

# Spatial and Temporal Influences of Thermokarst Failures on Surface Processes in Arctic Landscapes

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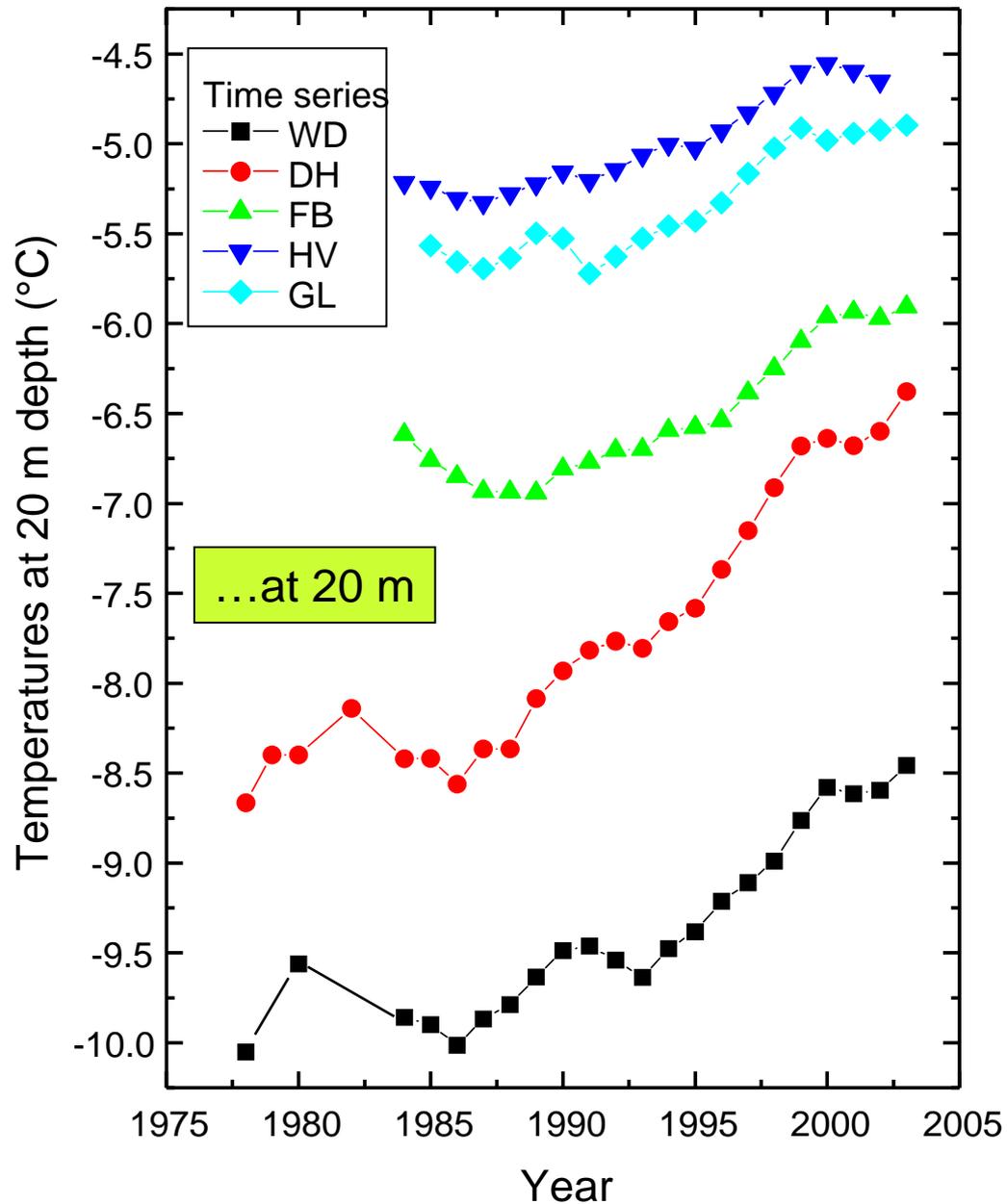
University of Vermont

State of the Arctic 2010

Session 1.2. Understanding the Linkages and  
Feedbacks Between Arctic System Components

16 March 2010

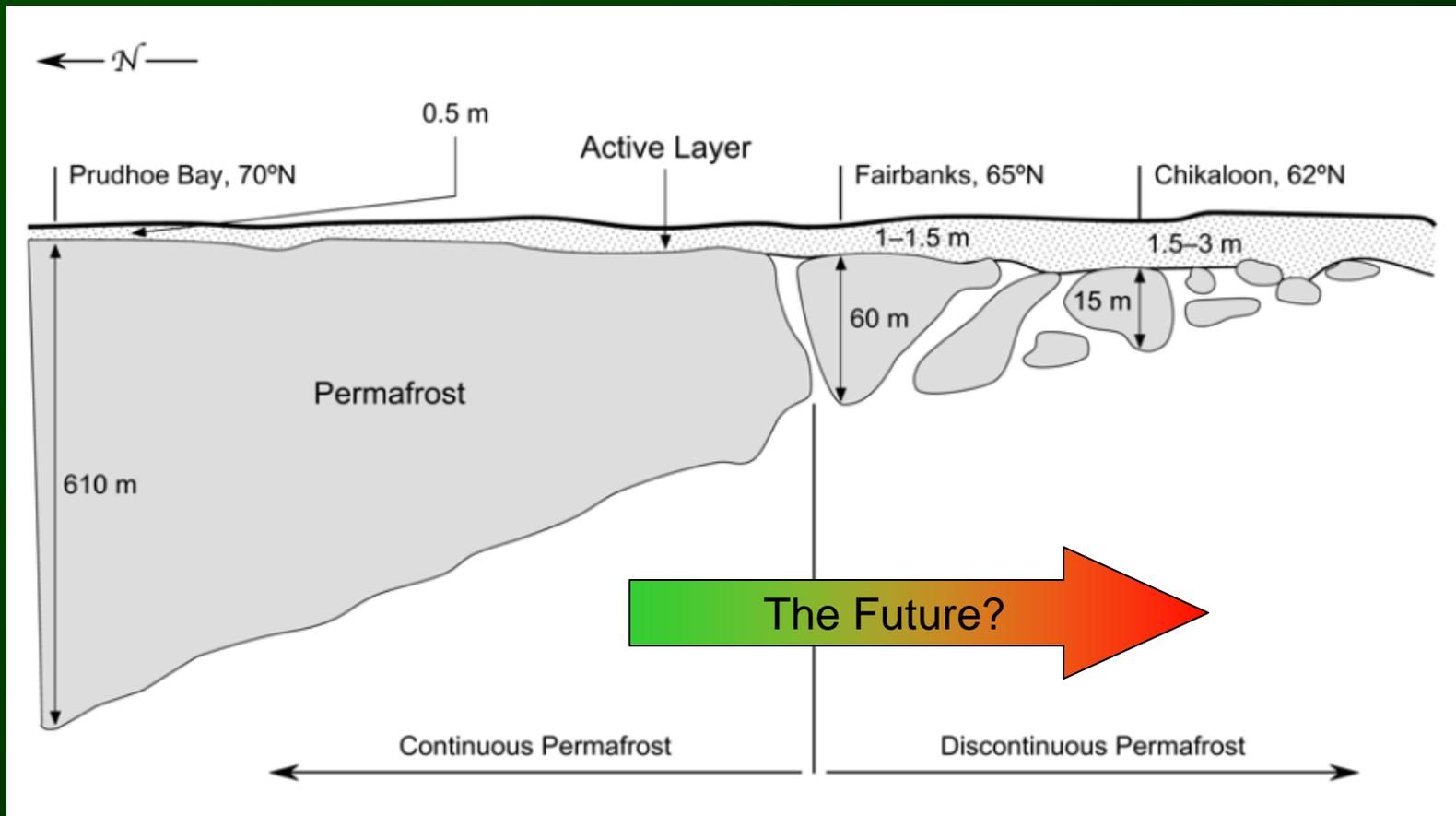




# Permafrost has been warming

- WD: West Dock
- DH: Deadhorse
- FB: Franklin Bluff
- HV: Happy Valley
- GL: Galbraith Lake

