

Does Fire Affect Climate?

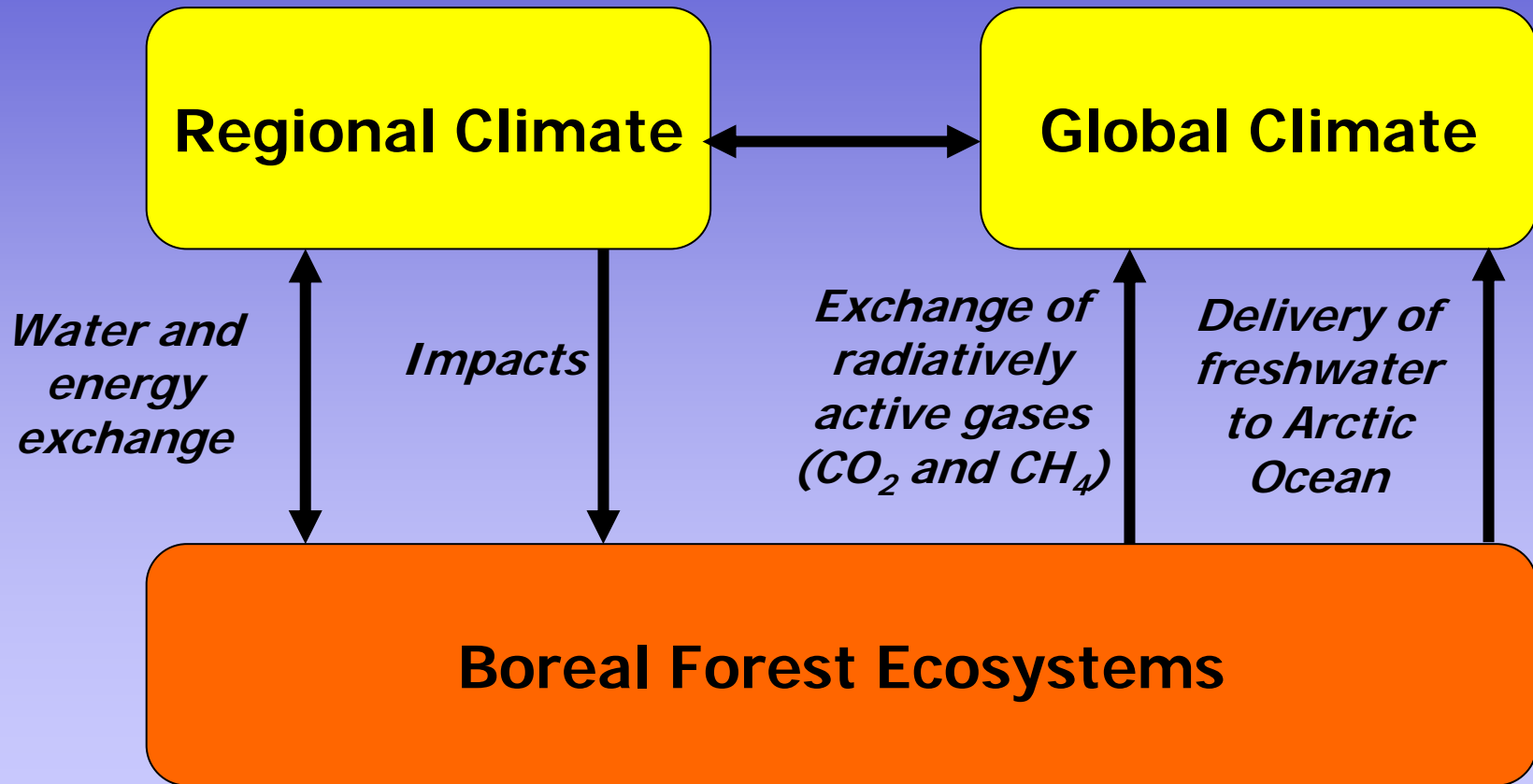
Fire Effects on Regional and Global Climate

