

Science theme 3:

Thresholds and regime shifts

Hypothesis: Novel boreal landscape patterns emerge when climate change leads to disturbance regimes that alter permafrost integrity & abundances of key functional types.

Participating Investigators:

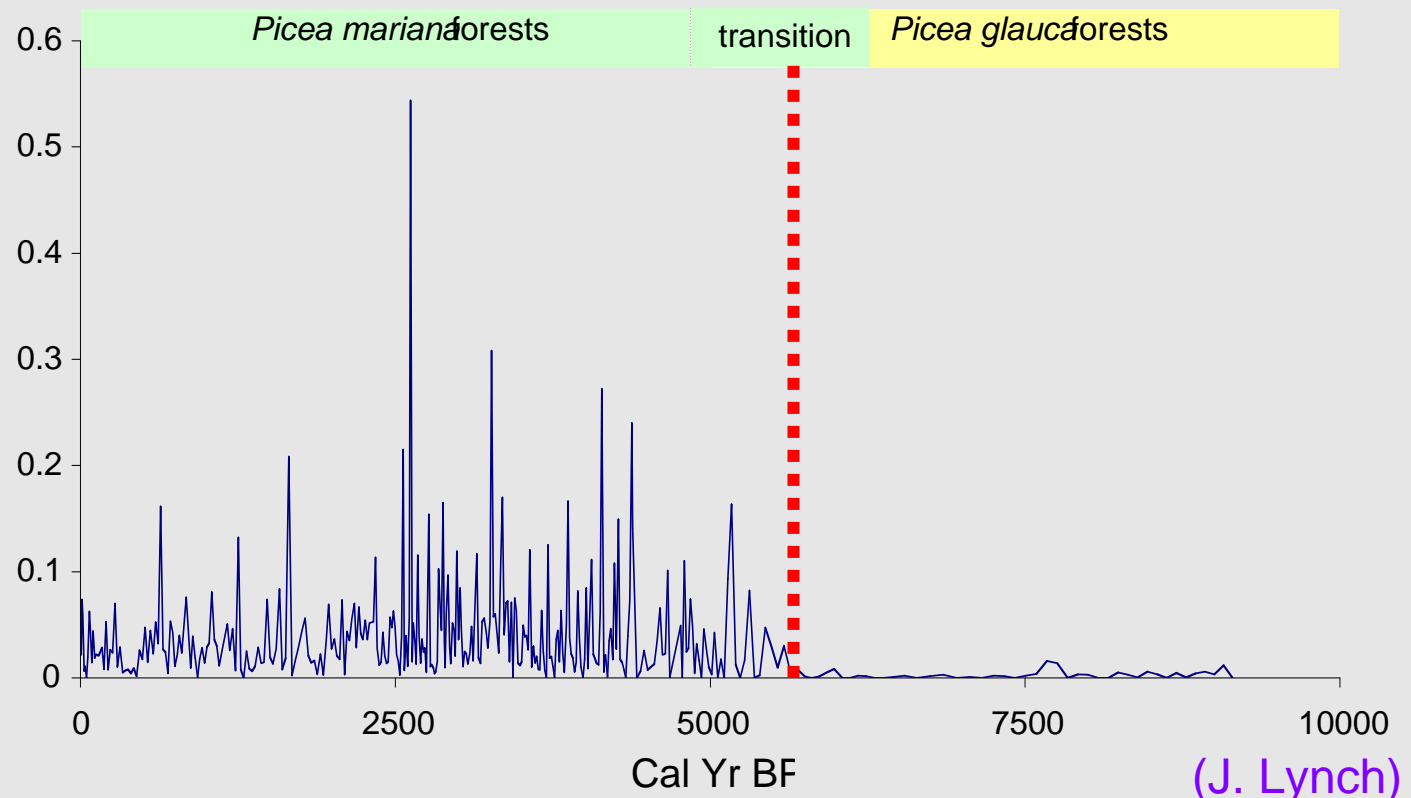
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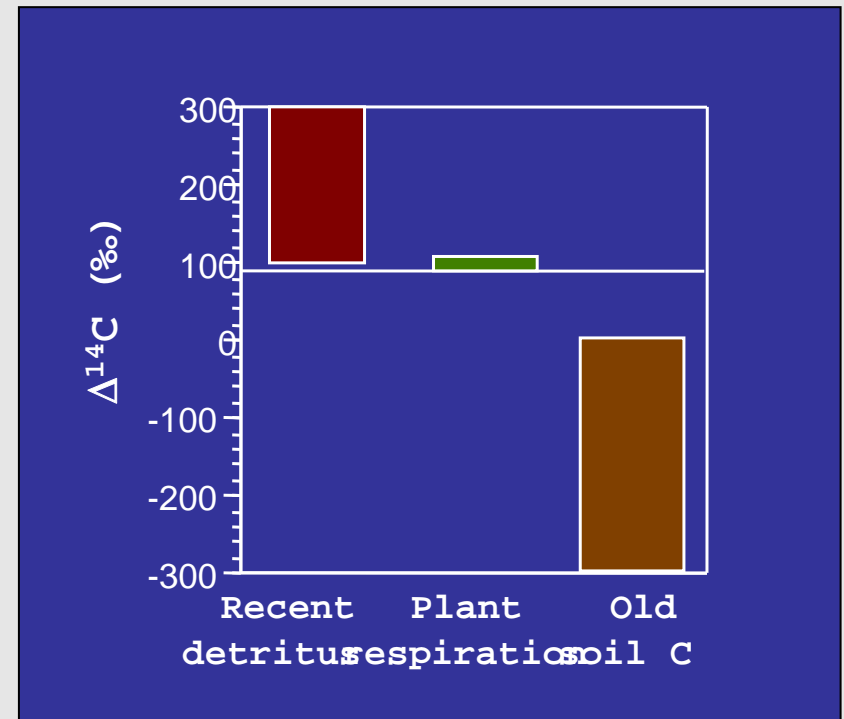
Three mechanisms to identify triggers of regime shifts:

- **First principles:** permafrost thaws at 0°C
- **Paleoecological studies:** fire-veg closely coupled



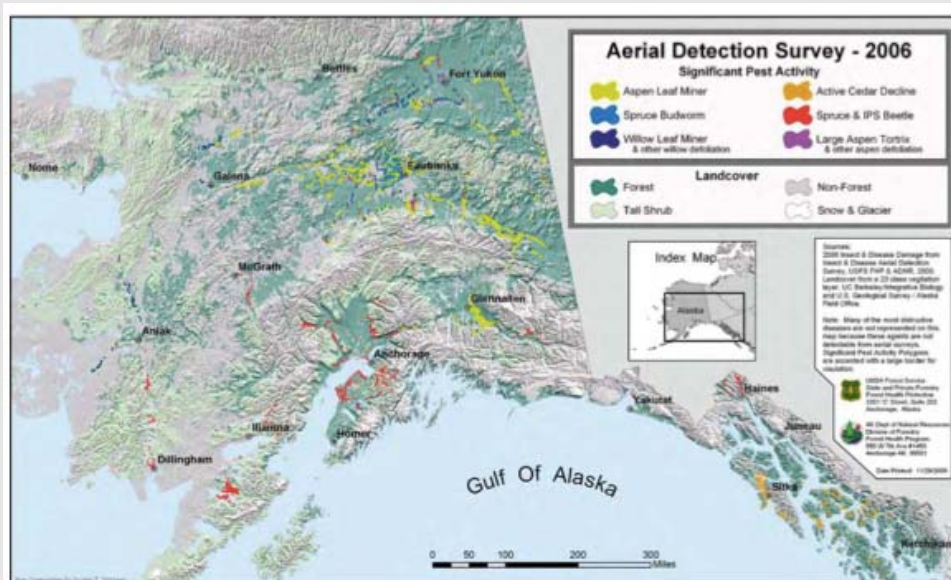
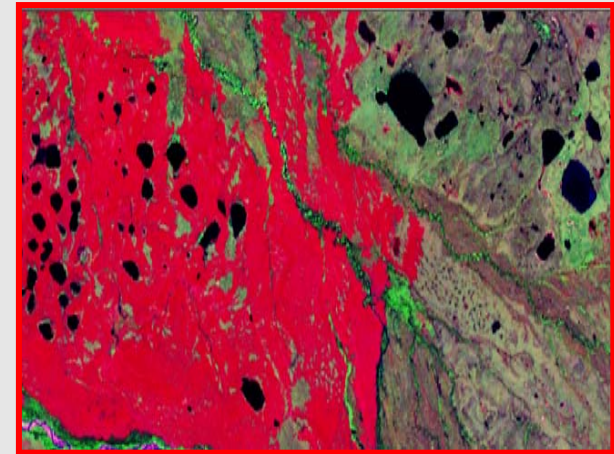
Three mechanisms to identify triggers of regime shifts:

