

An aerial photograph of a forest fire. The ground is covered in green vegetation, with a large area of brown, charred earth where the fire has burned. Thick white smoke rises from the fire, spreading across the sky and partially obscuring the landscape below. The smoke is most dense near the fire and becomes more wispy as it moves away. The overall scene is dramatic and highlights the impact of fire on the environment.

**LTER 1st Tuesday:
Resolving Soil Rh Response to Fire**

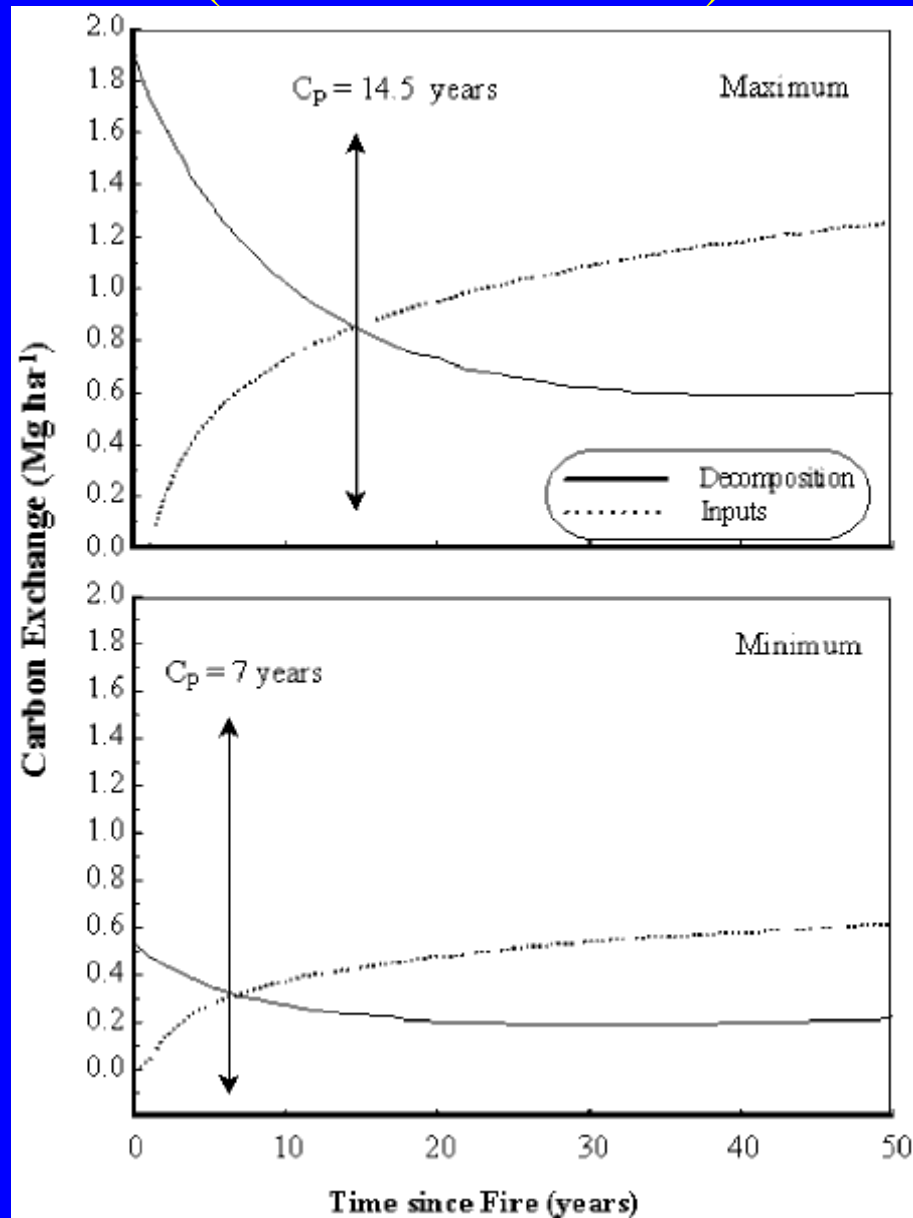
**David Valentine
Eric Kasischke**

Soil Respiration

- $R_s = R_a + R_h$
 - R_a operationally includes roots, rhizosphere, and mycorrhizae
 - R_h includes everything else
- C balance = $f(\text{NPP}, R_h)$
 - $R_h = f(\text{T}, \text{H}_2\text{O}, \text{Substrate})$

NPP, Rh, and C Balance

(O'Neill *et al.* 2003)

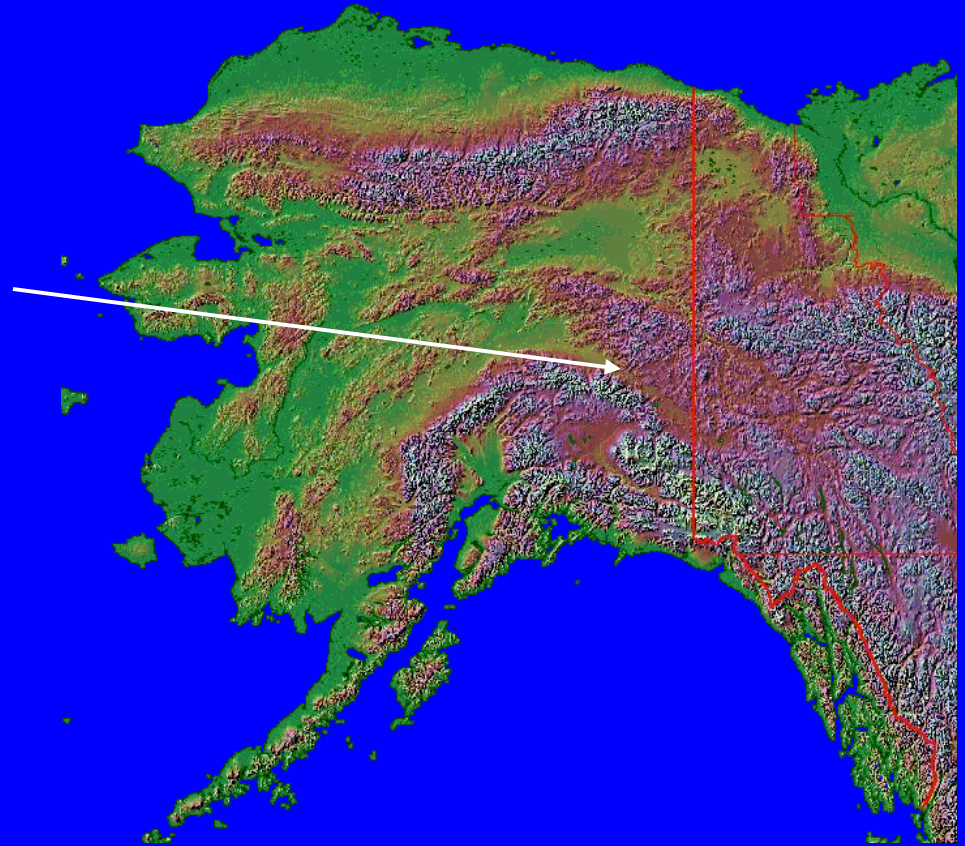


Fire effects on Rh?

- **Increases soil temperature:**
 - Remove canopy → greater insolation
 - Blackens surface → greater absorption
 - Consumes some of O horizon → less insulation
- **Changes soil moisture profile**
 - Warm surface → increase evaporation
 - Reduced LAI → reduced transpiration
 - Warm soils → deeper active layer
- **Changes substrate**
 - Fire severity → surface OM loss
 - Pulse of detritus inputs
 - Loss of root and foliar litter inputs

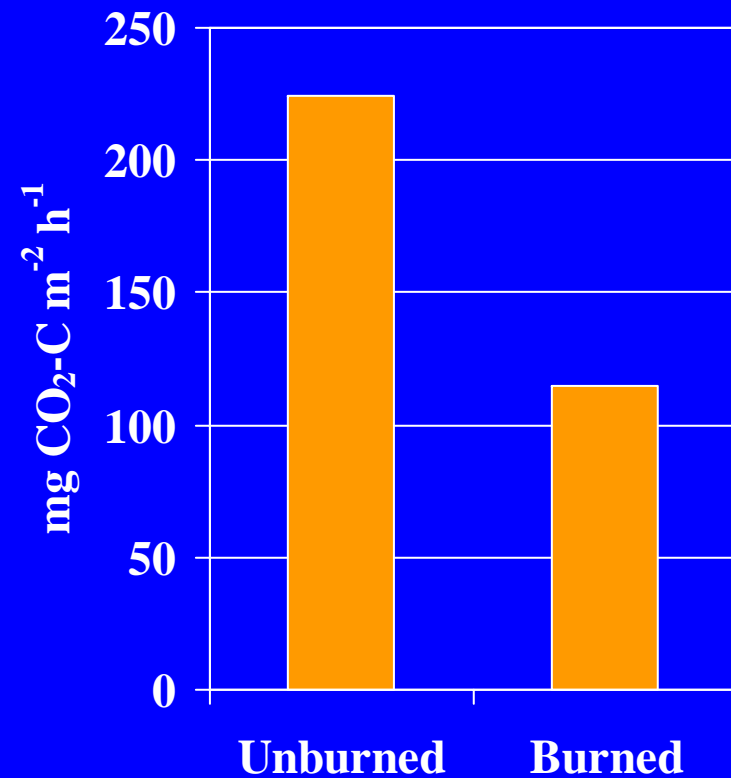
Fire stimulates Rh

- Lowland chronosequence near Delta & Tok, Alaska
 - Richter *et al.* 2000
 - O'Neill *et al.* 2002
- Glacial outwash underlain by shallow permafrost