# Permafrost will eventually thaw



*U.S. Arctic Research Commission (Hinkle et al., 2004)*

# When permafrost finally thaws, various *thermokarst* features may form

Glacial Thermokarst



Retrogressive Thaw Slump



Thermokarst Gully

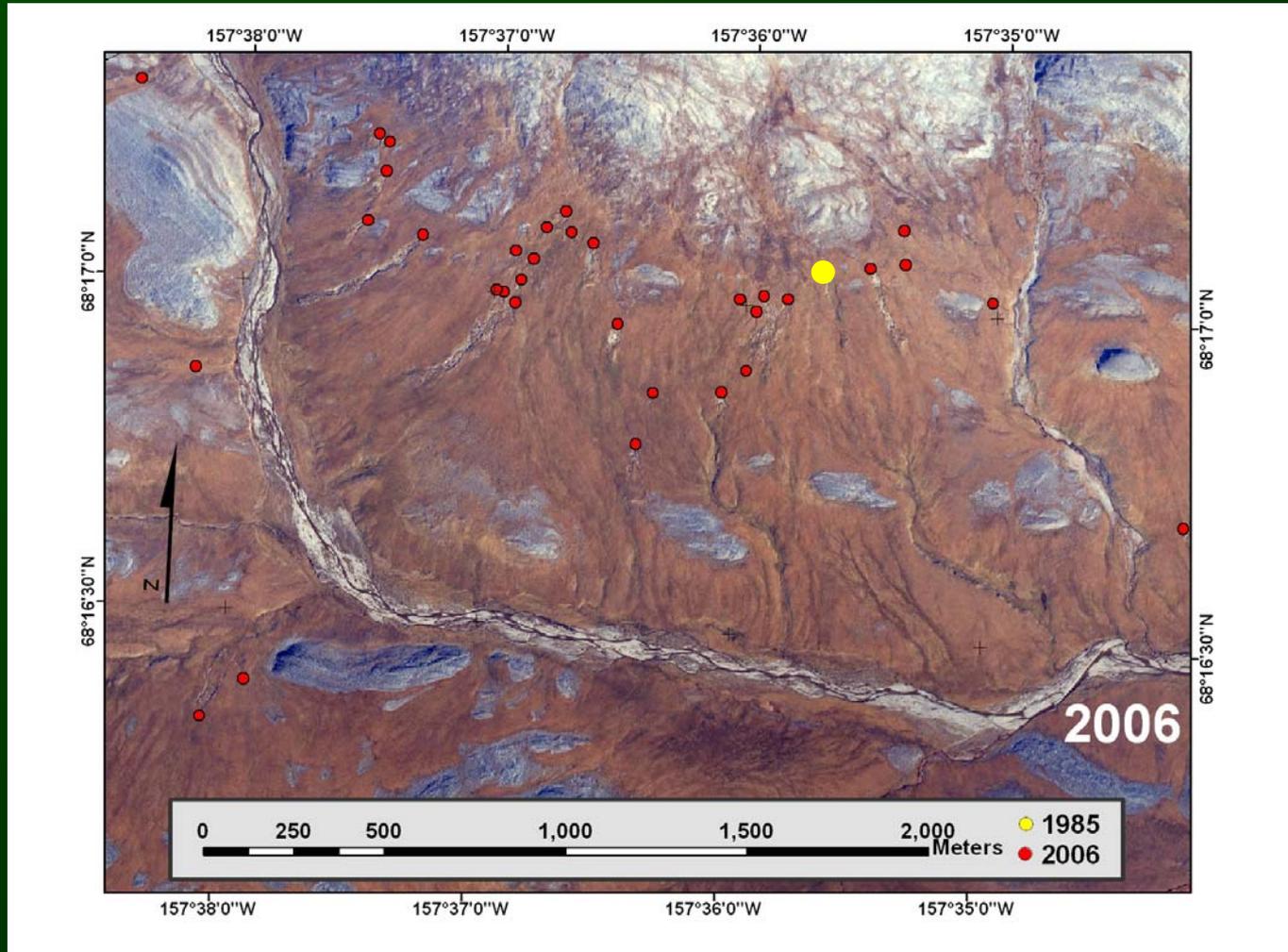


Active layer detachment slide



There are more of these features  
now than used to be the case

*Feniak Lake (Noatak) 1985 vs 2006*



*Gooseff et al. (2009)*

# Potential environmental impacts of permafrost degradation

- Subsidence and thermokarst
- Mass movement and soil loss
- Redistribution of nutrients across landscape
- New niches for plant growth (shrubs?)
- Increased sediment and nutrient loading to aquatic ecosystems
- Altered microbial processing
- Accelerated CO<sub>2</sub> and CH<sub>4</sub> emissions

# Spatial and Temporal Influences of Thermokarst Failures on Surface Processes in Arctic Landscapes



A systems approach to address hypotheses about how thermokarst failures influence the structure and function of the arctic landscape



# Overview: Structure and Focus of the ARCSS Thermokarst Project

- **The local scale**

- Hillslope processes  
(Gooseff, Godsey, Lewkowicz)
- Soil/emission processes  
(Jones, Schimel, Abbot)
- Vegetation processes  
(Mack, Schuur, Baron)
- Aquatic processes  
(Bowden, Kling, Larouche,  
Flinn, Kampman)

- **The regional scale**

- Permafrost dynamics  
(Jorgenson)
- Landscape dynamics  
(Crosby, Krieger)