A. David McGuire, E.S. Euskirchen,
M.S. Balshi, F.S. Chapin III

Alaska Human-Fire Interactions Symposium, August 15, 2006

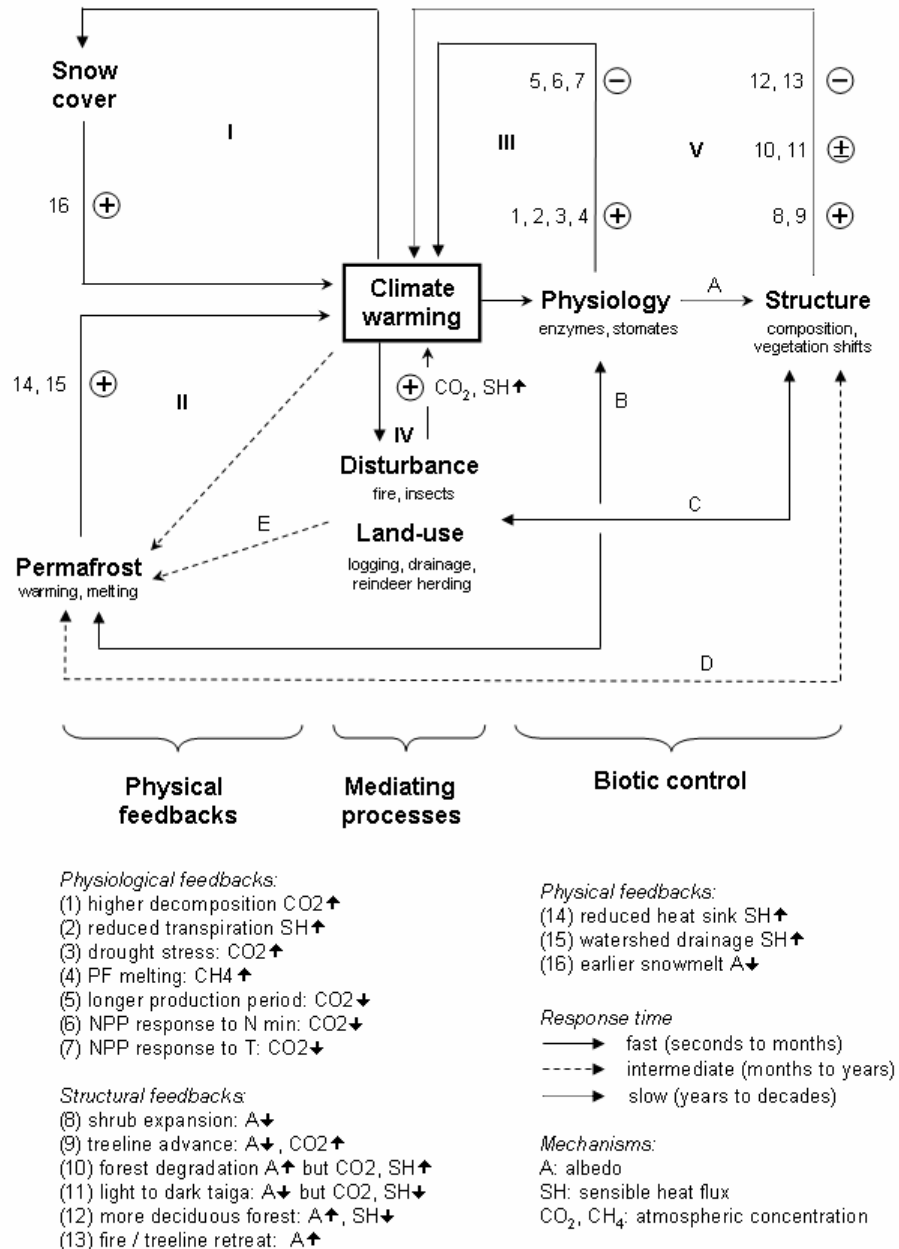


Interactions of Boreal Forest Ecosystems with the Earth's Climate System



Terrestrial responses to warming in the Arctic that influence the climate system. Responses of permafrost on the left are coupled with functional (physiological) and structural biotic responses on the right either directly (arrows B and D) or through mediating processes of disturbance and land use (arrows C and E). Functional and structural biotic responses are also coupled (arrow A). Response pathways are identified at three time scales (seconds to months, months to years, and years to decades).

From McGuire, Chapin, Walsh, and Wirth. In press. *Annual Review of Environment and Resources*.



How might fire regimes contribute to radiative forcing?

Two of the major contributors:

1. Changes in ecosystem metabolism (e.g., respiration and photosynthesis) can lead to cooling/heating through changes in greenhouse gas concentrations.

2. Fire contributes to changes in surface albedo. How long do these changes in surface albedo persist following fire? That is, what is the cooling effect of fire in the long term?