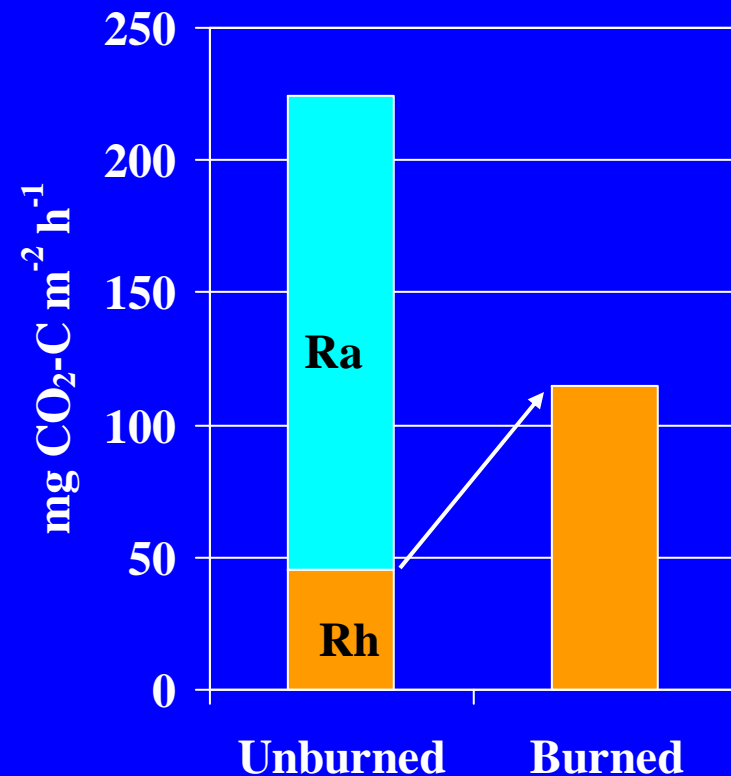
Richter et al. 2000

- R_s in burned soils \approx
 $0.5 \times$ unburned soils



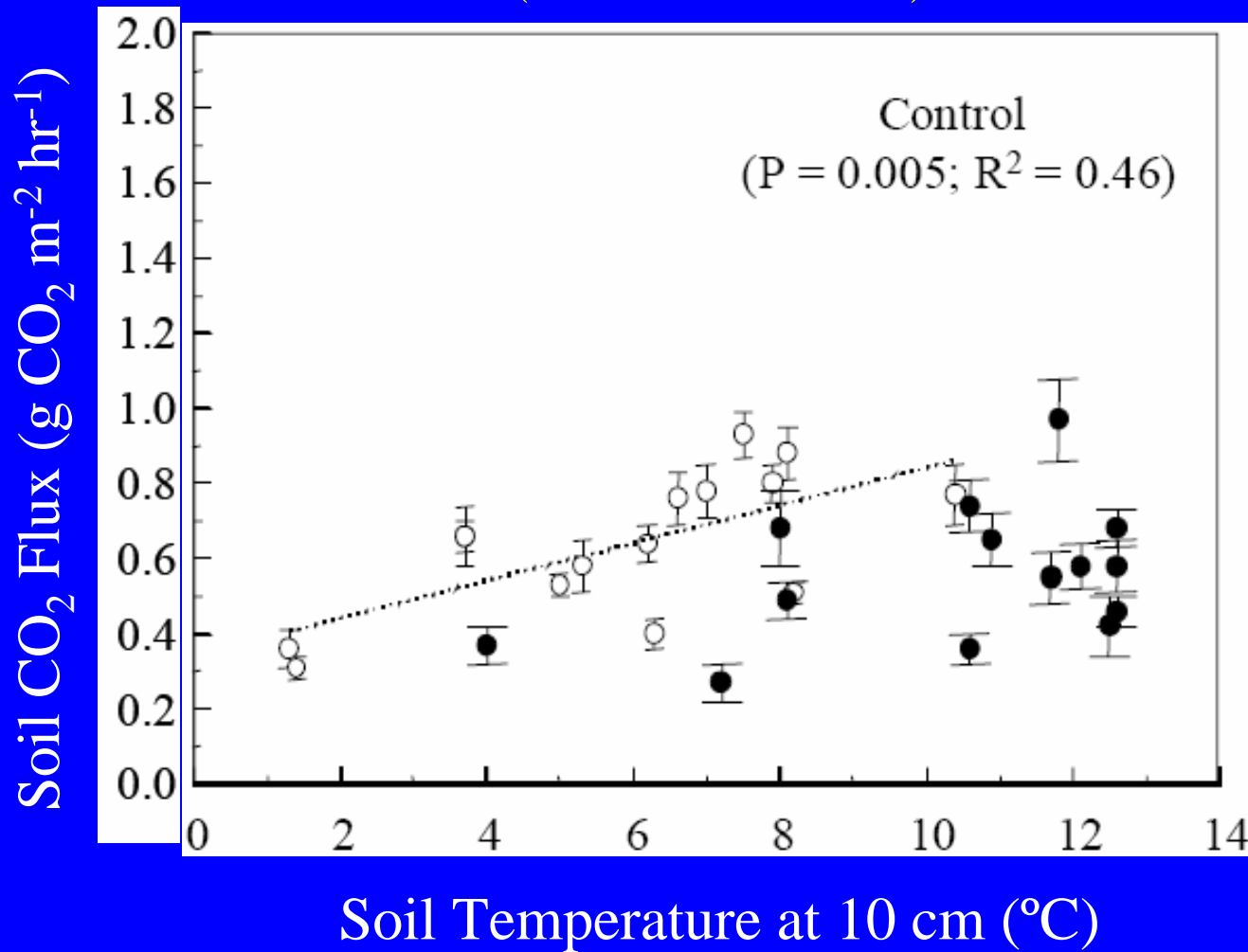
Lowland chronosequence

- R_s in burned soils $\approx 0.5 \times$ unburned soils
- Unburned $R_h \approx 0.2 \times R_s$
 - Schlentner and Van Cleve 1985



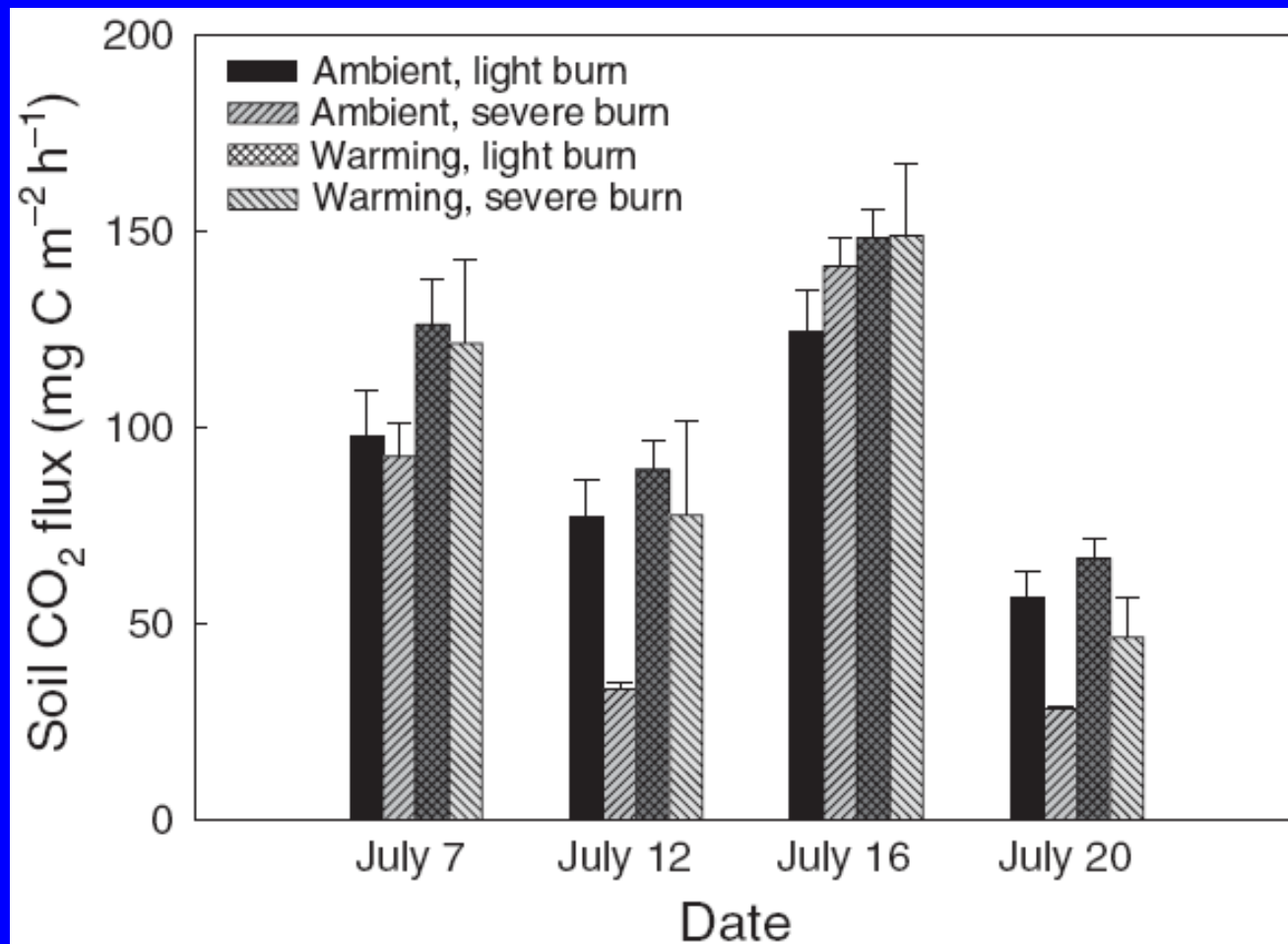
Soil temperature in black spruce

(O'Neill *et al.* 2002)



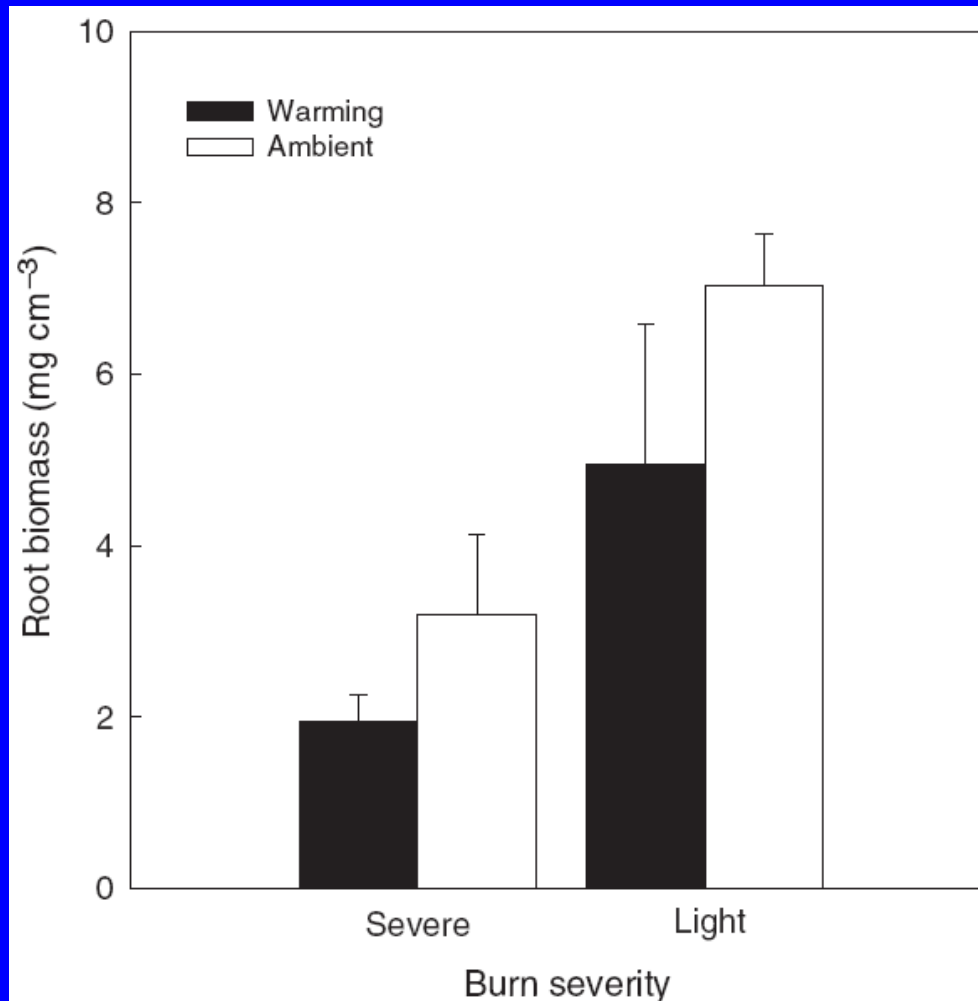
Soil Temperature in black spruce

(Bergner *et al.* 2004)



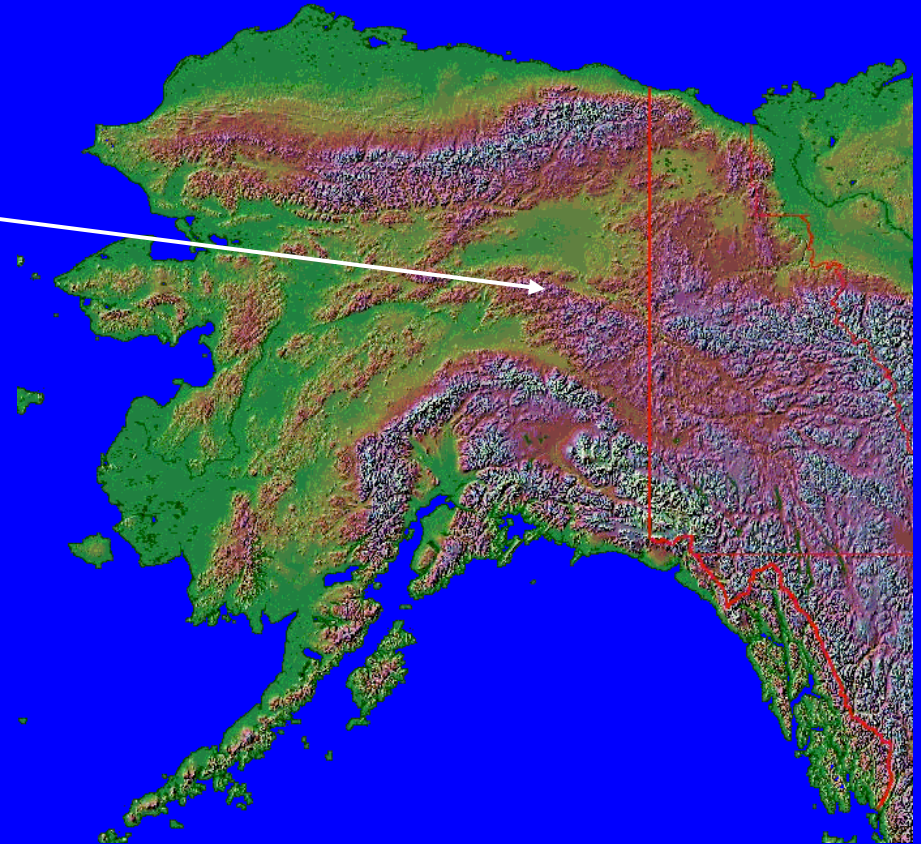
Role of roots following fire?