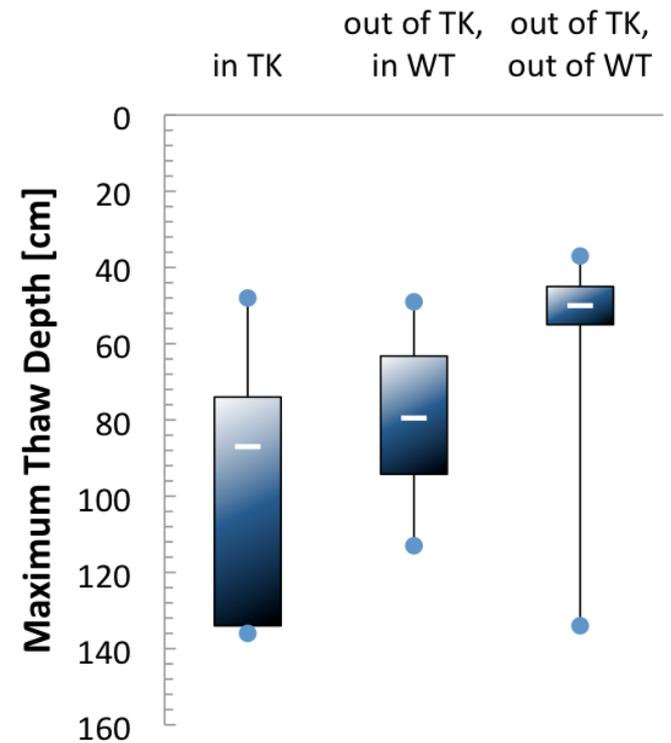
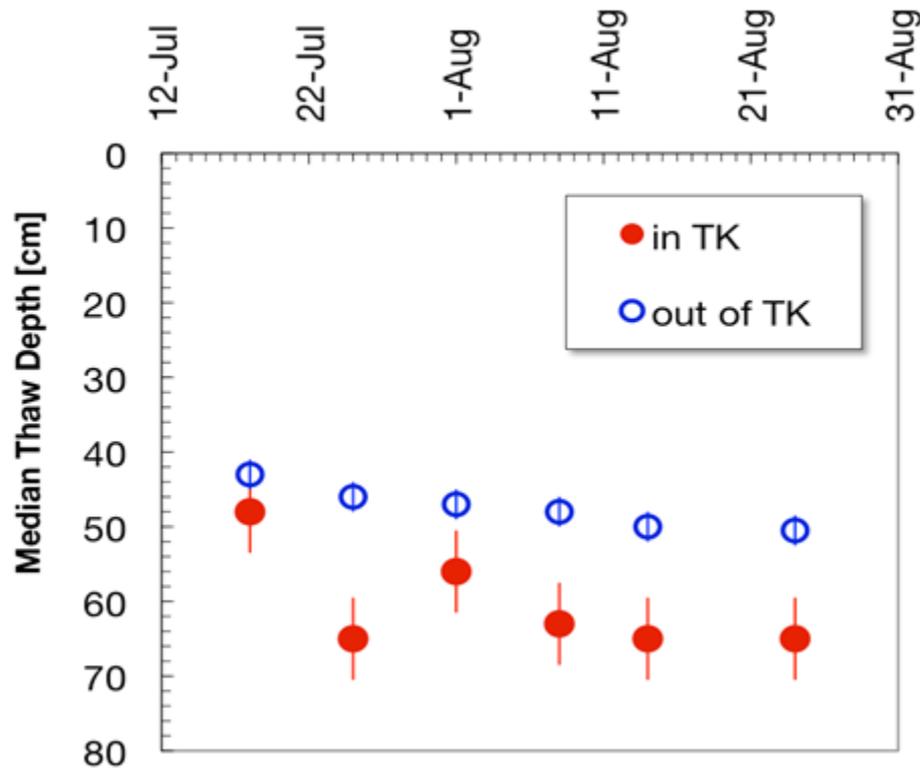
- **Synthesis**

- Extrapolation over space  
(Balsler, Gens)
- Prediction over space & time  
(Rastetter, Bowden)

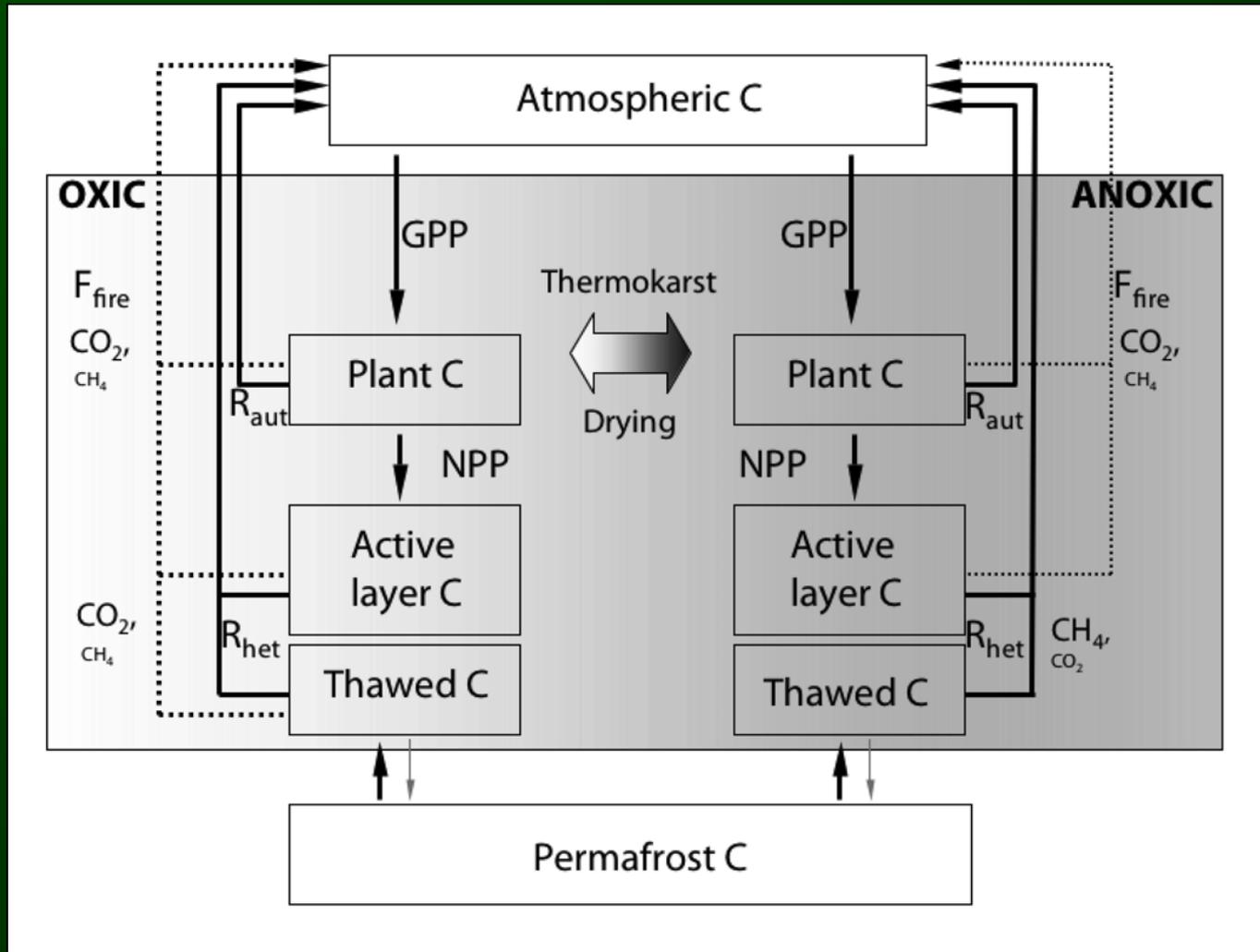
- **The Human Dimension**

- Social ecology of change  
(Kofinas, Butler)
- Outreach and education  
(Sparrow, Baeseman)

