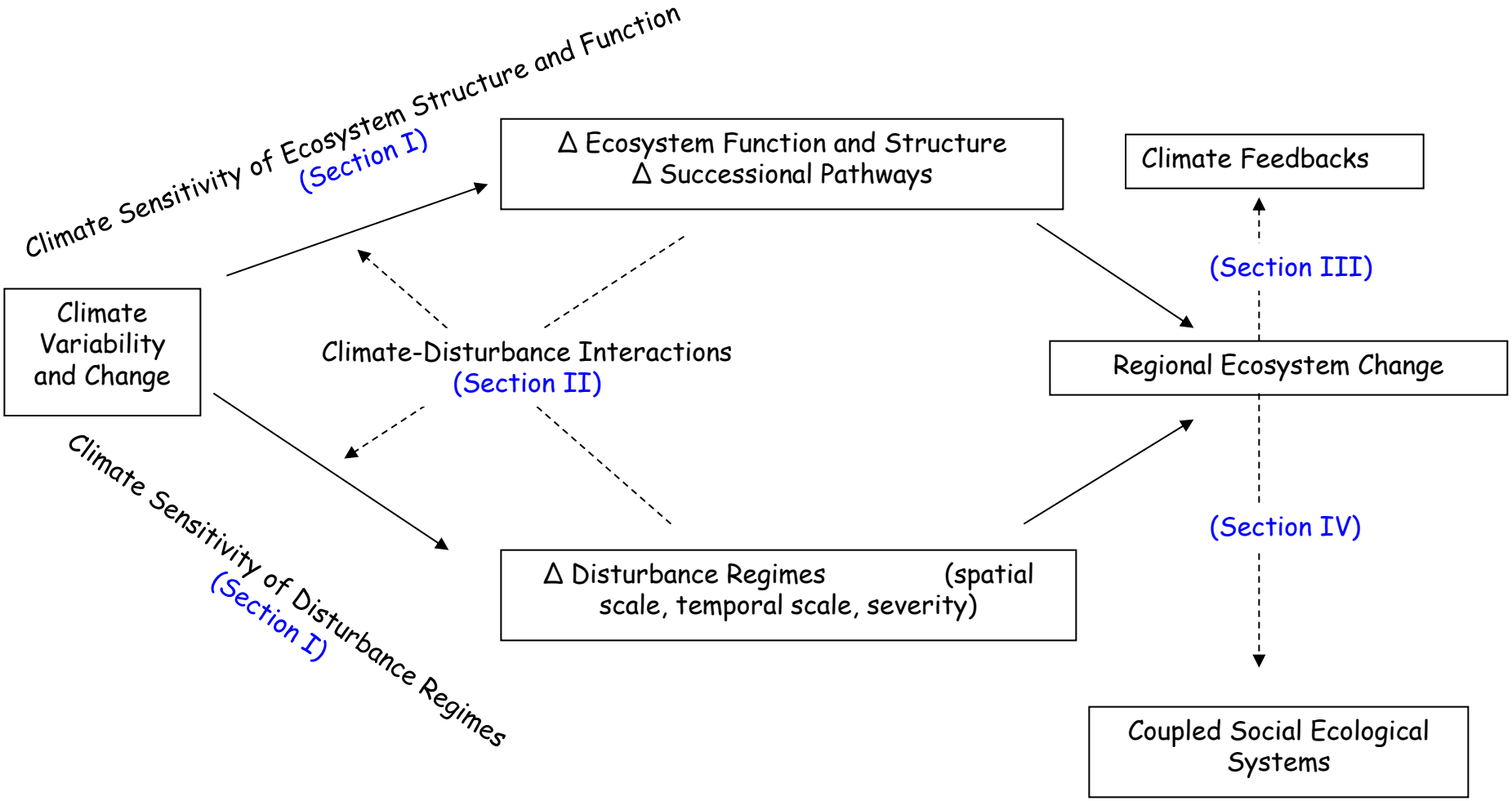
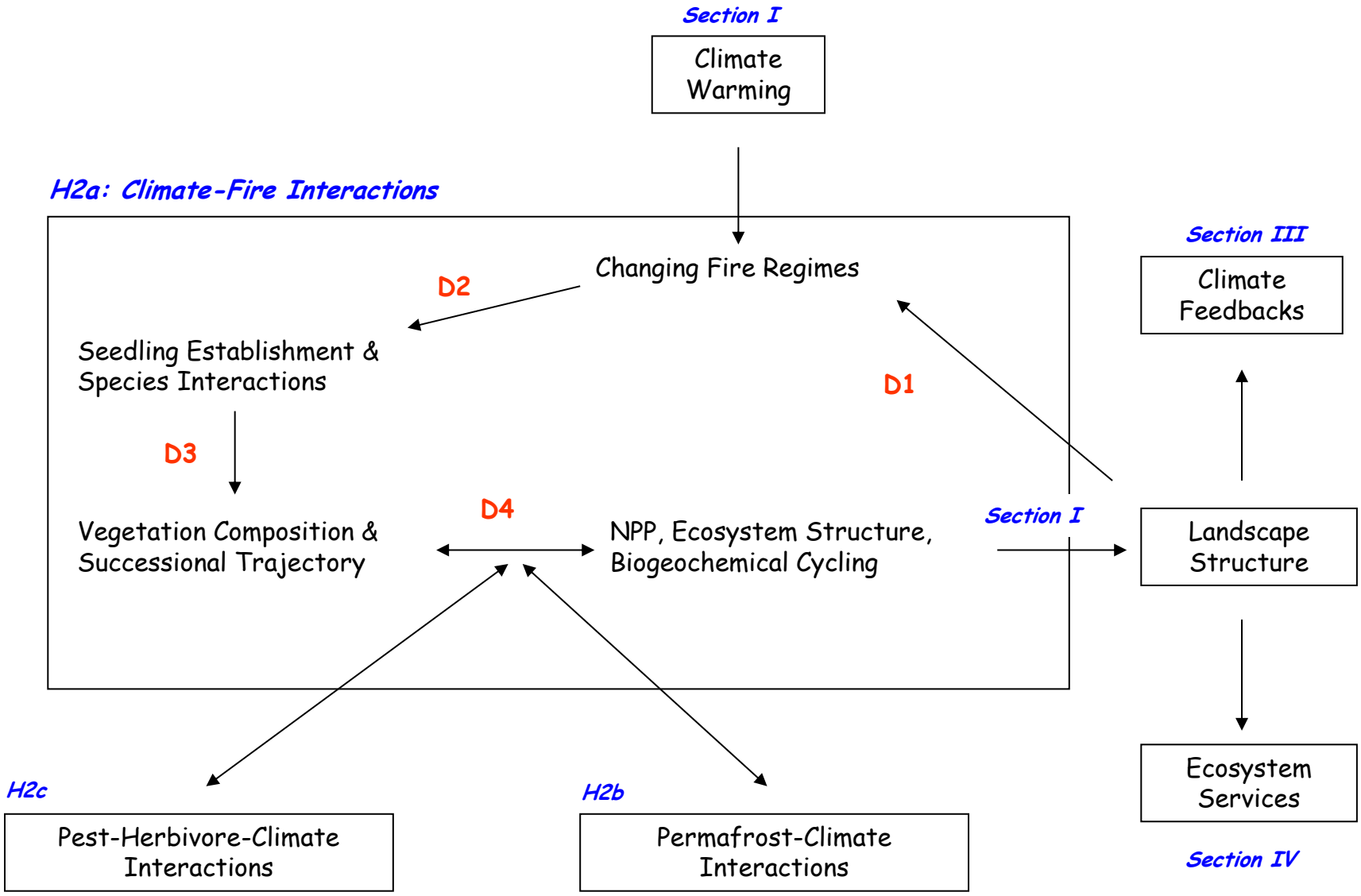
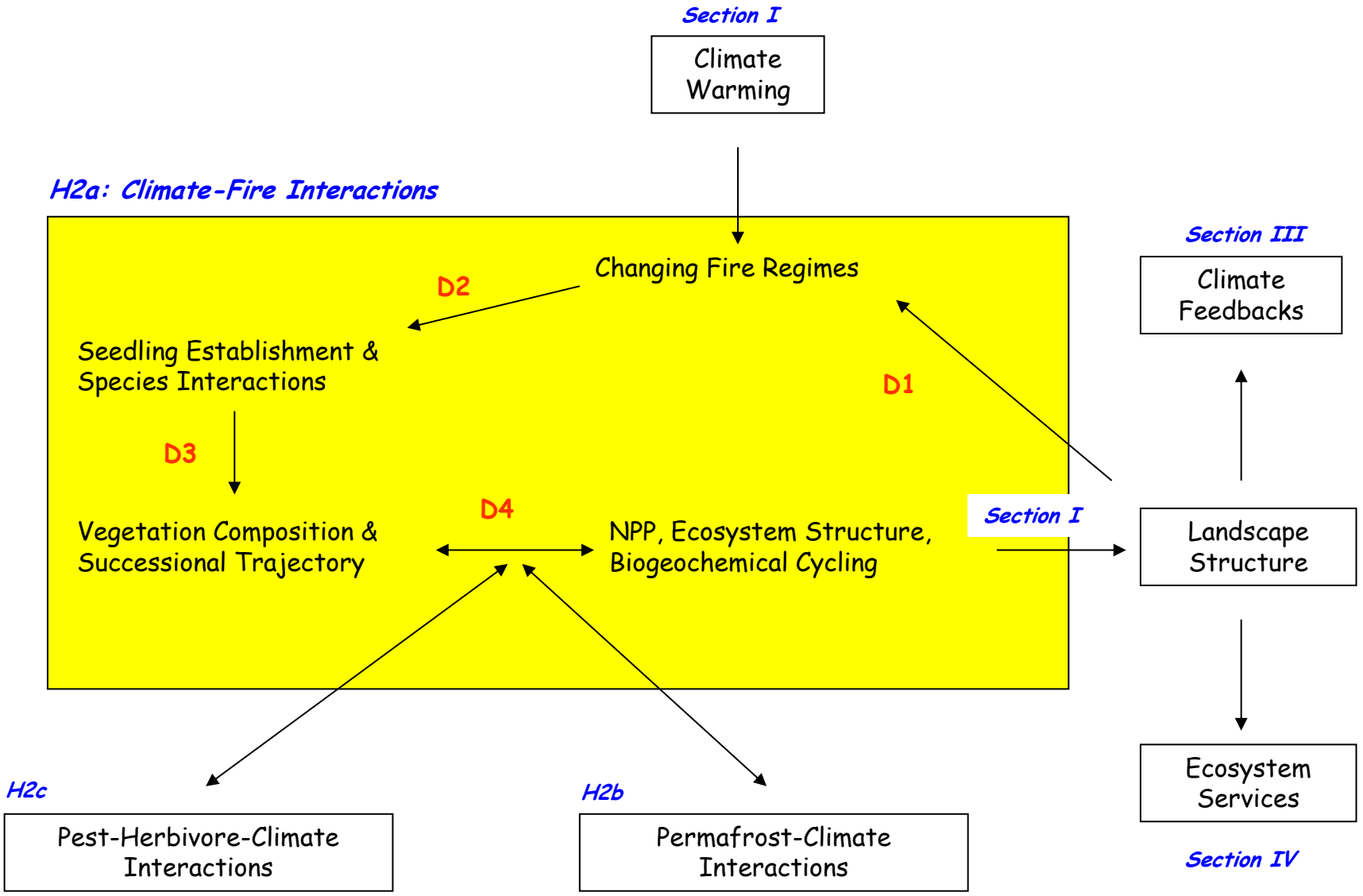
Carbon cycling feedbacks to climate