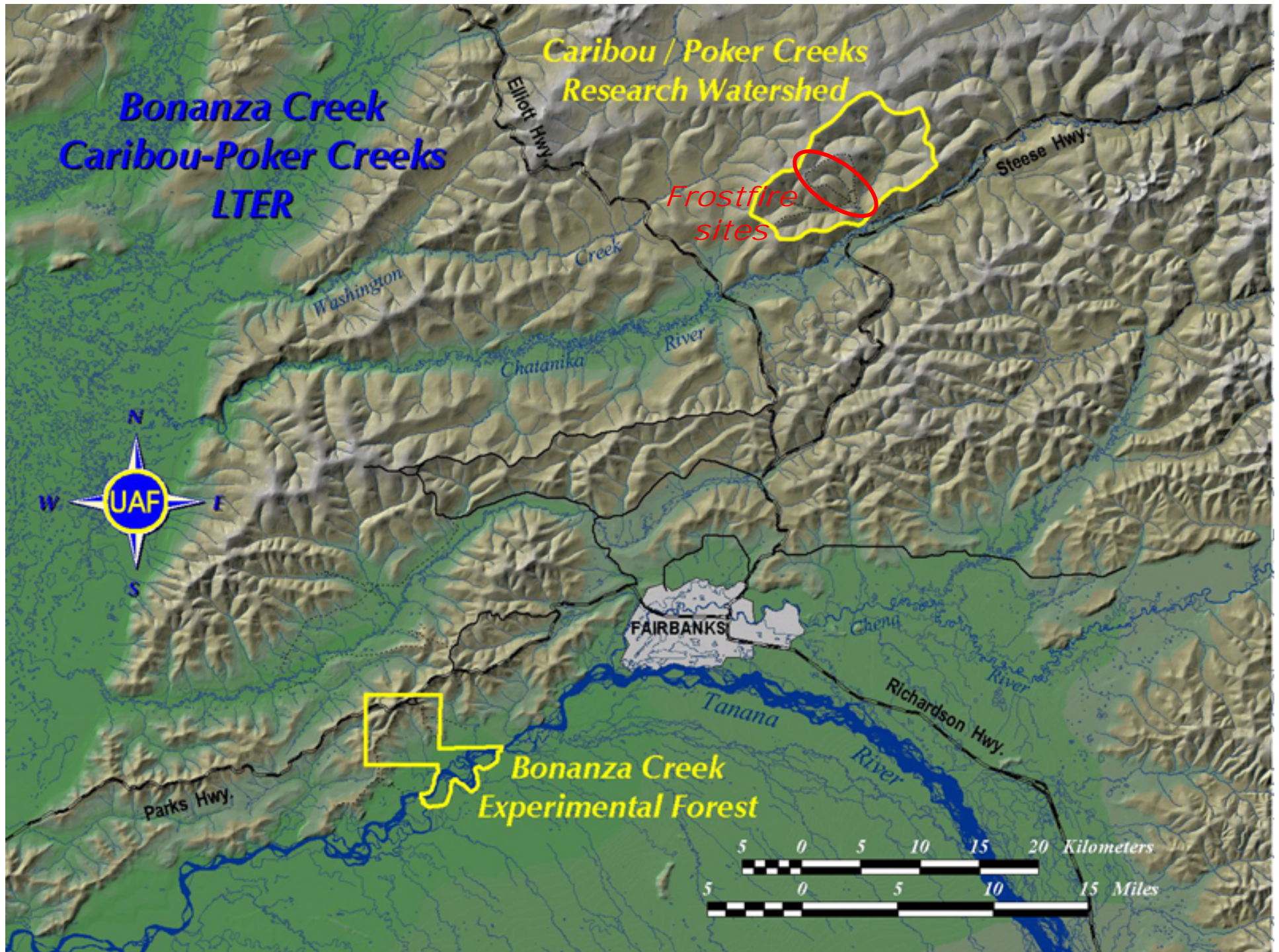
(Bergner *et al.* 2004)



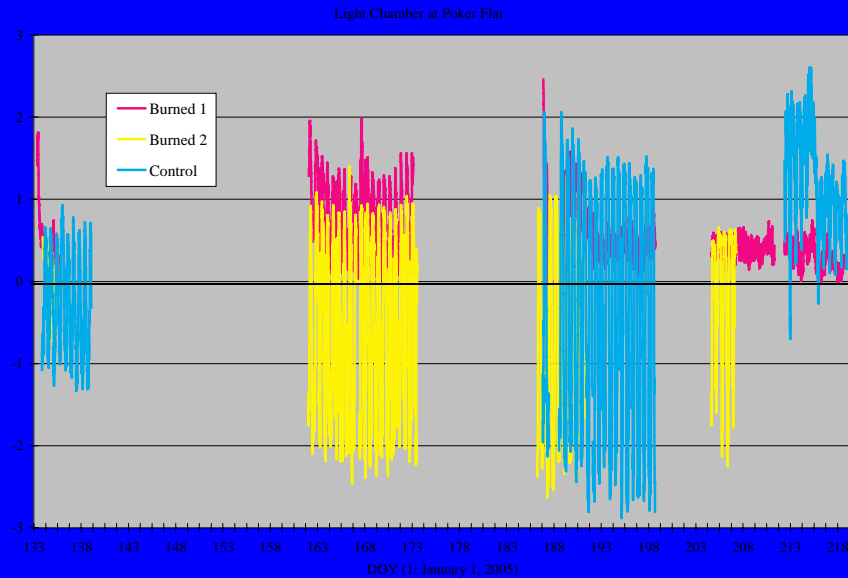
Fire suppresses Rh

- Frostfire experimental wildfire in uplands near Fairbanks, Alaska
 - Valentine 2002
 - Schuur *et al.* 2004
- Generally well-drained rocky soils near ridge

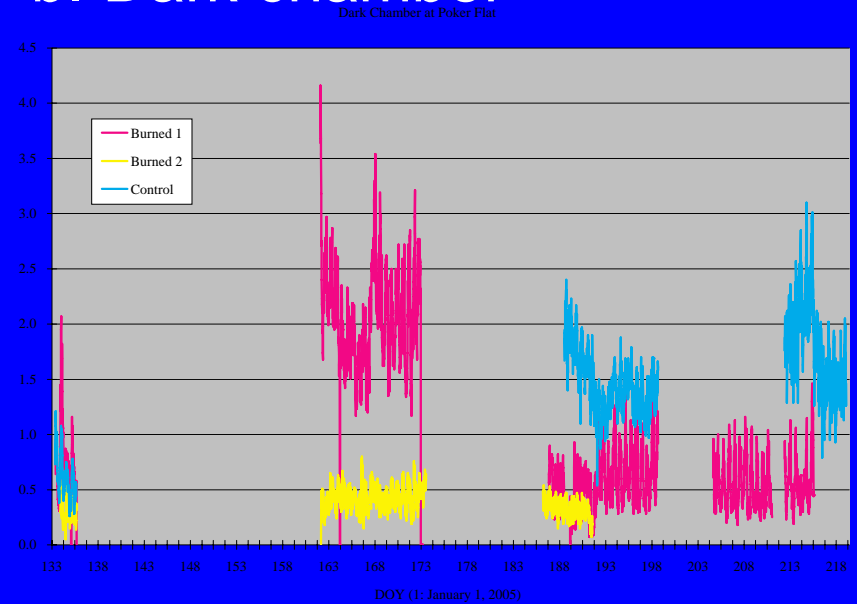




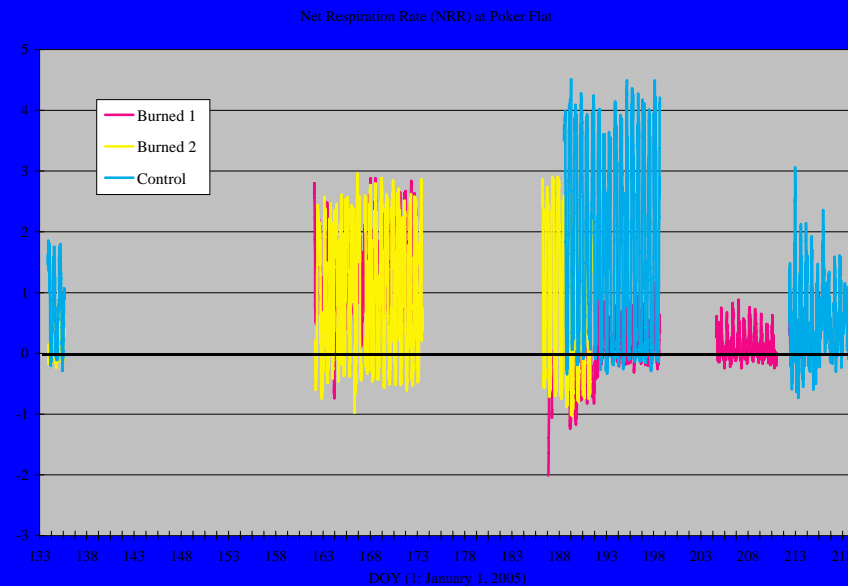
a. Light chamber at Poker Flat



b. Dark chamber



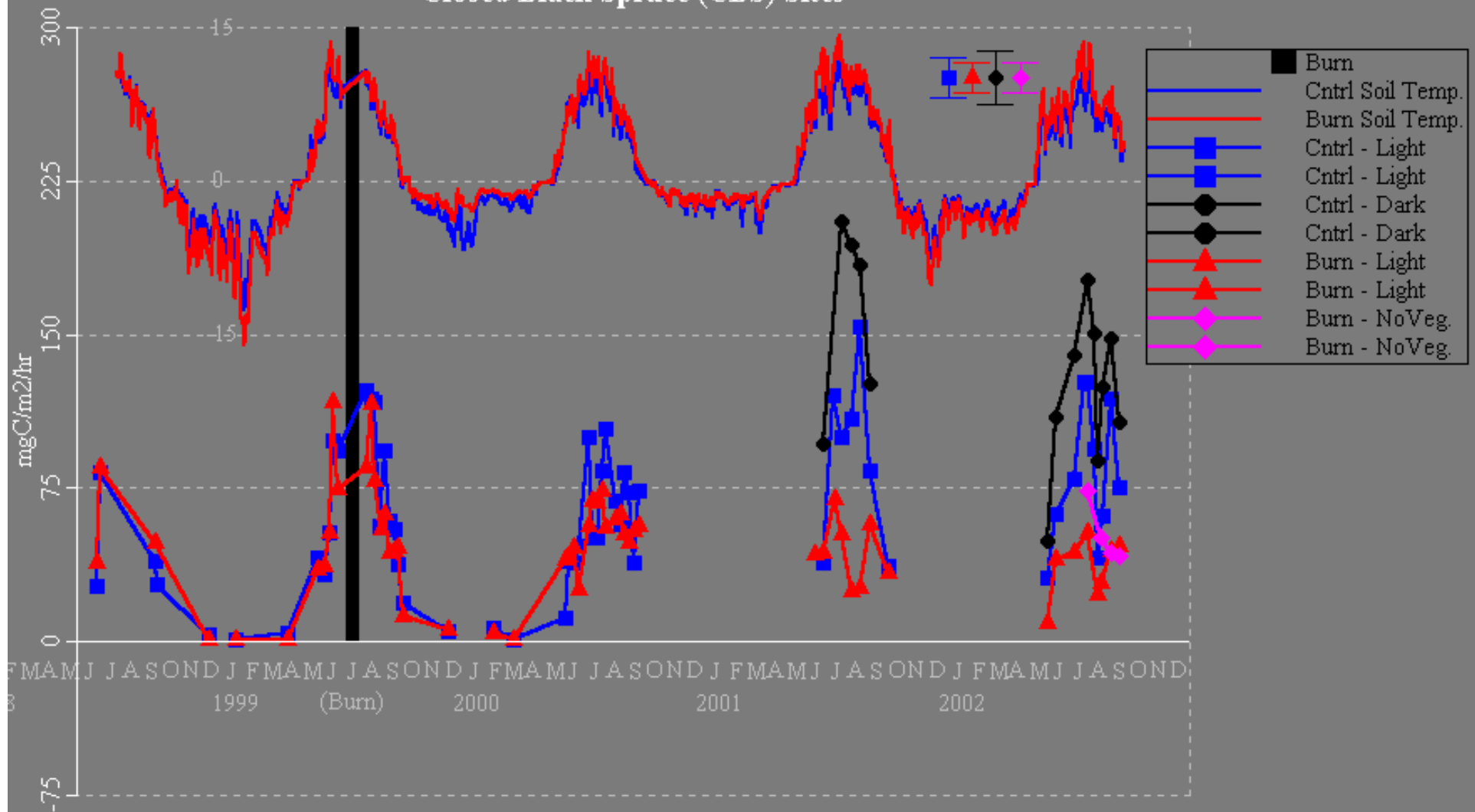
c. Net Respiration Rate (Dark-Light) Kim 2006