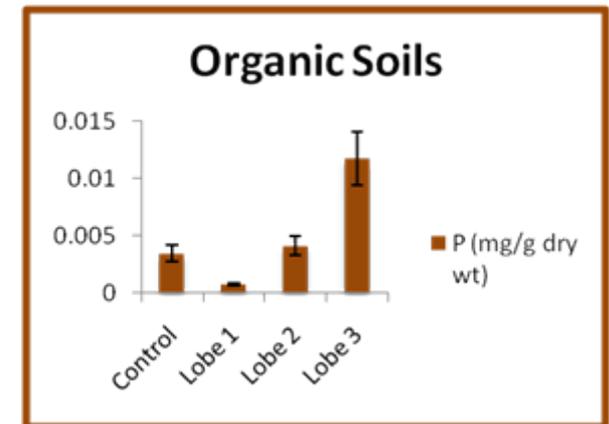
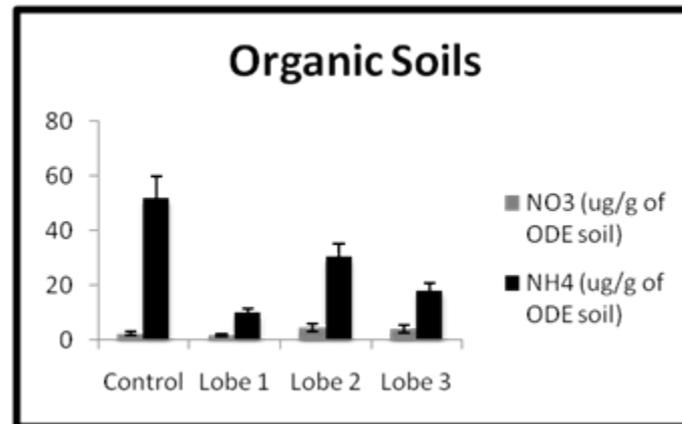
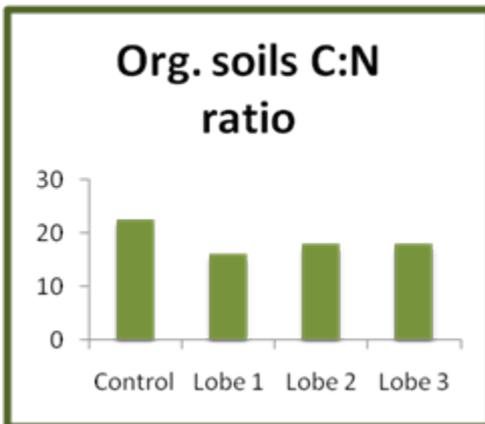
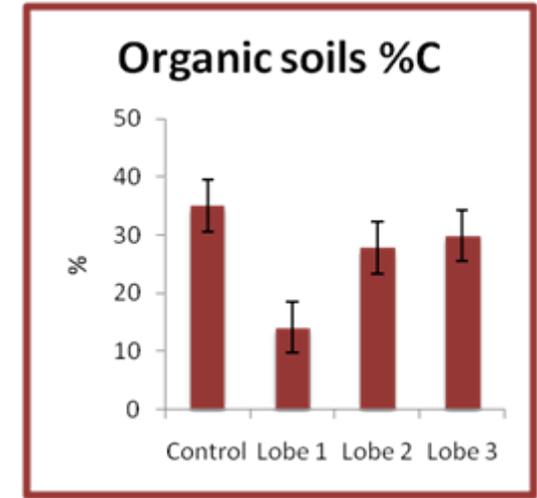
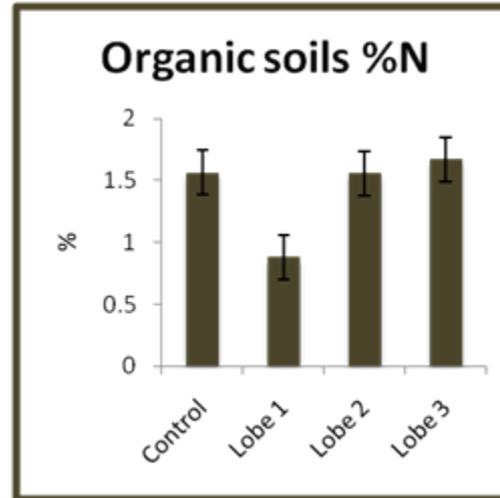
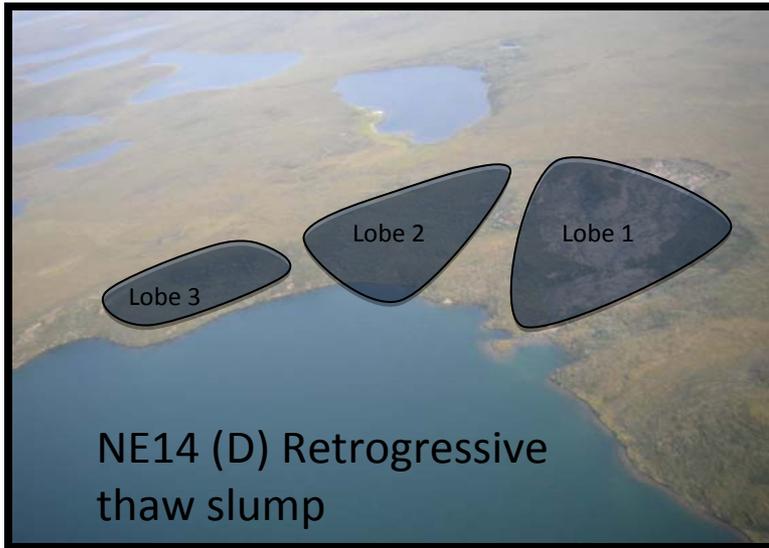
# Thaw depth is more variable in space and time with thermokarst features



