



2014 Connaught Summer Institute  
In Arctic Science: Atmosphere,  
Cryosphere, and Climate

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2014 Program



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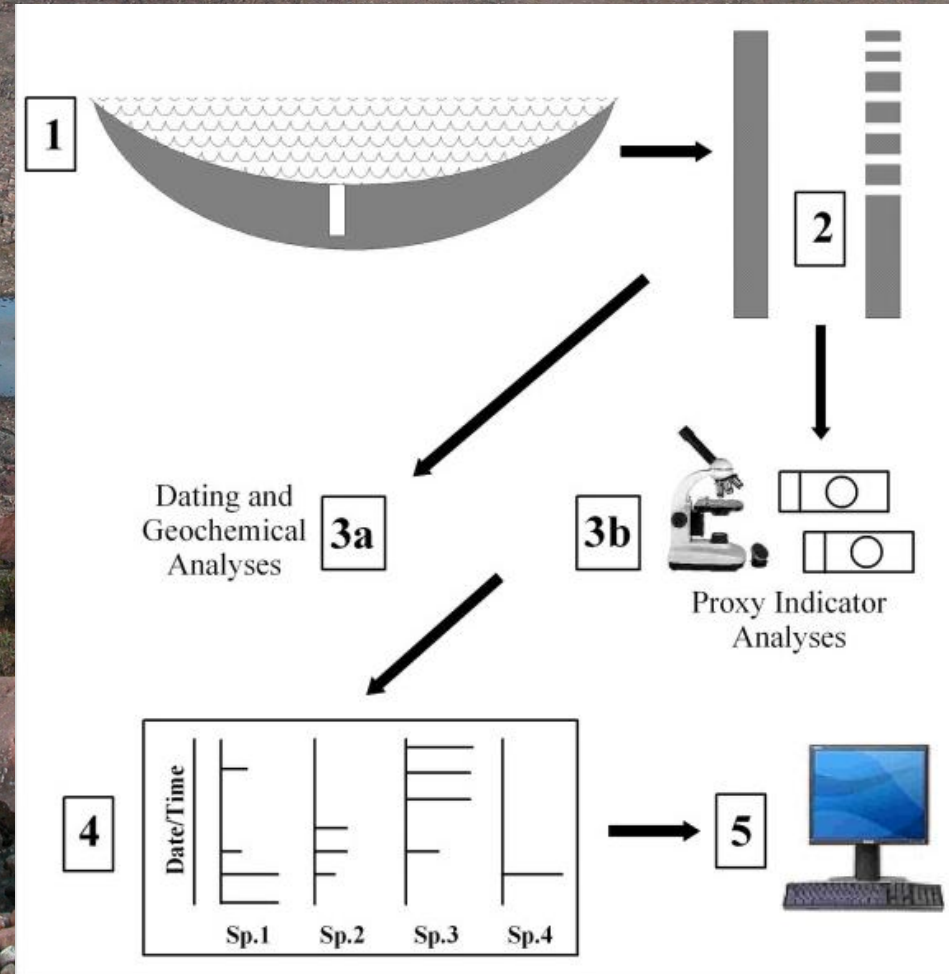


Photo D. Froese



# Three lectures ...

- Polar limnology
- Polar paleolimnology
- Environmental change

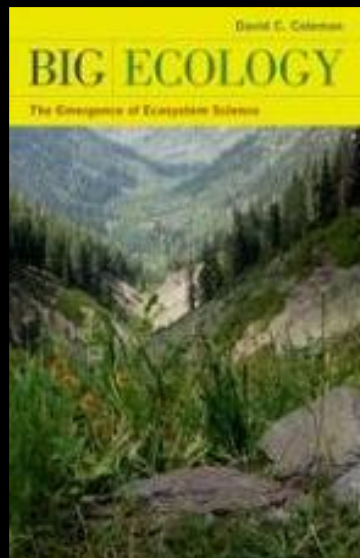


# IBP International Biological Program

- 1964 – 1974 (ca. IGY 1957 -1958)
- Canada + Europe, and US joined in 1968



- Large-scale ecological and environmental studies

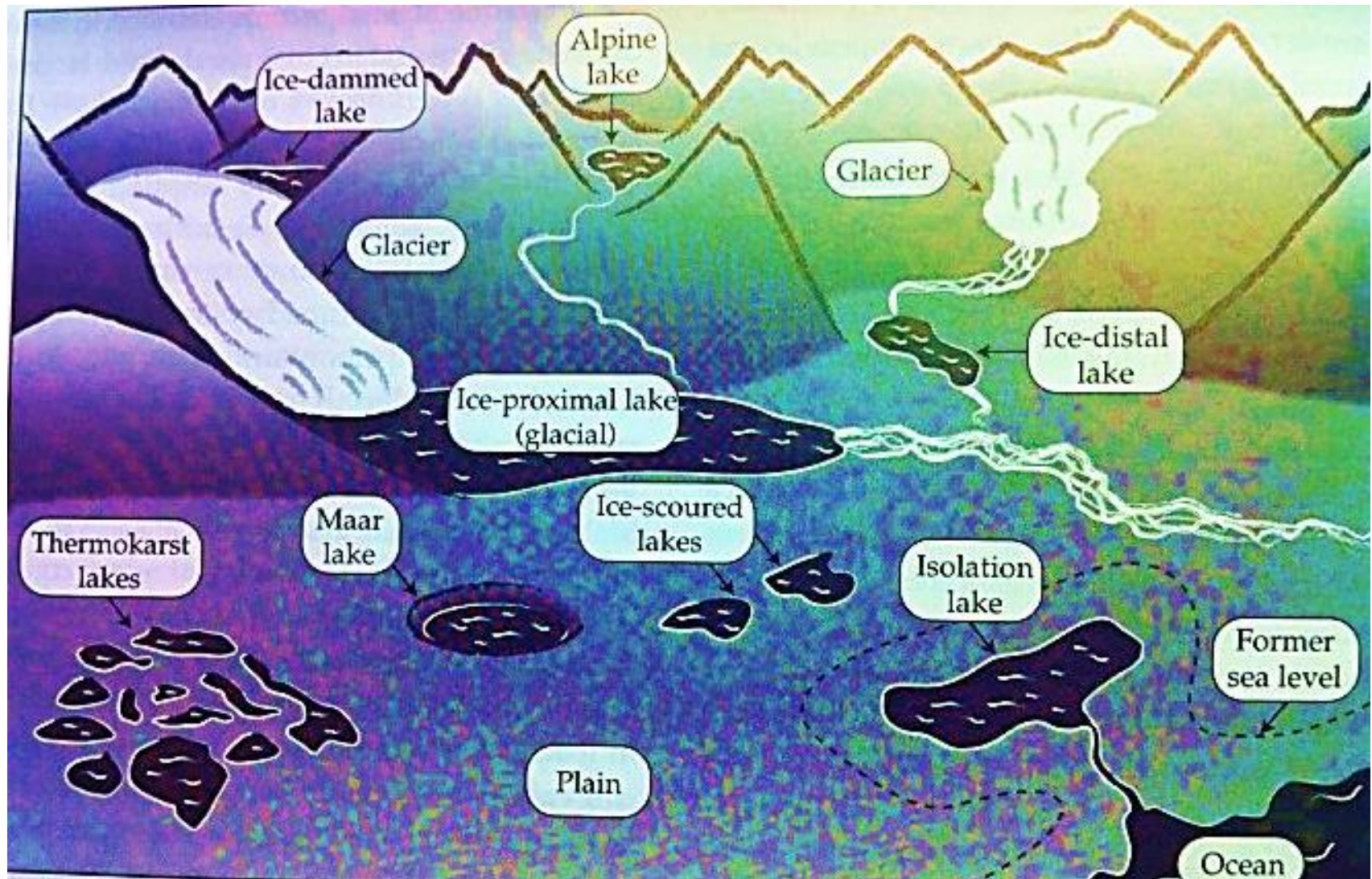


- Allowed for comparative studies of ecosystems across 5 biomes, → productivity
- Lakes: control of production, food web structure



Lakes are diverse ...

... and there are more!