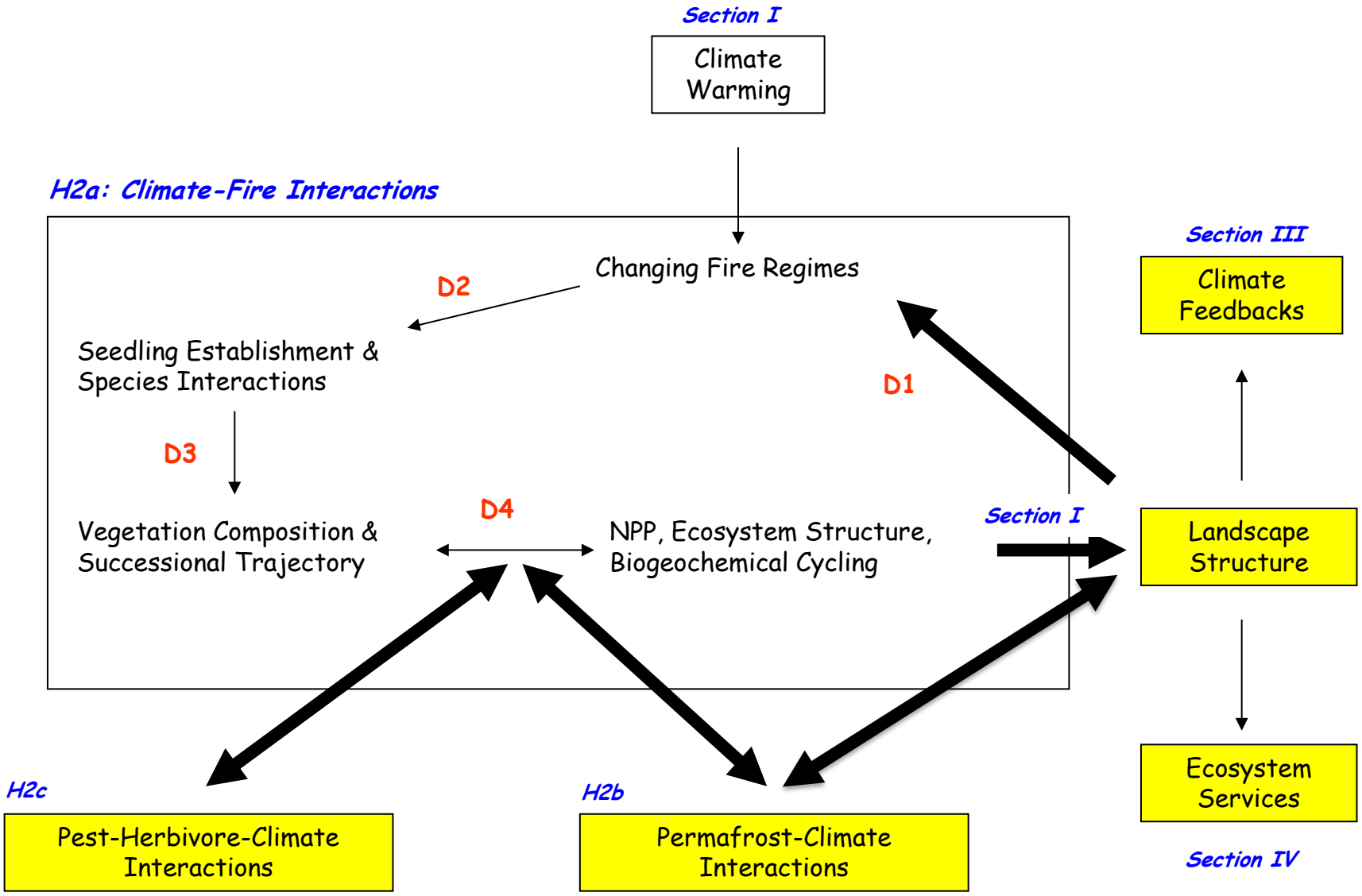
Climate-fire interactions



Climate-fire interactions



Climate-fire-*permafrost* interactions




How will a more deciduous landscape functio

What is next?

Cross-scale interactions and landscape resilience

Legacy locks and legacy links

1. Do deeper burns release legacy carbon?

2. How do unburned “kipukas” affect dynamics of regeneration and future fires?

3. Where and when does seed limitation drive patterns of tree establishment and succession?

4. Where and when does mycobiont limitation drive patterns of community assembly?

5. Can herbivores shift successional trajectories?

What is next?