# Thawed permafrost alters nutrient dynamics with feedbacks to the atmosphere

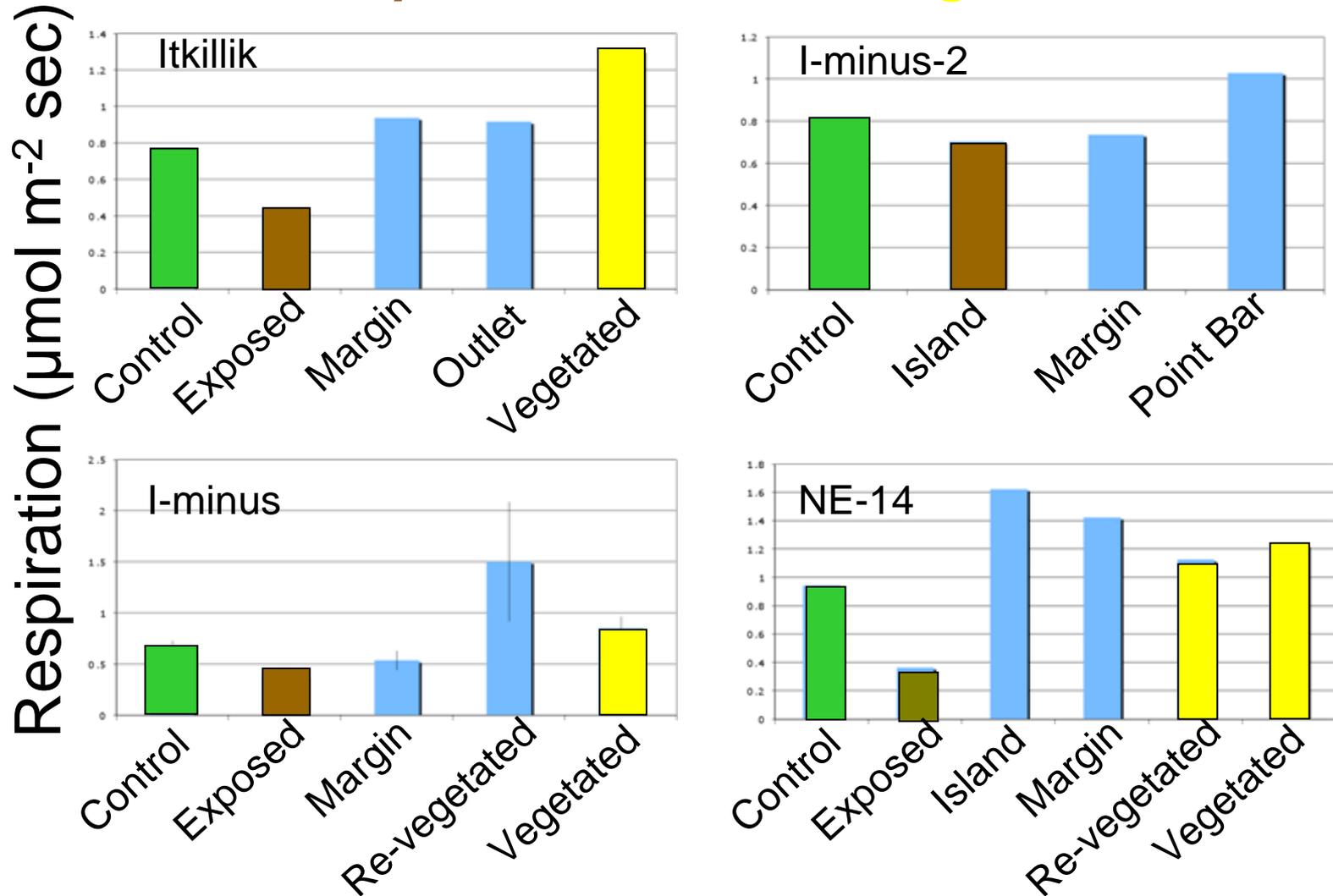


# Soil nutrients differ by thermokarst age

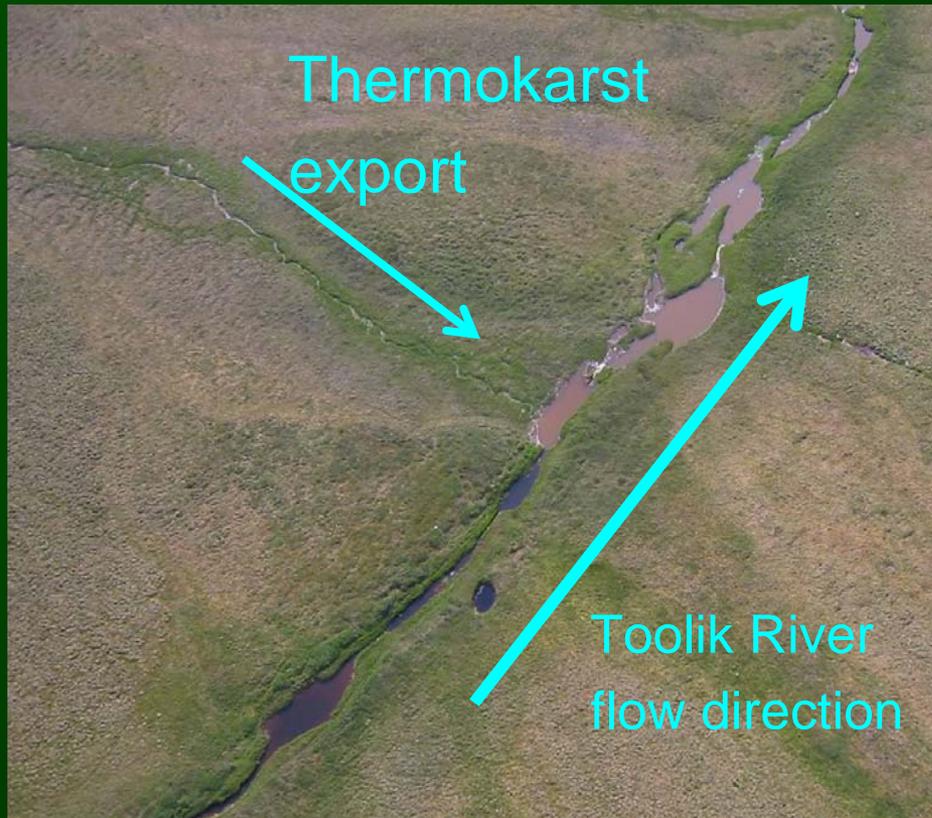


# Respiration Differs by Site Type

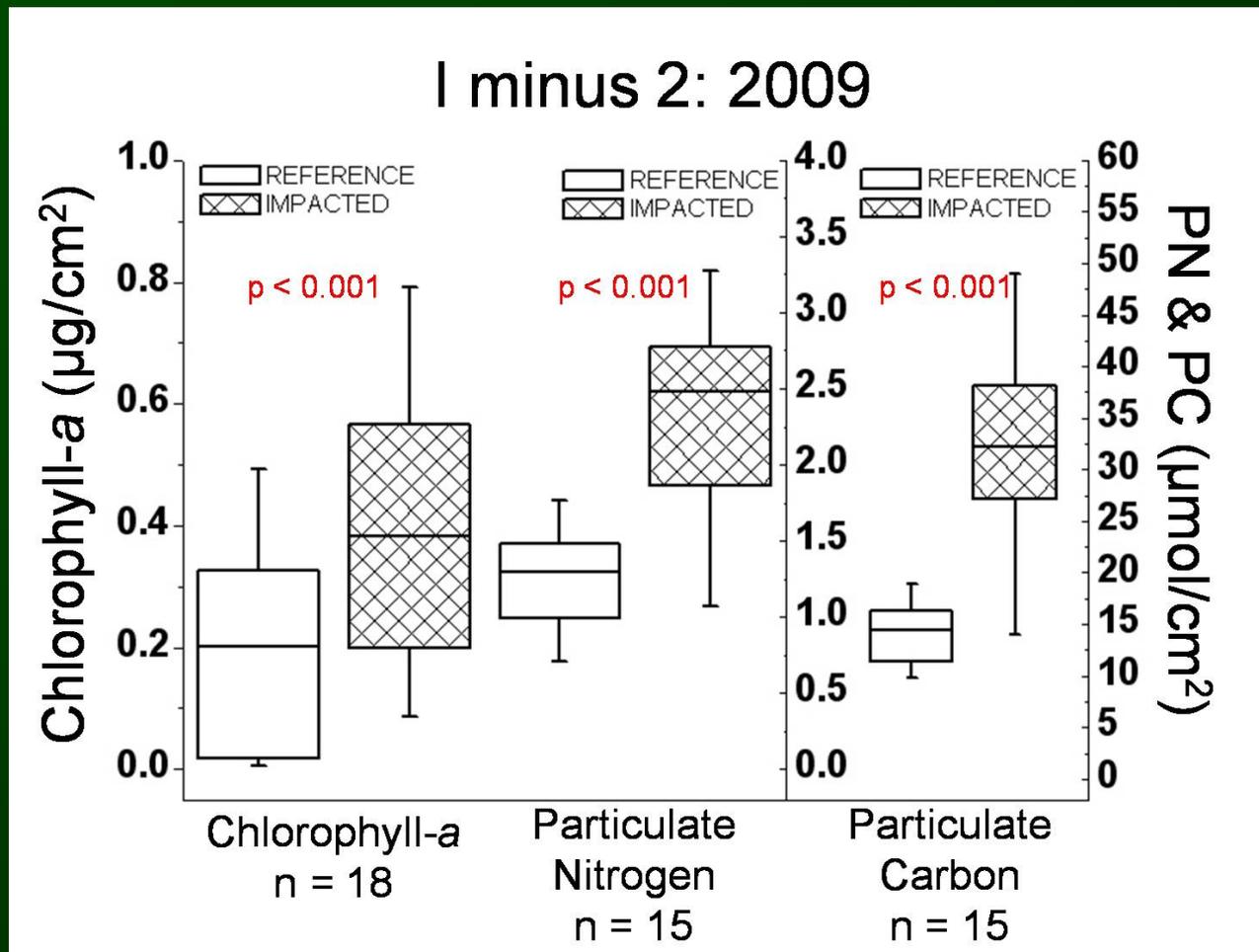