Modified from Pienitz et al. 2008

# Lake Hazen

$Z_{\max}$  289 m

Length 70 km

Width $_{\max}$  11km

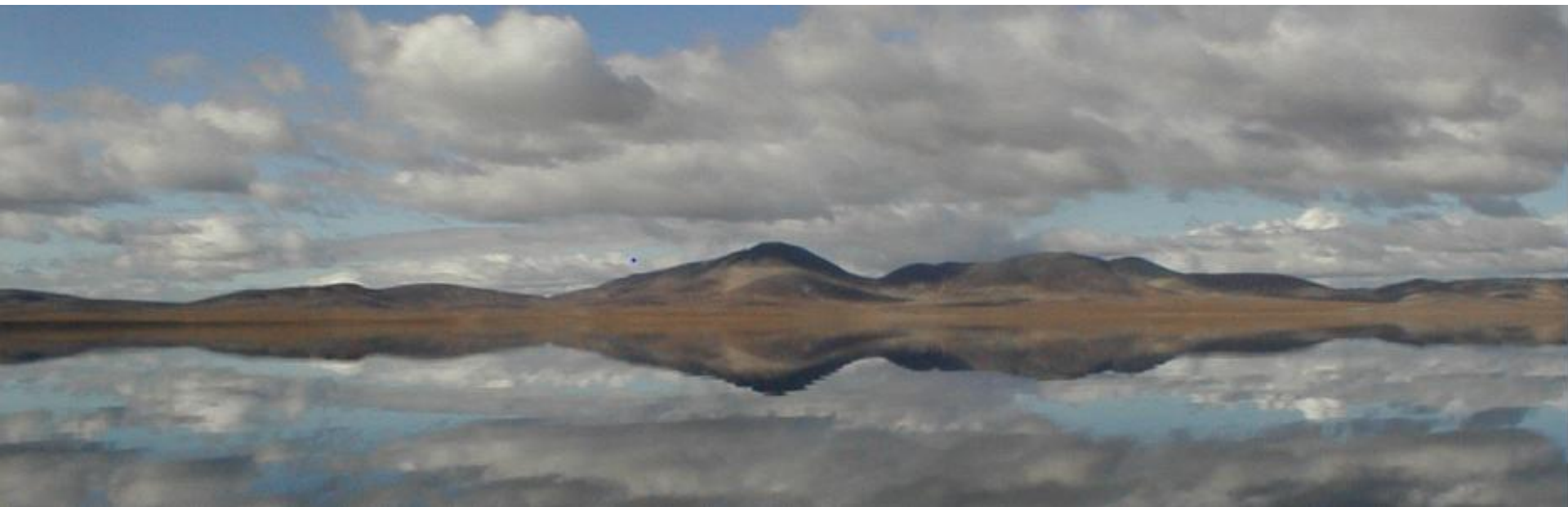
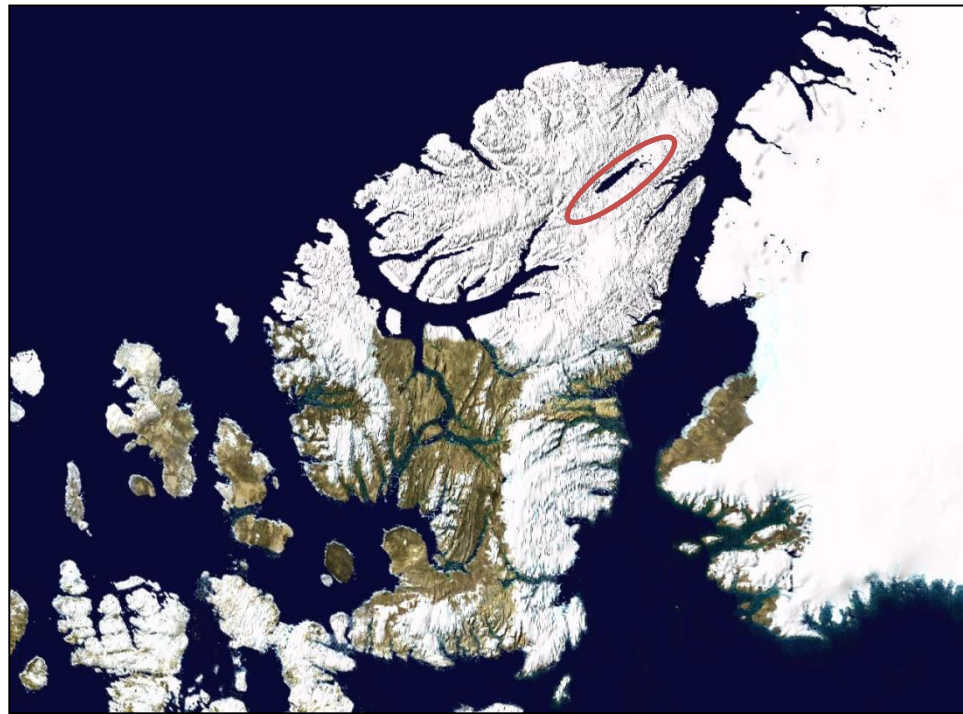
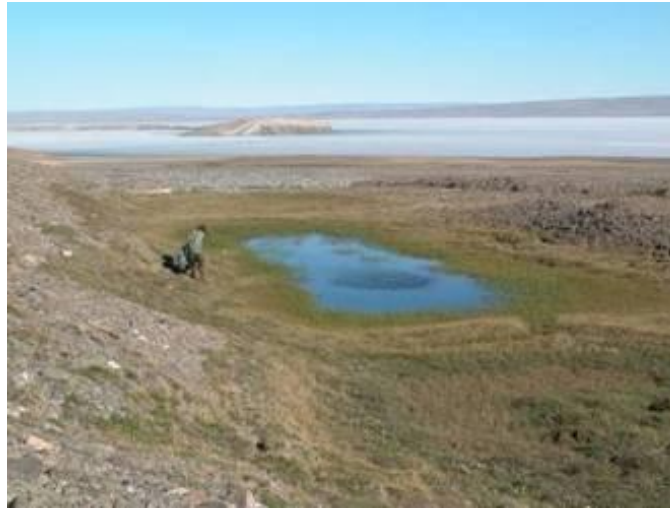






Photo: J England

# Lakes and ponds are a dominant feature of Arctic landscapes



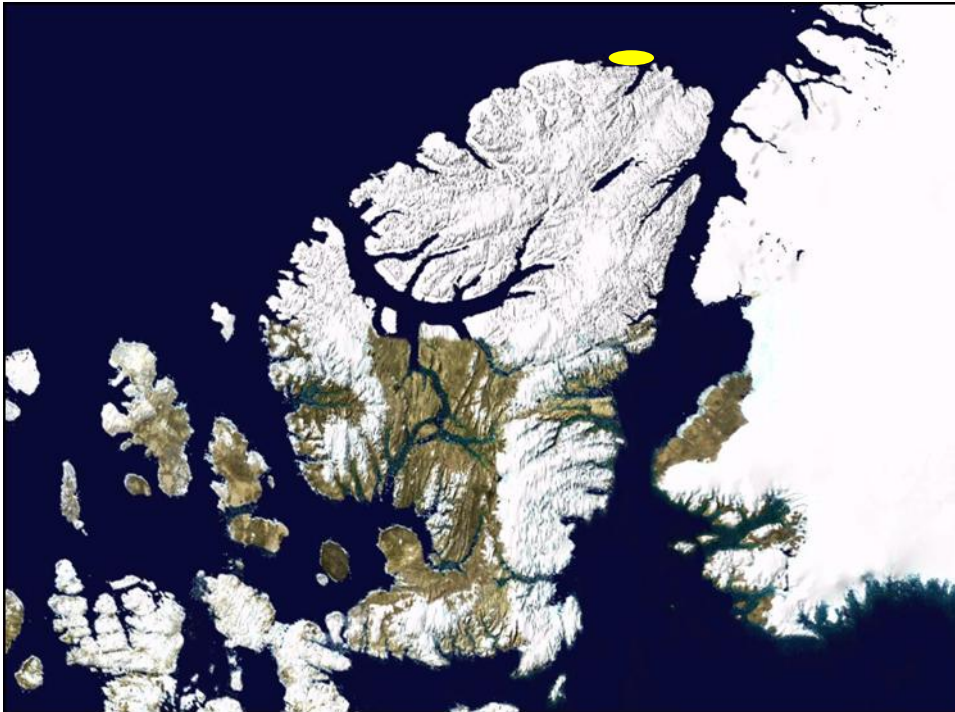
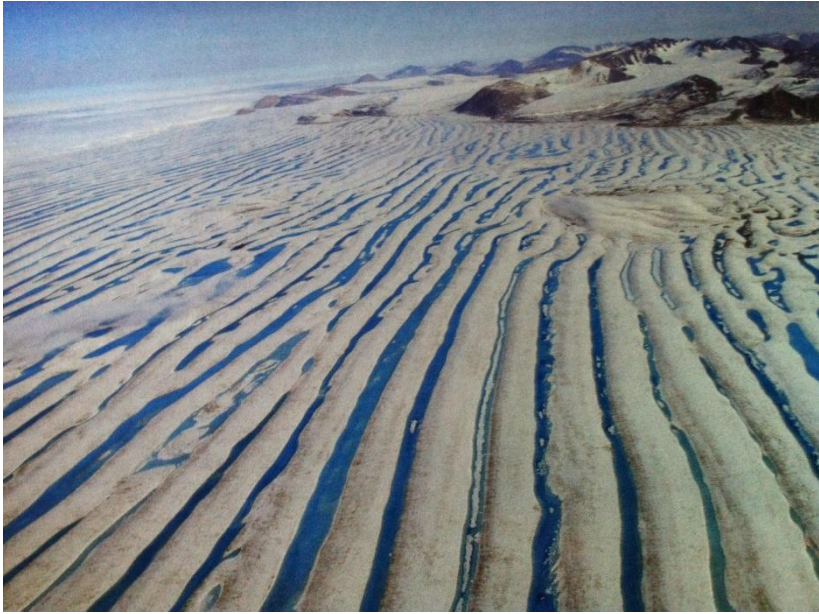
Important for  
migratory birds,  
mammals...



