Various components of the system are defined as follows:

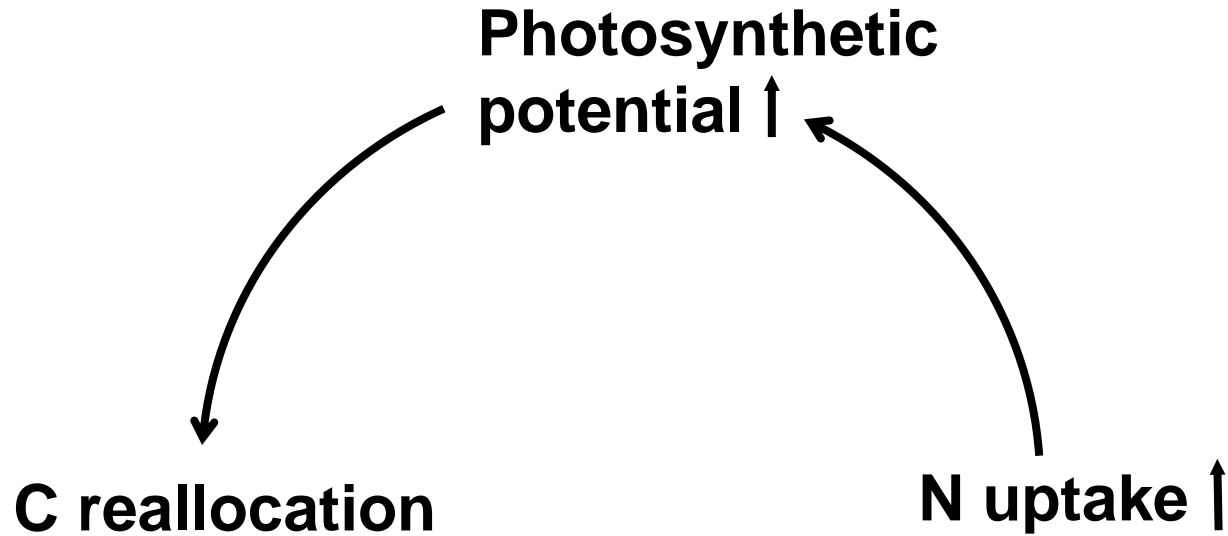


Vegetative growth is N-limited in this system

↑ **inorganic N** + ↑ **growing season**

**An increased rate of C
storage in woody tissues is
observed**