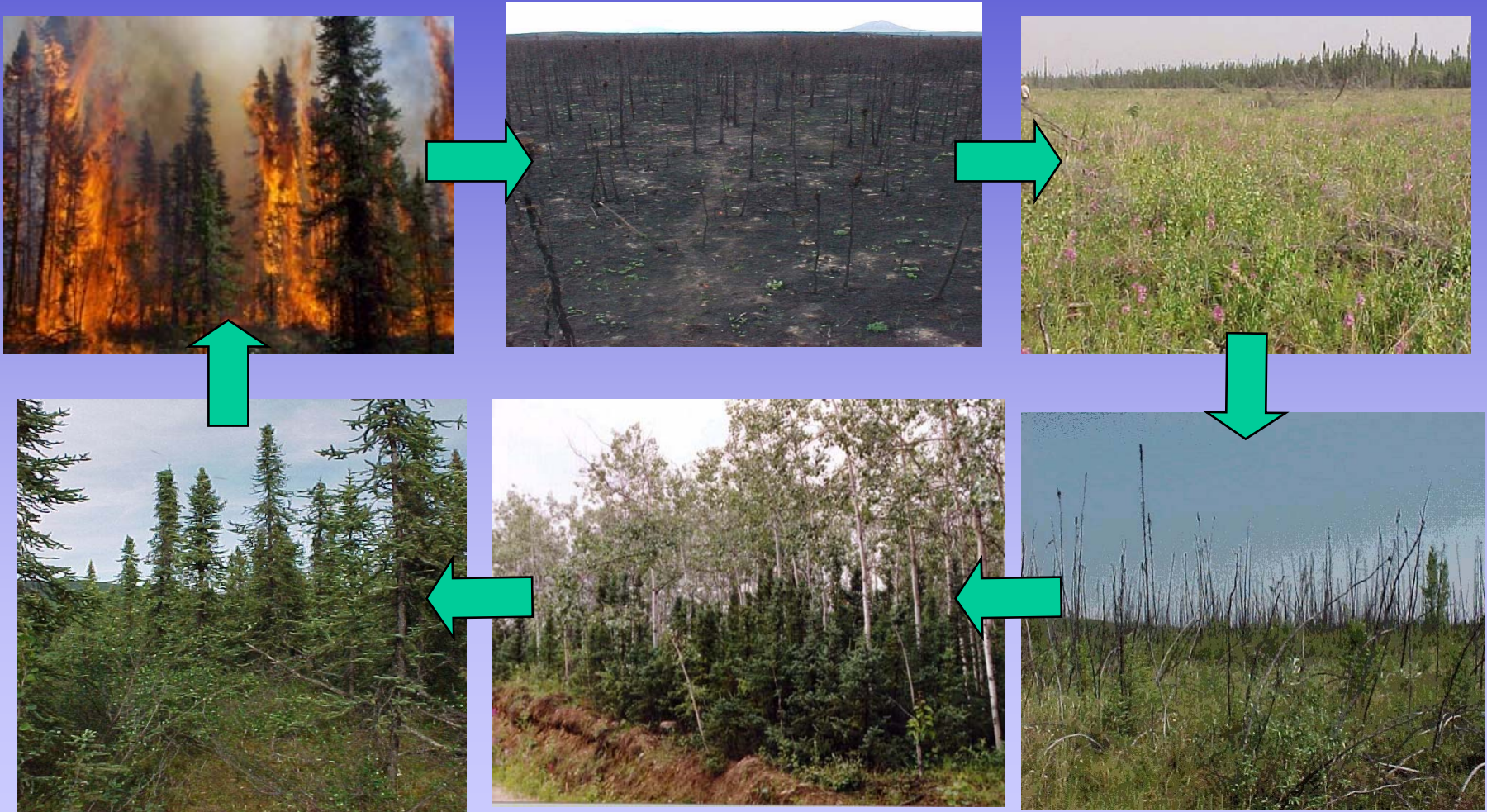
Question to ask:

**How do changes in the fire regime
of the boreal forest influence:**

- (1) ecosystem metabolism, and**
- (2) albedo**

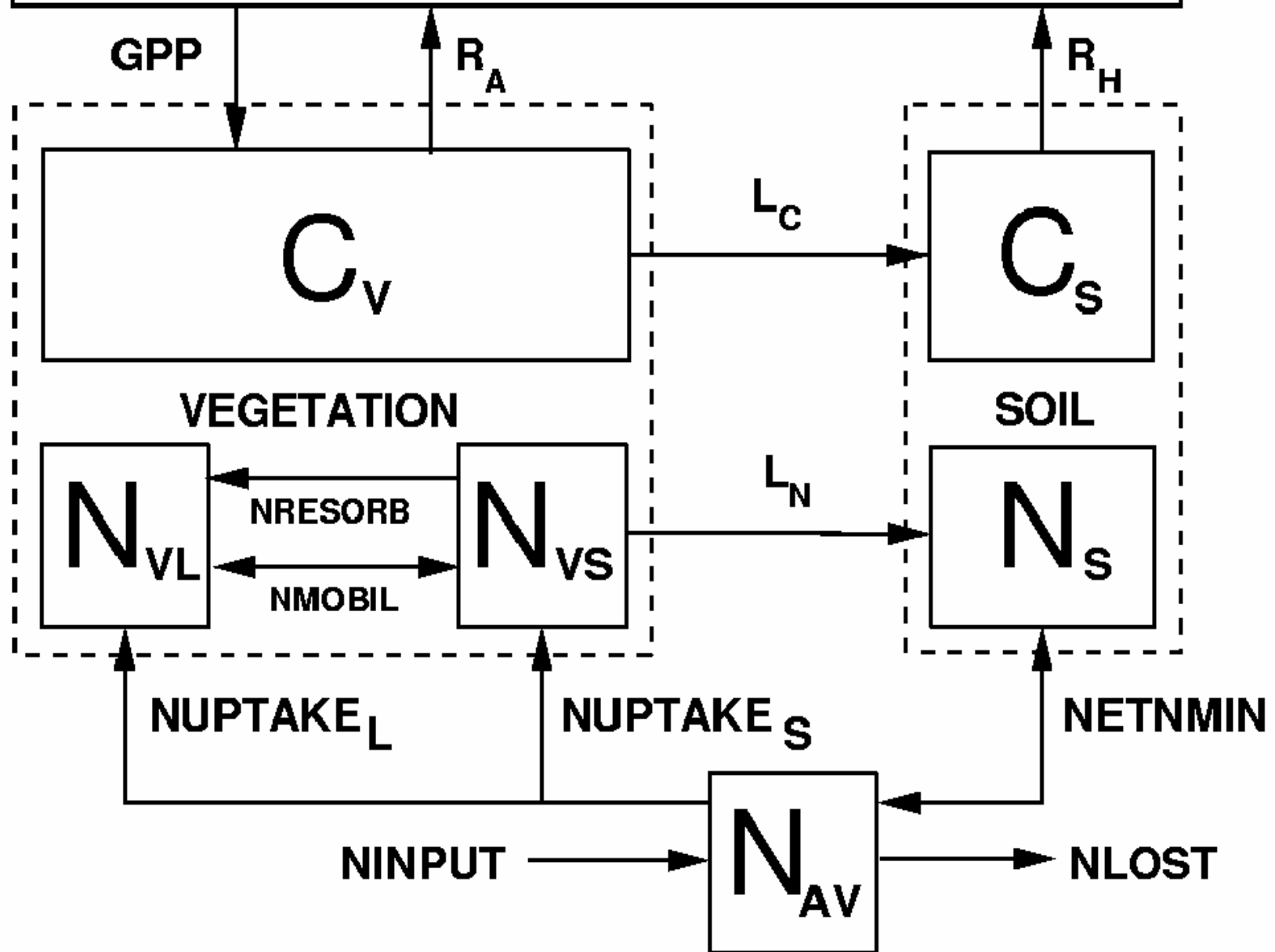
**in terms of radiative forcing
(e.g., heating or cooling)
to the atmosphere?**