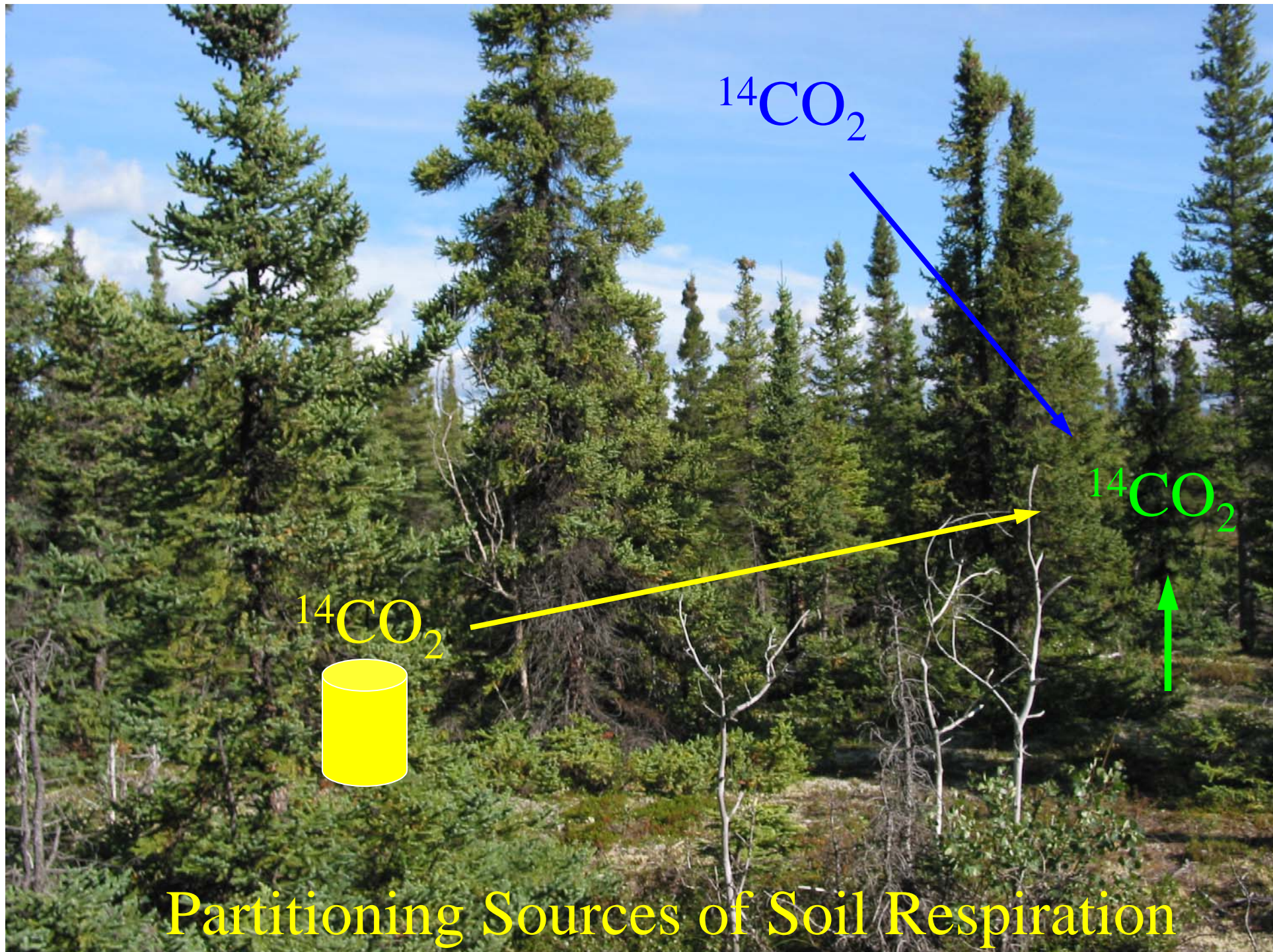


1. 30 min. interval
2. Diurnal Variation
3. C emissions (143 days)
 - * Burned: 143 g C m^{-2}
 - * Control: 253 g C m^{-2}
4. Continuous measurements of CO_2 flux since 2006

Post-fire Black Spruce

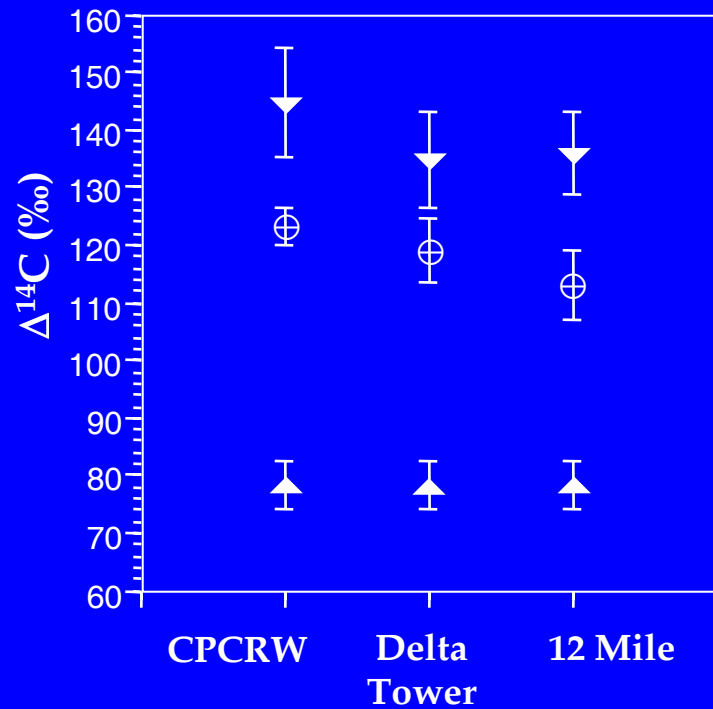
FrostFire Respiration and Soil Temp.
Closed Black Spruce (CBS) Sites



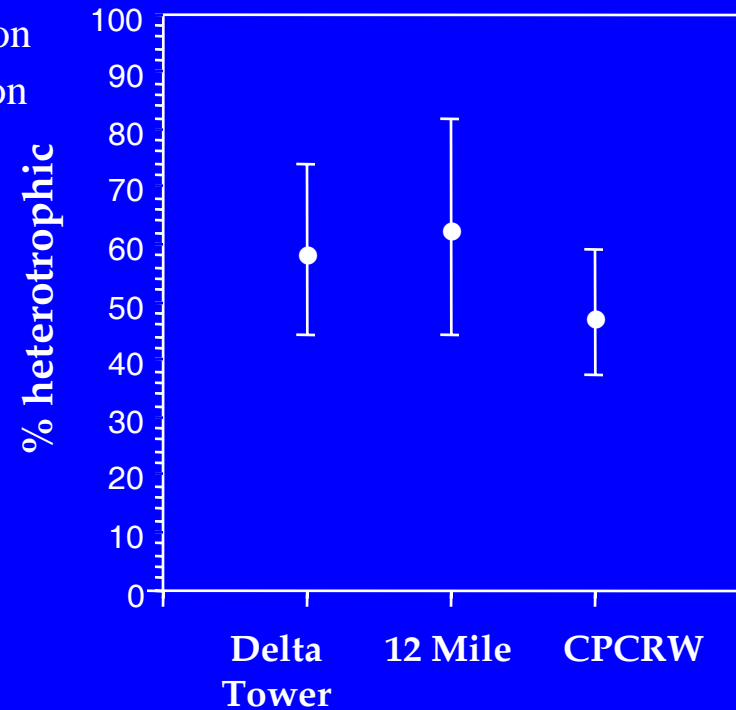


Partitioning Sources of Soil Respiration

Respiration Partitioning (Schuur)

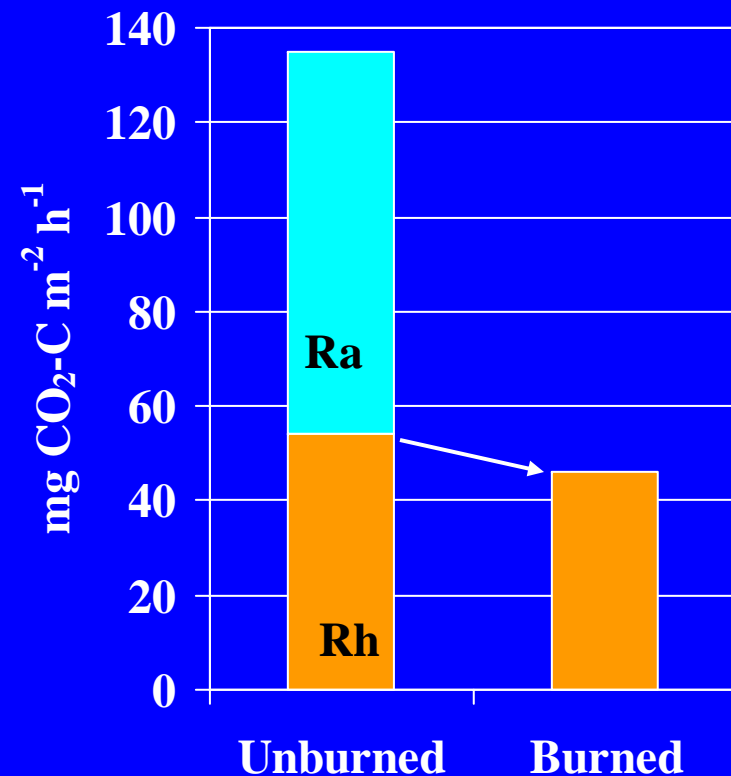


- soil respiration
- ▼ soil incubation
- ▲ atmosphere



Frostfire uplands

- R_s in burned soils $\approx 0.35 \times$ unburned soils
- Unburned $R_h \approx 0.4 \times R_s$
 - Vogel *pers. comm.*
 - Rocky soils obviated solid R_a vs. R_h



Growing Season Soil C Emissions

Burned, removal = 188.6 g C m^{-2}

Unburned = 512.8 g C m^{-2}

Growing Season Soil C Emissions (Schuur)