Cross-scale interactions and landscape resilience

Legacy locks and legacy links

1. How does permafrost play into successional trajectories?

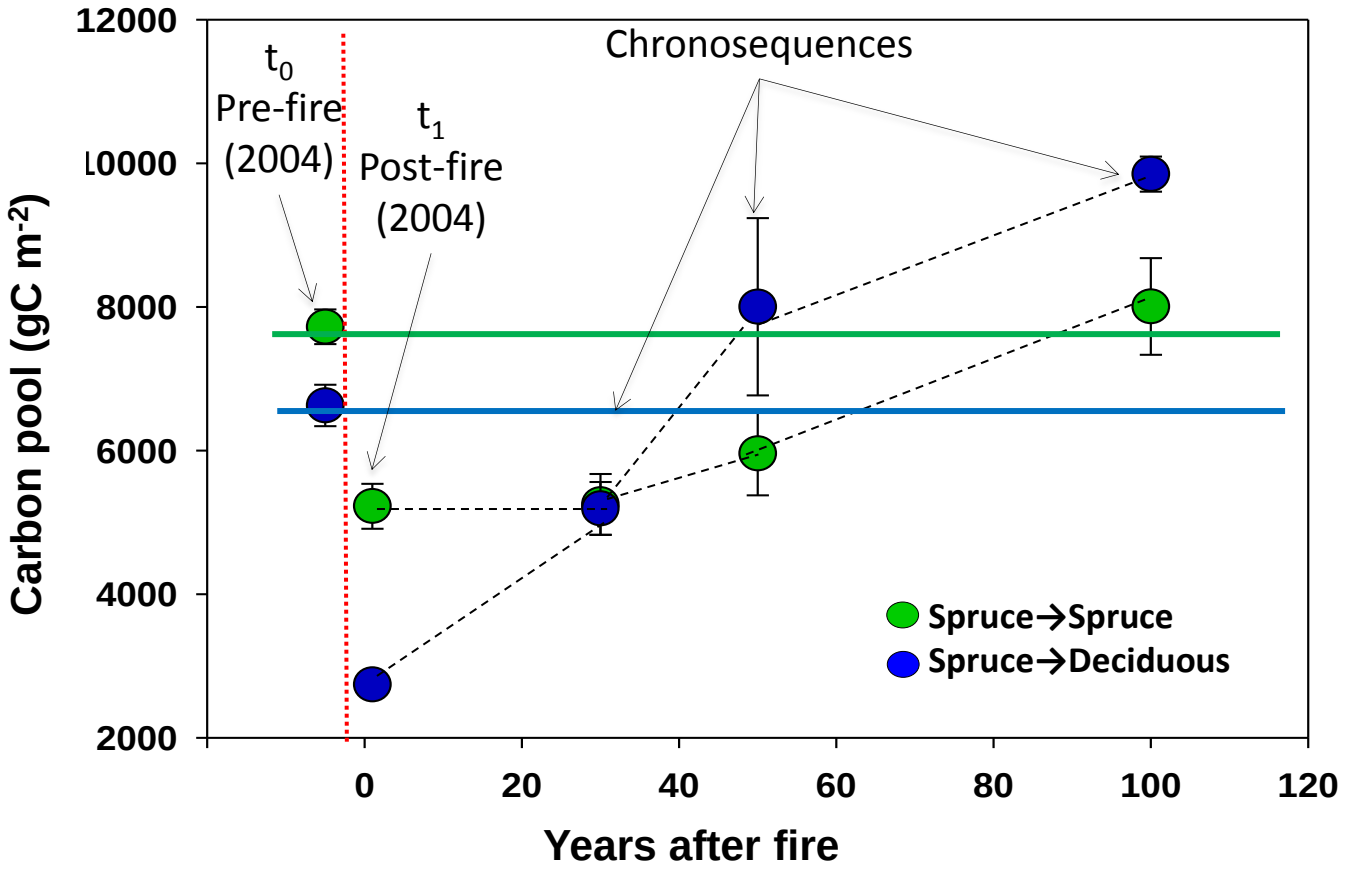
2. When successional trajectories shift, how does permafrost C loss compare to deciduous C gain?

3. What is the fate of permafrost N and how does it contribute to extant productivity?

4. How will terrestrial-aquatic linkages change in a more deciduous landscape?

1. Will changes in composition and age structure increase fire return interval in a warming climate?

Carbon pools over the disturbance cycle



Net C accumulation (t_{100}-t_1):

Spruce	2877 g C m^{-2}
Deciduous	7110

% legacy carbon at t_{100}:

Spruce	64 %
Deciduous	28

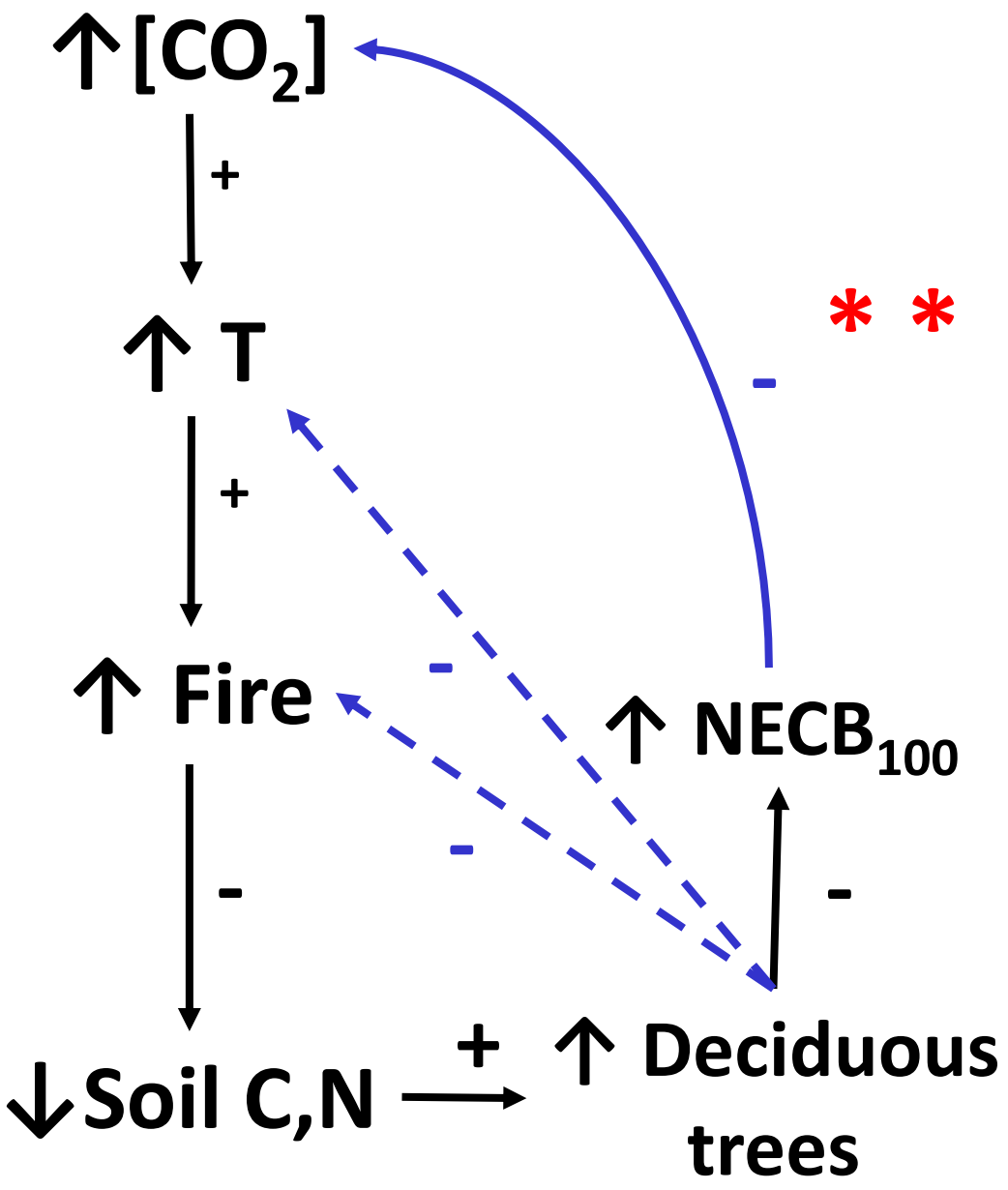
NECB (t_{100}-t_0):