Upland black spruce fire chronosequence in Delta Junction, Alaska (64°N)

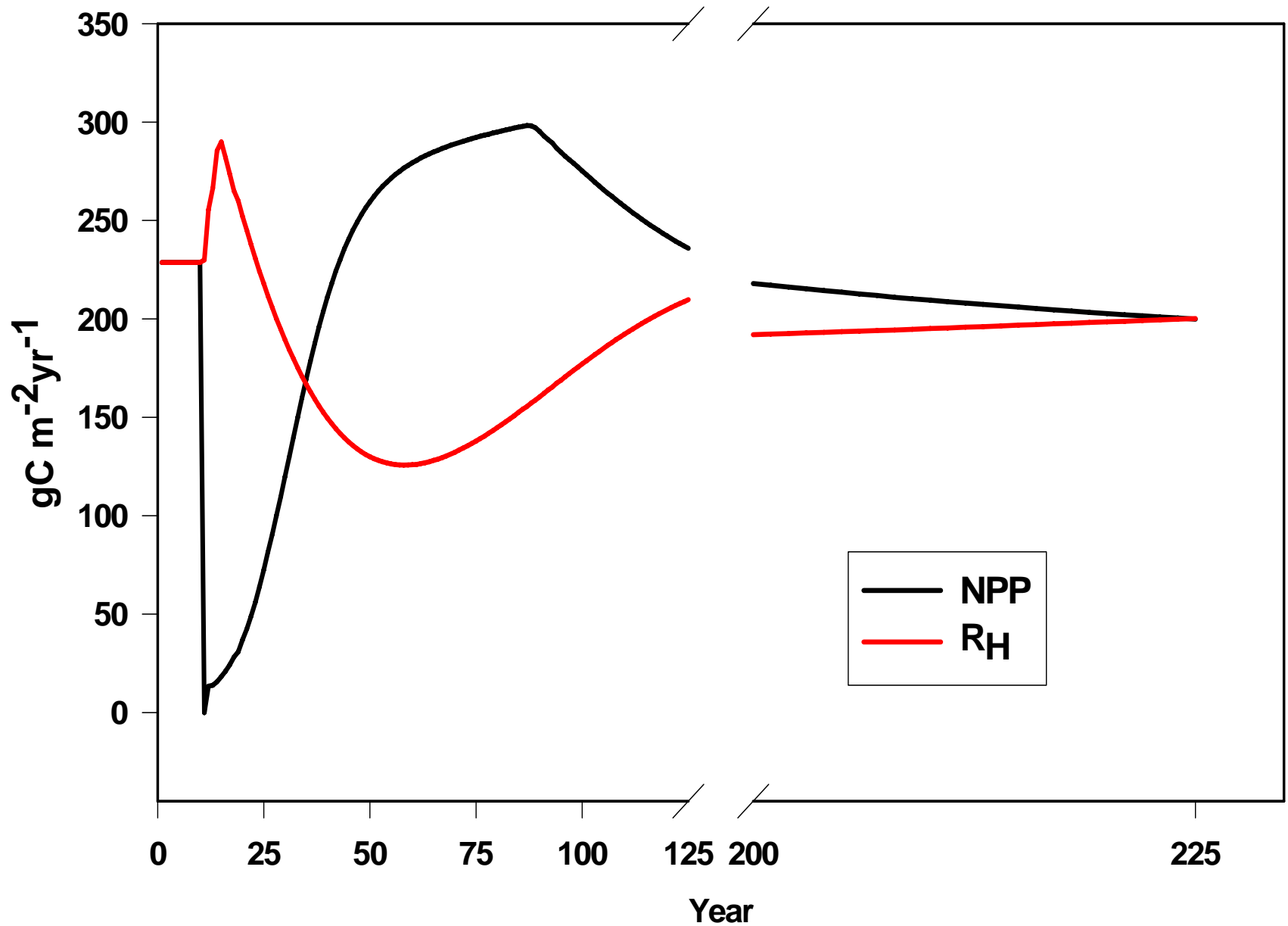


Photos: J. Randerson