C sequestration response to belowground warming



Rubisco (*cellular*) ↑

C:N (*leaf*) ↓

SLA (*leaf*) ↓ , —

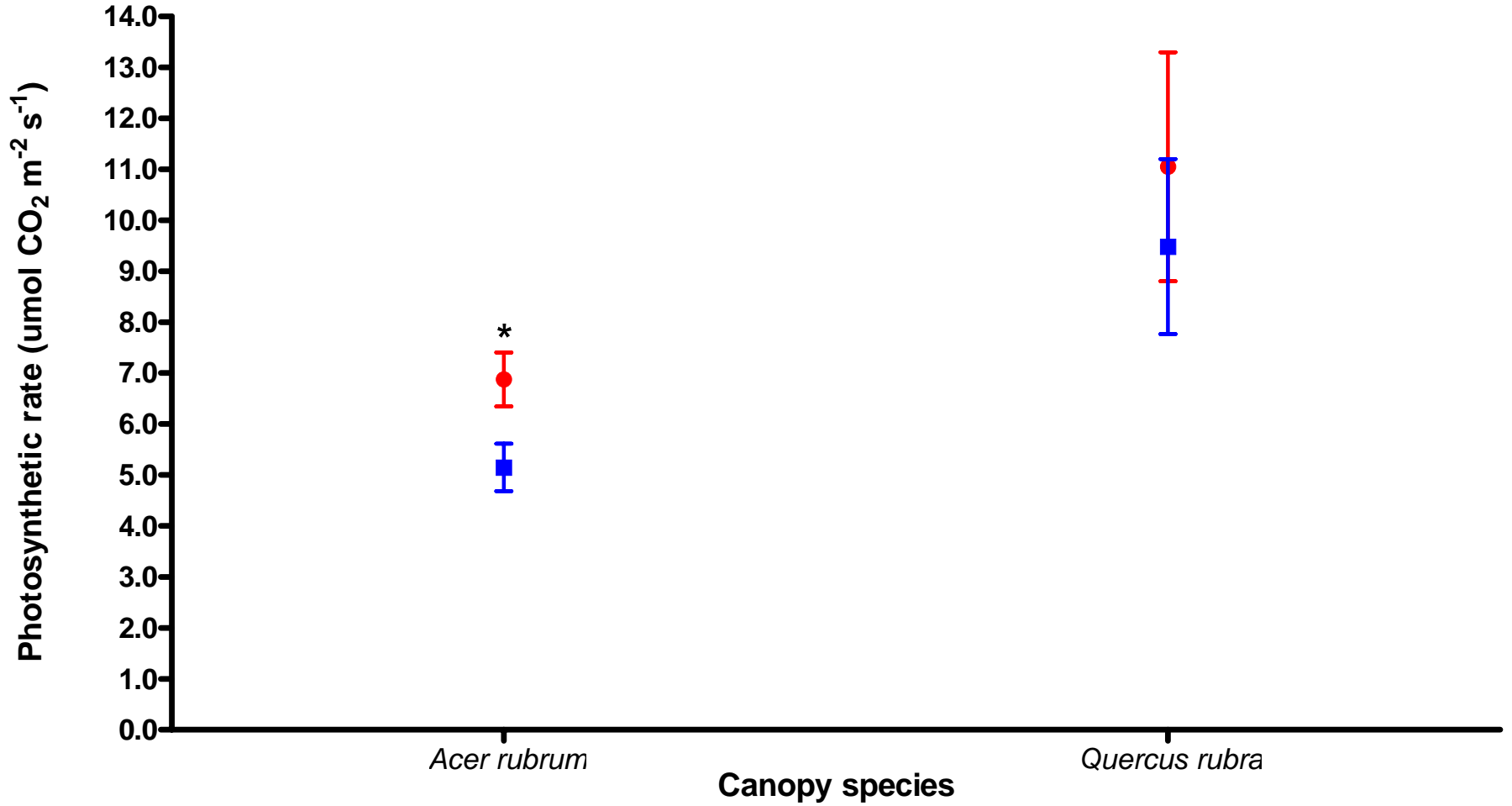
Total leaf area (*whole plant*) ↑ , —

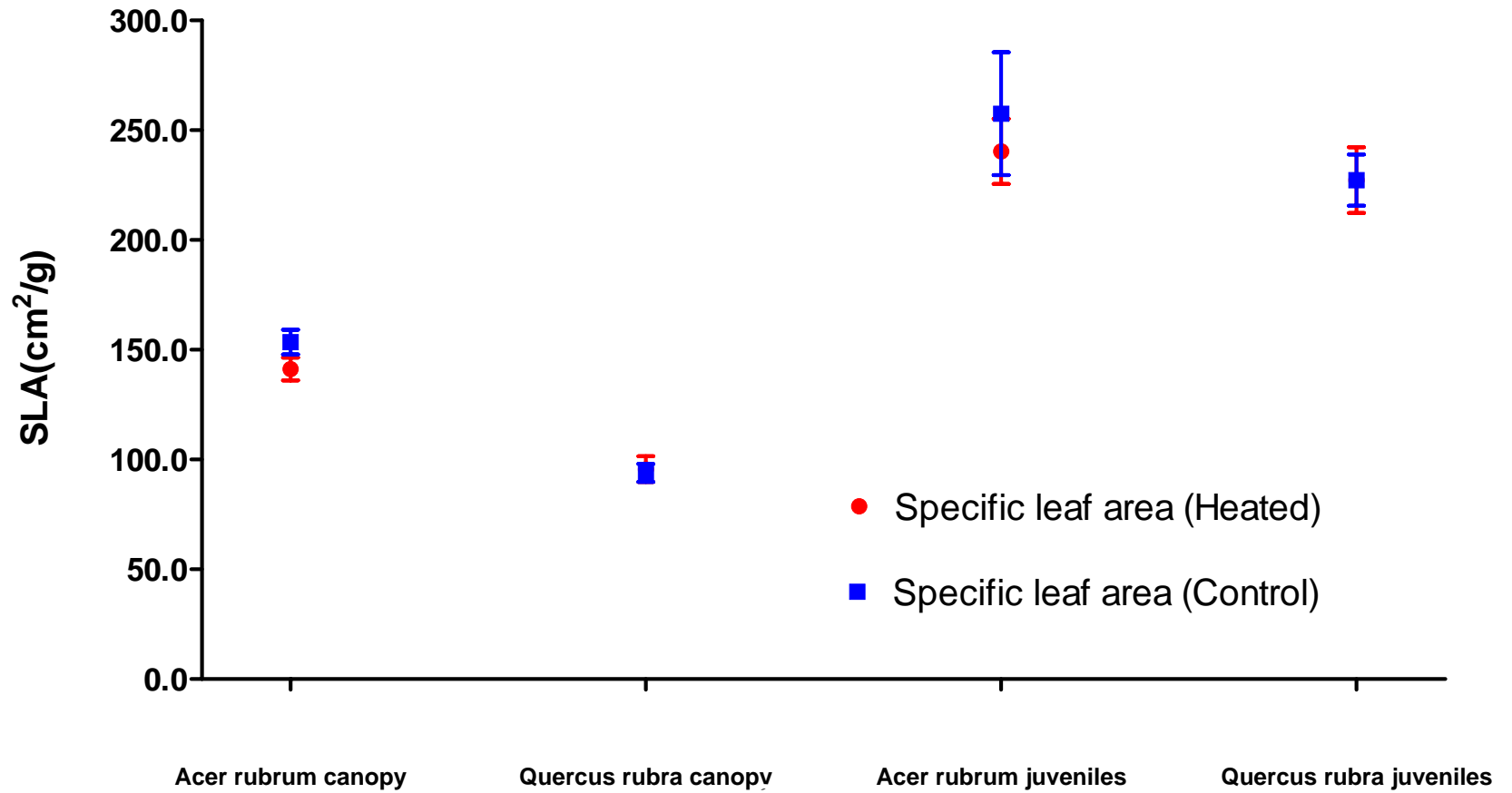
Aboveground studies

- Characterize LAI over multiple years of warming from canopy development through senescence.
- Analyze leaf morphology (e.g. SLA, stomatal density) and chemistry (e.g. C/N, cations).
- Characterize photosynthetic potential across species.