- First principles: permafrost thaws at 0°C
- Paleoecological studies: fire-veg closely coupled
- Early warning indicators:



Hypothesized triggers of threshold changes/ regime shifts in boreal Alaska:

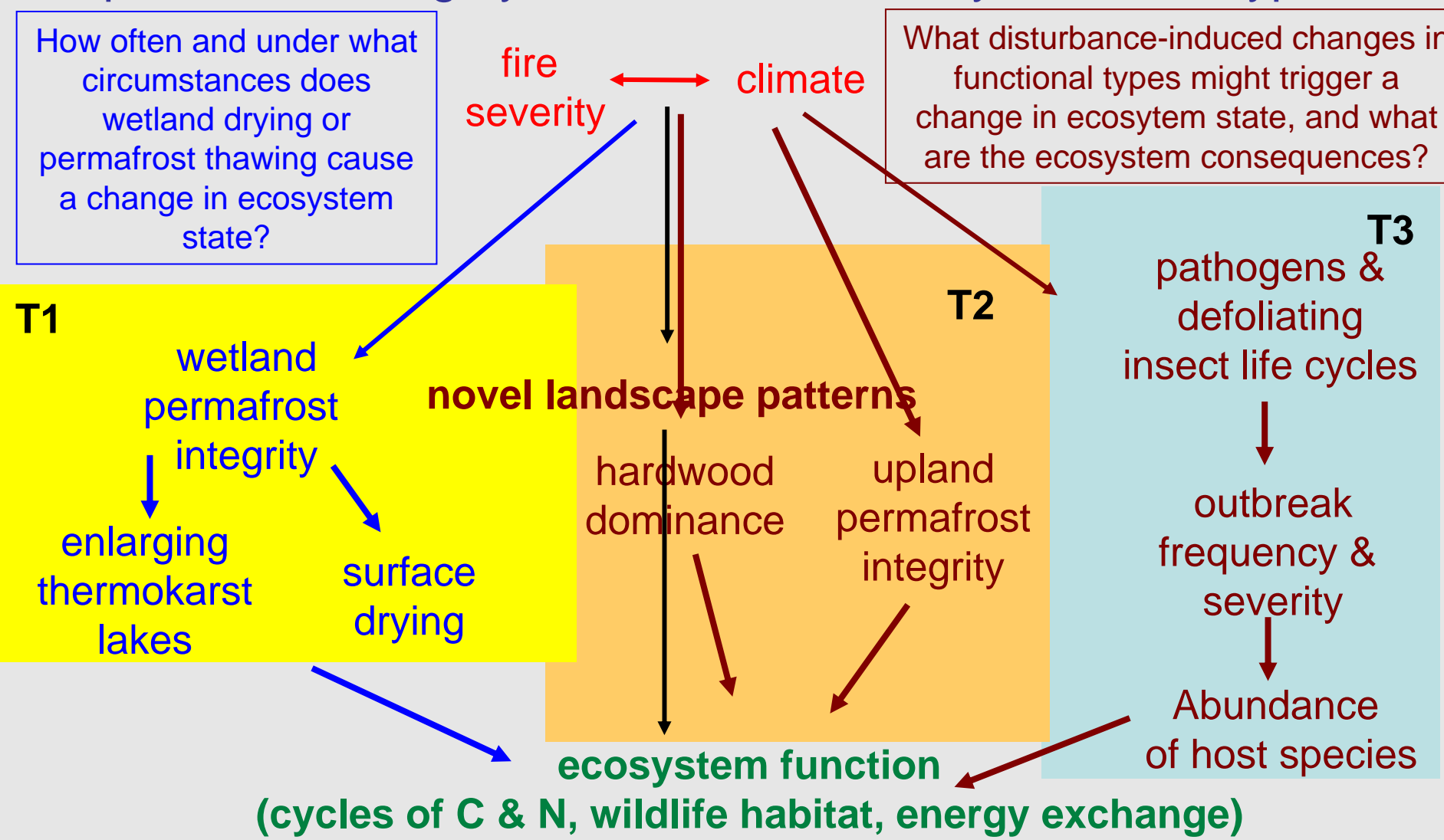
- Permafrost integrity (thermokarst)
- Fire
- Insect & pathogen outbreaks



Hypothesis: Novel boreal landscape patterns emerge when climate change leads to disturbance regimes that alter permafrost integrity & abundances of key functional types.

How often and under what circumstances does wetland drying or permafrost thawing cause a change in ecosystem state?

What disturbance-induced changes in functional types might trigger a change in ecosystem state, and what are the ecosystem consequences?

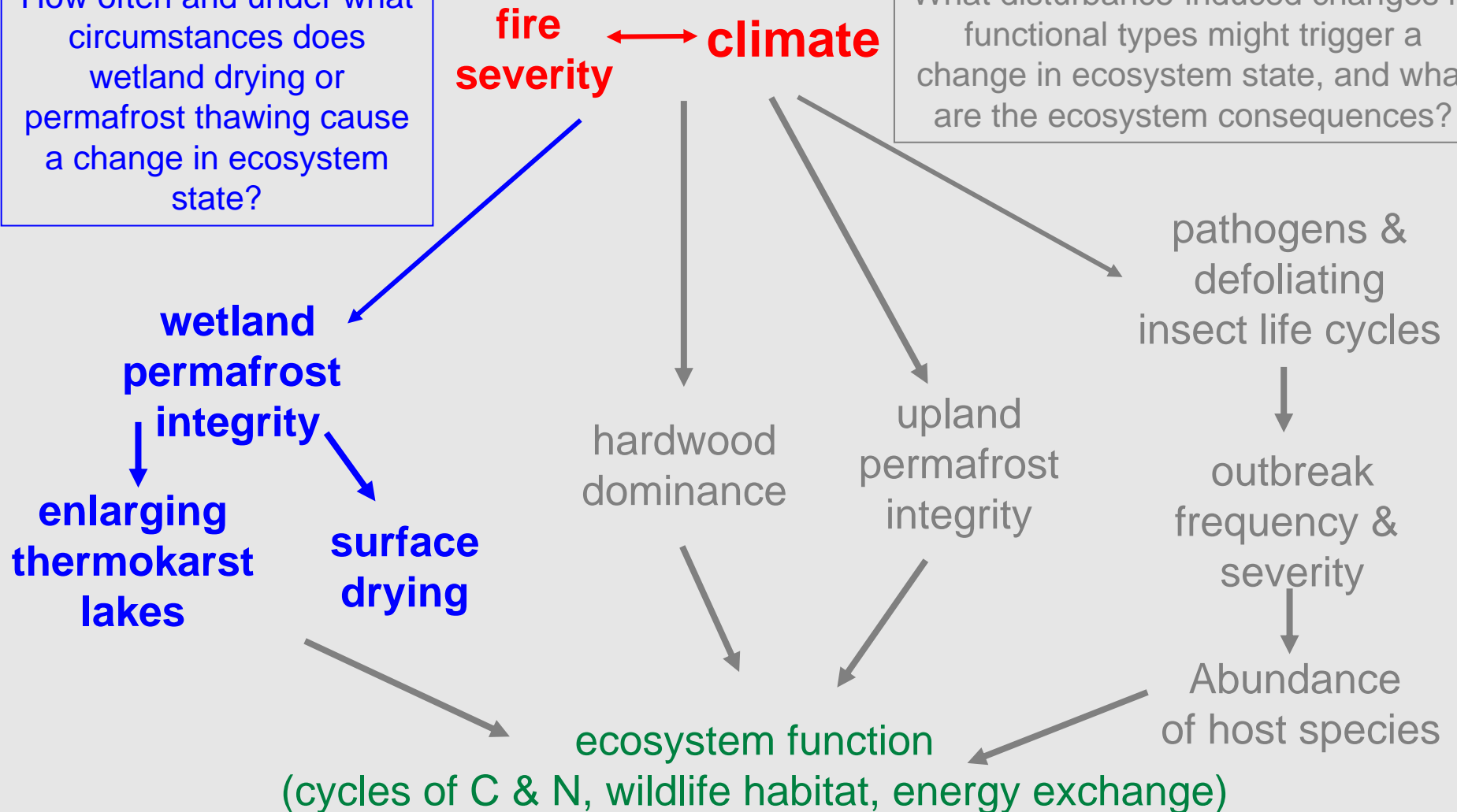


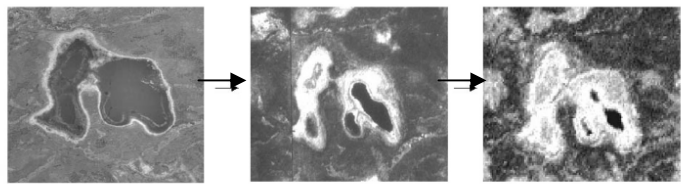
Question 1, Task 1

(Verbyla)

How often and under what circumstances does wetland drying or permafrost thawing cause a change in ecosystem state?