Burned, removal = 188.6 g C m^{-2}

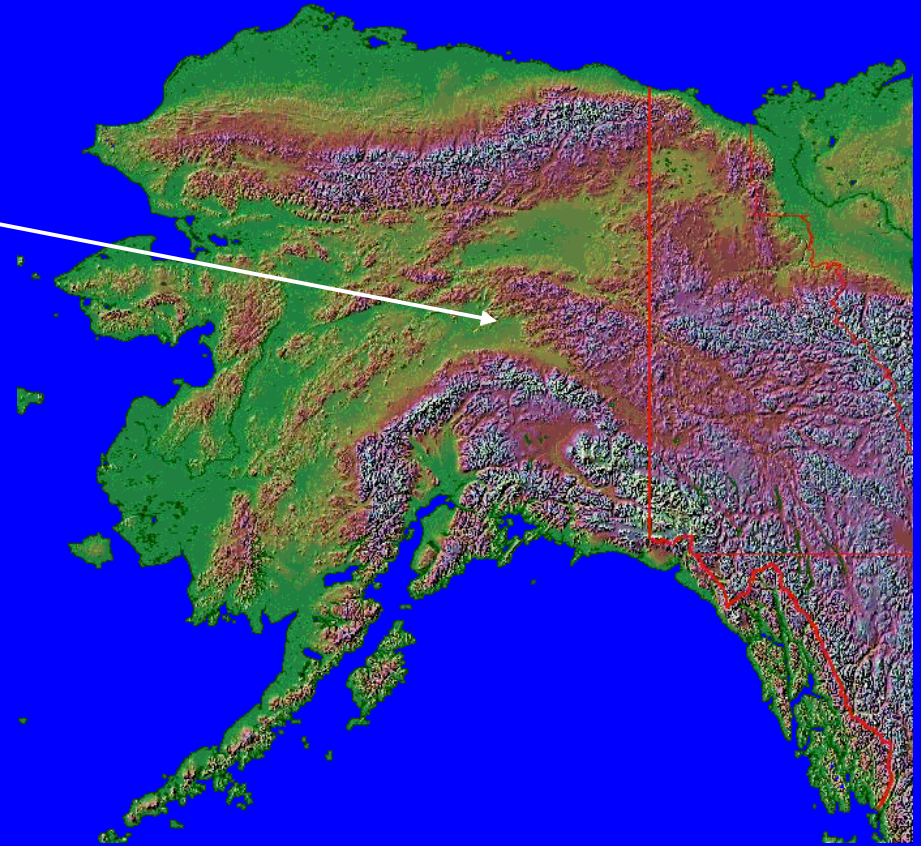
Unburned = 512.8 g C m^{-2}

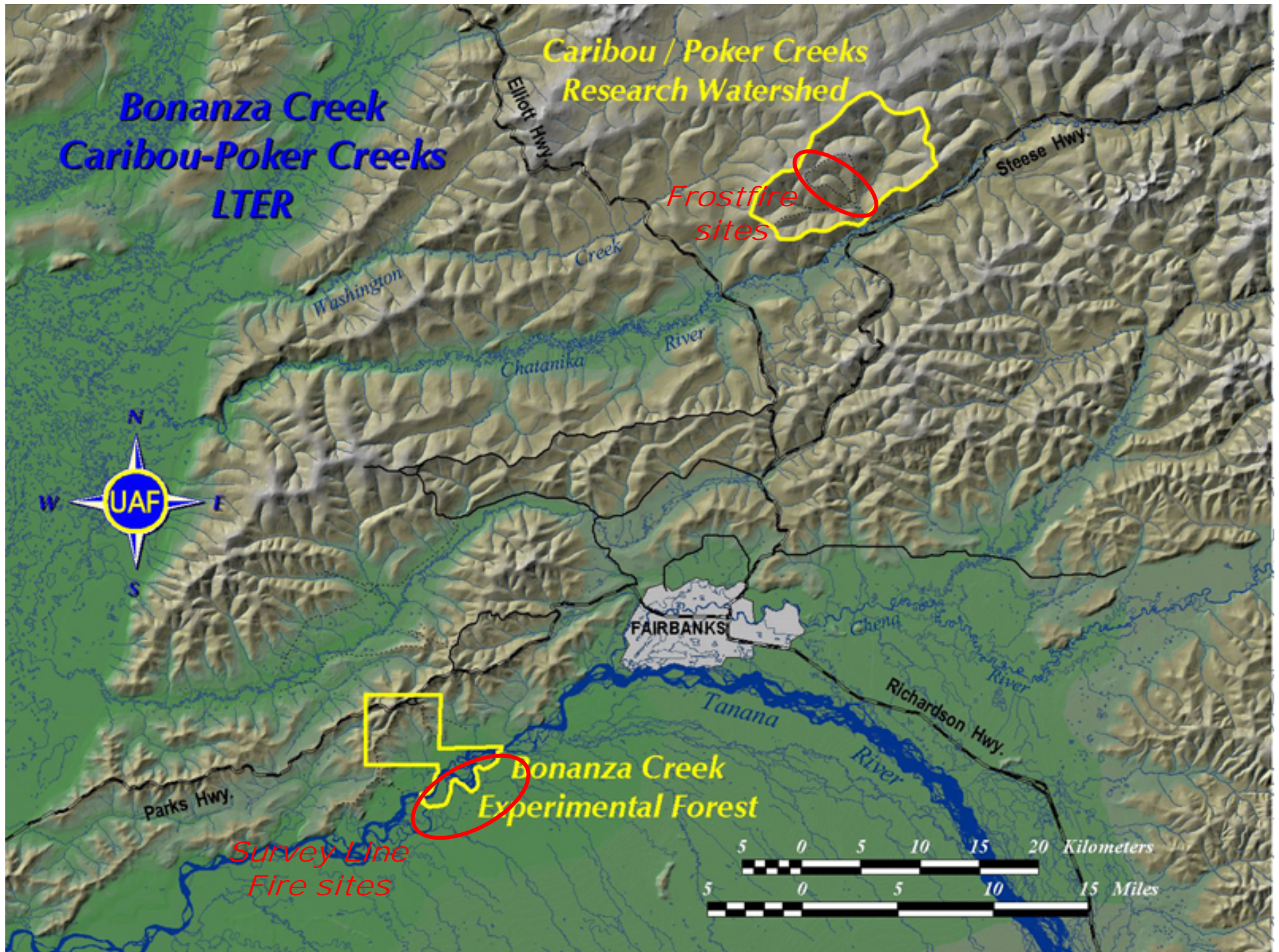
Autotrophic
 215.4 g C m^{-2}

Heterotrophic
 297.4 g C m^{-2}

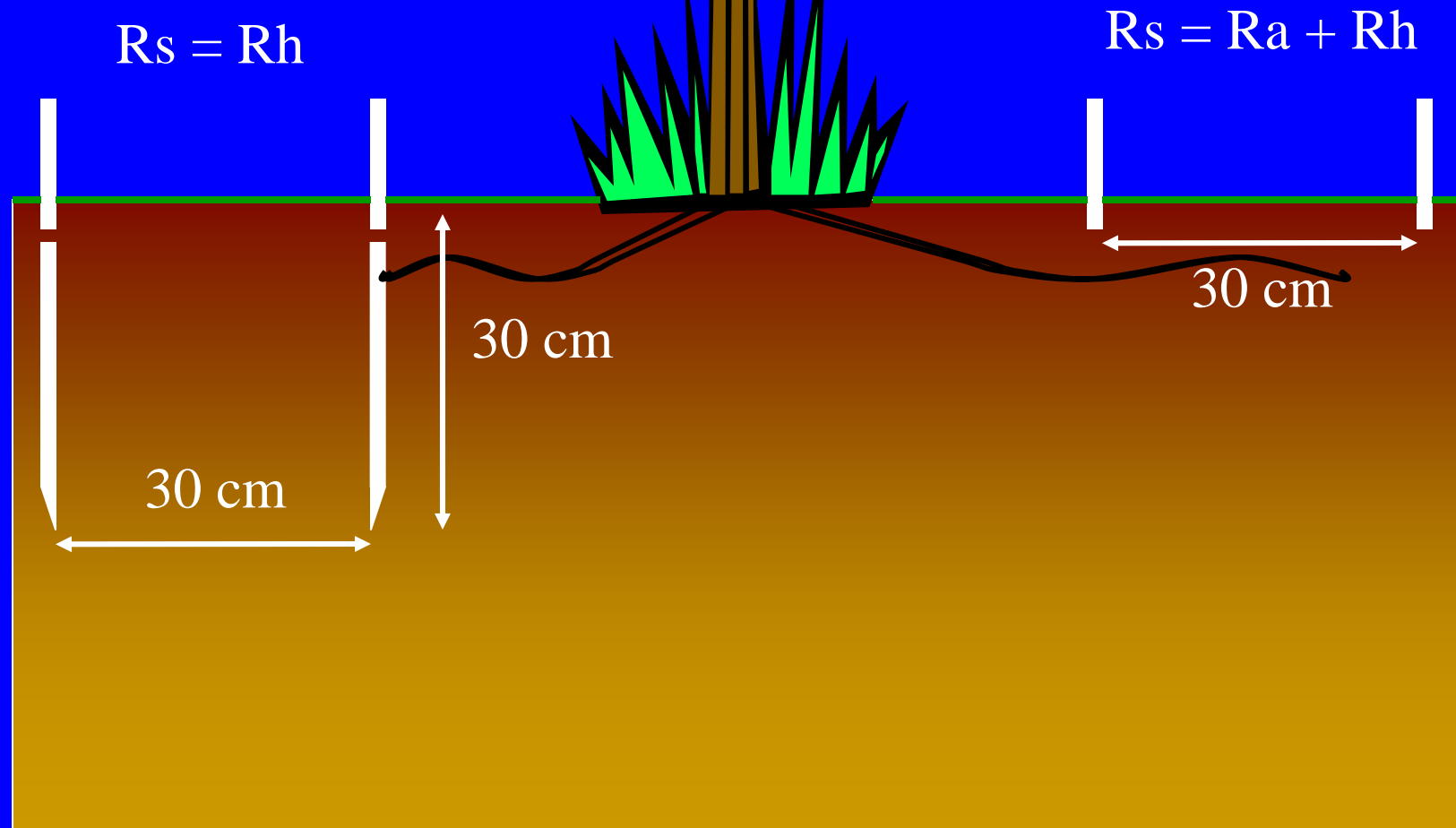
Survey Line Fire

- Accidental ignition in May 2001 by survey crews
- Poorly drained, fine-textured soils adjacent to Tanana River
 - No rocks





PVC Root Exclosures

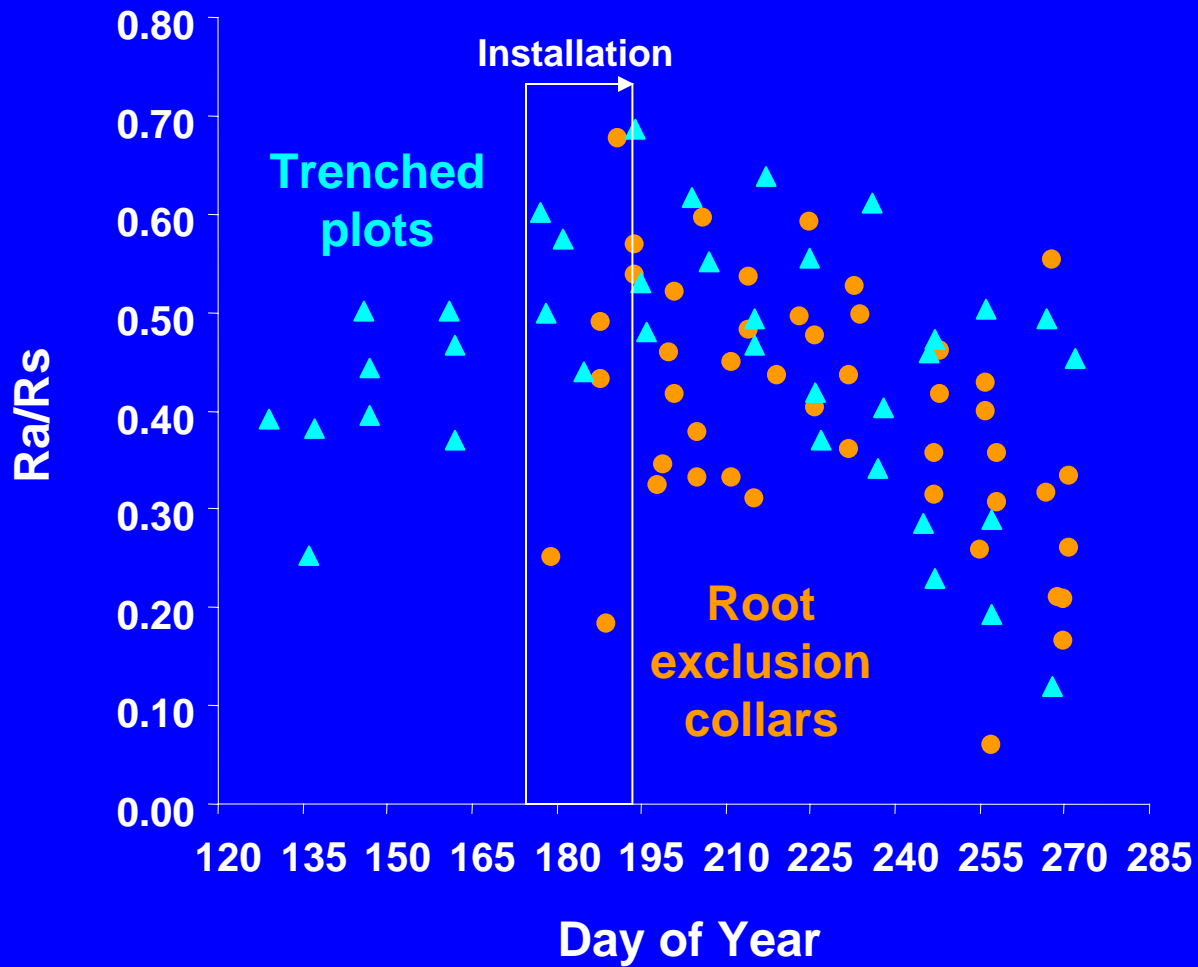


Root exclosure

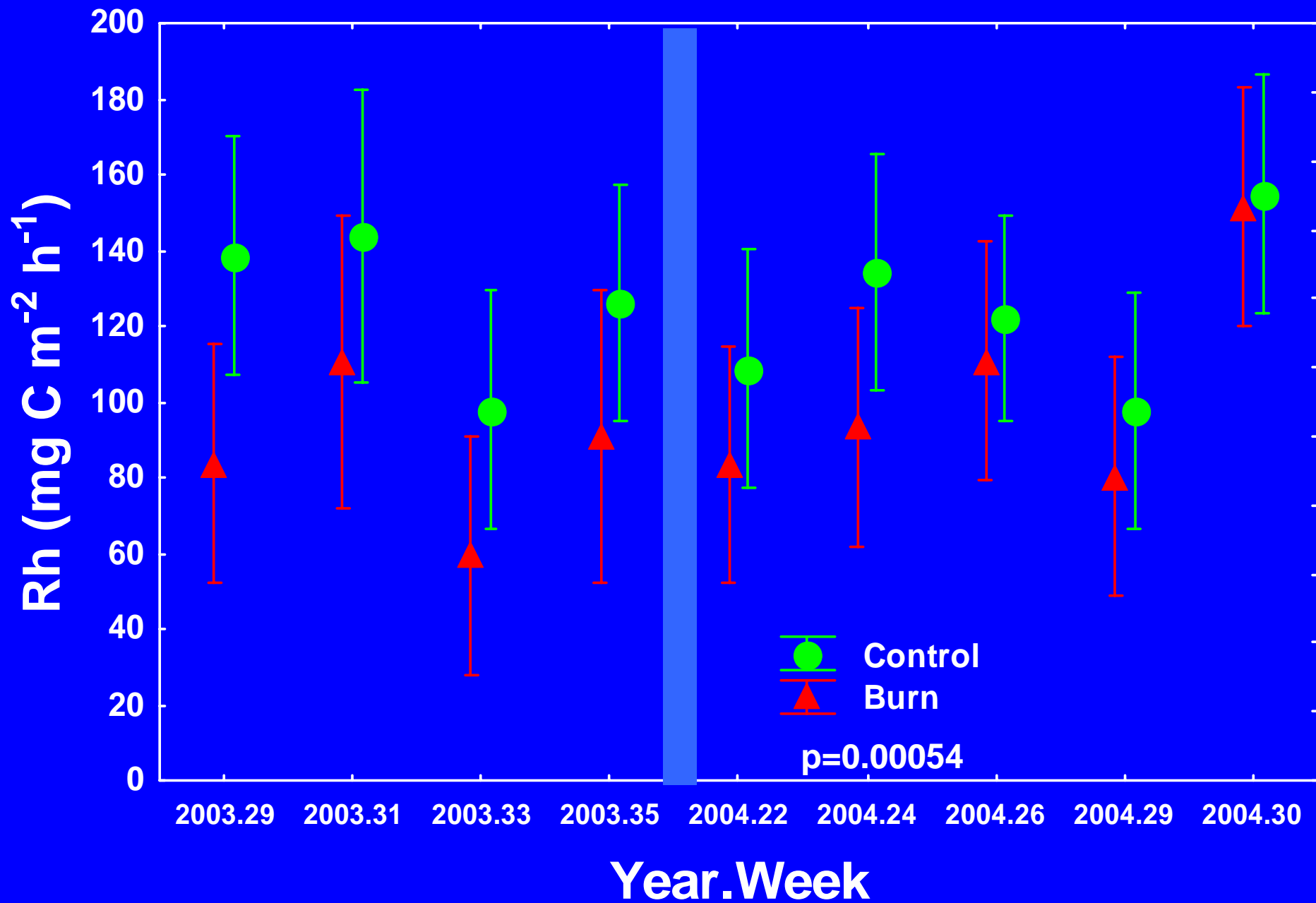


- Burned vs. unburned
- @ 3 transects
- @ 10 pairs per transect
- Vascular plants clipped