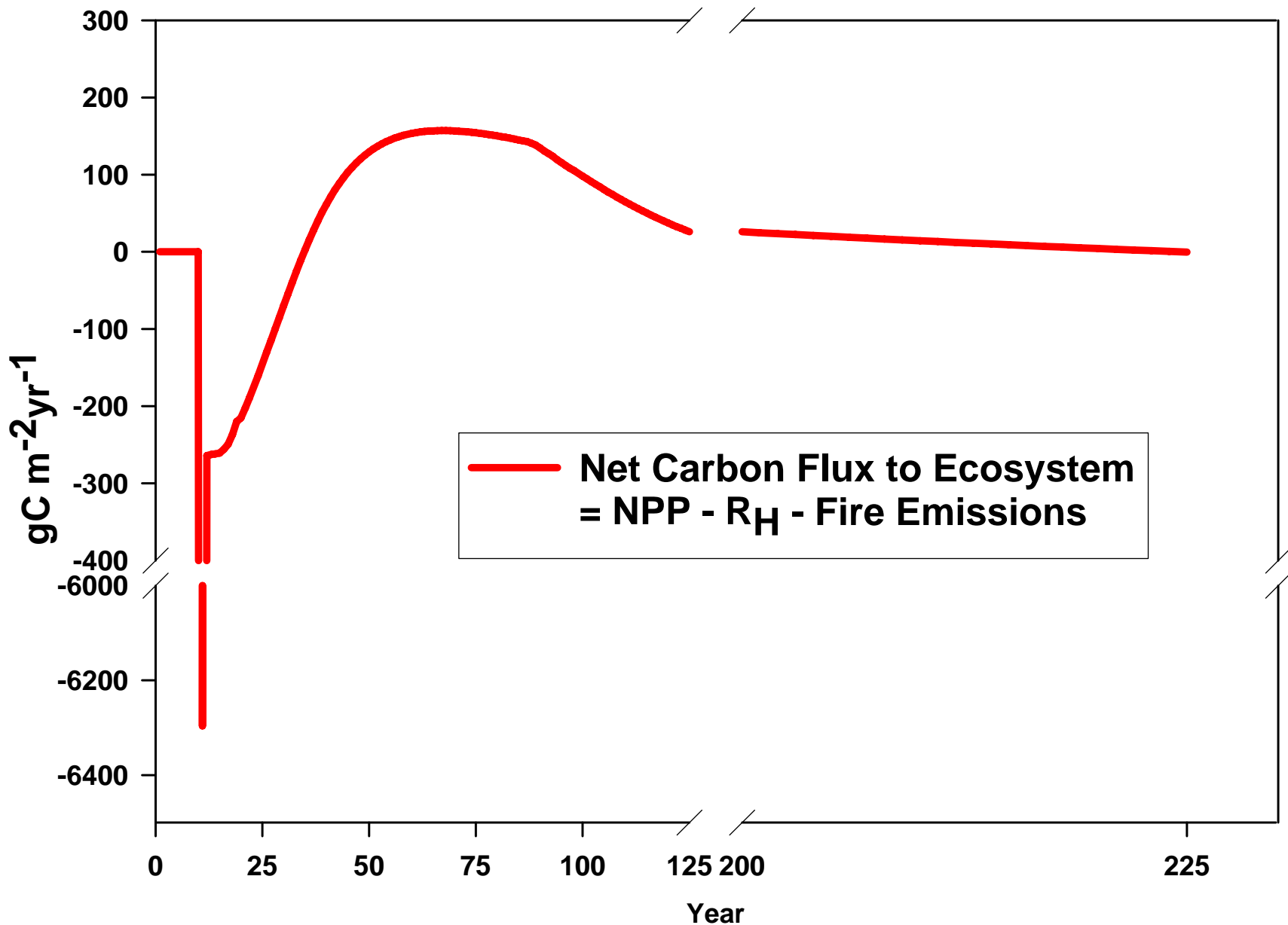
Atmospheric Carbon Dioxide



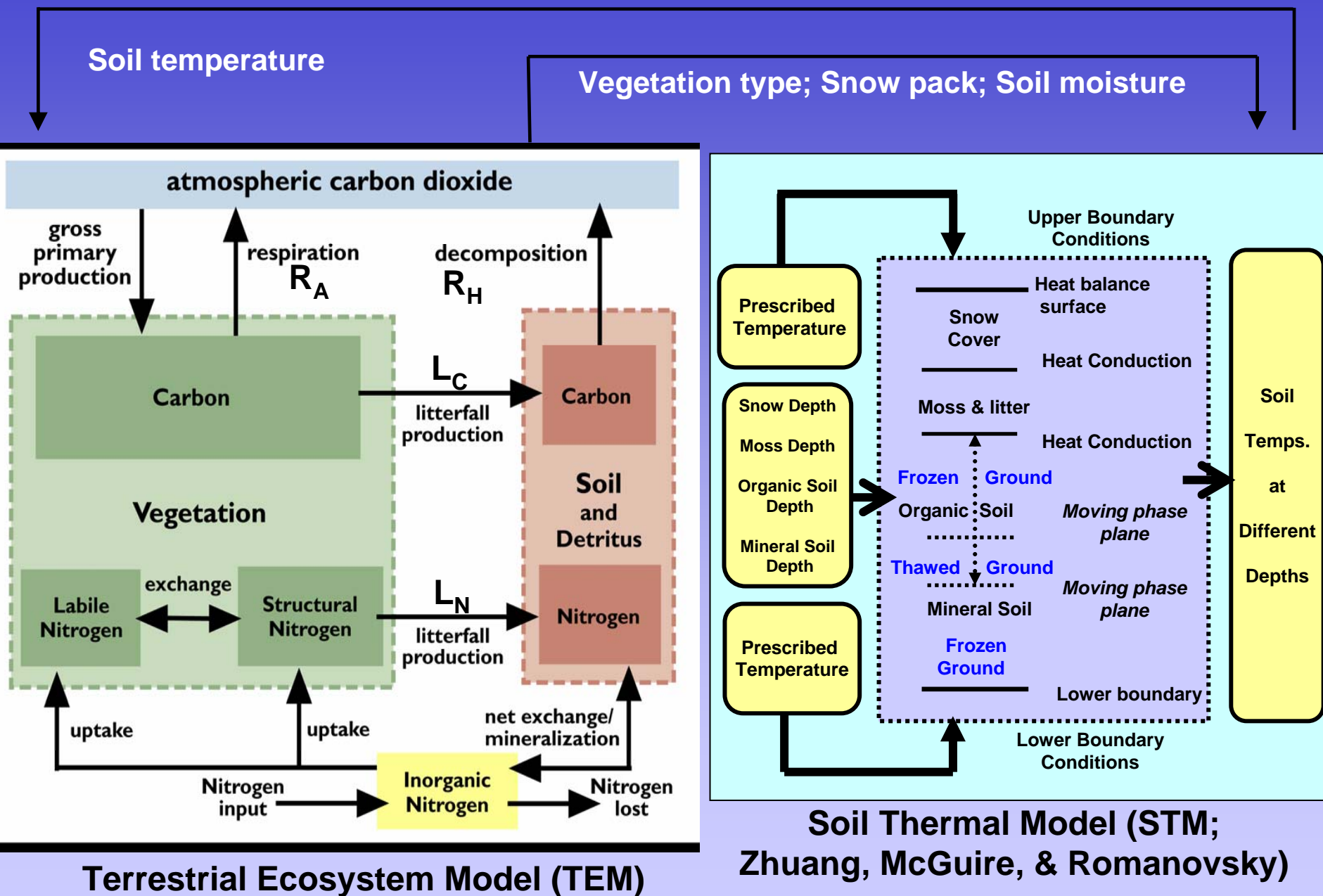
Responses of boreal forests