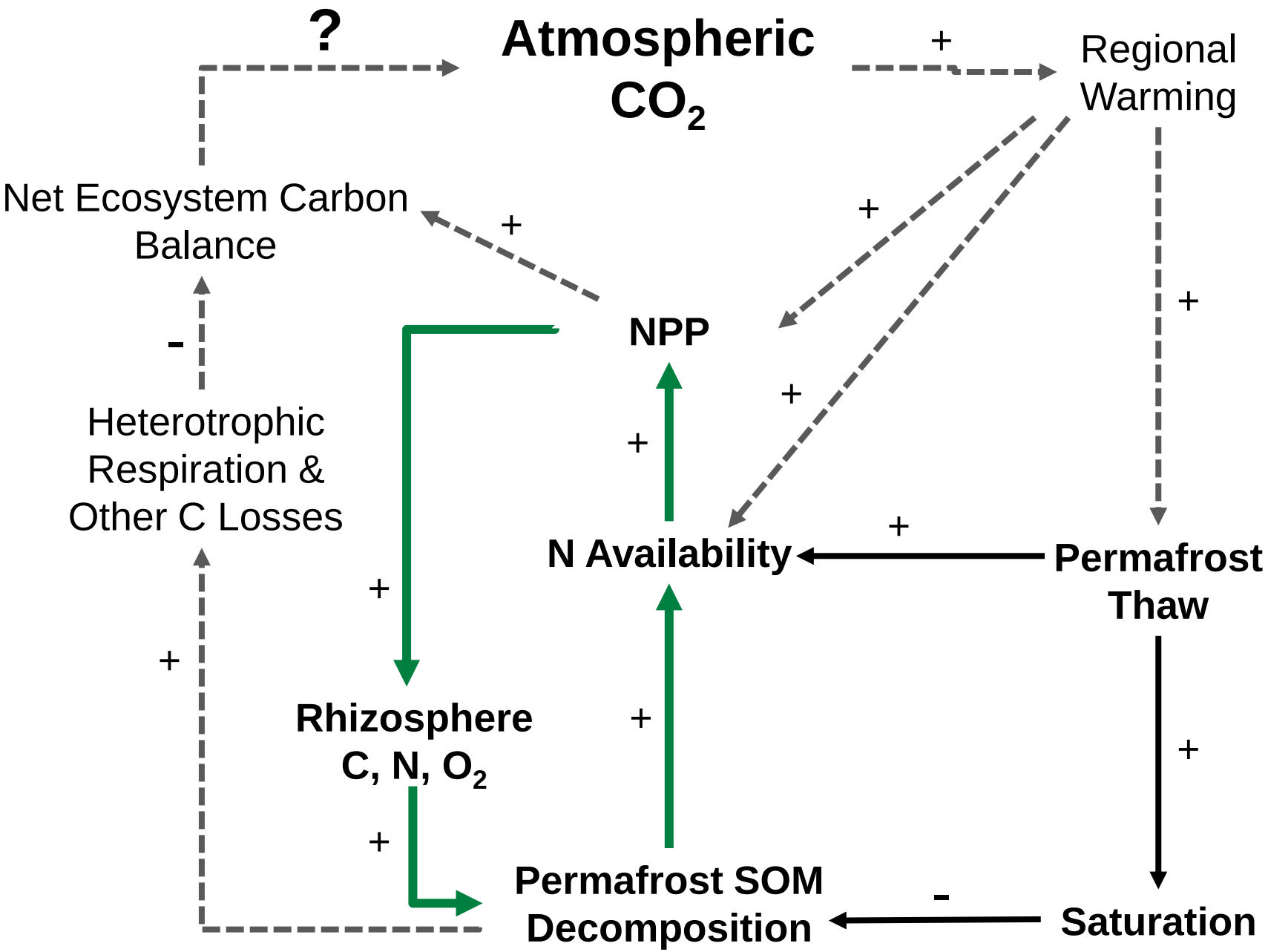
Spruce	375 g C m^{-2}
Deciduous	3,233

Results:

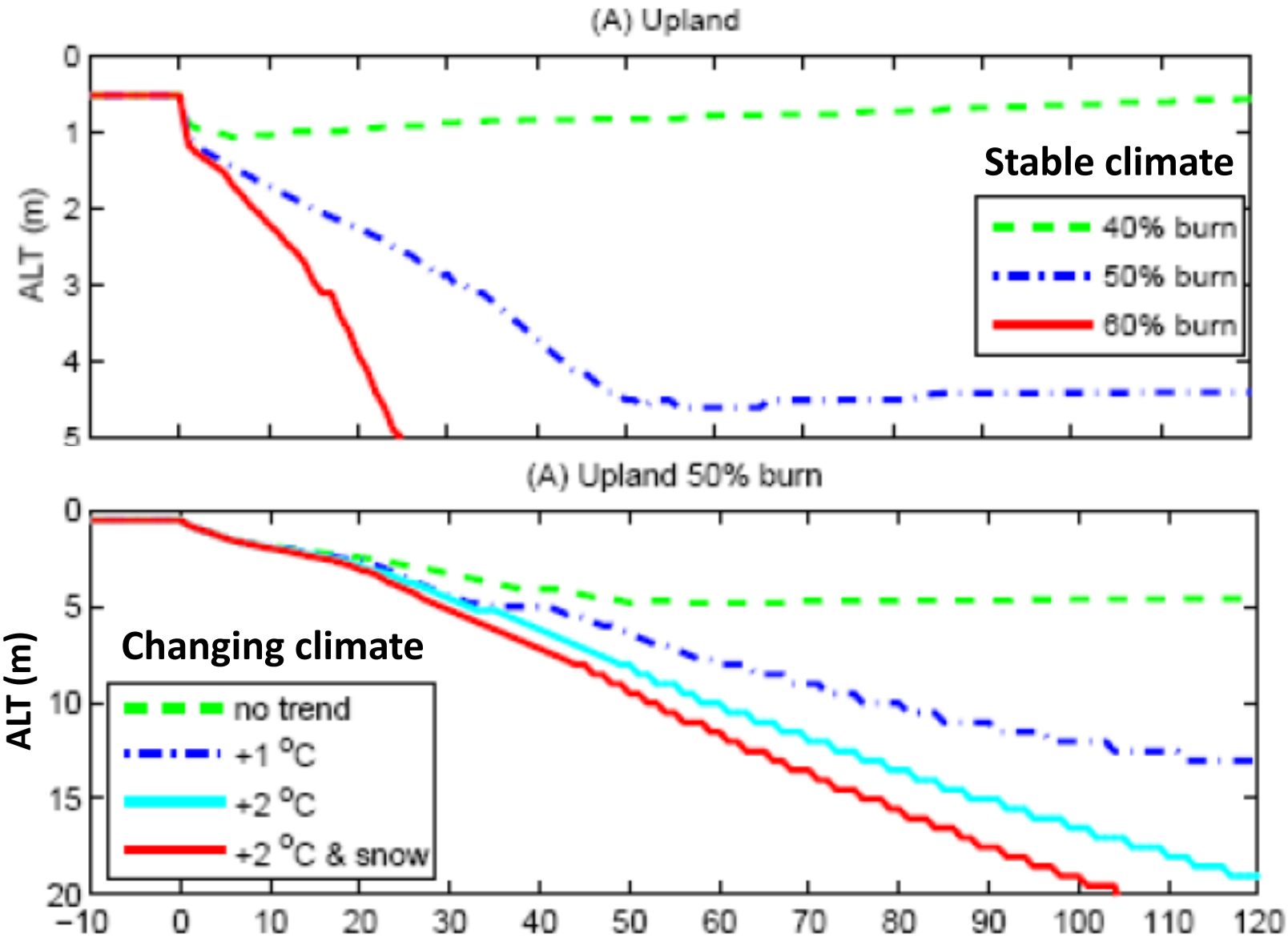
Spruce→Deciduous

↓ Soil C < ↑ Plant C



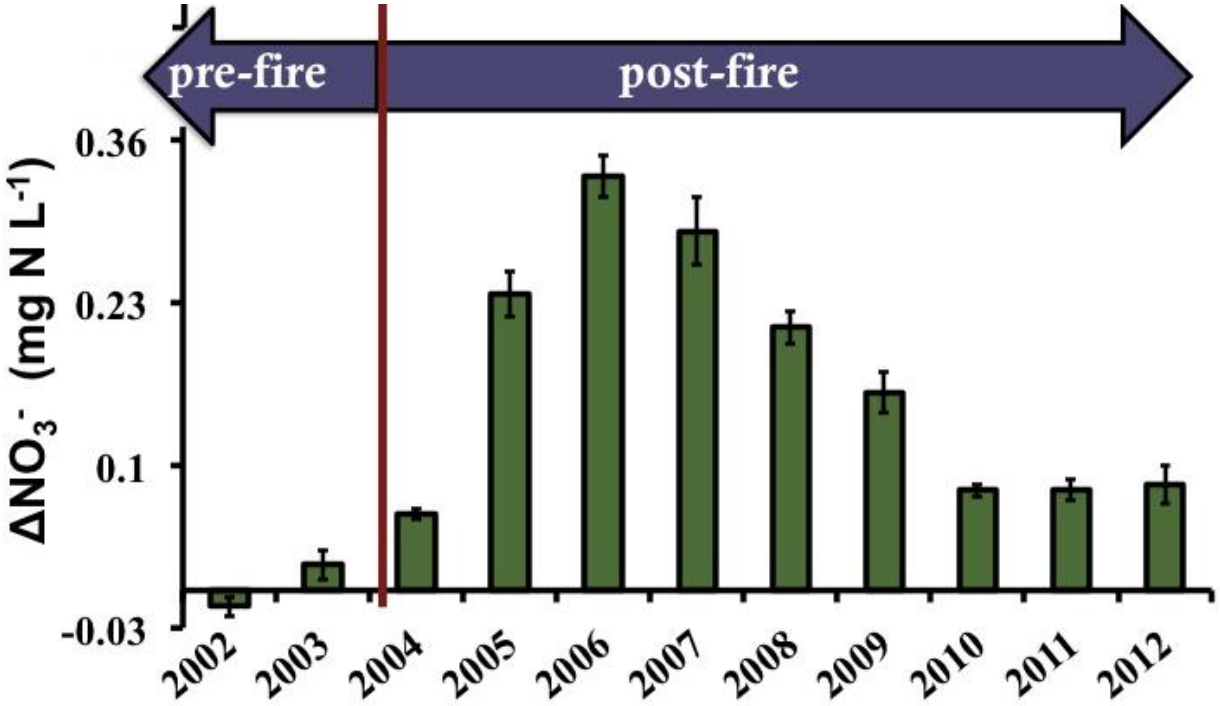

?
Atmospheric CO_2
+
Regional Warming
Net Ecosystem Carbon Balance
+
+
+
-
NPP
+
+
+
Heterotrophic Respiration & Other C Losses
+
N Availability
+
Permafrost Thaw
+
+
Rhizosphere C, N, O_2
+
+
+
Permafrost SOM Decomposition
-
Saturation

Permafrost response to depth of burning

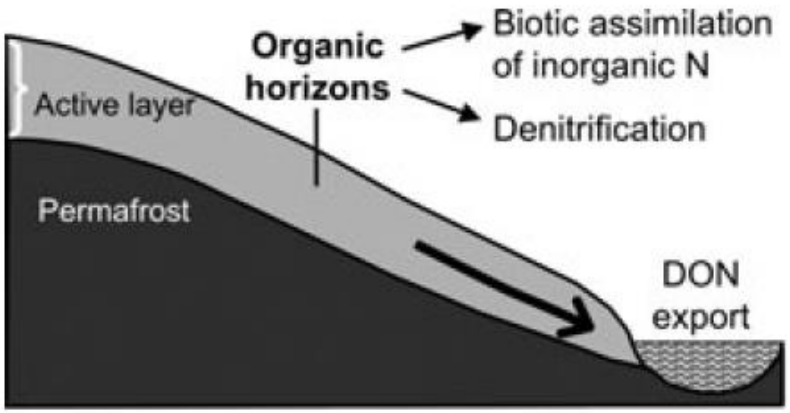


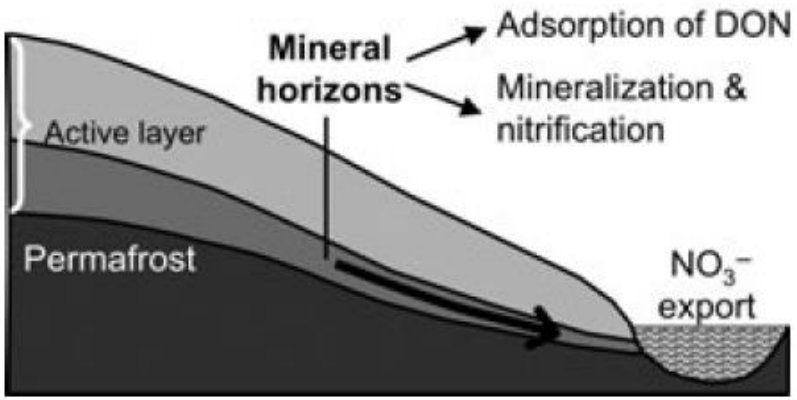
Romanvosky et al. in progress

Stream chemistry response to fire, permafrost



Deepening of the active layer could drive sustained release of nitrate.





Betts and Jones 2009, Harms and Jones 2012

What's next?

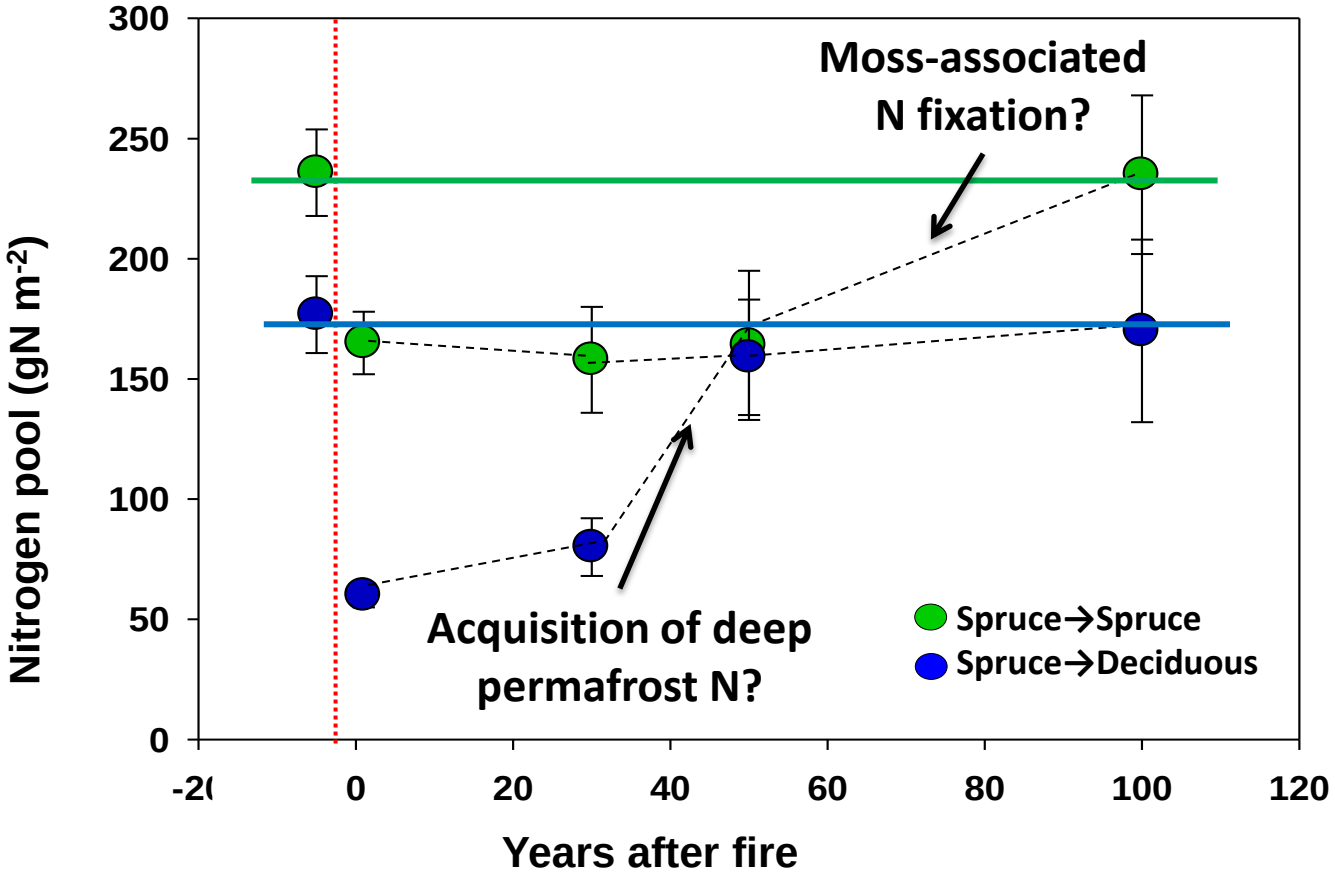
What have we learned?

- Fire regimes are intensifying in black spruce forest and tundra
- Area burned is increasing
- Bigger burns are deeper burns
- Intensity may be unique in paleo-record

What new questions are emerging?