What disturbance-induced changes in functional types might trigger a change in ecosystem state, and what are the ecosystem consequences?

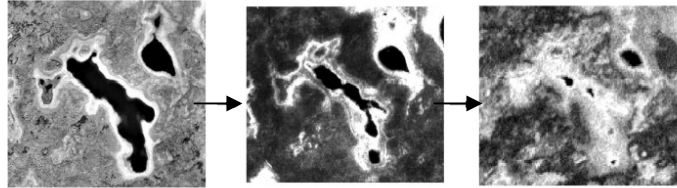




1960s

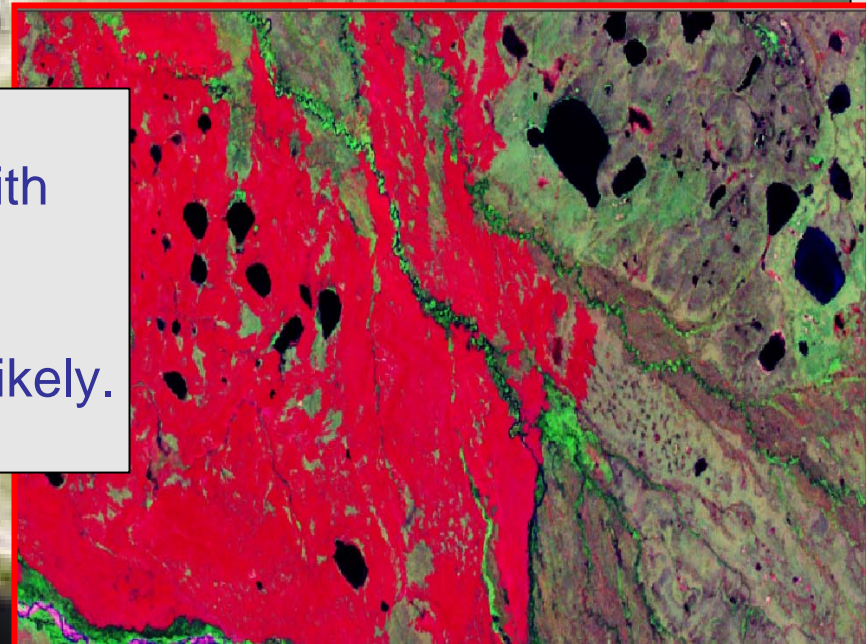
1970s

2000s



Changes in surface hydrology can be detected & mapped from time series of Landsat imagery.

Analyses of how these changes vary with topography, soils, disturbance can produce rules for predicting where threshold changes in hydrology are most likely.

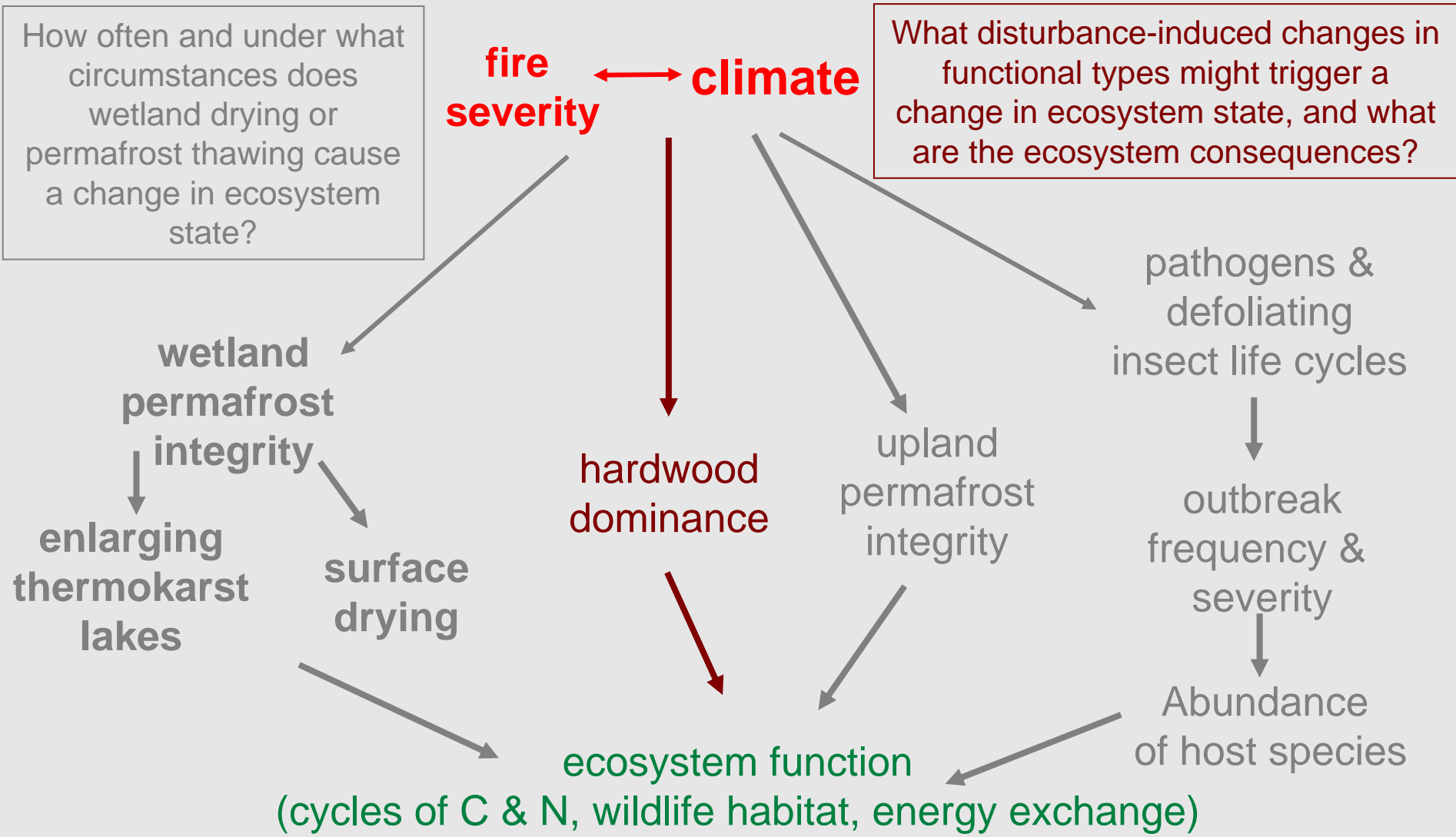


Source: Riordan et al. (2006)