Northern peoples  
(hunting and fishing)







Vincent and Laybourn-Parry, 2008

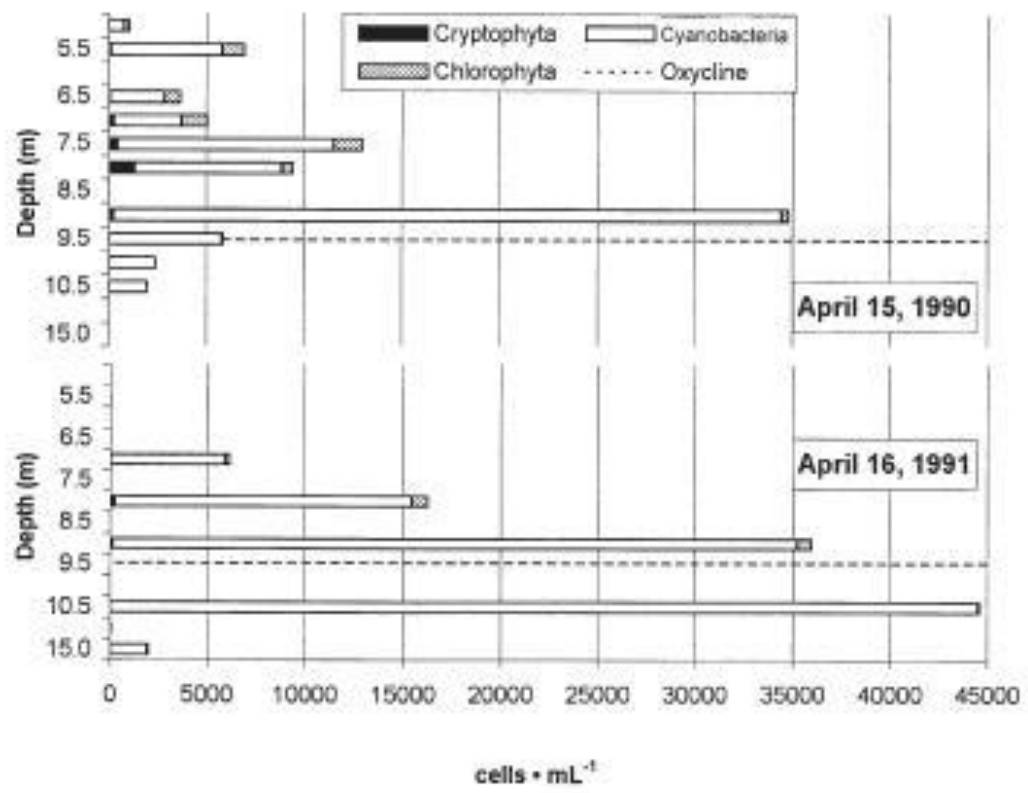


...and Antarctic ...ice free regions



and  
englacial  
regions

# Dry Valleys: Antarctica's weird algal mats



NO DIATOMS IN THE PLANKTON

Spaulding et al., 2000

The dim light to penetrate



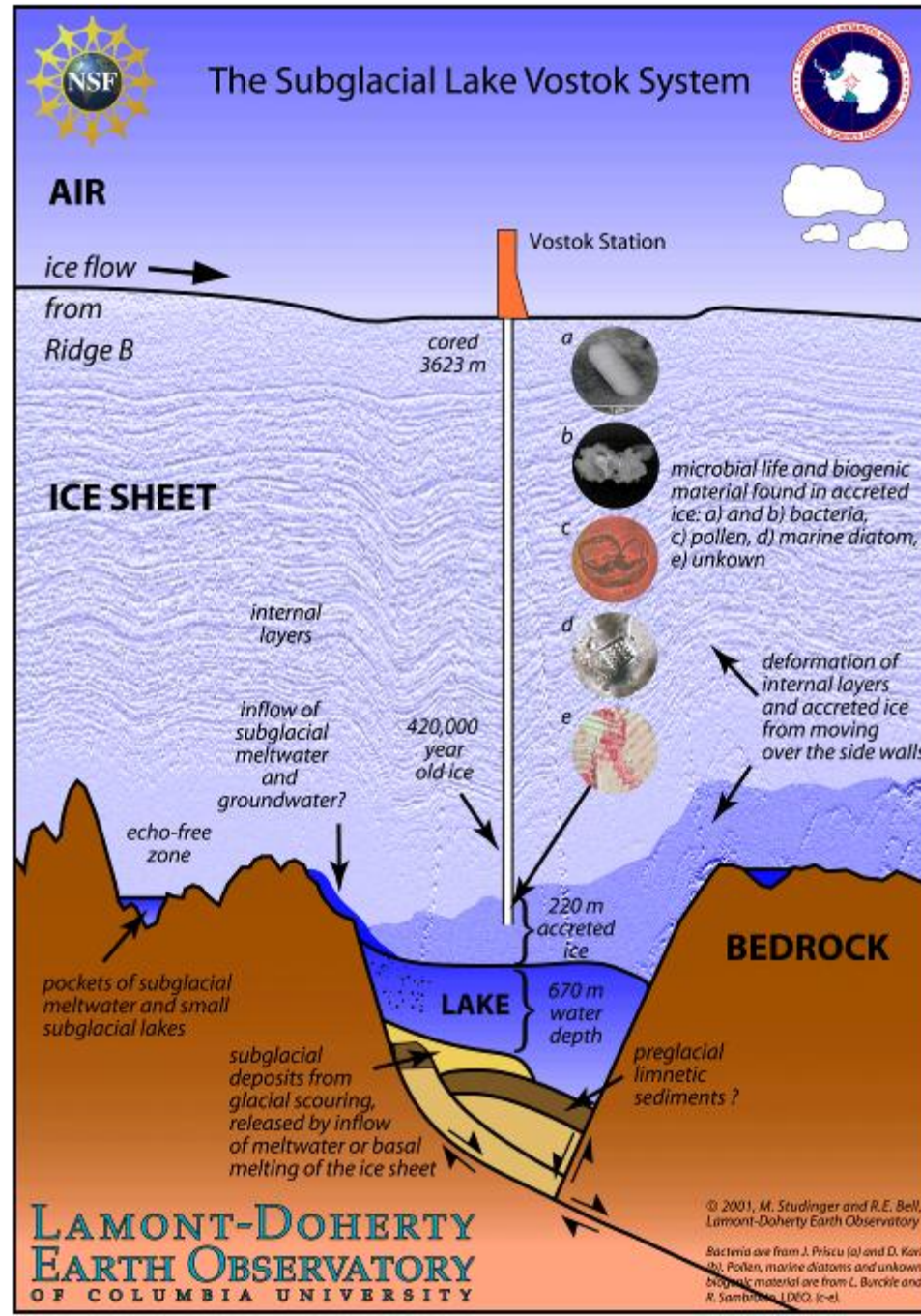
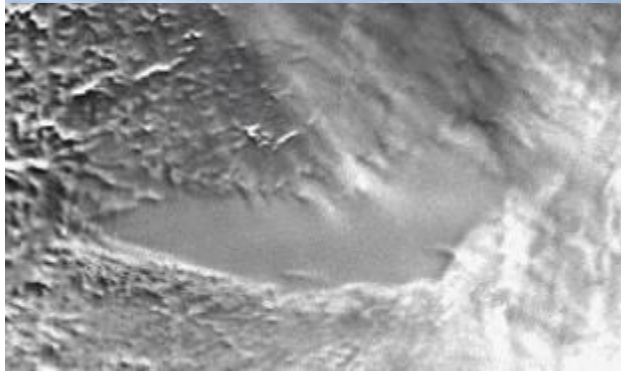
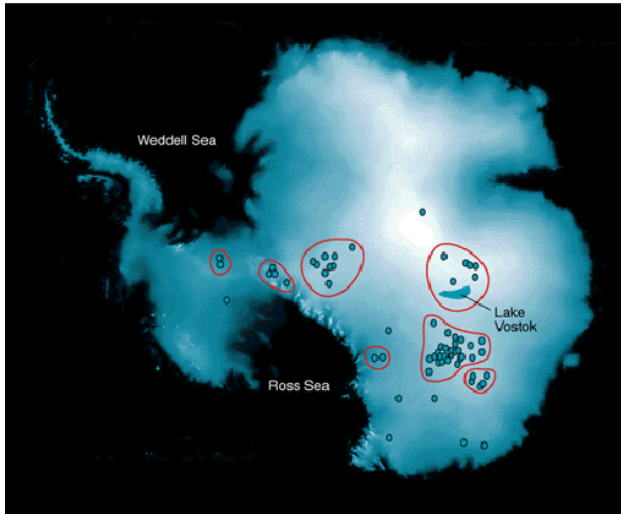