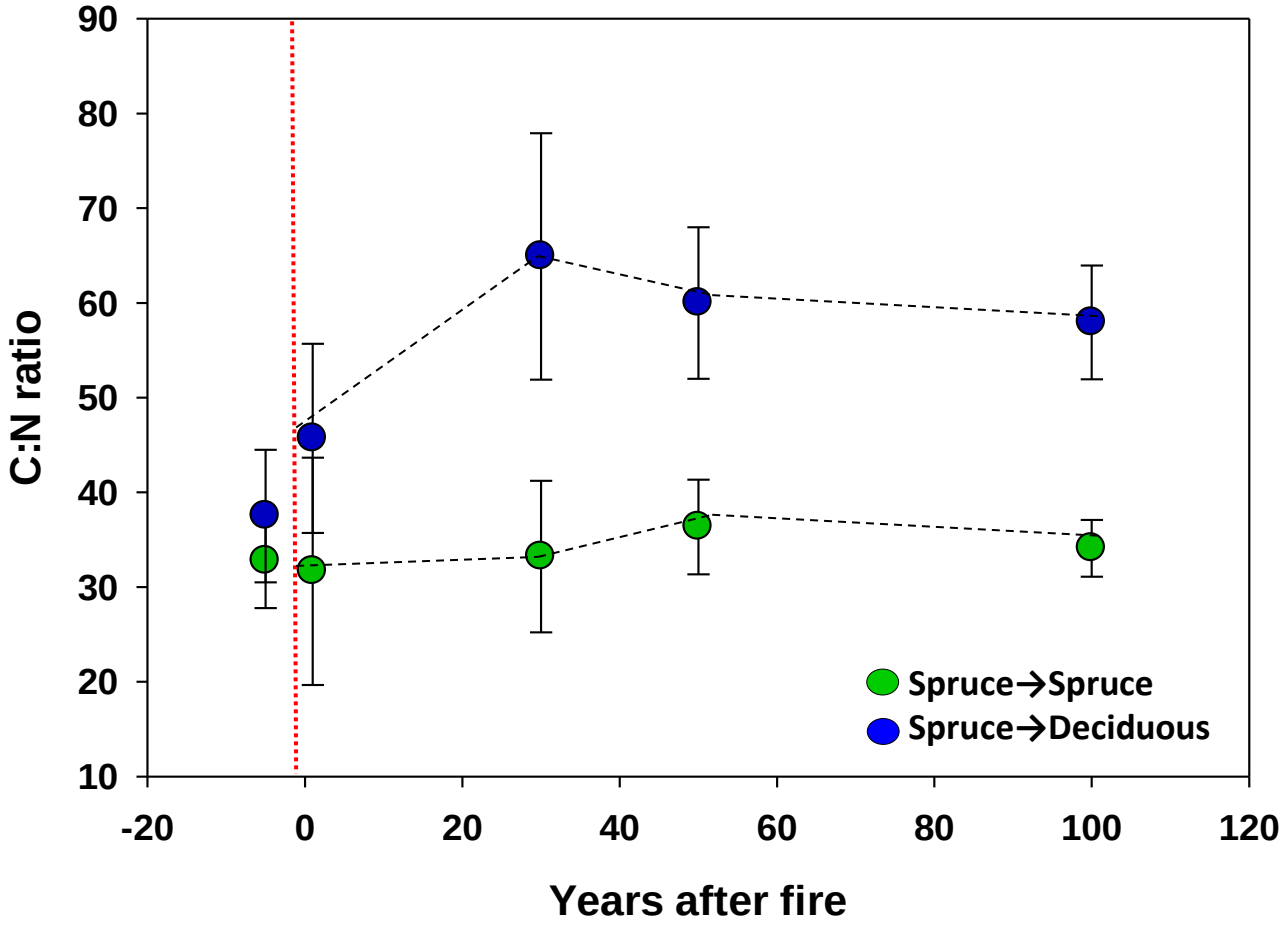
- Spatial heterogenaity within fires
- Linking current depth of burning to historic burning
- Landscape flammability feedbacks (demography, composition)

Nitrogen pools over the disturbance cycle



Net N accumulation (t_{100}-t_1):		% legacy N at t_{100}:		NENB (t_{100}-t_0):	
Spruce	70 g N m^{-2}	Spruce	70%	Spruce	-0.8 g N m^{-2}
Deciduous	110	Deciduous	35	Deciduous	-6.8

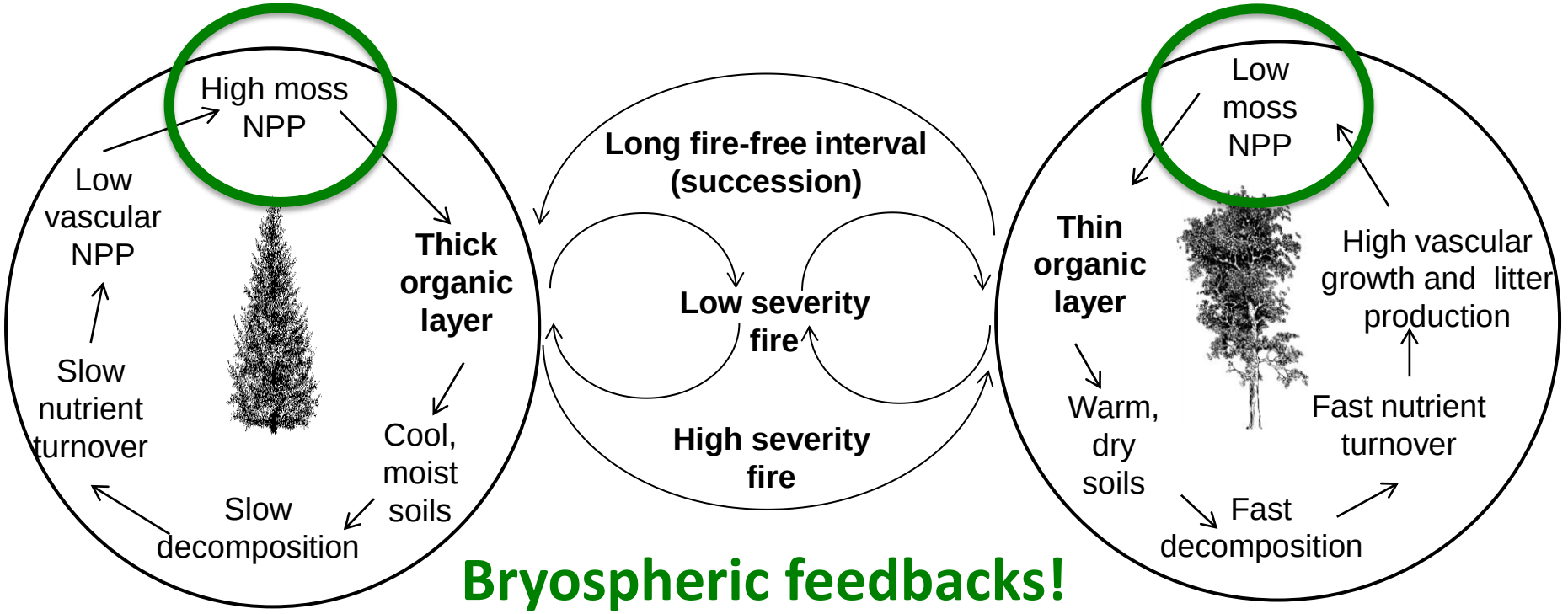
C:N ratio over the disturbance cycle



Summary

- **NECB was an order of magnitude greater in spruce→ deciduous than in spruce→spruce**
- **Spruce→spruce harbored twice as much legacy C and N as spruce→ deciduous**
- **Over both trajectories, N pools were resilient, recovering to pre-fire pool sizes by 100 years**
- **Change in species composition catalyzed transfer of N from low C:N soil organic matter to high C:N trees, resulting in greater ecosystem N use efficiency**

Stabilizing feedbacks that maintain trajectories



Bryospheric feedbacks!

Hypothesis:

Spruce→Deciduous

↓ Soil C > ↑ Plant C

↑[CO_2]