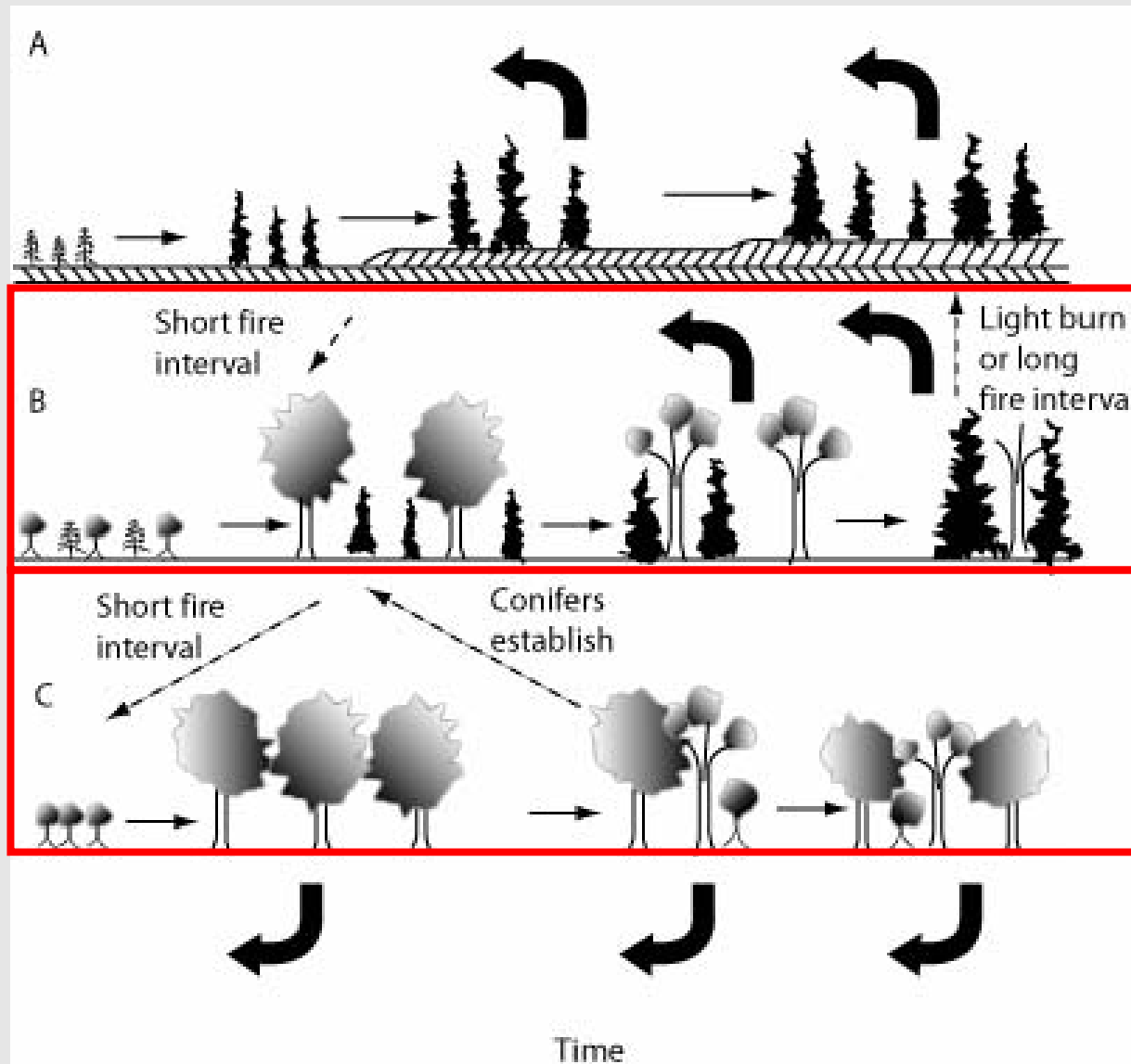
(Verbyla)

Question 2, Task 2a

(Chapin, Hollingsworth, Johnstone, Mack)



Hypothesis: Changes in fire severity lead to altered successional trajectories.



High severity fires promote hardwood dominance.