to fire disturbance in Bonanza Creek



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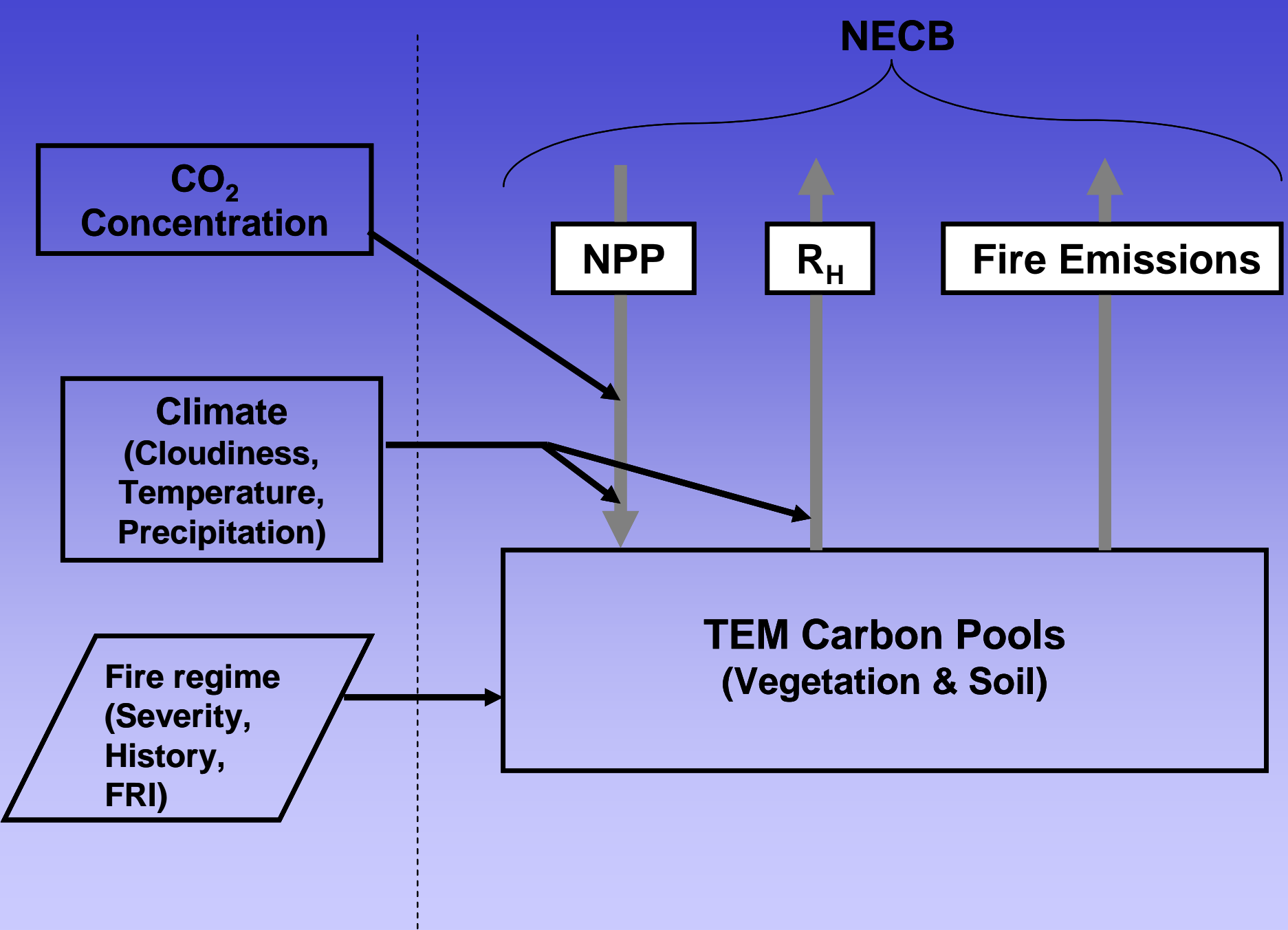