Exposed < Control < Vegetated



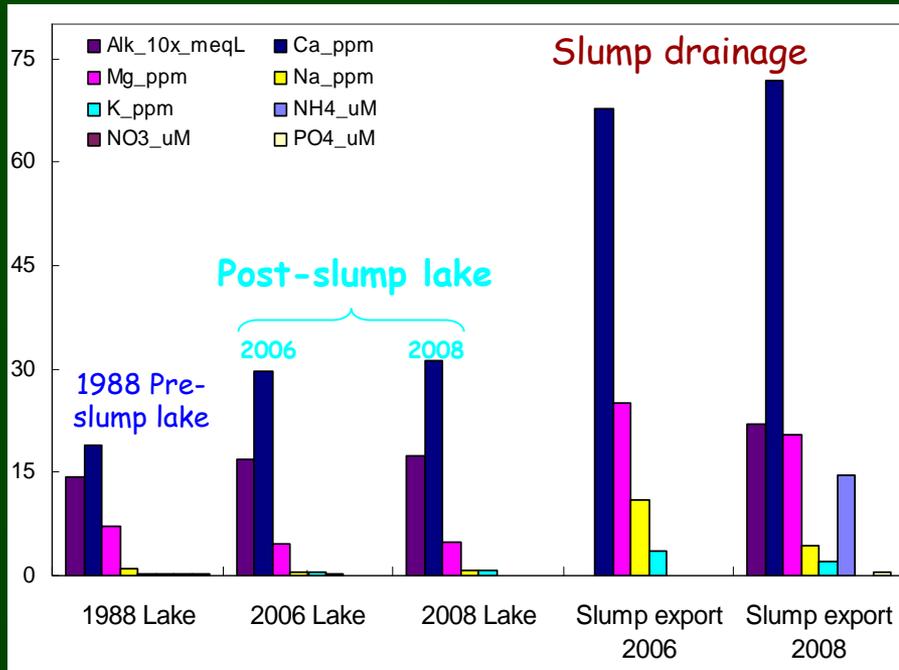
# Thermokarst export sediment and nutrients to streams and lakes



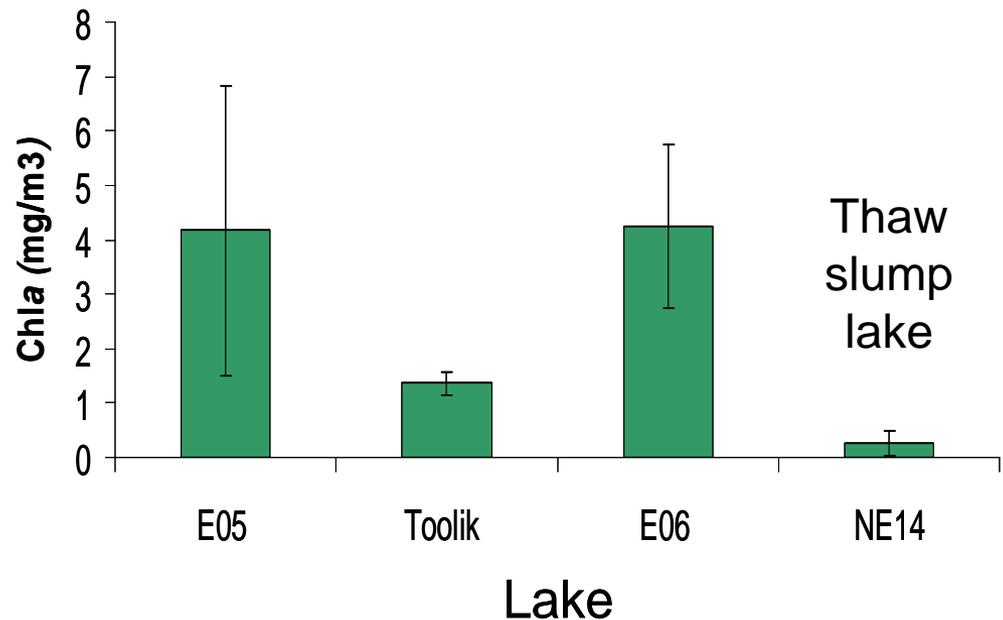
# Thermokarst feature increase stream benthic primary producers and particulate nutrients