Vogel & Valentine 2005

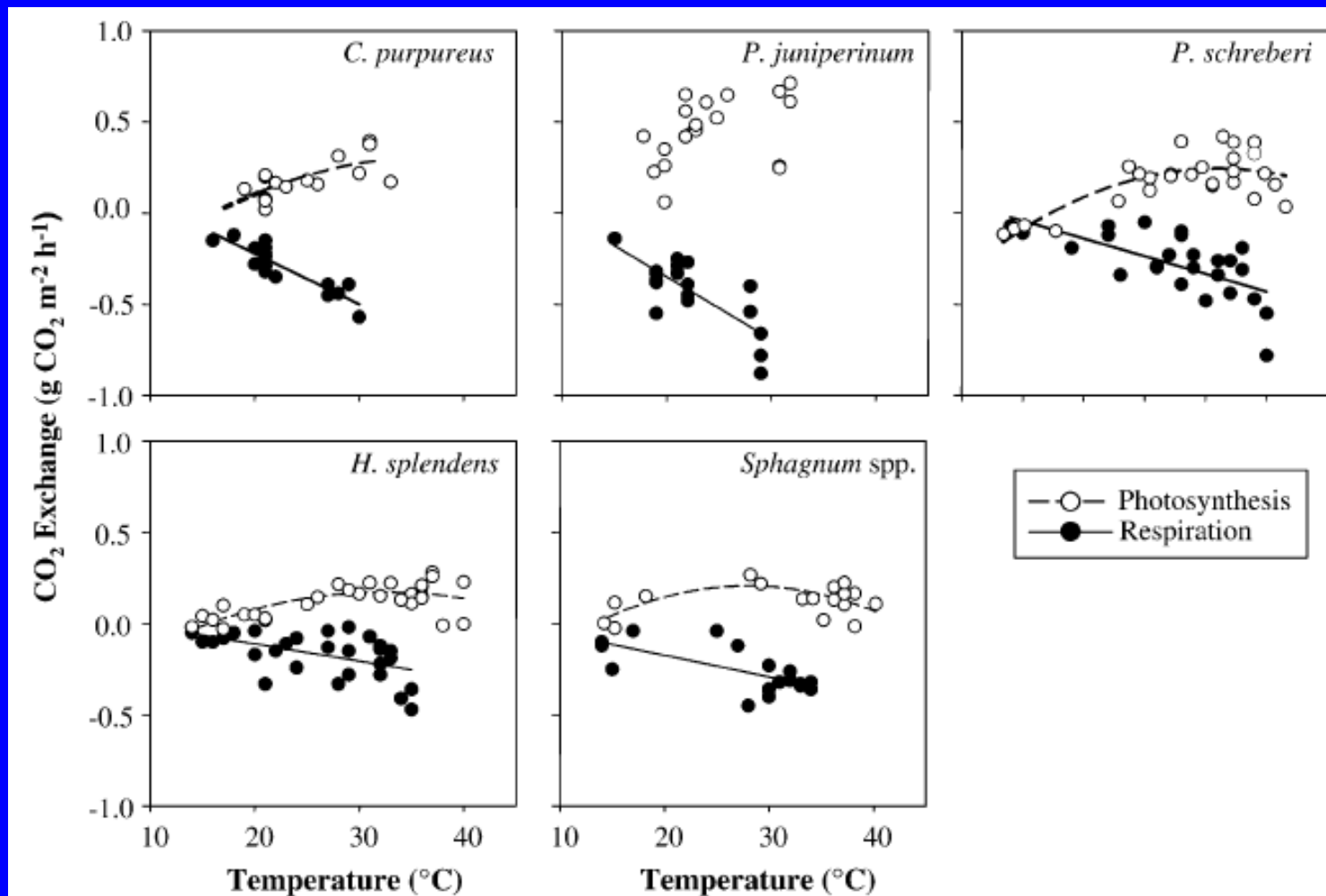


Rh vs. time



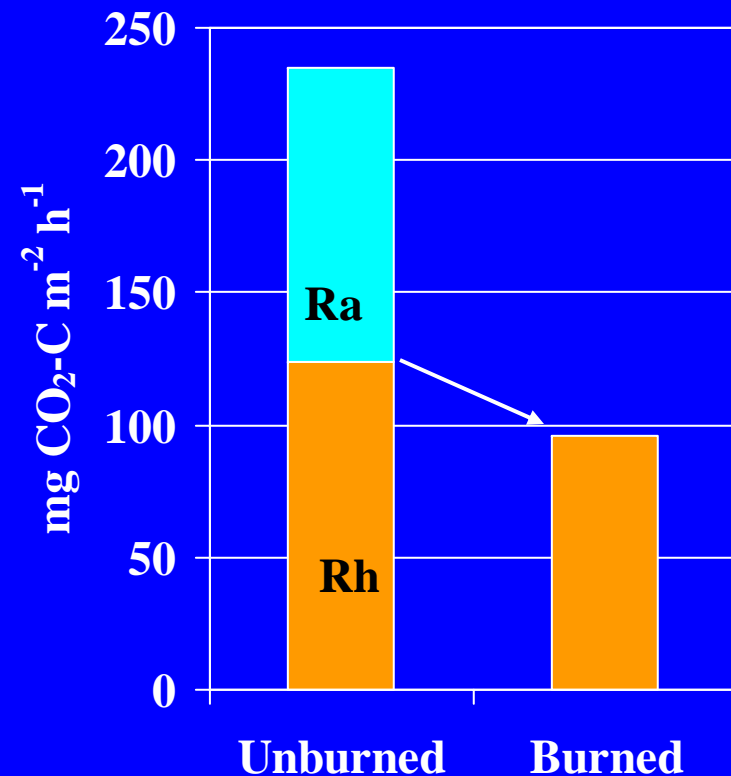
Moss respiration

(O'Neill *et al.* 2006)

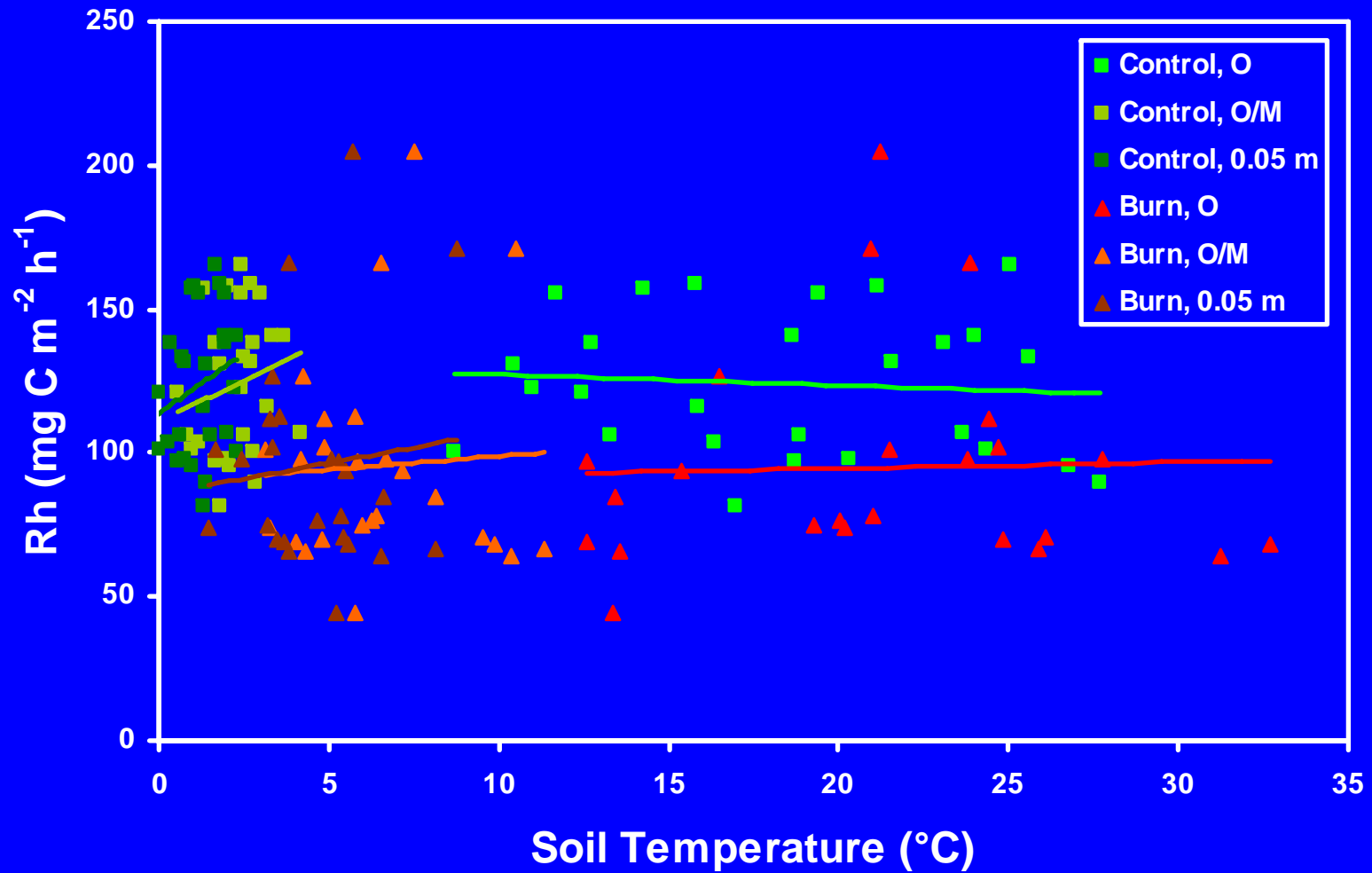


Survey Line Fire Lowlands

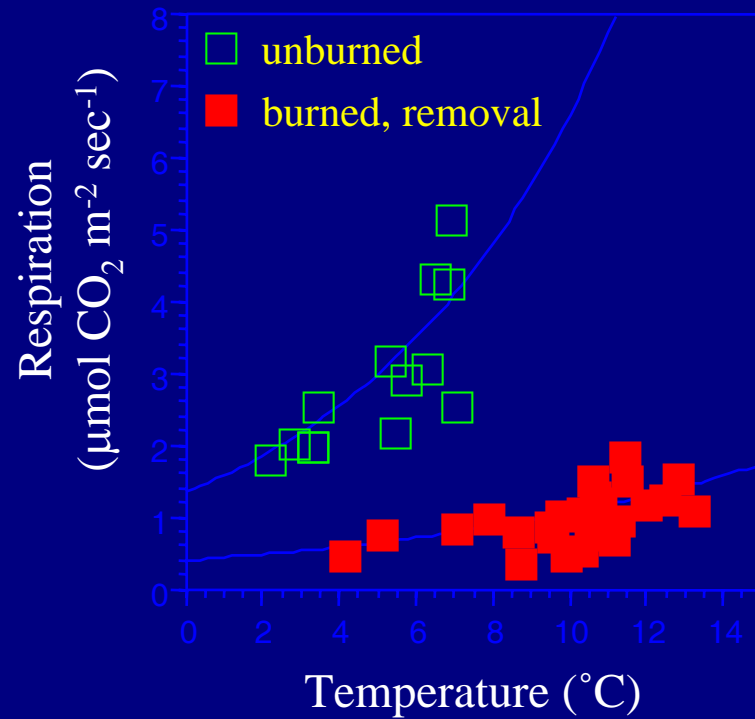
- R_s in burned soils $\approx 0.4 \times$ unburned soils
- Unburned $R_h \approx 0.5 \times R_s$