# Don Juan Pond, Dry Valleys, Antarctica.

So saline, it  
never freezes!



# Subglacial lakes





# Lakes and ponds are a dominant feature of Arctic landscapes



Vary according to:

Size

Depth

Chemistry

pH

conductivity

nutrients

Ice cover

Biology

fish

fishless



Geology, climate, ...

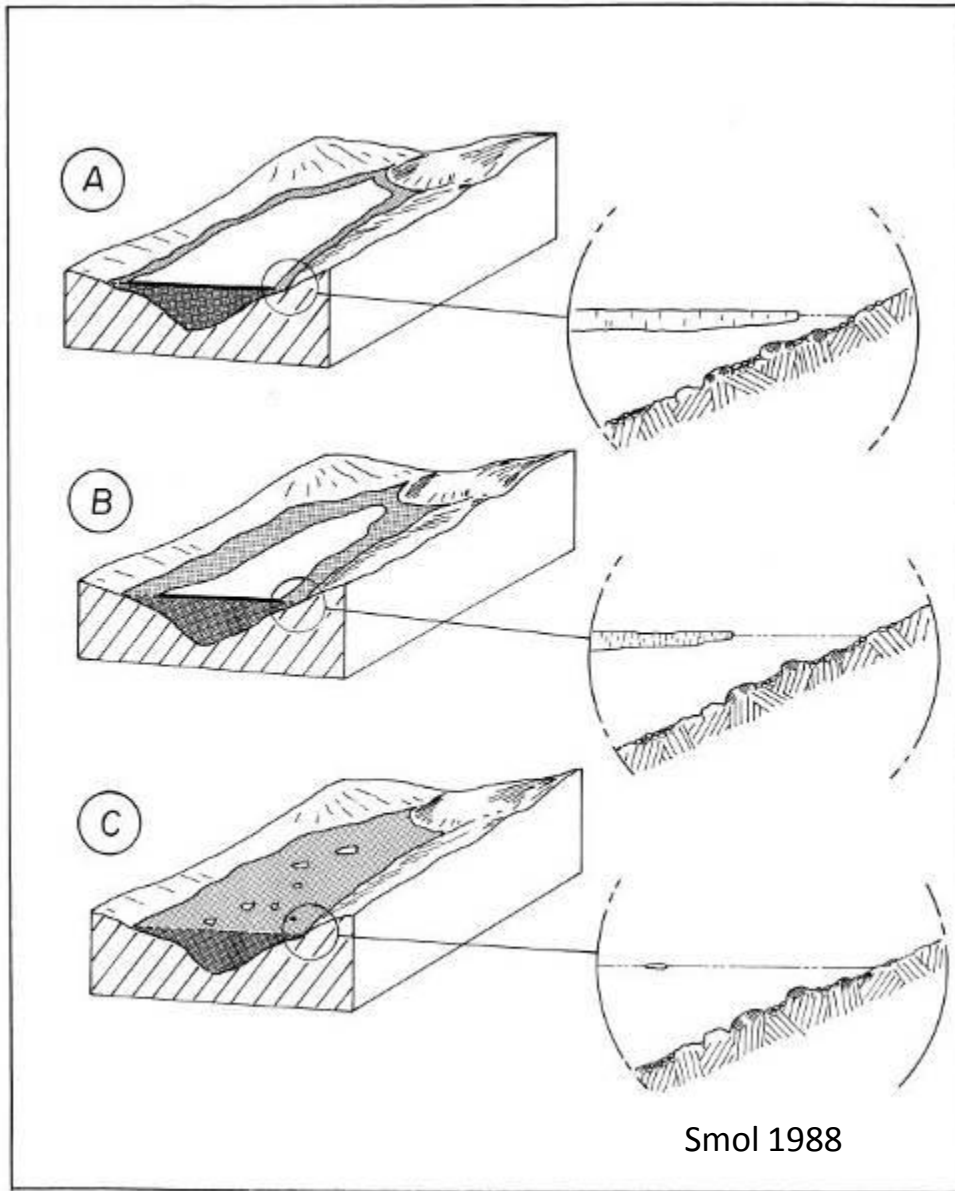
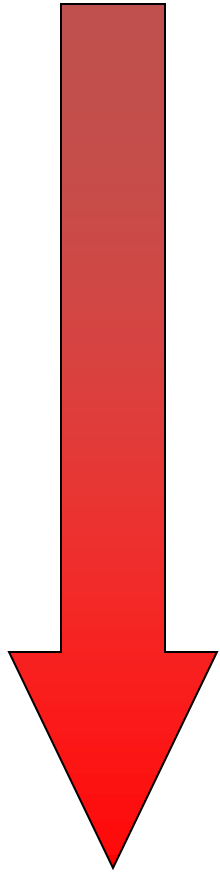
vegetation