+

↑ T

+

↑ Fire

-

↓Soil C,N

+

↑ Deciduous trees

-

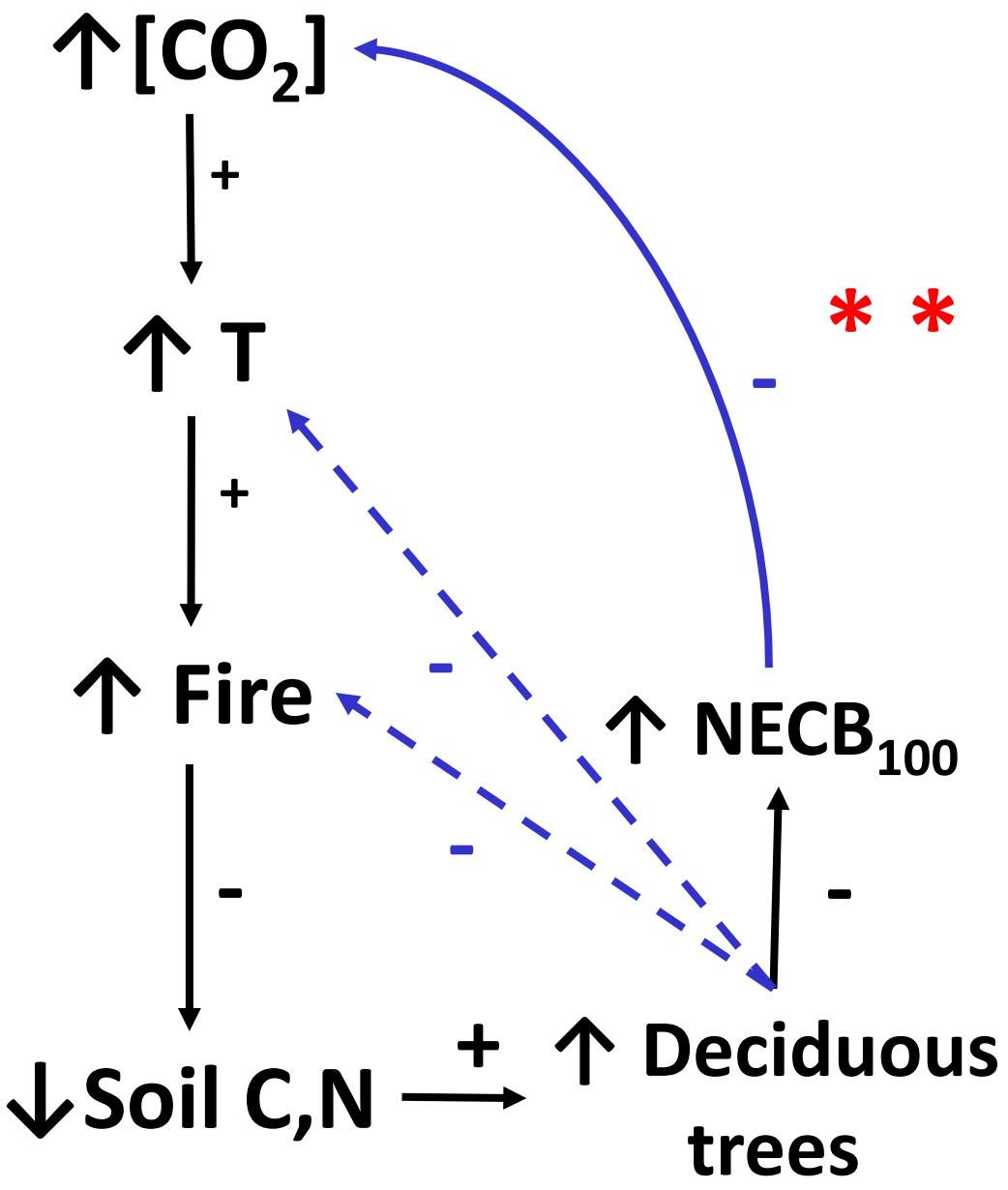
↓$NECB_{100}$

+

Results:

Spruce→Deciduous

↓ Soil C < ↑ Plant C



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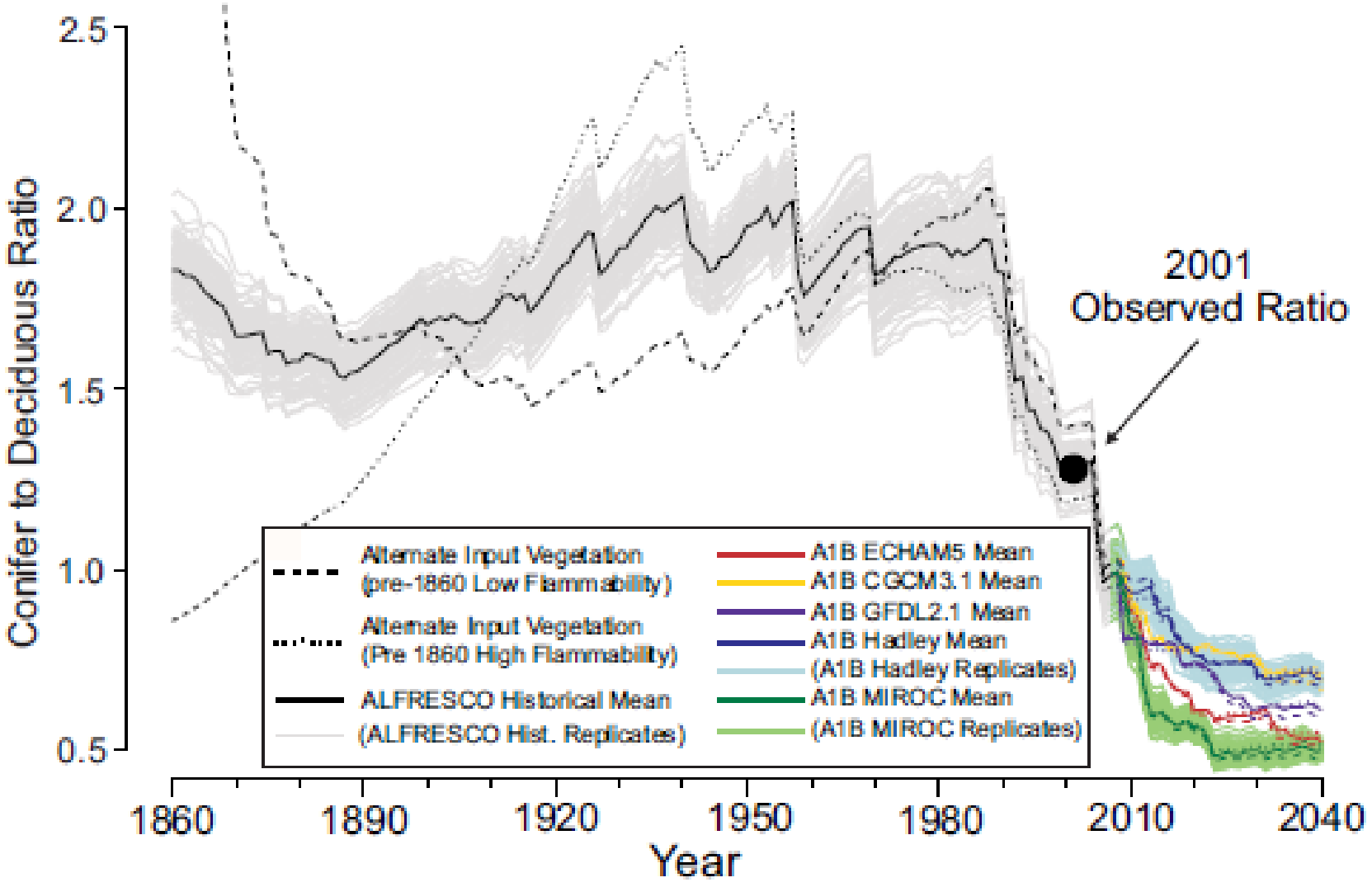
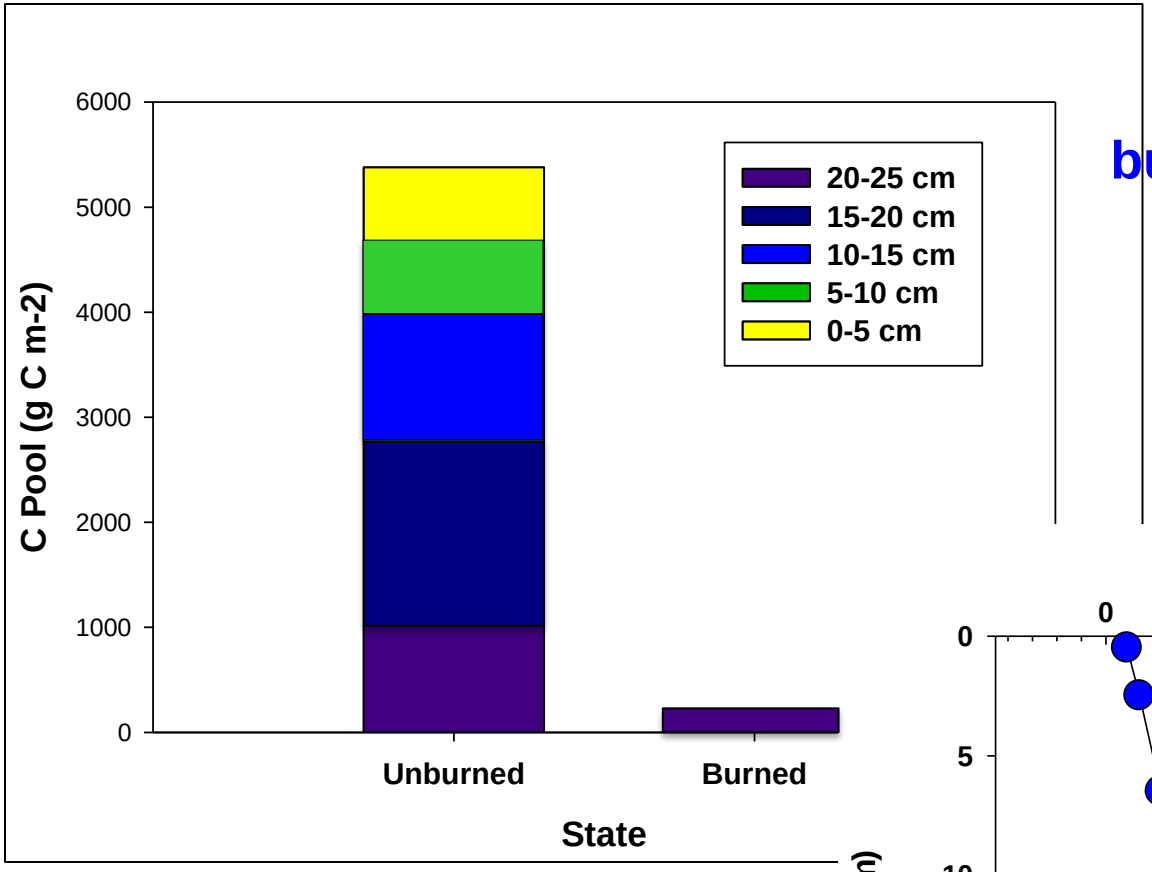
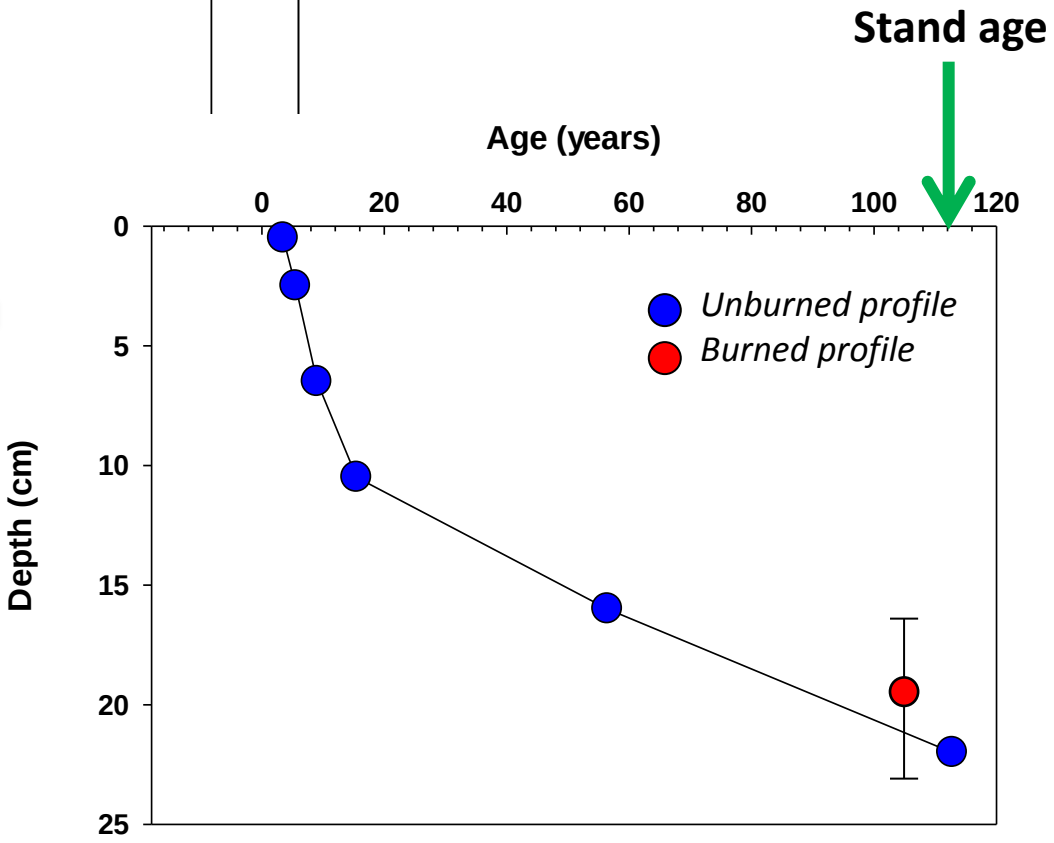
A deciduous tipping point in boreal forest?