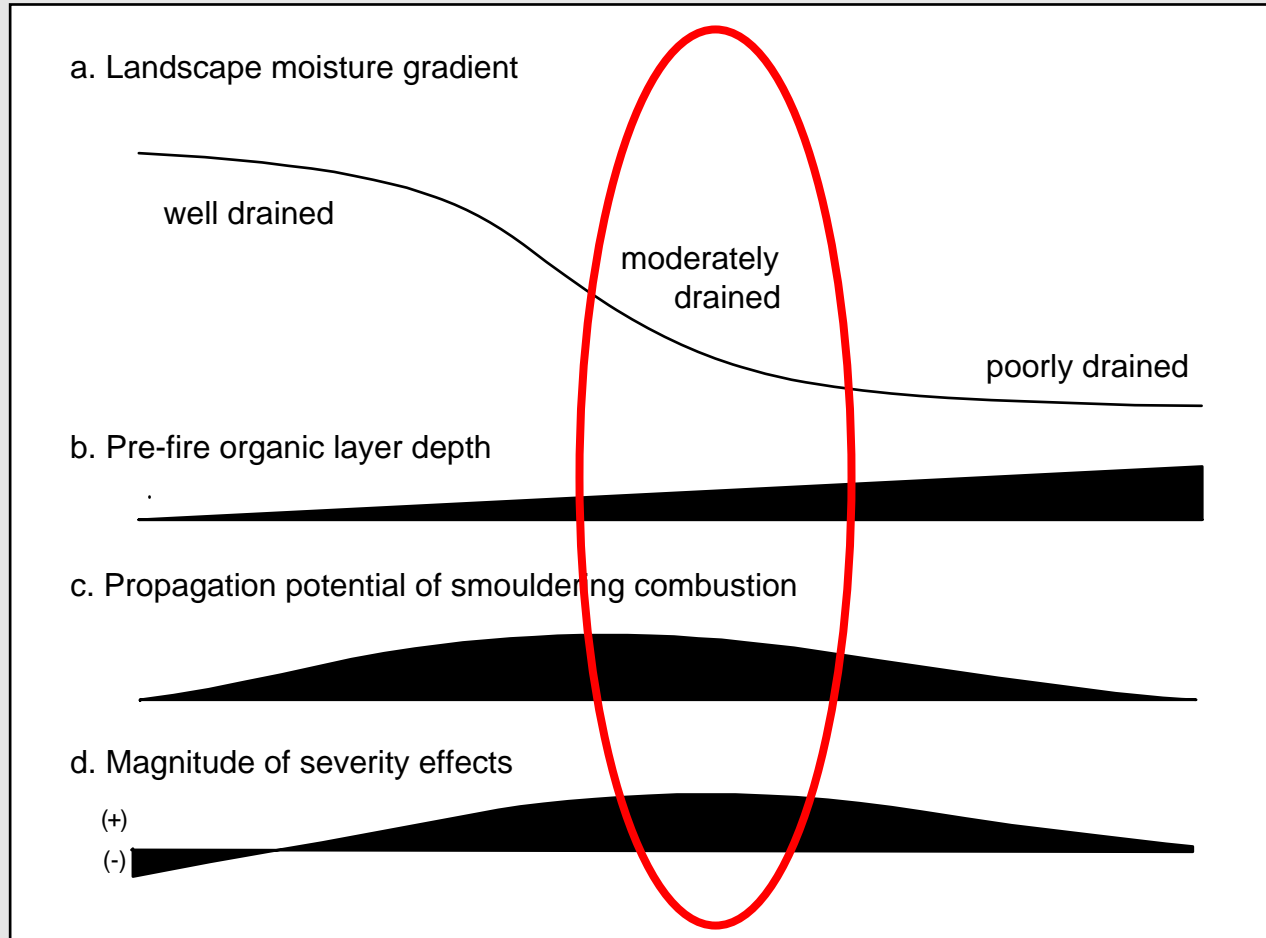


low severity
↓
organic seedbed
↓
conifer dominance

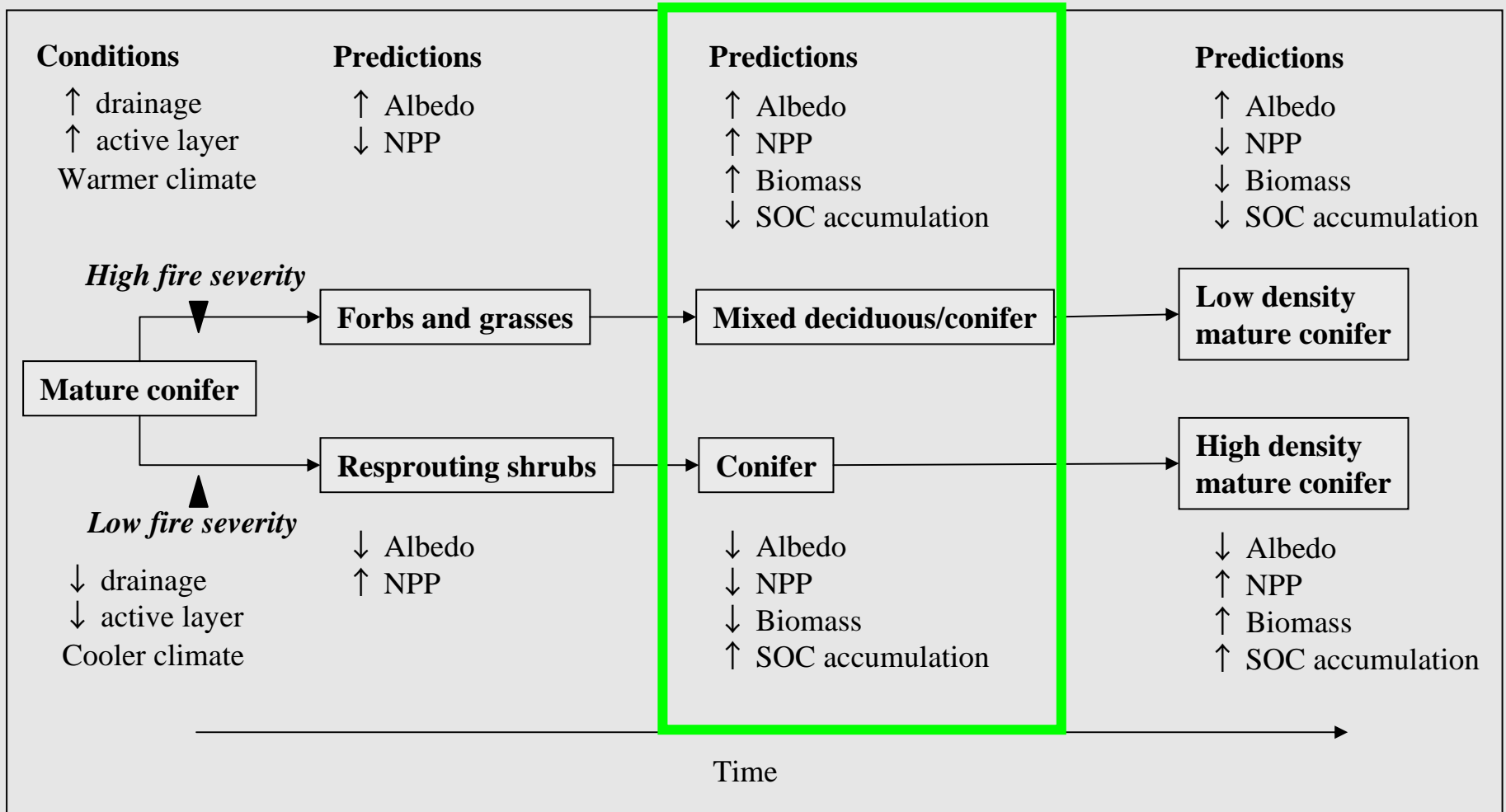


high severity
↓
mineral seedbed
↓
hardwoods dominance

How does the potential for threshold responses vary across the landscape?

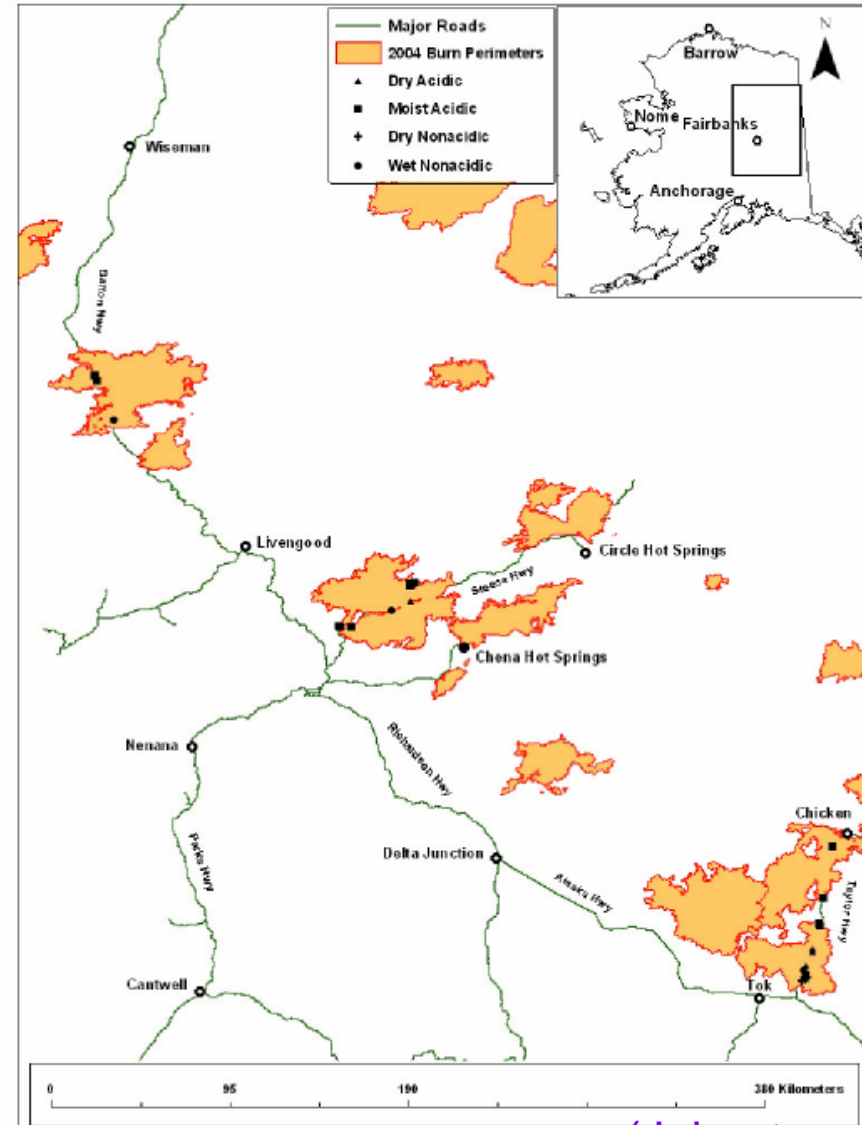


What are the ecosystem consequences of altered successional trajectories?



Study Design

- 82 forest sites in 3 large fire complexes from 2004 fires
- Variation in burn severity and site moisture
- Dominated by black spruce before burning; early recruitment on severely burned sites dominated by hardwoods
- Observational and experimental components
- Document changes in “integrative variables” & early warning indicators of change



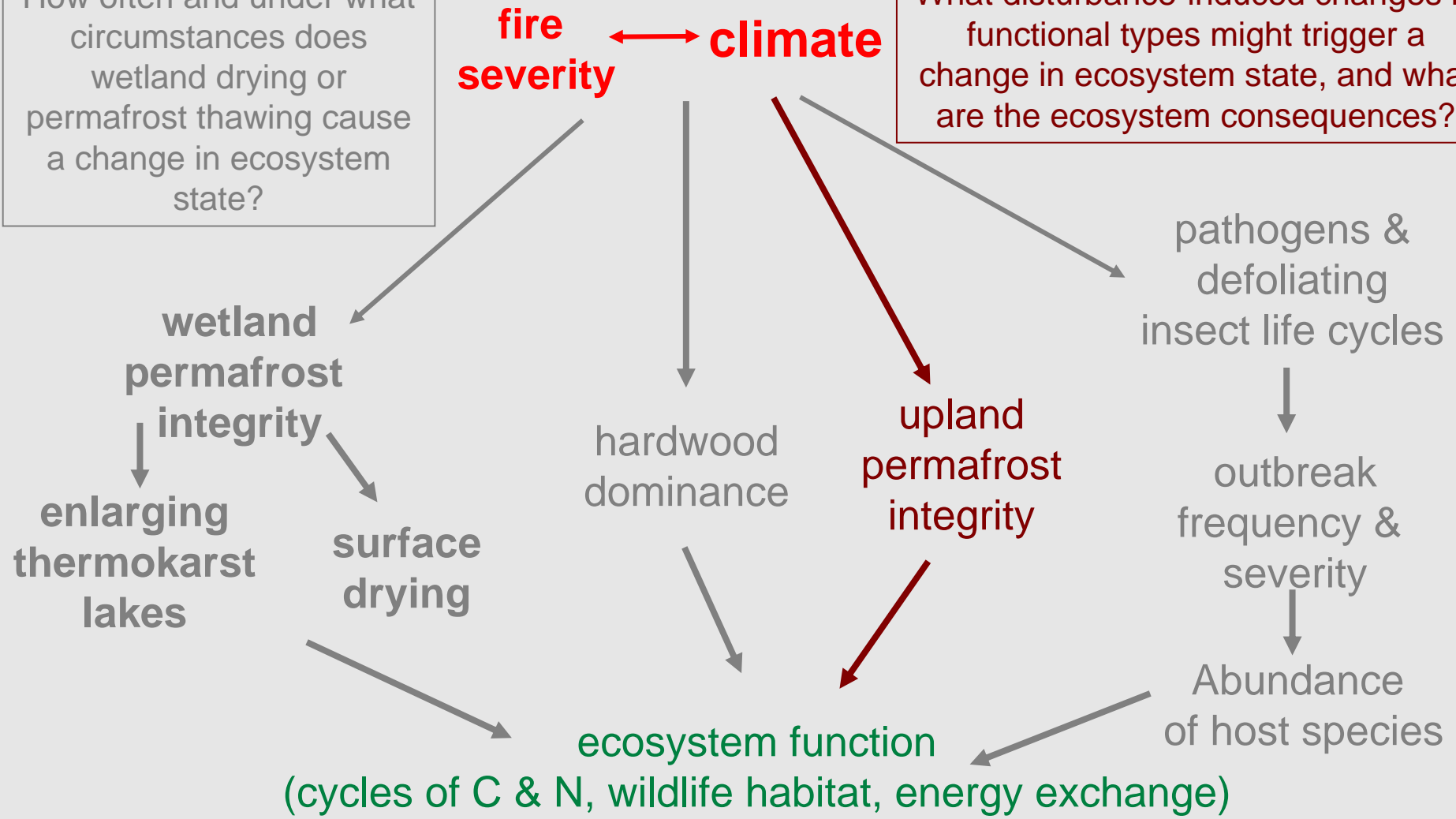
(Johnstone)

Question 2, Task 2b

(Schuur)

How often and under what circumstances does wetland drying or permafrost thawing cause a change in ecosystem state?