# Ice thickness varies

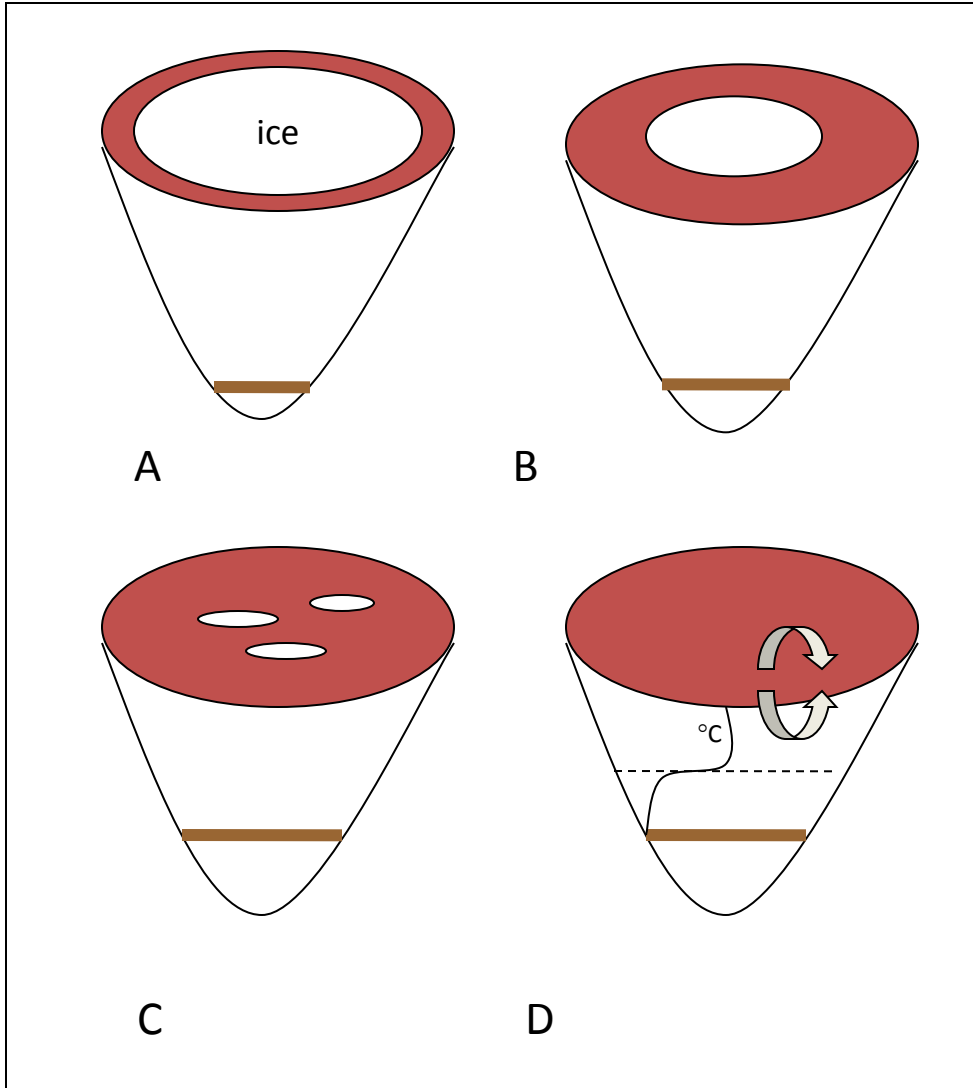


Implications for what kinds of organisms are present:  
planktonic (open water) vs benthic (bottom &/or  
attached to substrate)



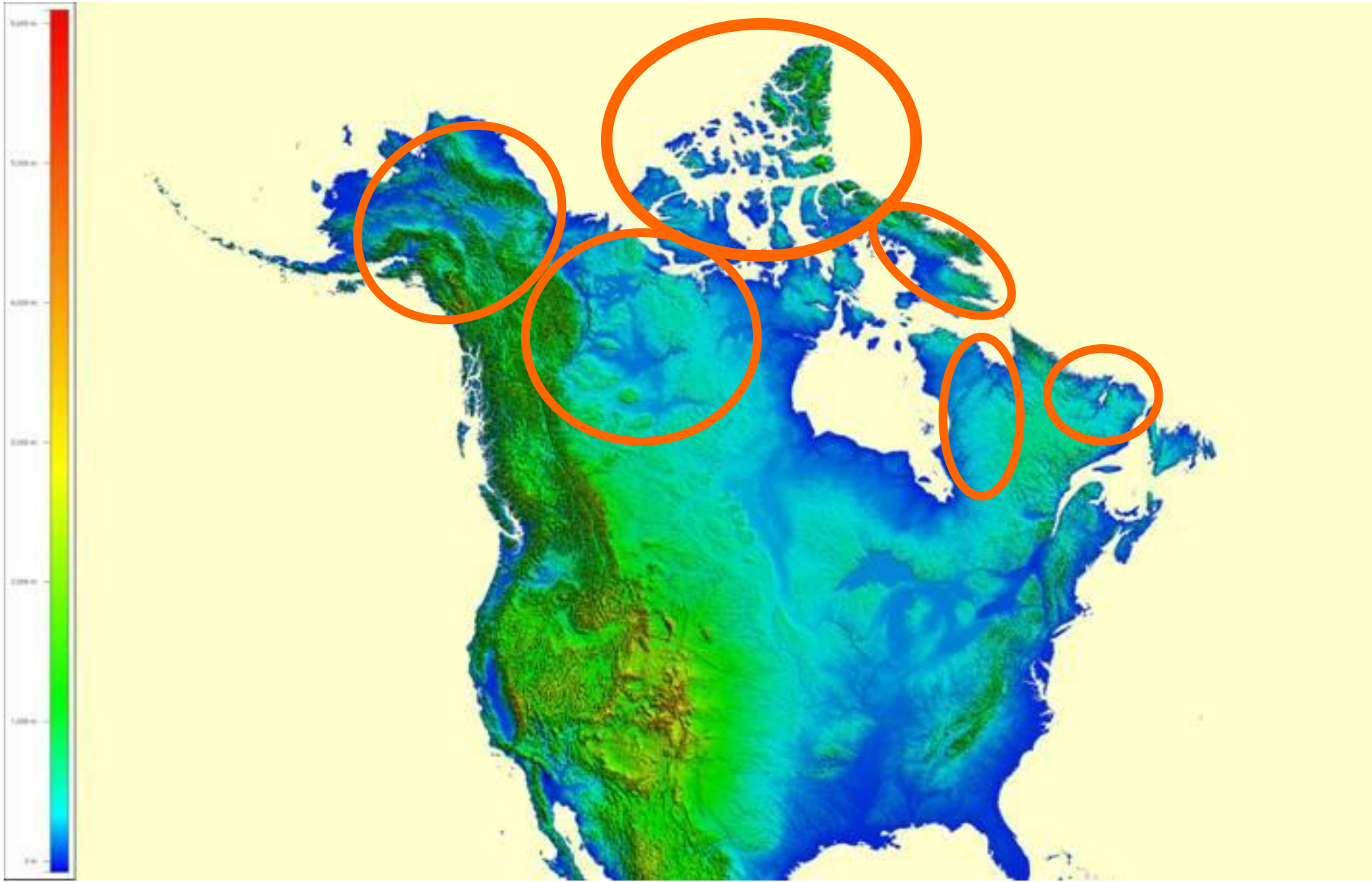


Overriding effect  
of ice on  
microhabitat  
availability



- Thermal stratification strengthened
- Increased nutrients
- Increased sedimentation
- Increased methane production (?)