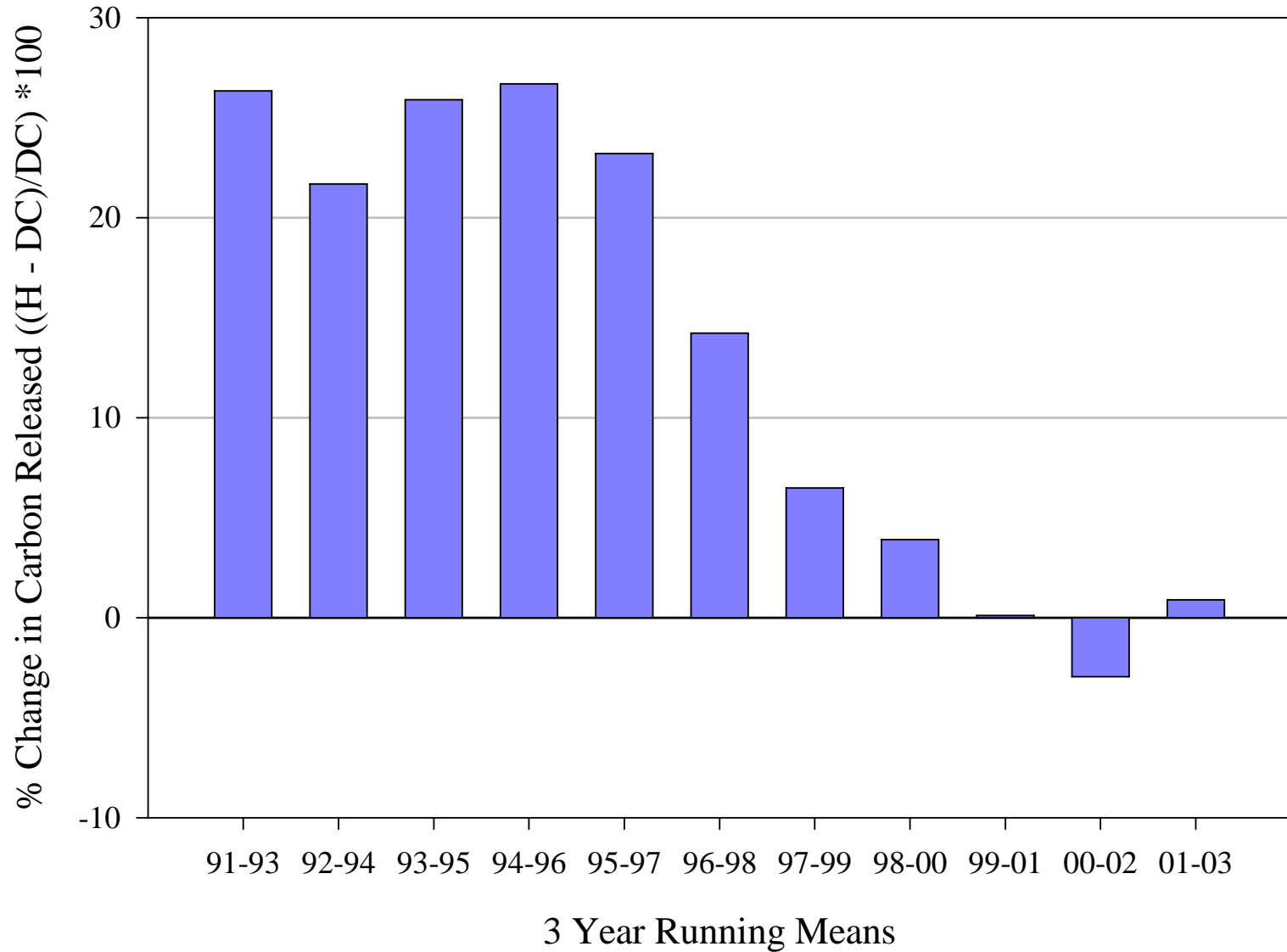


Relative photosynthetic rate of canopy leaves at 2500 PAR



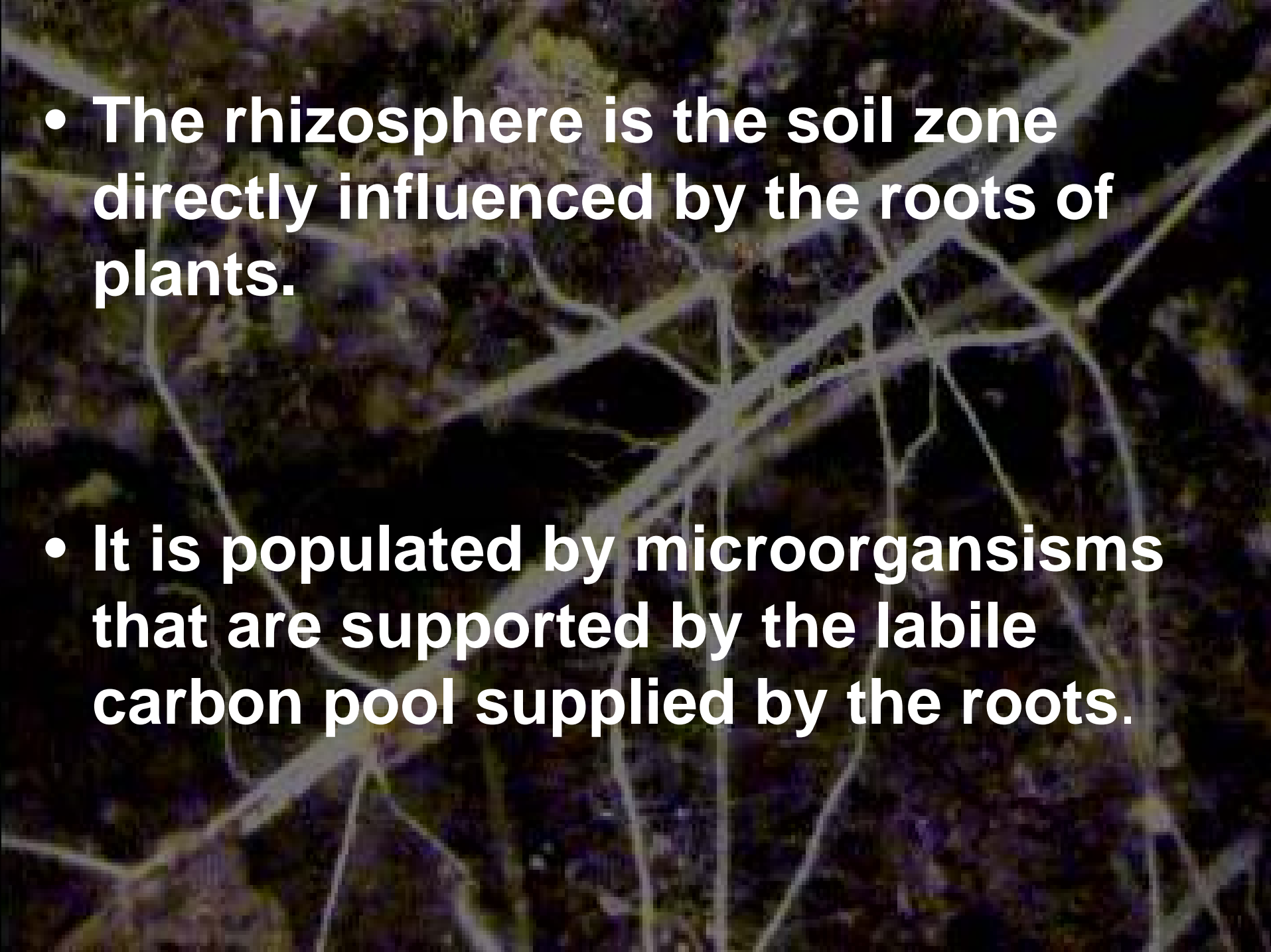


Changes in Carbon Release in Response to Warming Heated vs. Disturbance Control, 1991-2003



What's driving this decrease in soil respiration?

- Decreasing soil labile C availability
 - ❖ Increased SOM decomposition rate
 - ❖ Decreased rhizosphere surface area

- 
- **The rhizosphere is the soil zone directly influenced by the roots of plants.**
 - **It is populated by microorganisms that are supported by the labile carbon pool supplied by the roots.**

Belowground studies

- Assay fine root biomass and production in new soil warming experiment.
- Test cold girdling system in 2007 field season and potentially implement it in the warming plot.
- Utilize alternate methodologies as needed (e.g. diel measurements).

The effects of soil warming on fine root dynamics are being characterized using biomass and in-growth core methods.