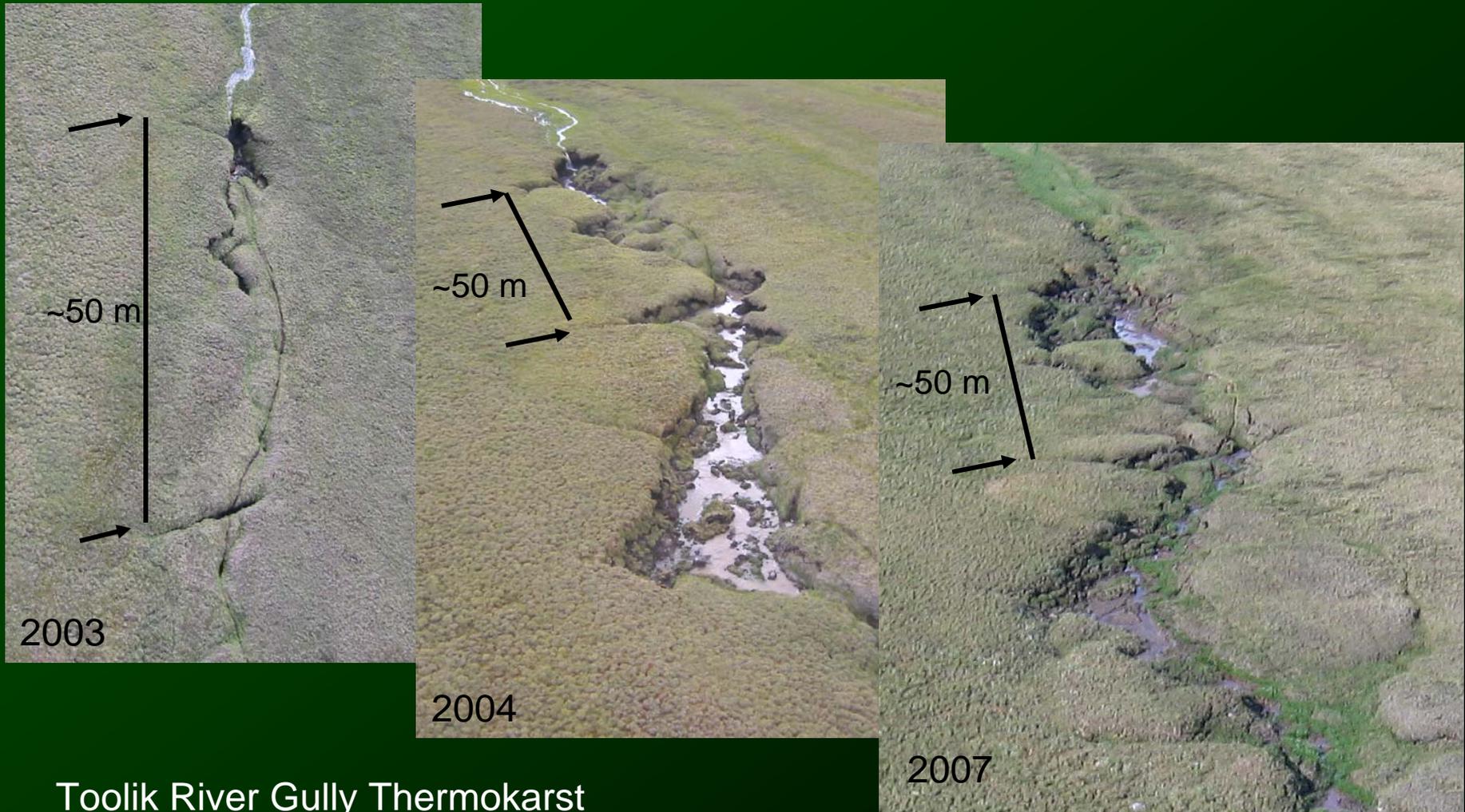
Thermokarst features increase nutrient and sediment loading to lakes but decrease benthic primary producers



G. Kling, Objective B.2



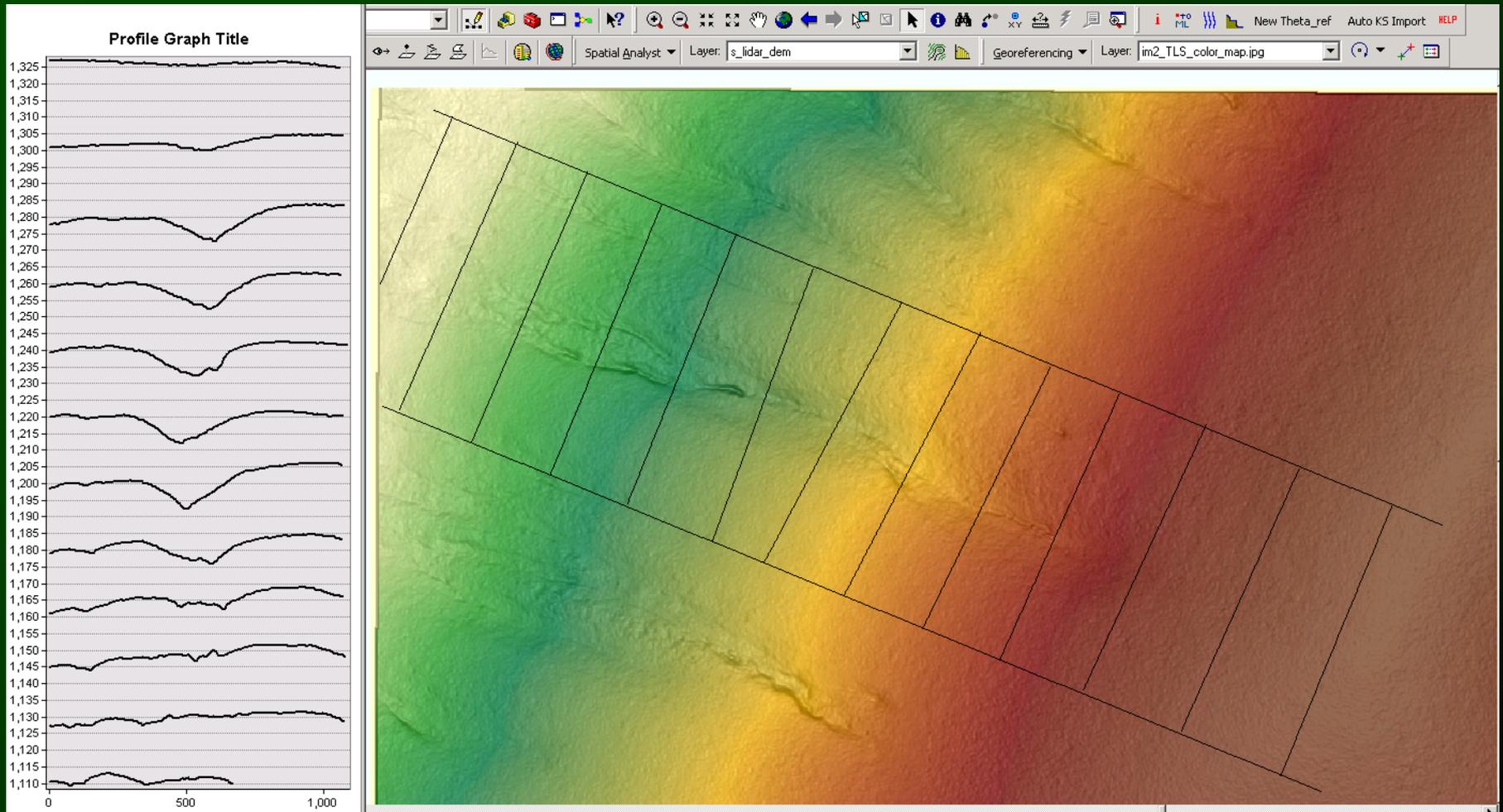
# How do thermokarst features age?