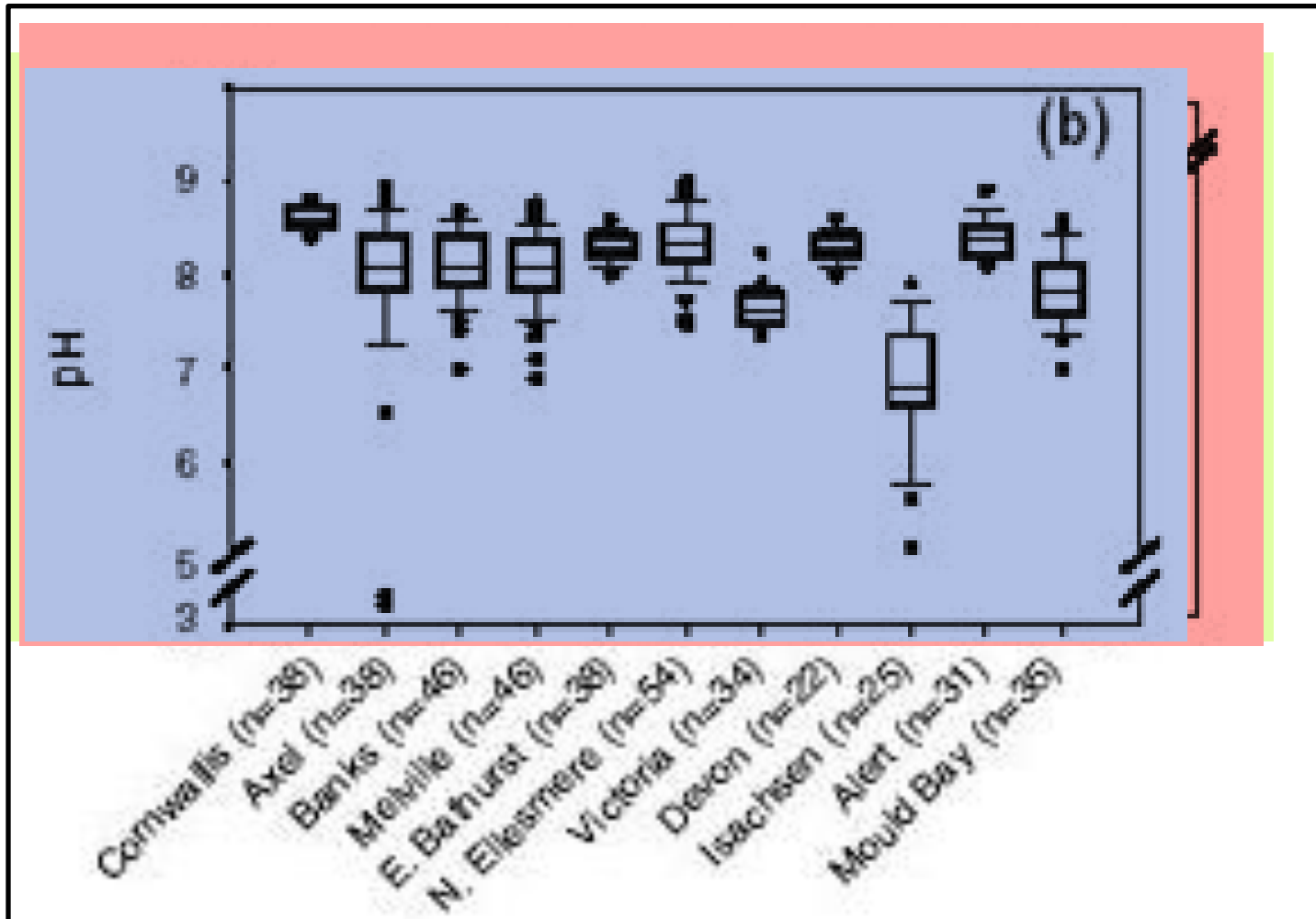








# pH, Cond, DOC, Total P across Canadian Arctic Archipelago





Camp Pond, 14 Jul 1979



Camp Pond, 24 Aug 1987



Camp Pond, 12 Jul 2006



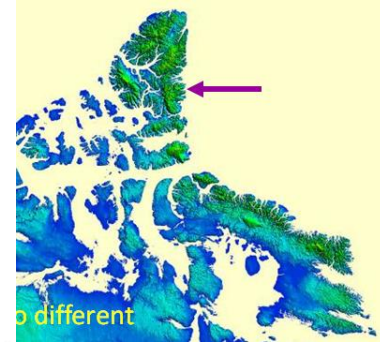
Willow Pond, 21 Aug 1987



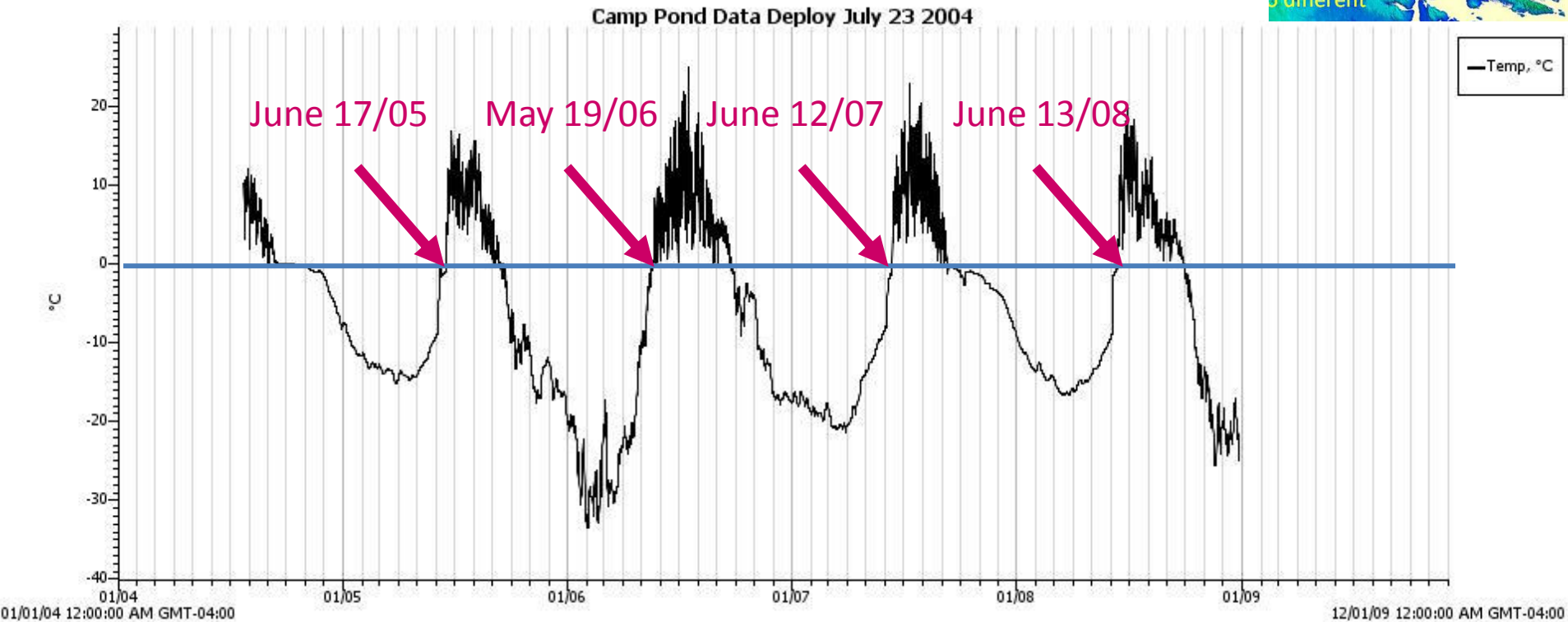
Willow Pond area, 18 Jul 2006



# Thermister data from Camp Pond

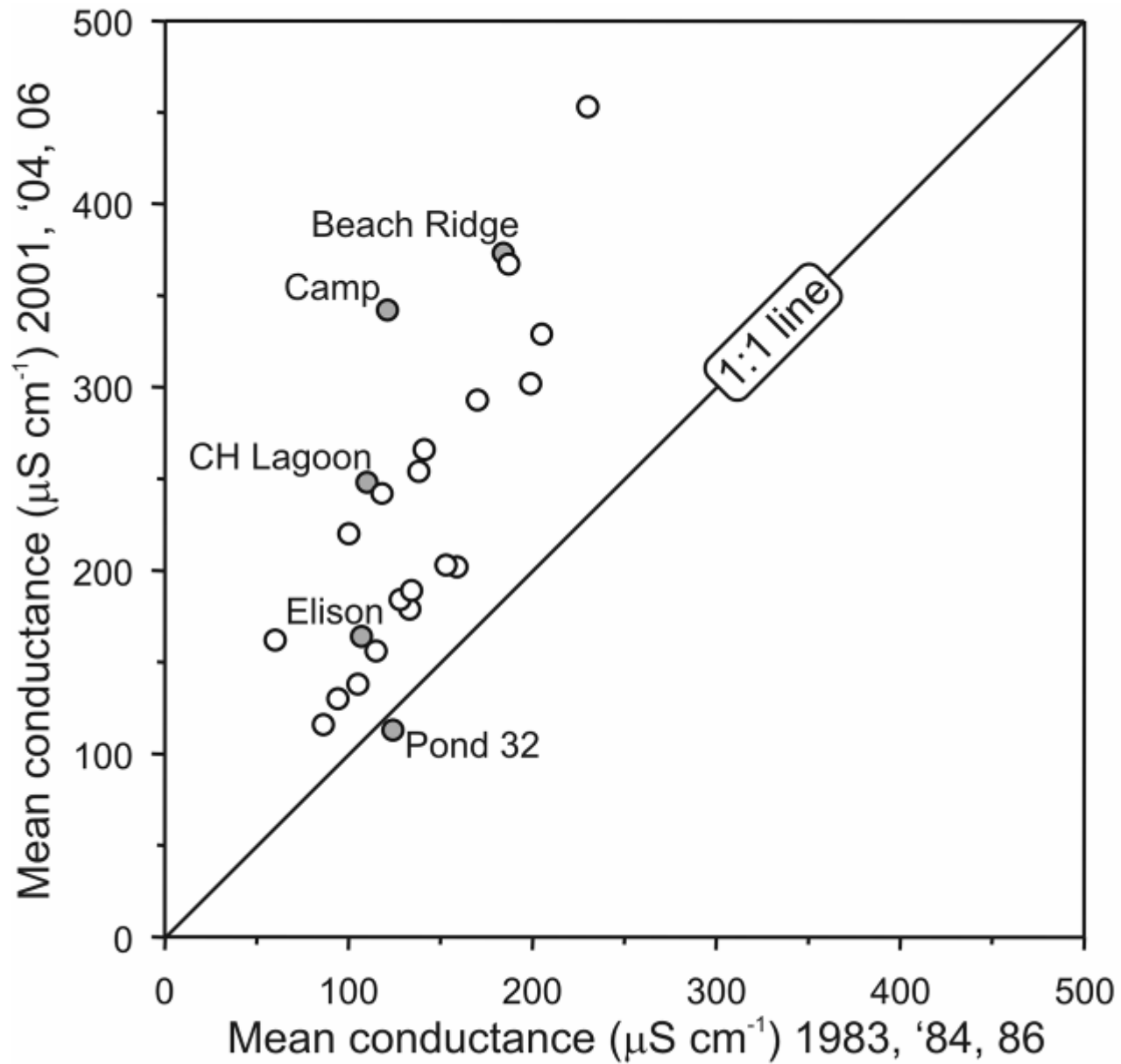


← July 4th 1986



Growing seasons (ice free season in lakes) is longer

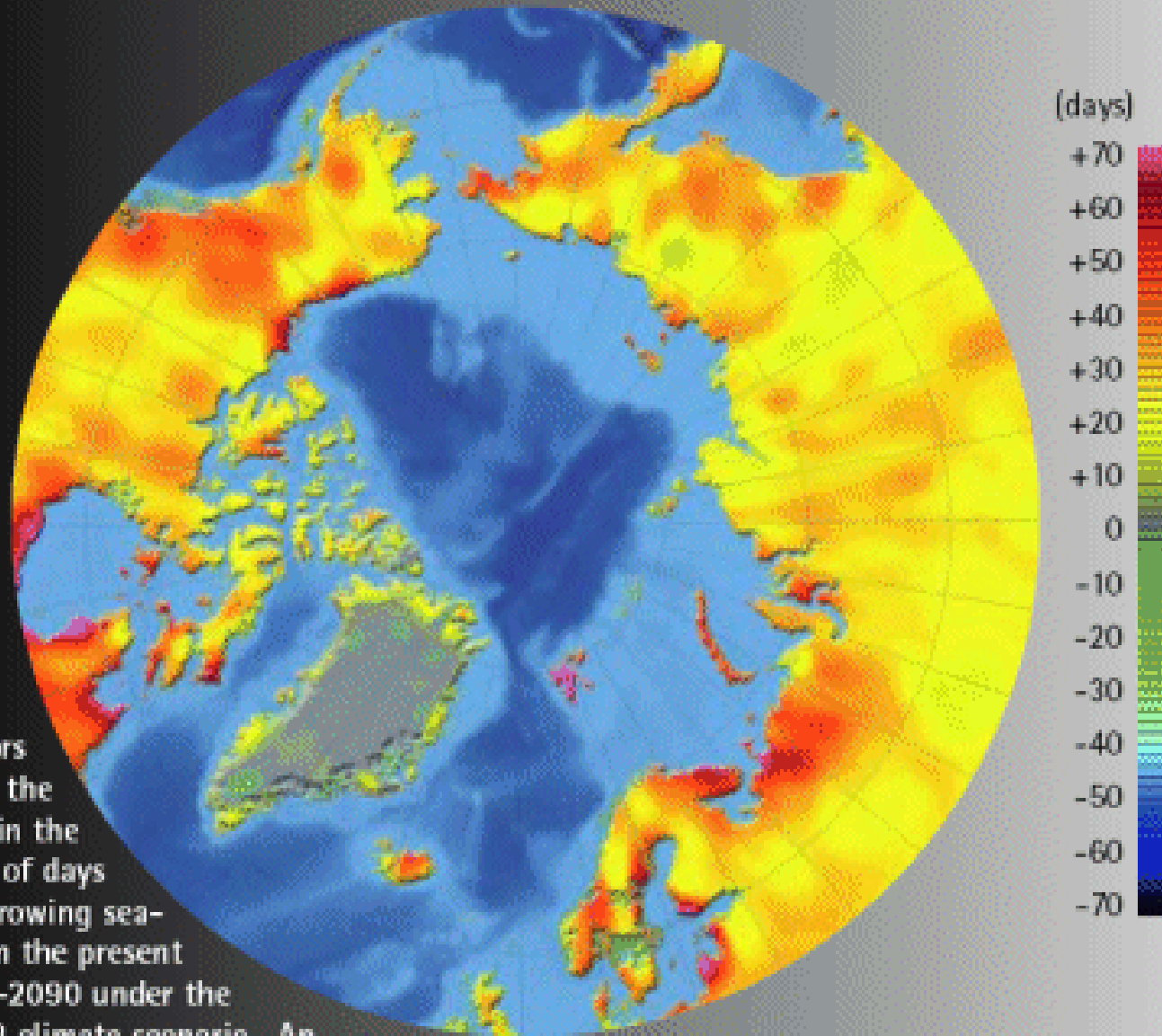
(M. Douglas, unpublished data)



Smol & Douglas (2007) *PNAS* 104: 12395-7.