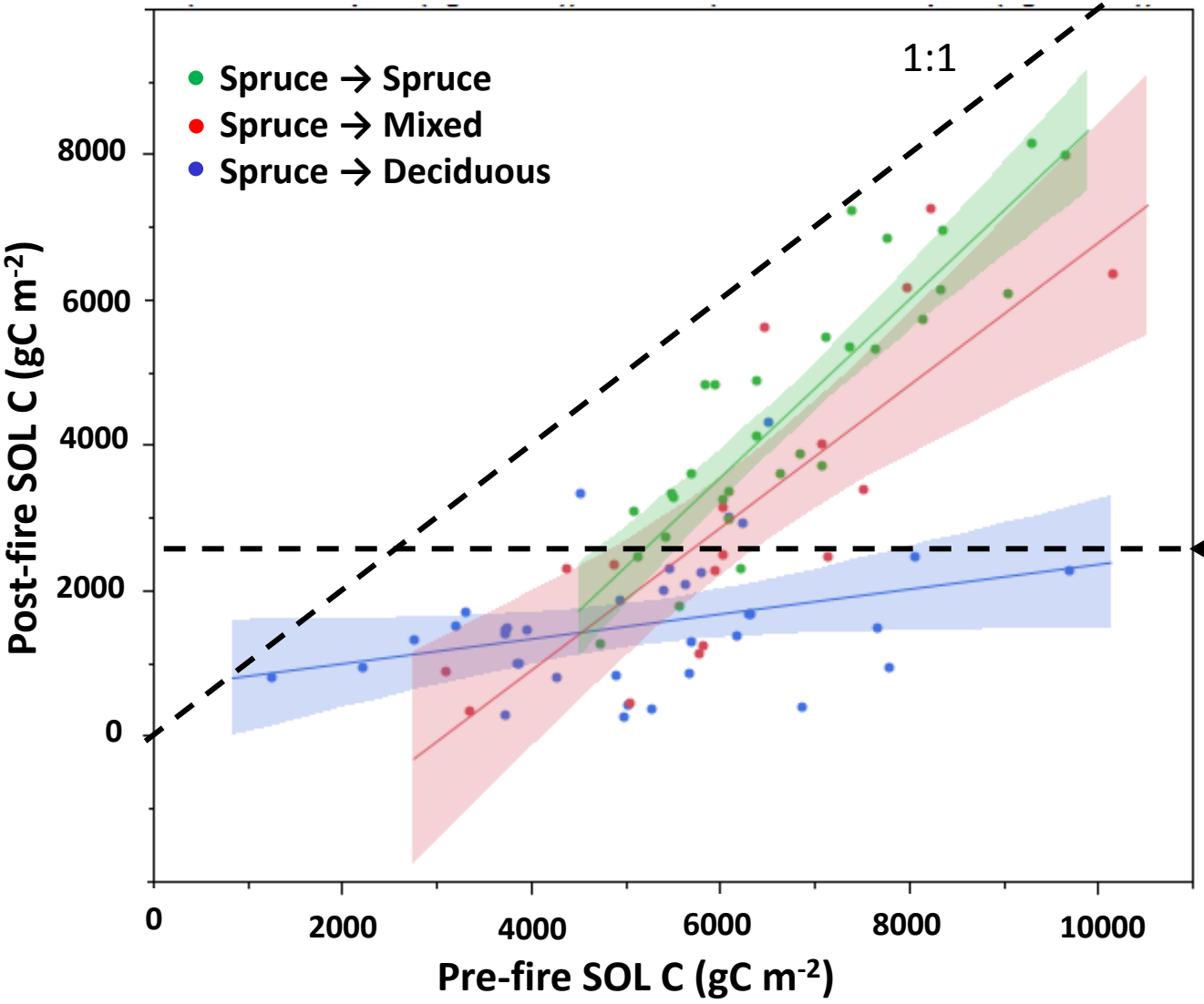
Mann, Rupp et al. 2012

Carbon stocks and age in burned and unburned profiles at Willow Creek





Residual SOL-C pools and successional trajectory



Trajectories in year 10:

Spruce = 30

Mixed = 17

Deciduous = 35

[0 trees = 8]

← **Mean depth ~ 9cm**