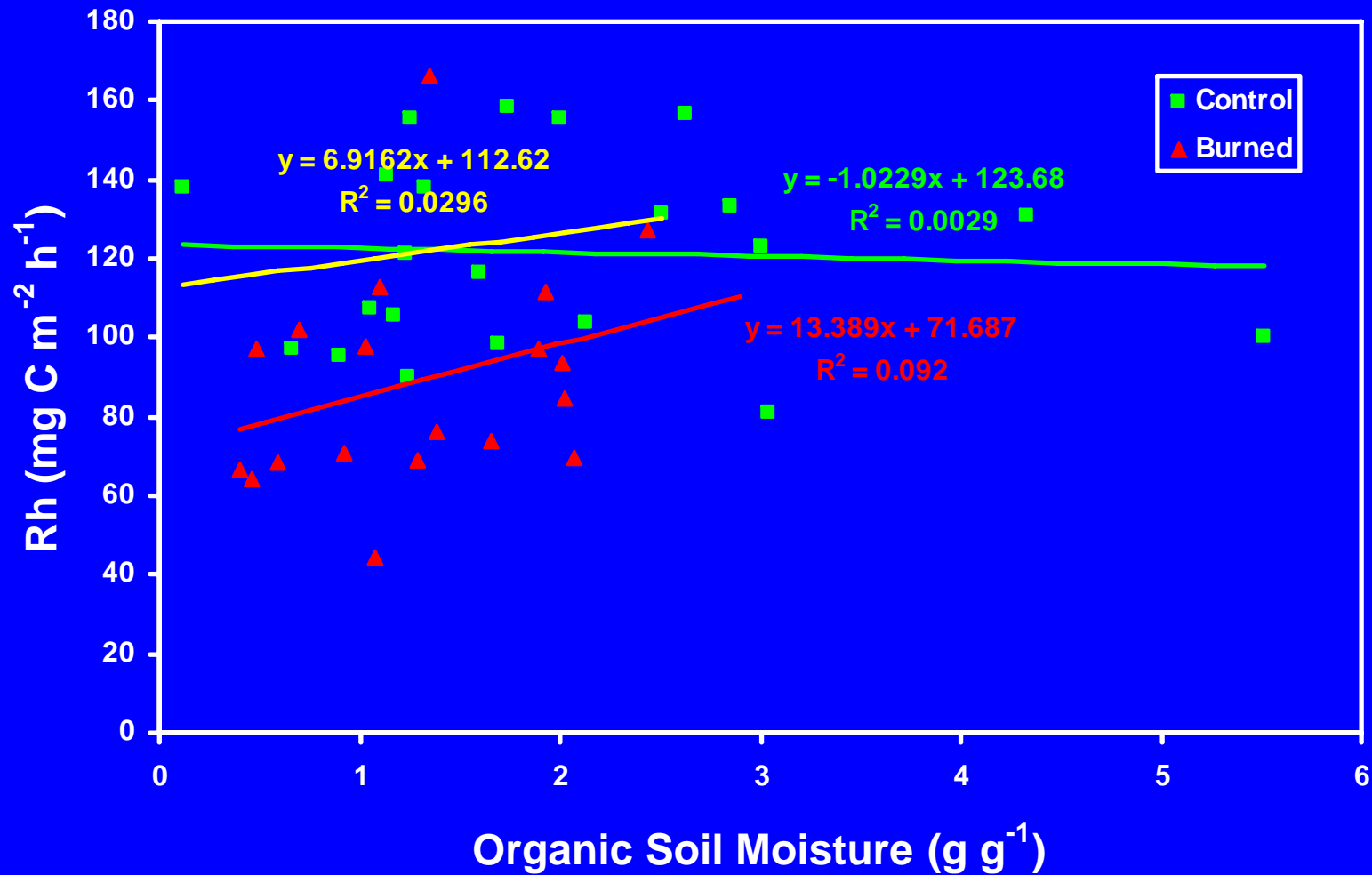
Rh poorly related to soil T



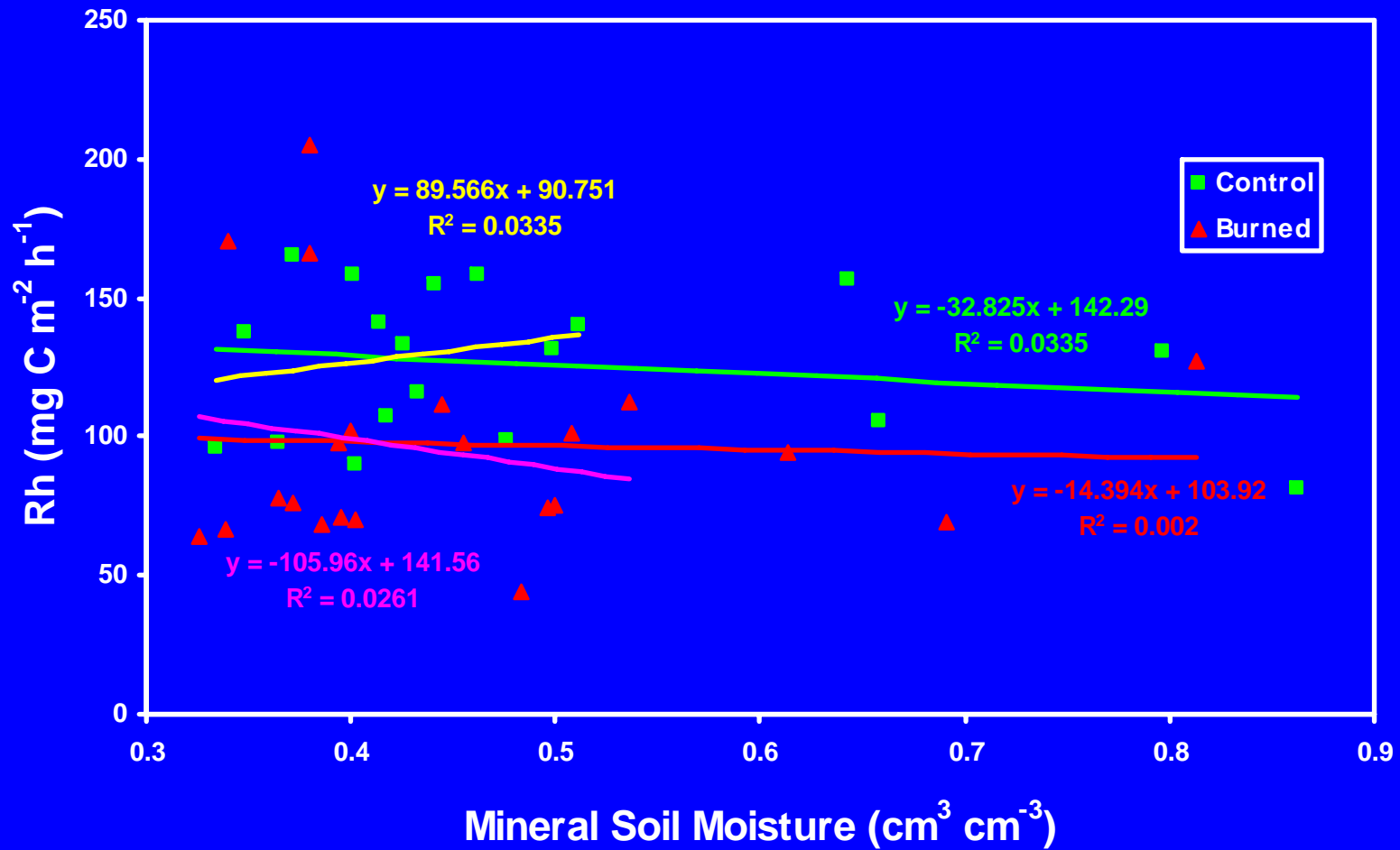
Temperature Sensitivity of Soil C Emissions (Schuur)



Organic layer moisture



Mineral soil moisture



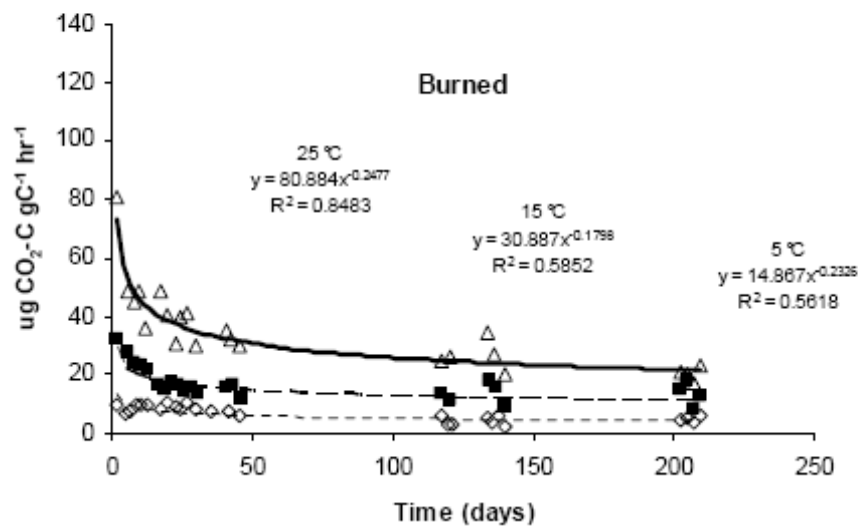
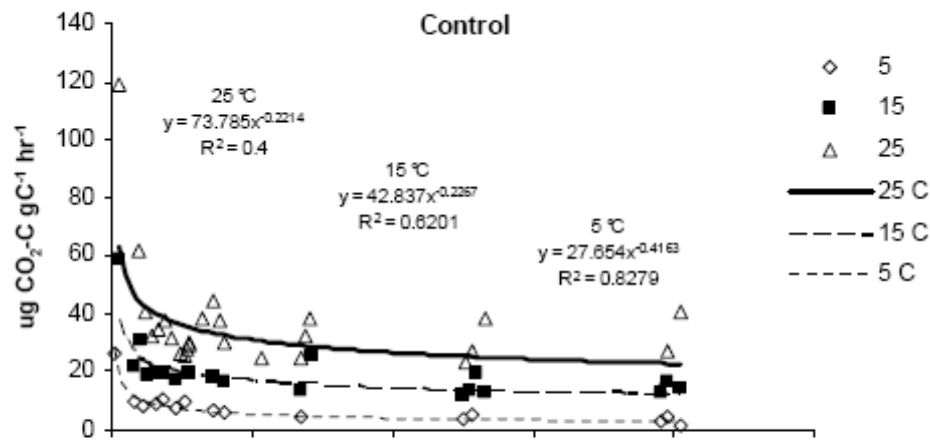
What fuels Rh?

- Burned and unburned Rh potentials similar
 - Unburned had initially higher Rh
 - Masco MS thesis
- Root allocation $\geq 5 \times \text{ANPP}$
 - Vogel *et al.* in press
- Isolated O horizon lost 15% mass over 3 y
 - MRT = 20 y
 - Much faster than supposed
 - Vogel *et al.* in press

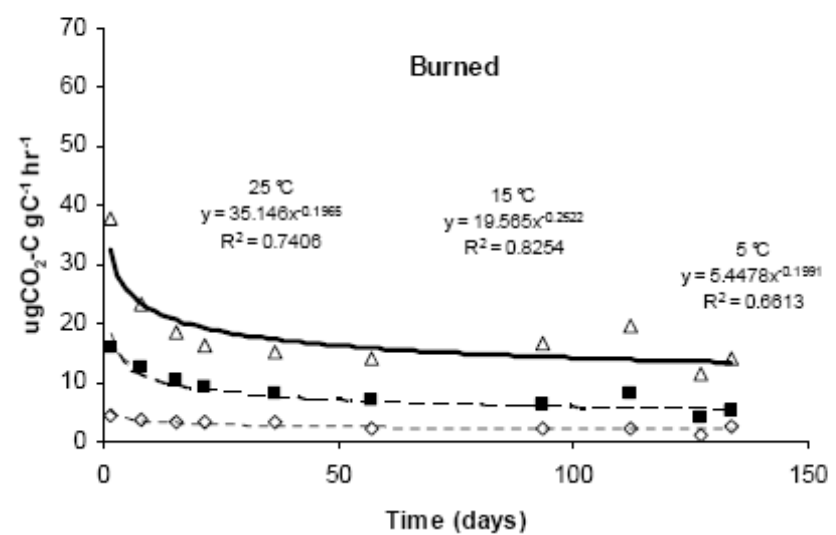
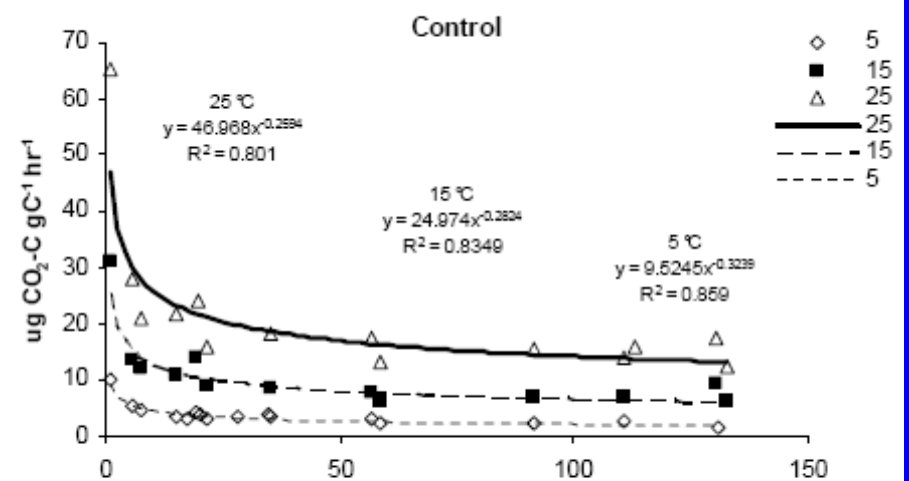
Substrate quality