- 144 cores per plot taken out for fine-root biomass characterization.
- In-growth cores were replaced excavated cores.
- Sub-samples will be harvested yearly for the next 4 years of warming treatment.



Root respiration has been estimated to contribute from 10% to 90% of total CO₂ soil efflux.

*Girdling trees reduced CO₂ efflux ~54%

* Trenching ~ 33% total soil respiration

Methodological Problem: Destructive and non-reversible!

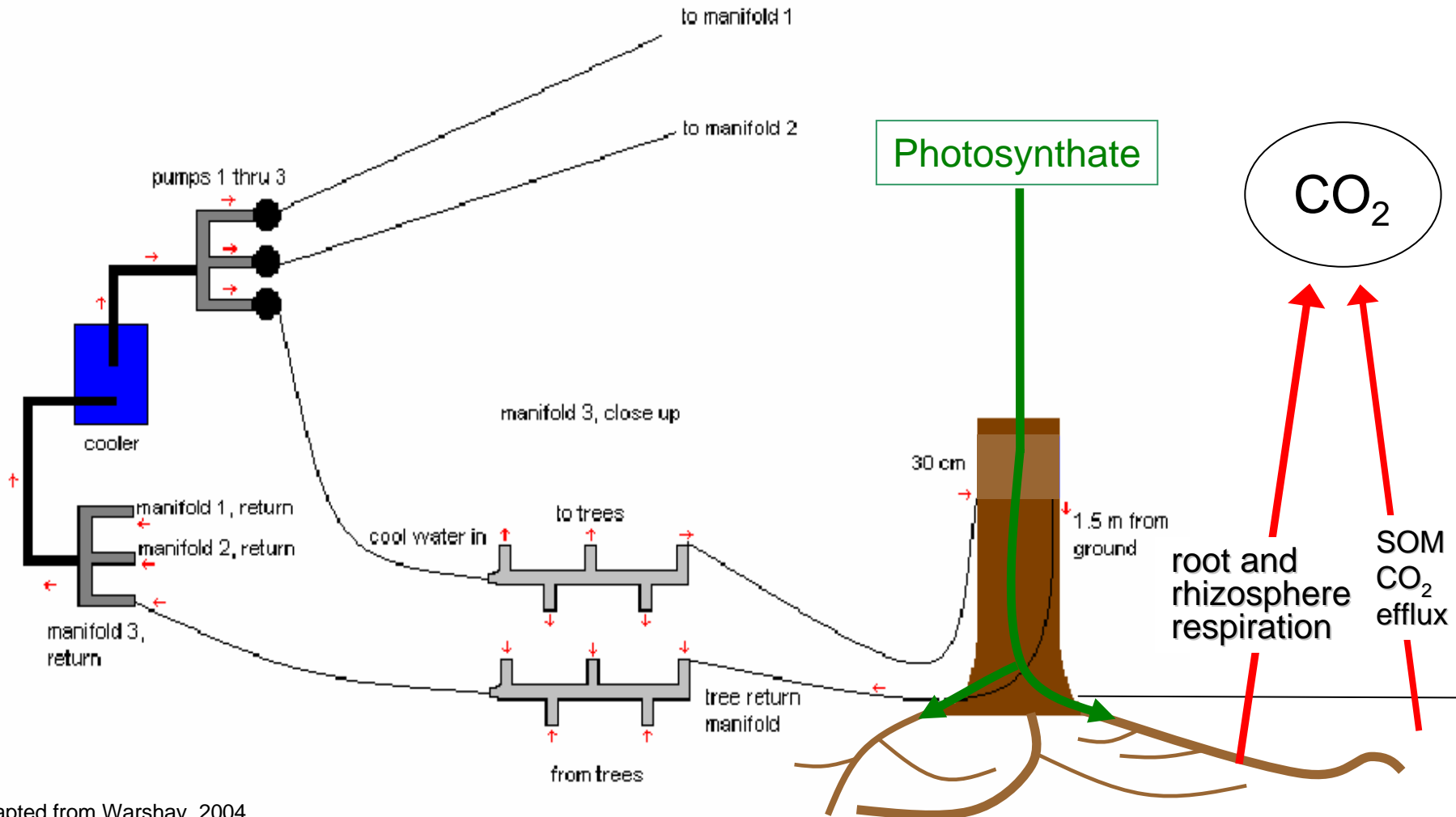


C. E. Swift



Cold girdling: A reversible method

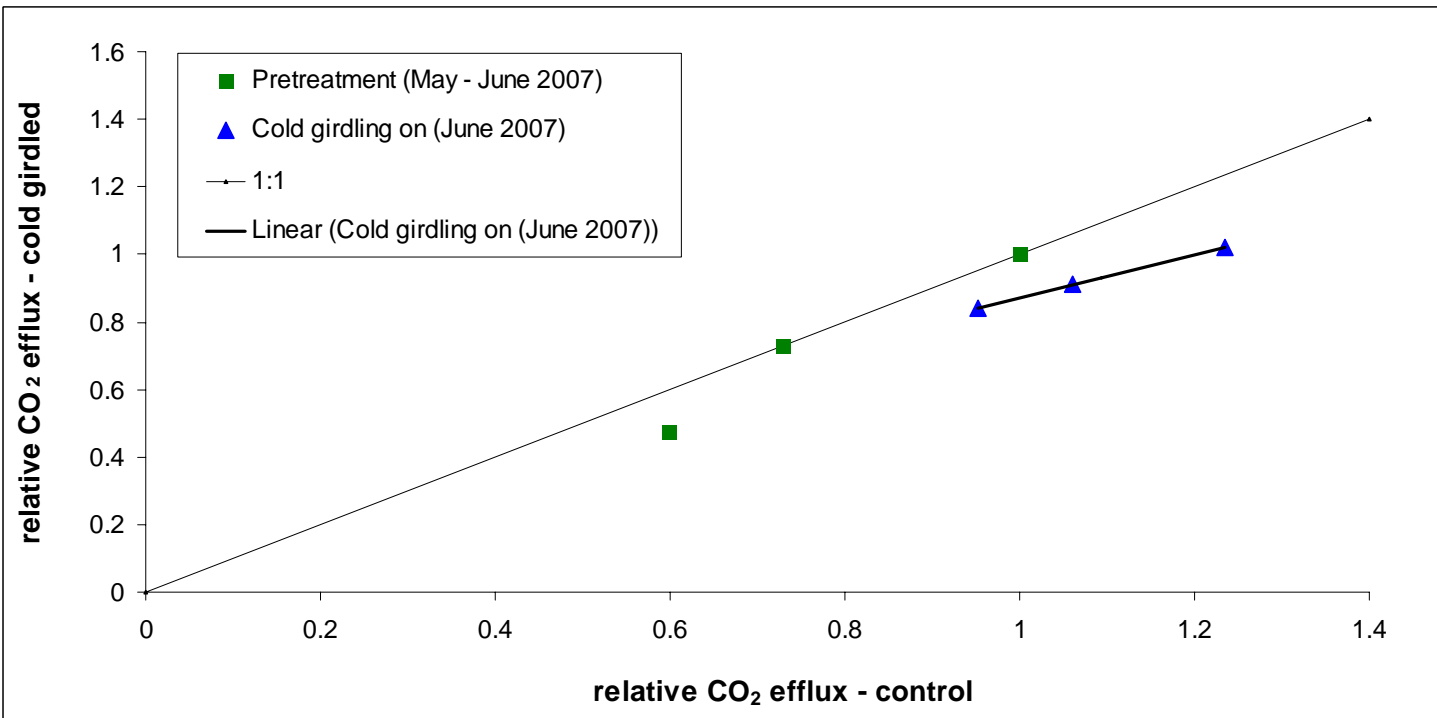
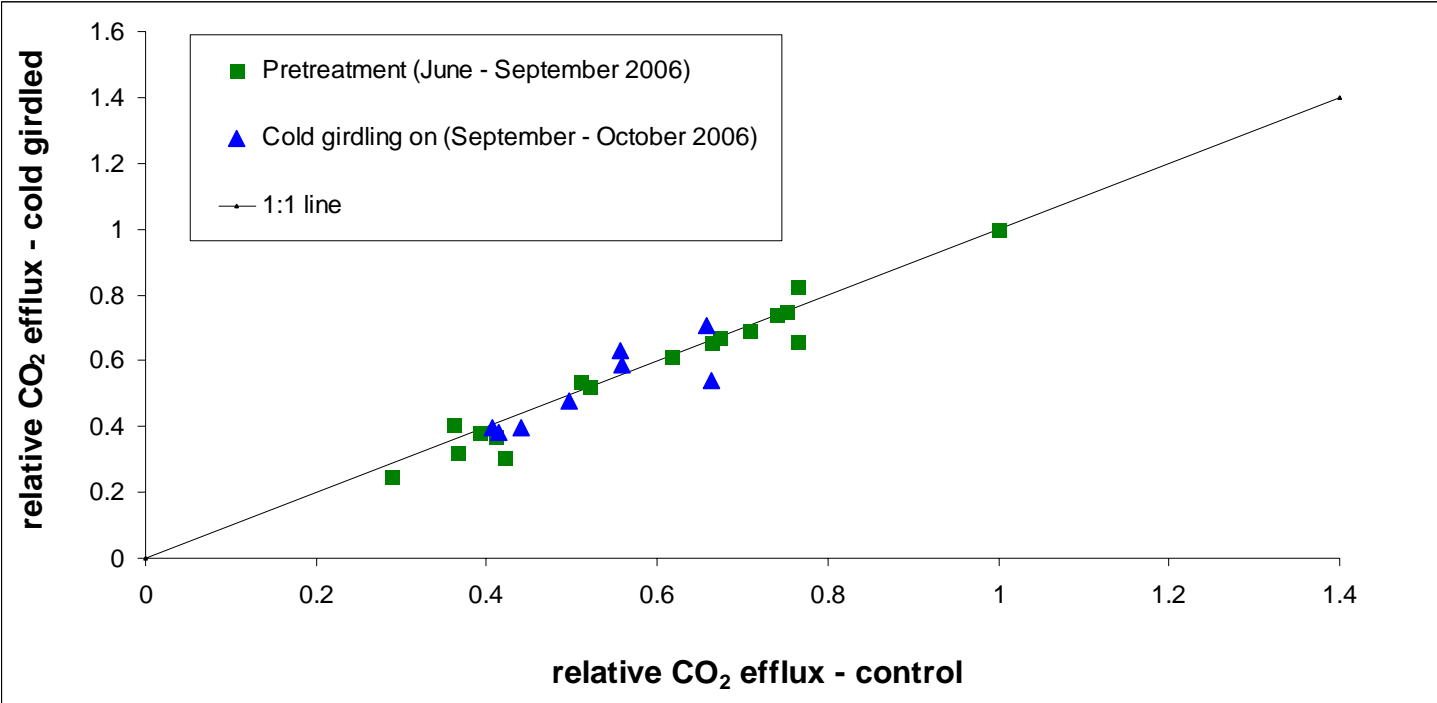
not to scale



Adapted from Warshay, 2004







Approximately 44% more C has been respired from heated soils than is being stored in new wood growth

Further characterize canopy response patterns to soil warming and correlate with changes in aboveground biomass.

Continue experiments to separate components of soil respiration in soil warming plot in development

Changing soil respiration in response to warming over time

may reflect changes in:

- Labile soil C**
- Rhizosphere dynamics**
- Microbial dynamics**

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