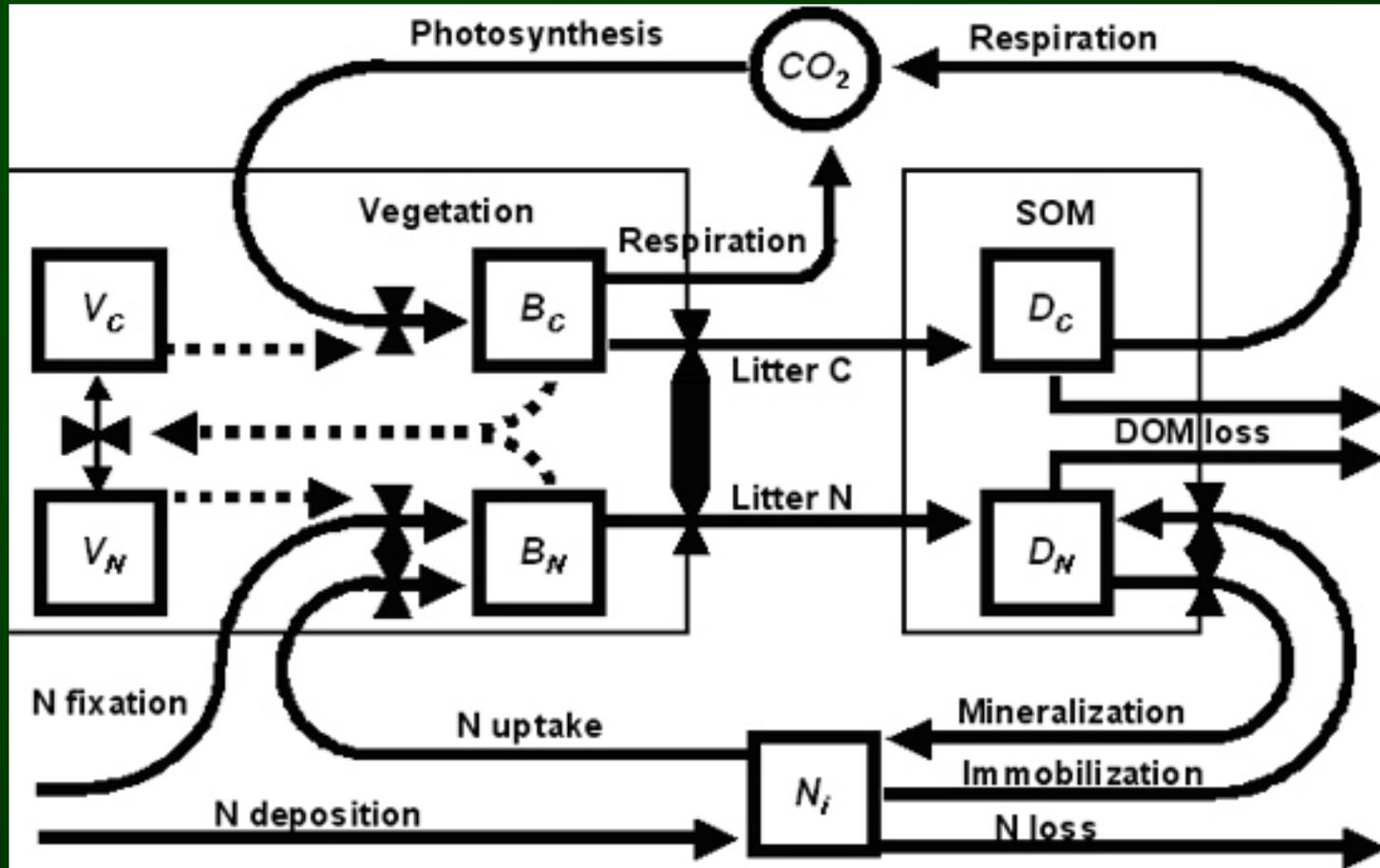
Toolik River Gully Thermokarst

# Over time thermokarst features help sculpt the arctic landscape

*Watertracks north of "Horn" Lake, Anaktuvuk Burn area*



# The Multi-Element Limitation (MEL) Model



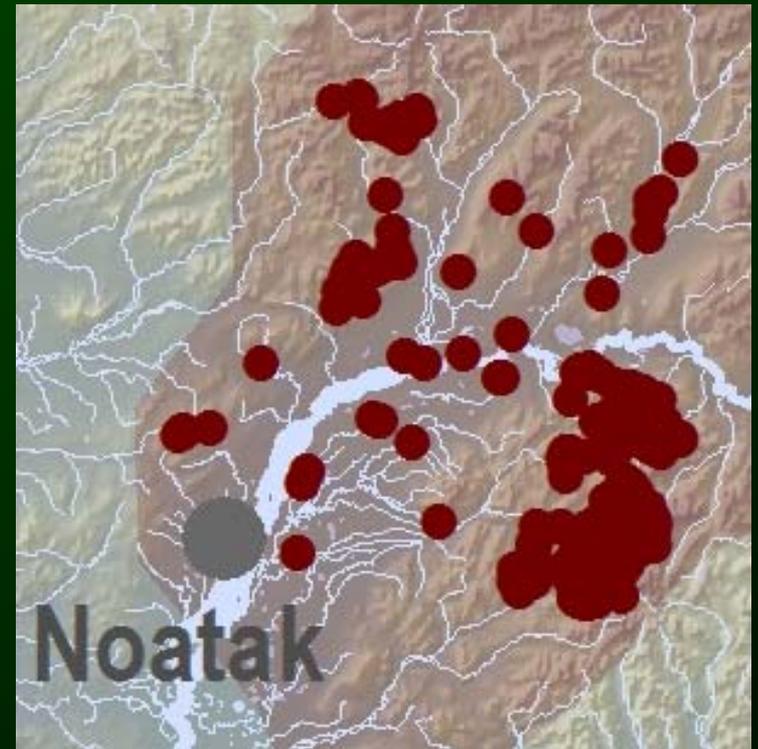
*E. Rastetter et al. (1997)*

# Application of MEL

...locally across habitats in a feature



...regionally across the landscape



*E. Rastetter and W. Bowden, Objective C.4*

# Summary

- Thermokarst features are common and their rate of formation has probably increased in recent years
- Thermokarst features, especially hillslope mass failures, have the capacity to rearrange massive quantities of soil and the C/N/P it contains, on the landscape.
- These thermokarst failures open new niches for plant colonization, create sites of intense microbial activity and trace gas emission, are sources of nutrients and sediment to receiving waters, and alter the local topography with impacts on snow accumulation.
- The “risk” of thermokarst formation may be predictable (at least in an aggregate sense)
- Thermokarst failures after permafrost thaws have the capacity to substantially alter the form and function of the arctic landscape.

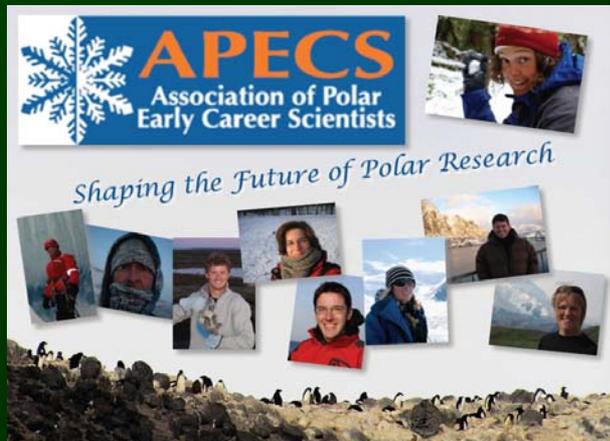
# Connecting Science to People



Students measuring depth of freezing of active layer using a frost tube



Scientists meeting with journalists to share perceptions and misperceptions



Contributions to development of young polar scientists

# Collaborators and Facilitators



MBL  
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UCSB



UF UNIVERSITY of FLORIDA  
The Foundation for The Gator Nation

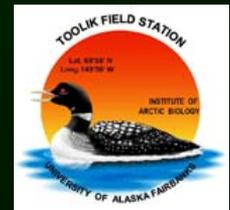
M UNIVERSITY OF MICHIGAN



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FAIRBANKS



MURRAY STATE UNIVERSITY  
Murray, Kentucky



ABR environmental research & services



*Thank you!*

For additional information please see:

<http://thermocarst.psu.edu/>

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