What disturbance-induced changes in functional types might trigger a change in ecosystem state, and what are the ecosystem consequences?



Hypothesis: Surface disturbance from thermokarst leads to threshold changes in ecosystem C cycles

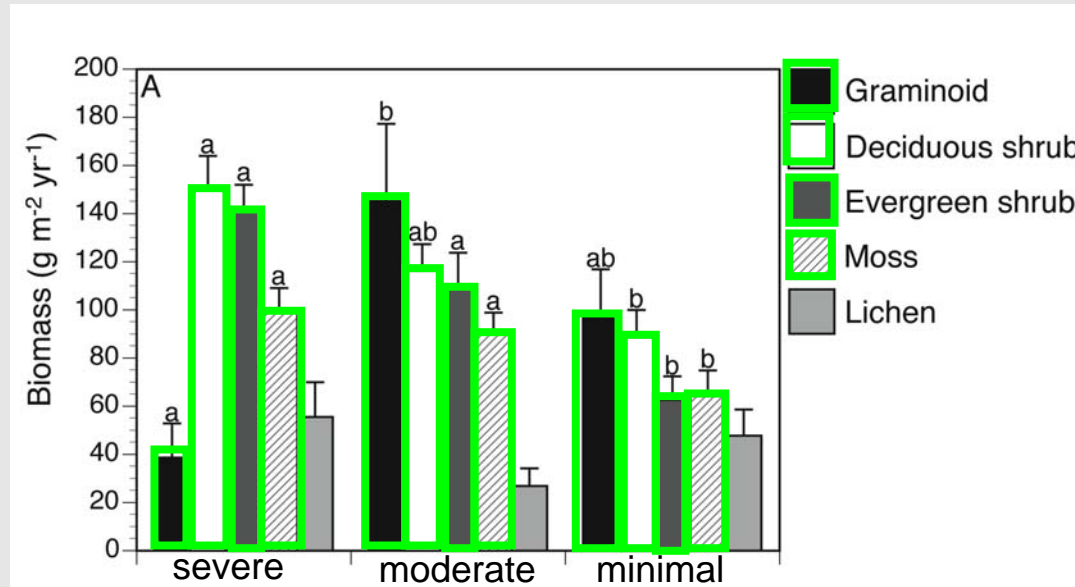


Study Design

- Gradient of thaw severity: severe, moderate, minimal
- Aquatic measurements: water chemistry, isotope measurements on DIC, DOC, POC
- Terrestrial measurements emphasize integrative variables; ^{14}C measurements to document age of respired C



Thermokarst--> changes in functional group composition:

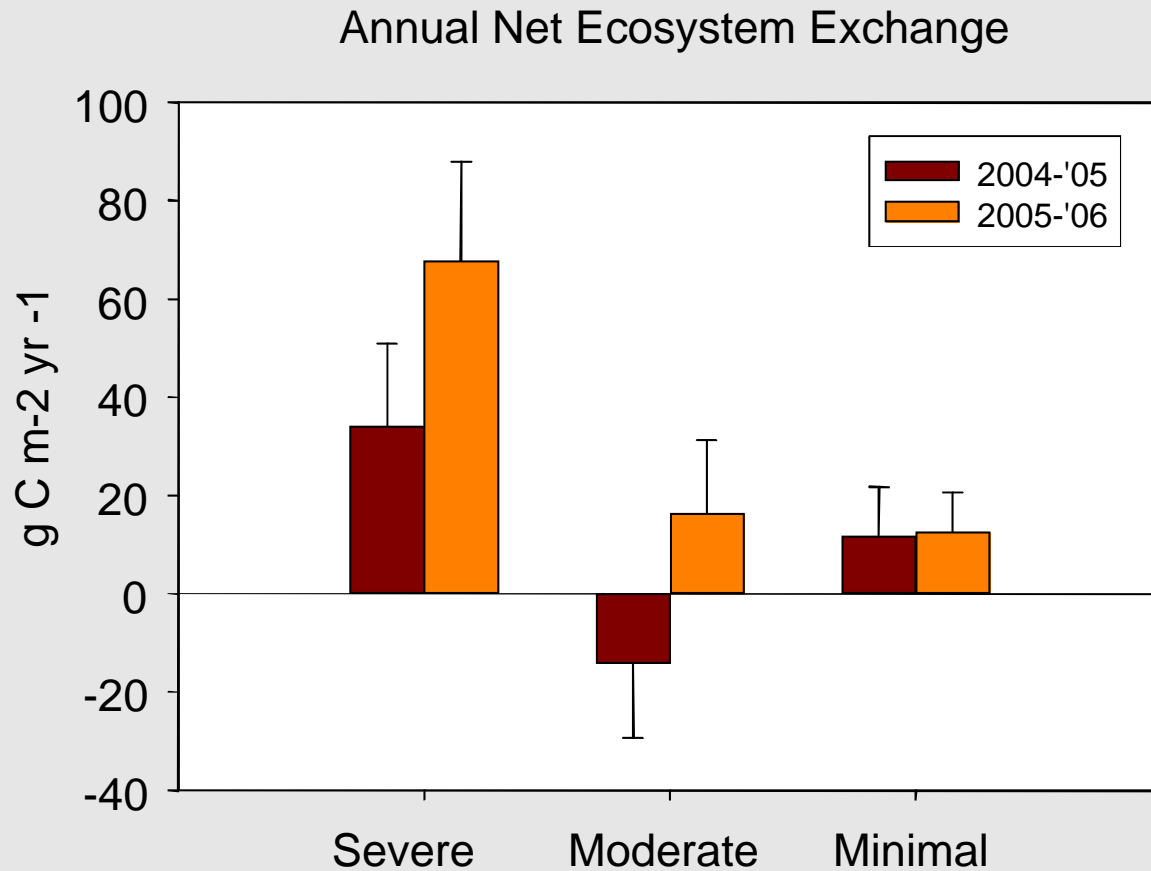


Shrubs, moss

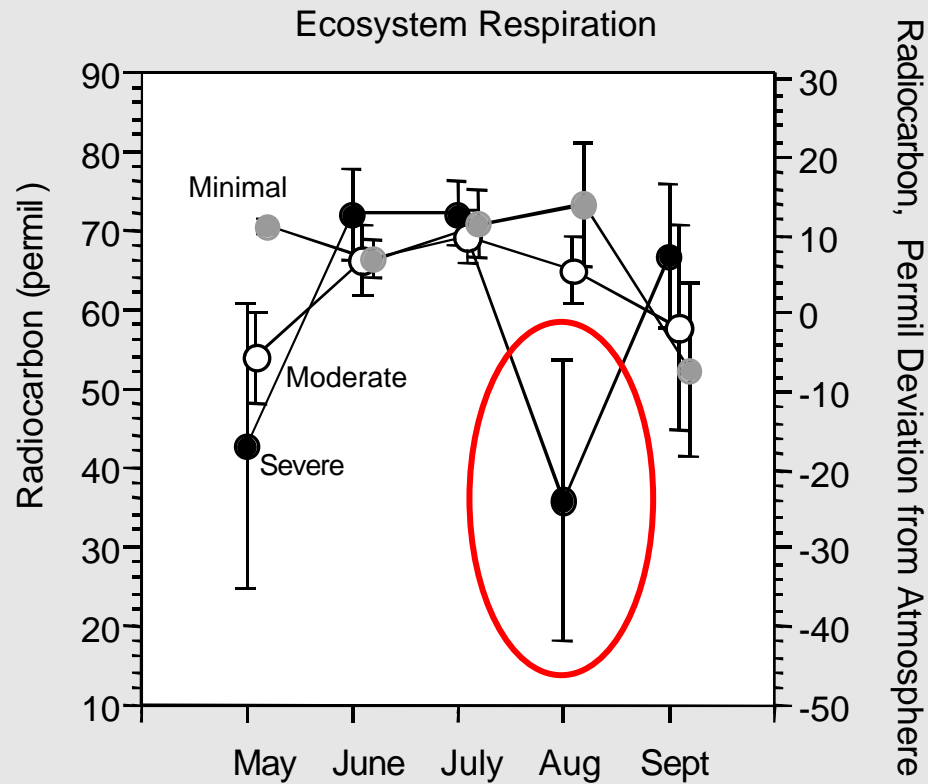


graminoids

C cycling varies along gradient of thermokarst severity.