Terrestrial Ecosystem Model couples biogeochemistry & soil thermal dynamics



Terrestrial Ecosystem Model (TEM)

Soil Thermal Model (STM; Zhuang, McGuire, & Romanovsky)



We conducted a simulation in which we allowed fire frequency to increase across the boreal forest region by 1% per year so that annual area burned was approximately doubled by between 2000 and 2100 across the boreal forest.

Some of our simulations indicated that the boreal forest region lost 1000 g C m^{-2} during the 21st Century. This is equivalent to approximately a “local area” forcing of 3 W m^{-2} .

However, at the global scale this effect will only influence atmospheric concentrations of CO_2 by a few ppm.

After Zhuang et al. In press. *Geophysical Research Letters*.



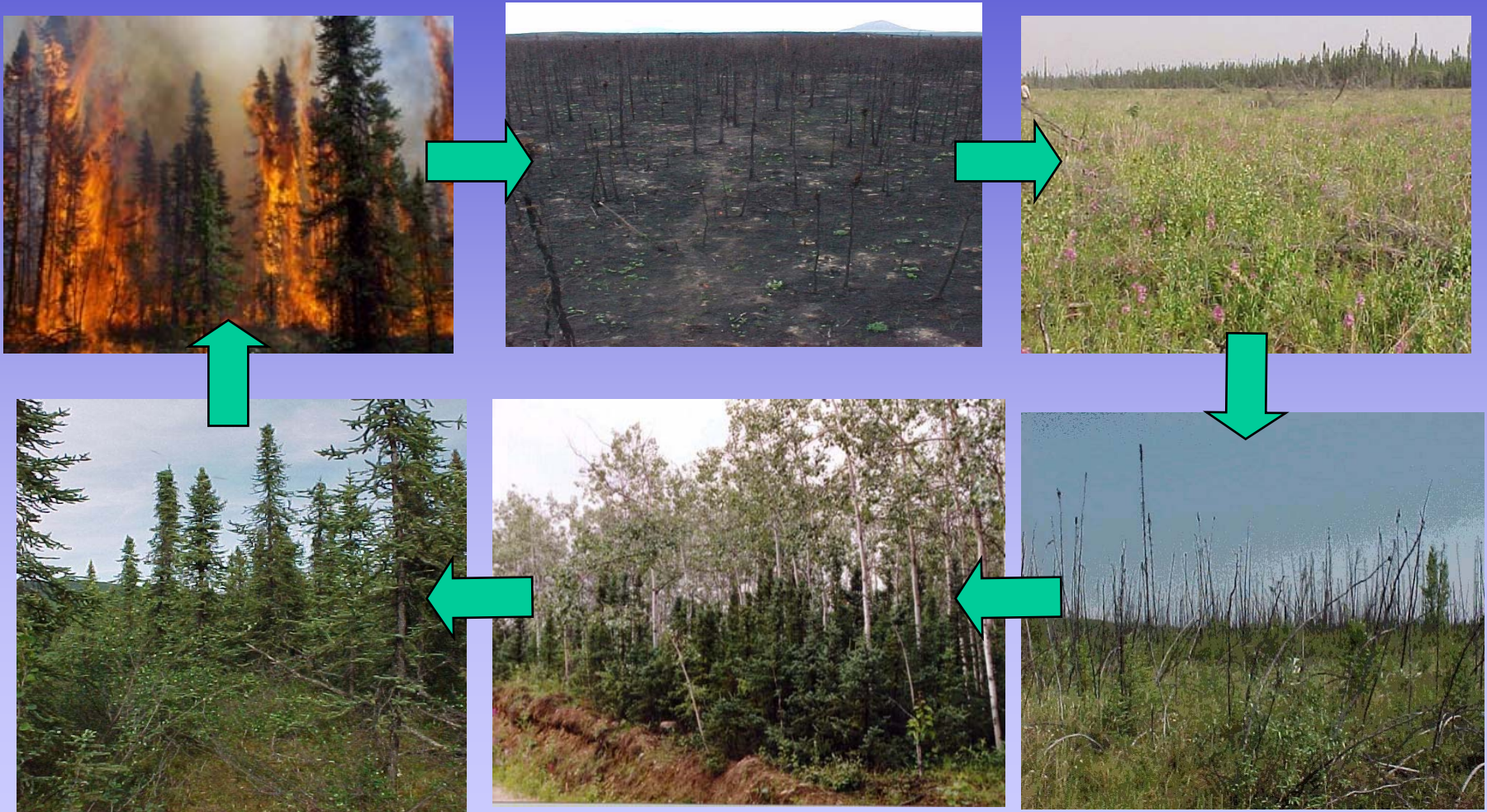
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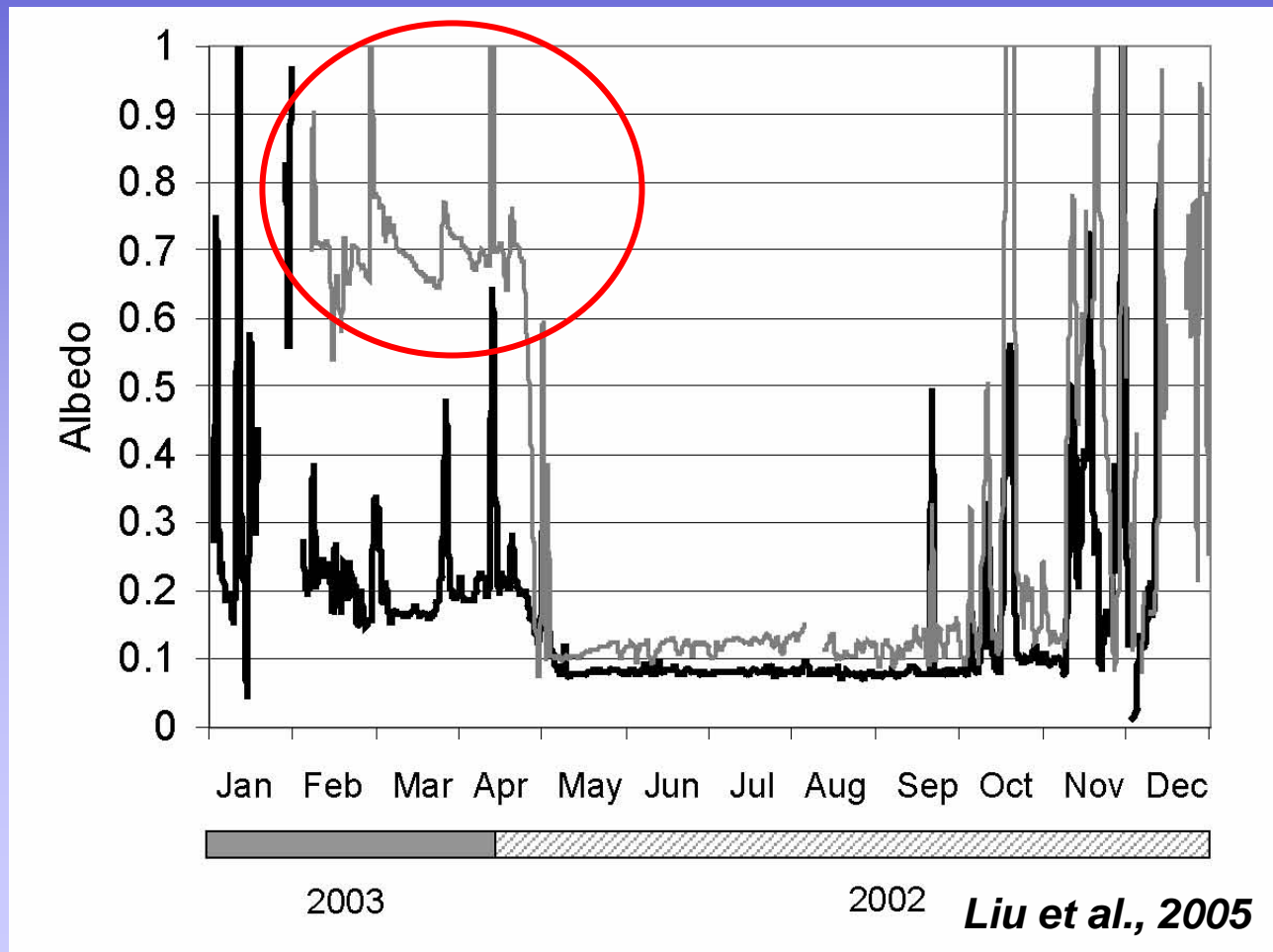