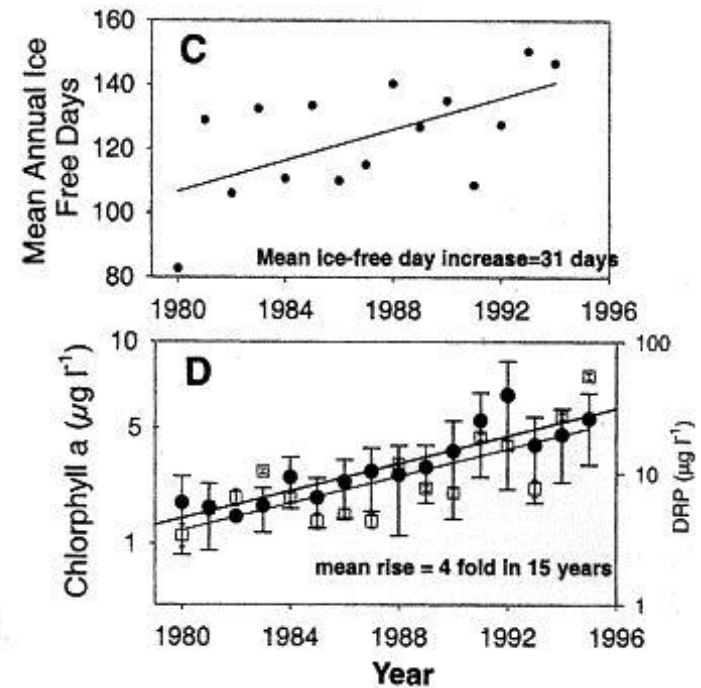
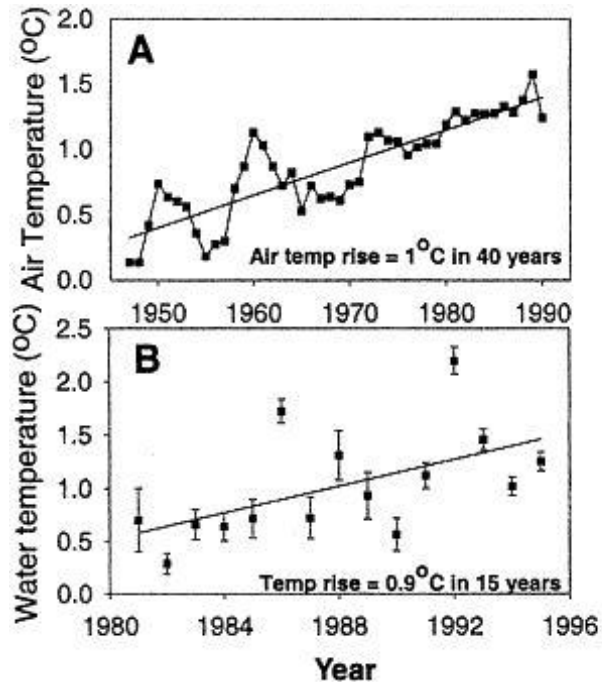


## Projected Change in Growing Season Length by 2070-2090 Minimum Temperature greater than 0°C



The colors indicate the change in the number of days in the growing season from the present to 2070-2090 under the Hadley 3 climate scenario. An average of three climate model's results suggests about a 20-30 day increase in the growing season for areas north of 60° latitude. The growing season is defined as the number of consecutive days in which the minimum temperature is above 0°C.