(Masco 2005)

Soil Respiration in F Layer

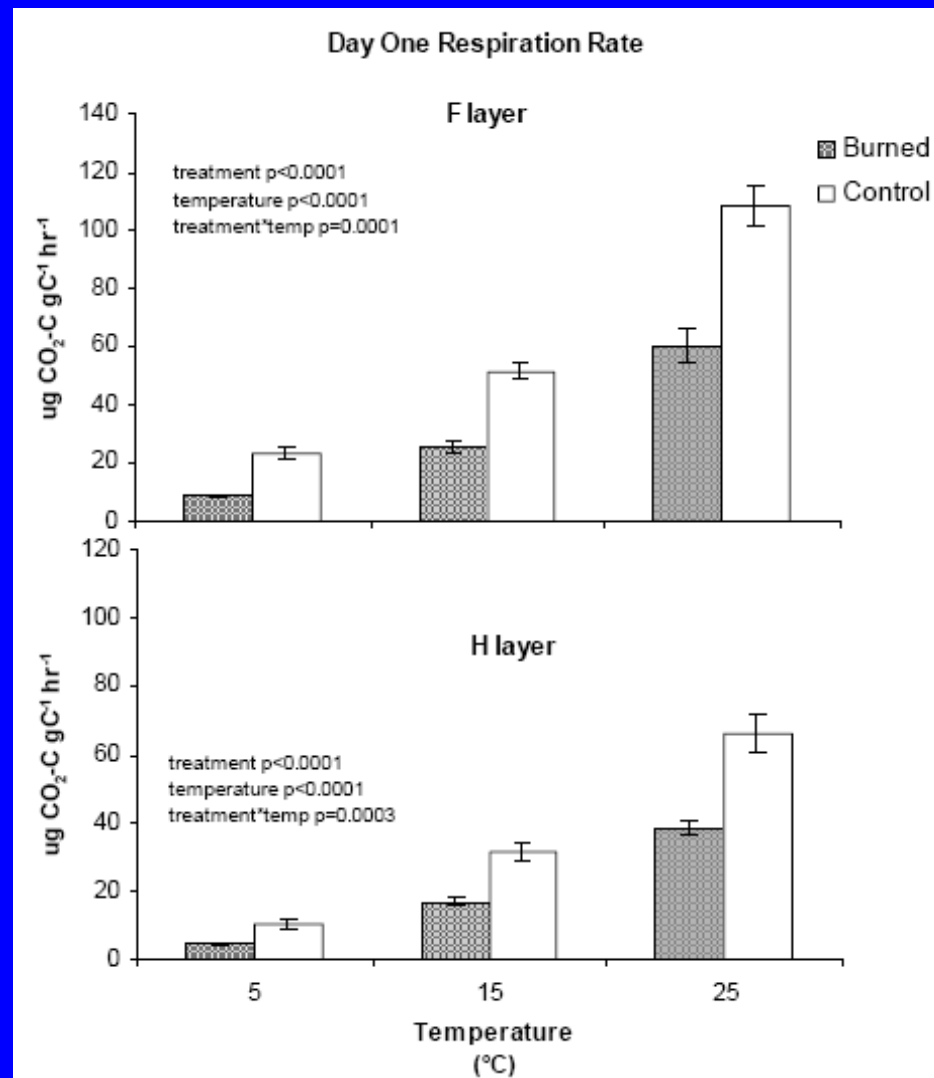


Soil Respiration in H layer



Substrate quality

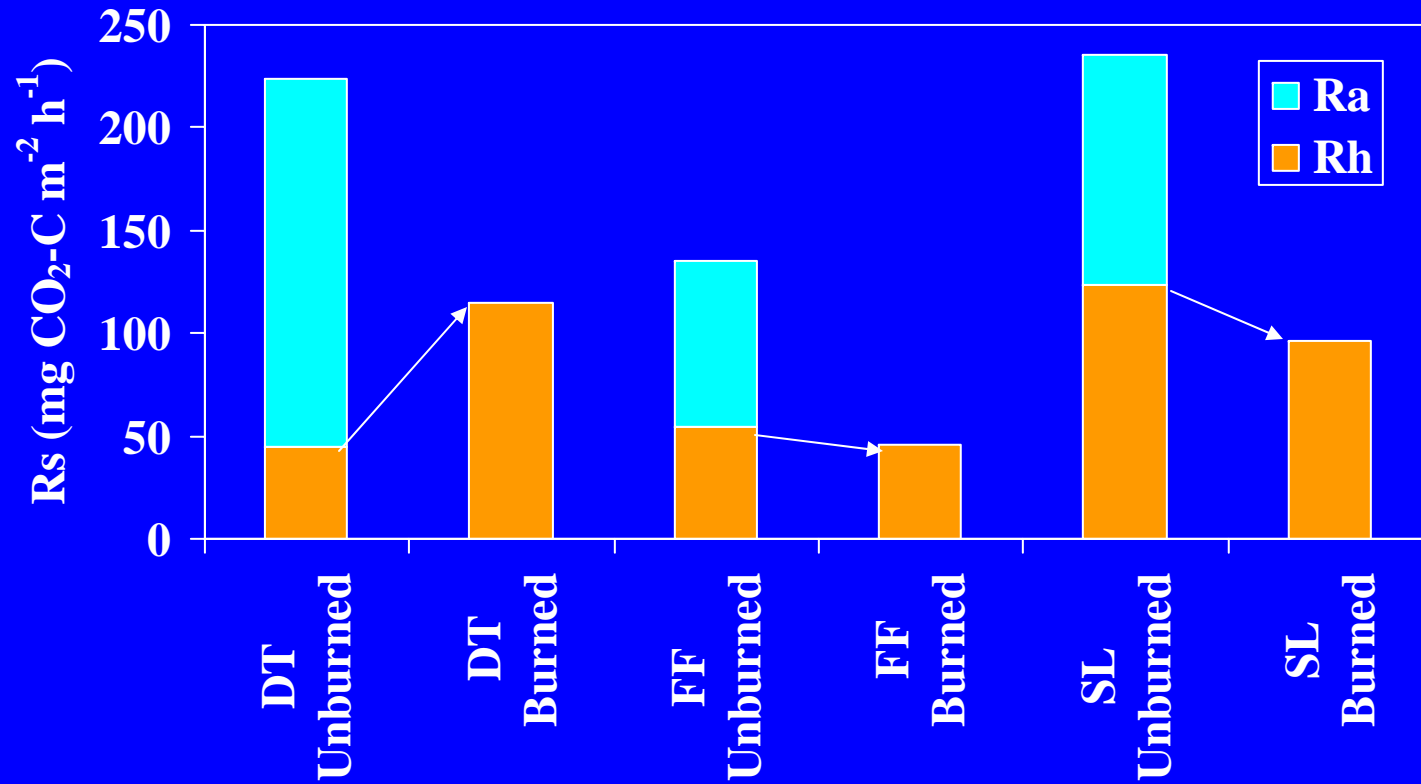
(Masco 2005)



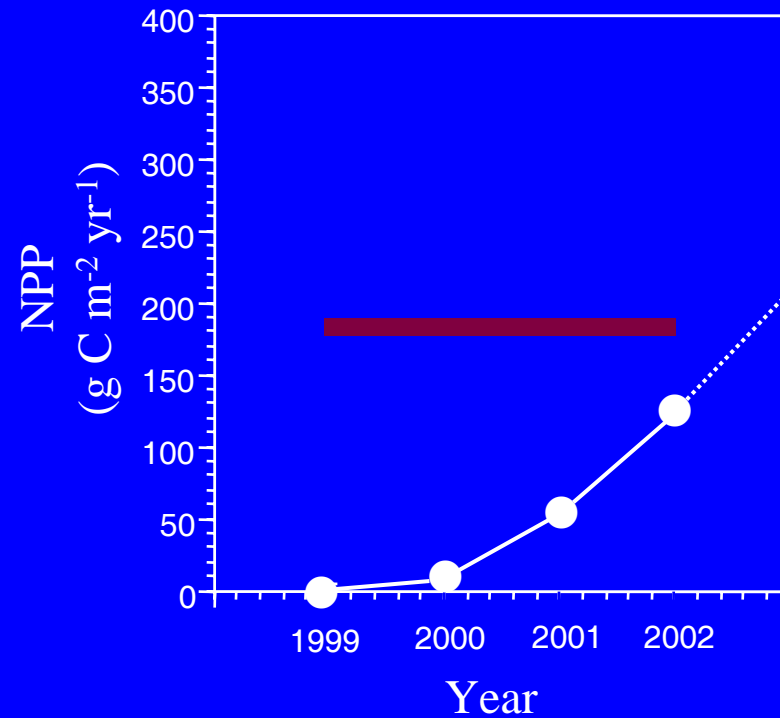
Belowground allocation

- Hypothesis:
 - Recent root turnover is important source of current Rh.
 - Fire deprives microbial community of fresh detritus
 - Rh depressed until post-fire root turnover recovers

Fire impacts on Rh

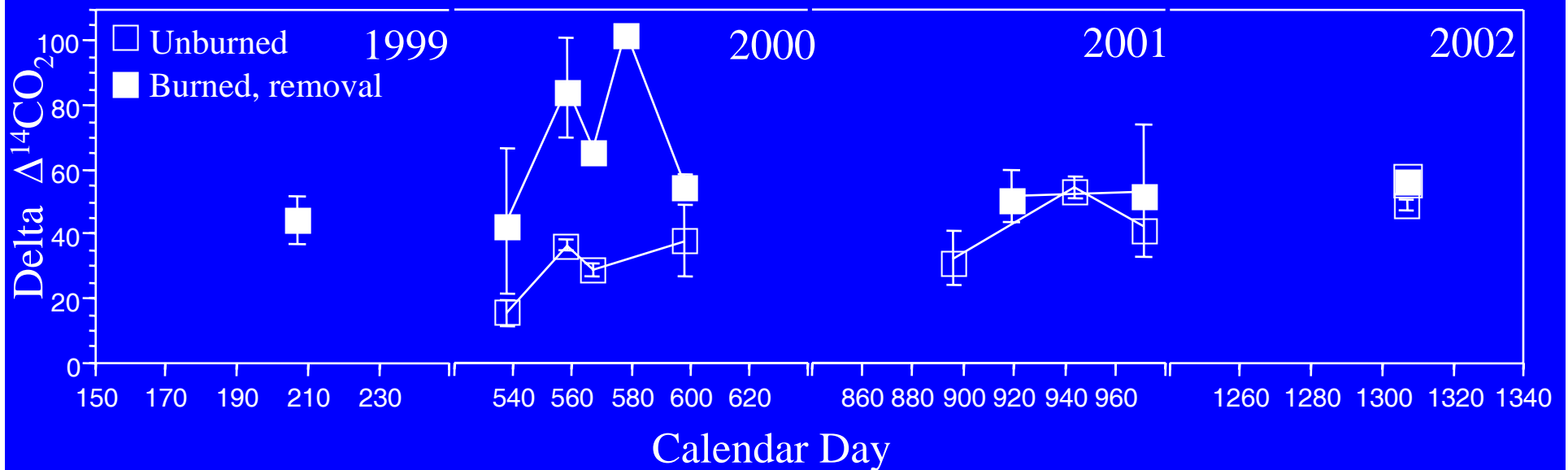


Net Primary Productivity Following Fire (Schuur)



Can old soil C be lost via soil respiration following fire?

Soil Respiration Isotopes



1999 Burn Delta Junction, AK

Schuur concluded:

Heterotrophic respiration is not significantly stimulated following fire

Respired C following fire was fixed over the past several decades

Net C loss from ecosystems to the atmosphere in the early stages of succession is a result of decreased plant uptake.

Discussion points

- Increased temperature may stimulate Rh if
 - Surface soil moisture adequate
 - Substrate quality allows
 - Fire severity mild
- Role of fire severity
 - Decreases surface OM (& substrate quality)
 - Regime shift