For how long does higher albedo persist following fire?

How does an increasing fire cycle affect albedo in the long run?

Changes in surface albedo at the Delta Chronosequence

Grey line = Recent burn
Black line = Control



Randerson et al. (in review):

report measurements and analysis of a boreal fire near Donnelly Flats, integrating the effects of greenhouse gases, ozone, aerosols, black carbon deposition on snow and sea ice, and post-fire changes in surface albedo. The net effect of the fire was to increase radiative forcing during the first year ($33 \pm 31 \text{ W m}^{-2}$ of burned area). Over the first 80 years after fire, however, the net effect of all agents was to decrease radiative forcing ($-2.3 \pm 2.2 \text{ W m}^{-2}$) largely due to sustained increases in surface albedo.

However, a reduction in fire return interval from 100 years to approximately 80 years will decrease radiative forcing by only about 0.2 W m^{-2} across the landscape.



Conclusions

- It is clear that an integrated analysis of the responses of ecosystem metabolism and ecosystem structure (albedo) is necessary to estimate the effect that fire may have on climate. The degree to which the climate system is vulnerable depends on the rate at which the fire regime changes as this has consequences for both the rate of carbon loss as CO_2 and the rate of conversion of conifer forests to deciduous forests.

- Fire seasons like the ones we experienced in 2004 and 2005 released substantial amounts of CO_2 to the atmosphere and will have lasting impacts on albedo over the next century. Will these large fire years lead to local cooling?