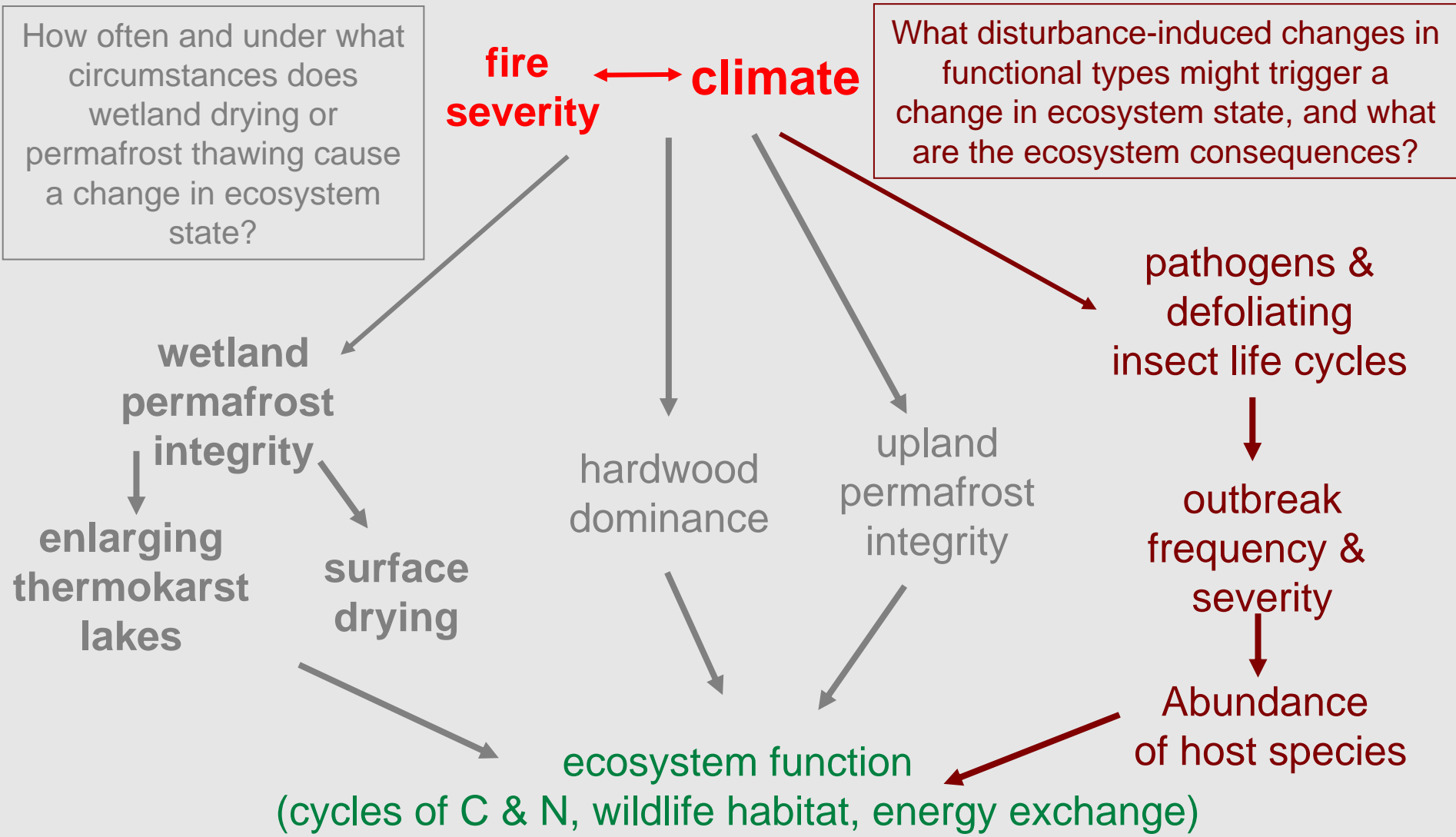


Sites with severe thermokarst respire more 'ancient' C.



Question 2, Task 3

(Mulder, Ruess, Werner)



Climate



Insect life cycle



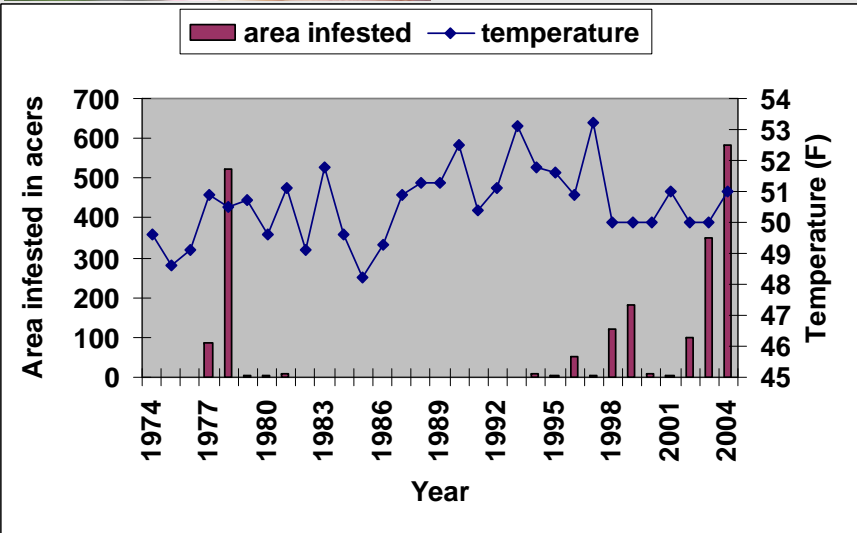
Outbreak dynamics



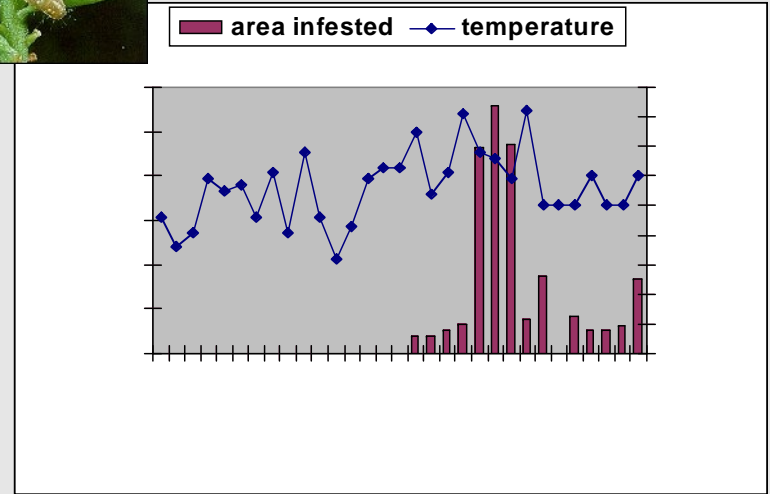
What are outbreak dynamics of key insect species?



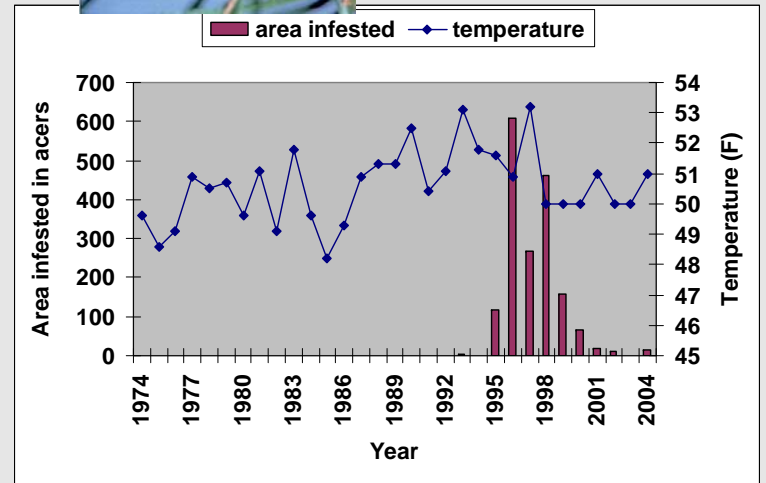
Aspen leaf miner



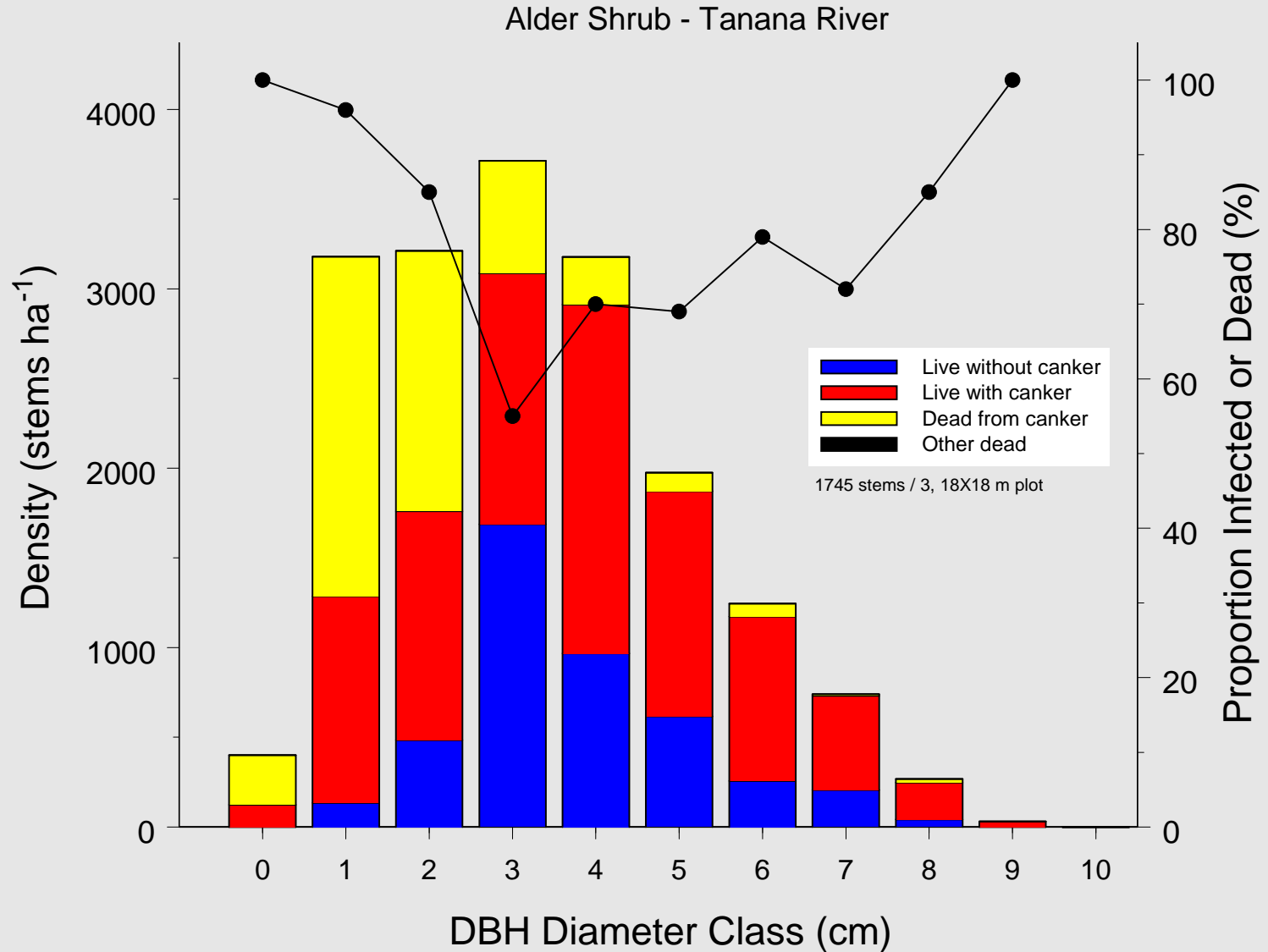
Spruce budworm

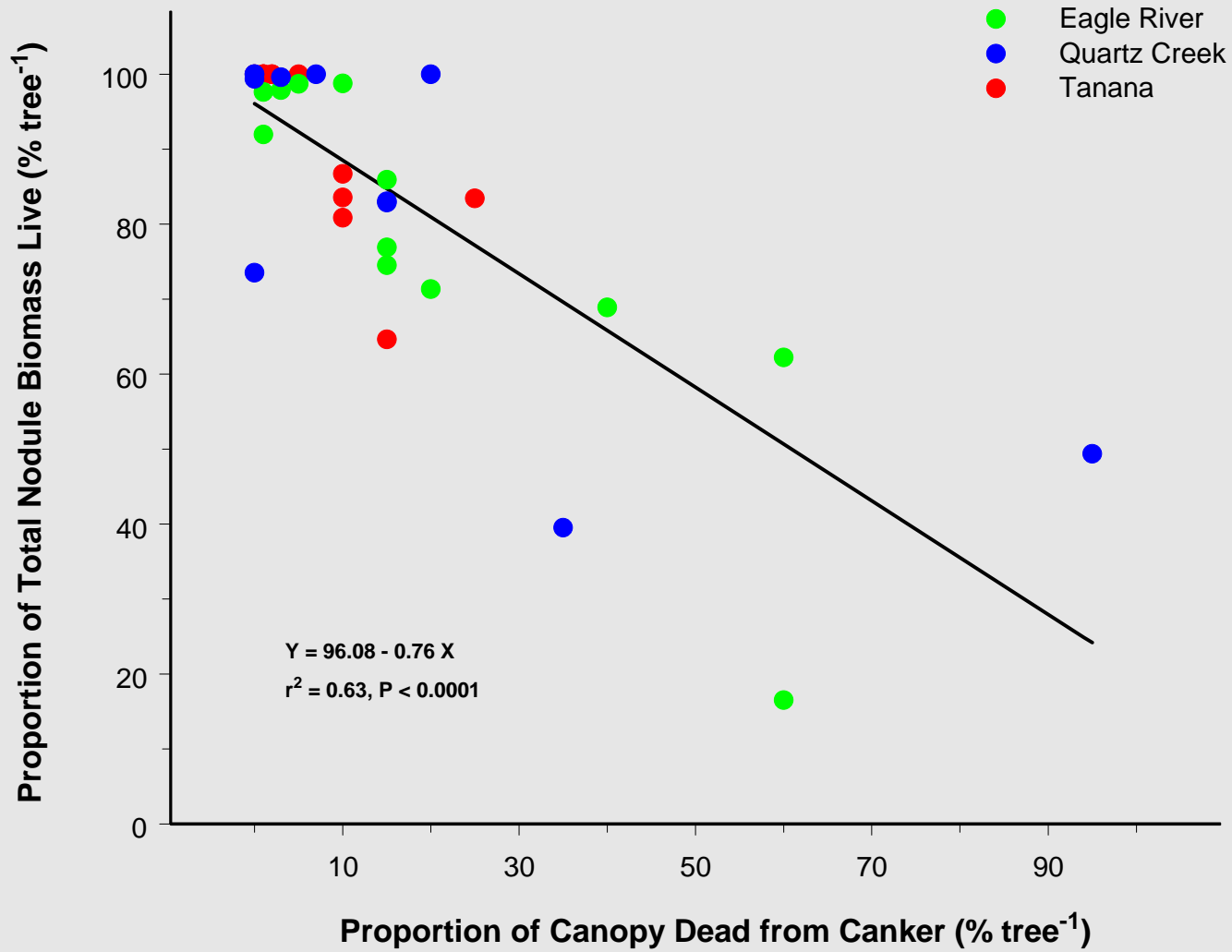


Larch sawfly



What are the ecosystem consequences of pathogens?





Hypothesis: Novel boreal landscape patterns emerge when climate change leads to disturbance regimes that alter permafrost integrity & abundances of key functional types.