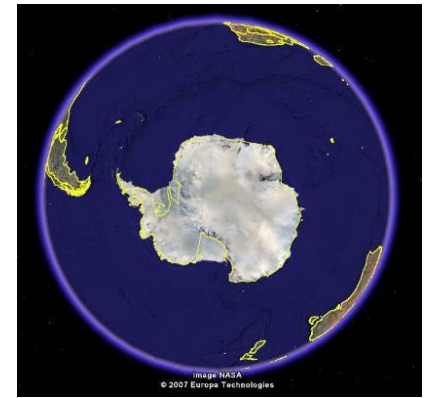
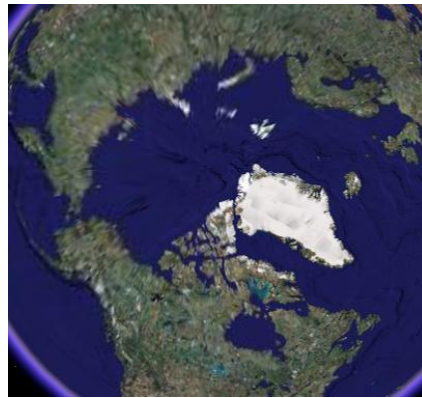
# Evidence is bi-polar!



Quayle et al. 2002. *Science*

- Air temperature increased 1°C over 40 years
- Water temperature increased 0.9°C over 15 years
- Mean ice-free days increases 31 days over 15 years
- Productivity increased 4 fold in 15 years





**Cold environment:**  
**Snow and ice**  
**Pronounced seasonality**



**Connected continent**  
**→ climate, colonization,**  
**and biodiversity**

connected



isolated

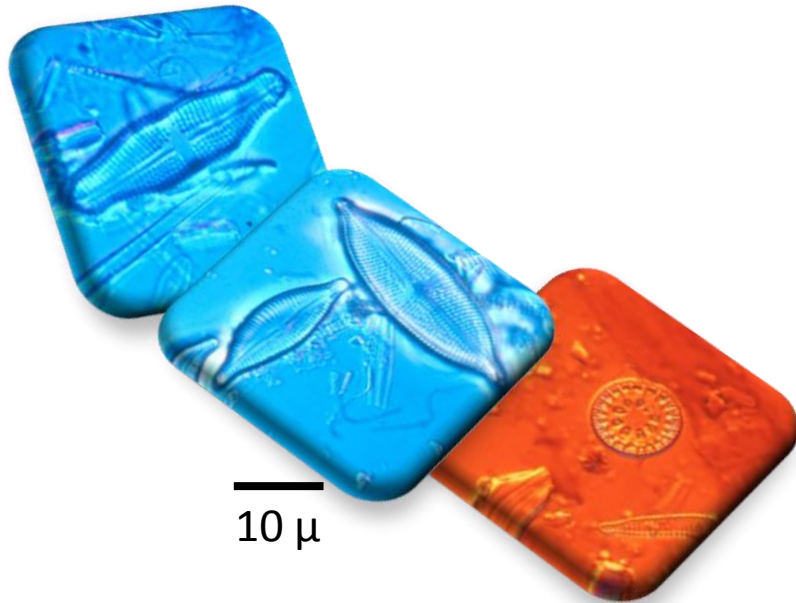
Lakes and ponds:  
terrestrial vegetation and  
sources of allochthonous C  
Aquatic mosses  
Higher plants



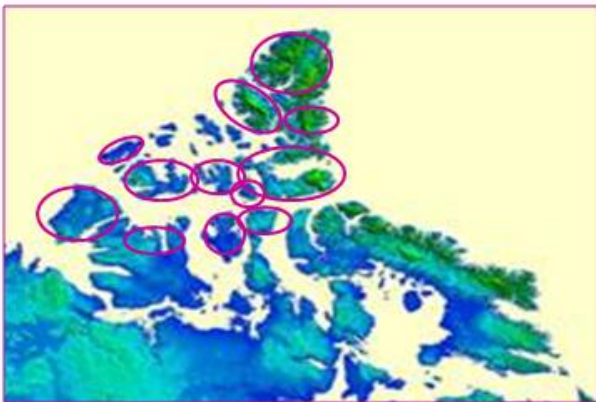
Benthic microbial mats



# Diatoms - algae



- Algal class
- Taxa have distinct environmental optima and tolerances
- Useful in assessing ecosystem health and paleoenvironmental conditions





# Factors affecting diatom distributions in polar regions:

<b>Environmental Characteristic</b>
Chemical pH salinity conductivity DOC
Physical <u>Ice Cover</u>
<u>Microhabitat</u> Rock, moss, sediment <u>Lotic (streams, rivers)</u>
<u>Temperature</u>
<u>Thermal Stability</u>
<u>Lake Level/Hydrology</u>

# Responses to climate scenarios

Environmental Variable	Colder		Warmer	
Growing season	↓	□■	↑	□■
Ice cover	↑	□■	↓	□■
Thermal stratification	↓	□■	↑	■
Water levels	↑ or ↓	□■	↑ or ↓	□■
Plankton	↓	□■	↑	□■
Mosses	↓	□■	↑	□■
Diversity	↓	□■	↑	□■
Nutrients	↓	□■	↑	□■
Production	↓	□■	↑	□■
pH	↓	□■	↑	□■
Conductivity	↓	□■	↑	□■
DOC	↓	□■	↑	□■
River Discharge	↑ or ↓	□■	↑ or ↓	□■

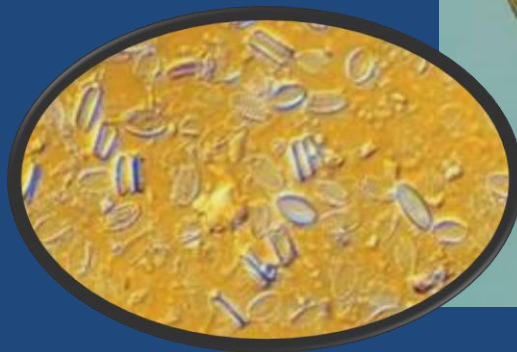
Lake ■ or Pond □



# Community diversity model:

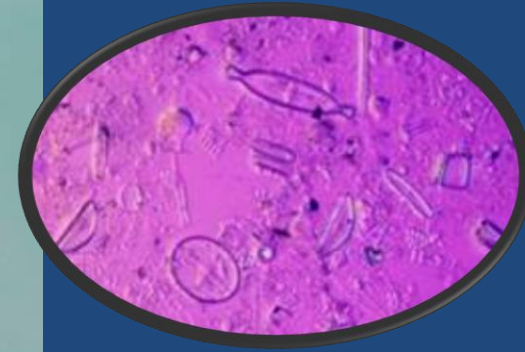
Cooler: few taxa,  
simple

Shorter growing  
season



Warmer:  
diverse,  
intricate

Longer  
growing  
season



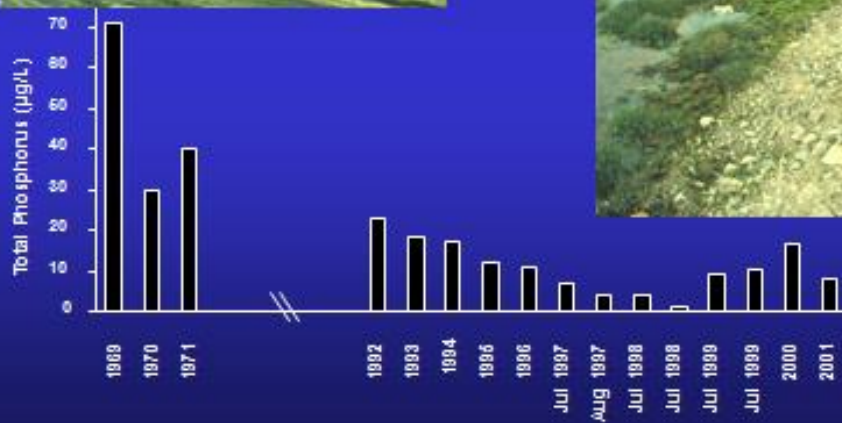




August 1970



August 1997

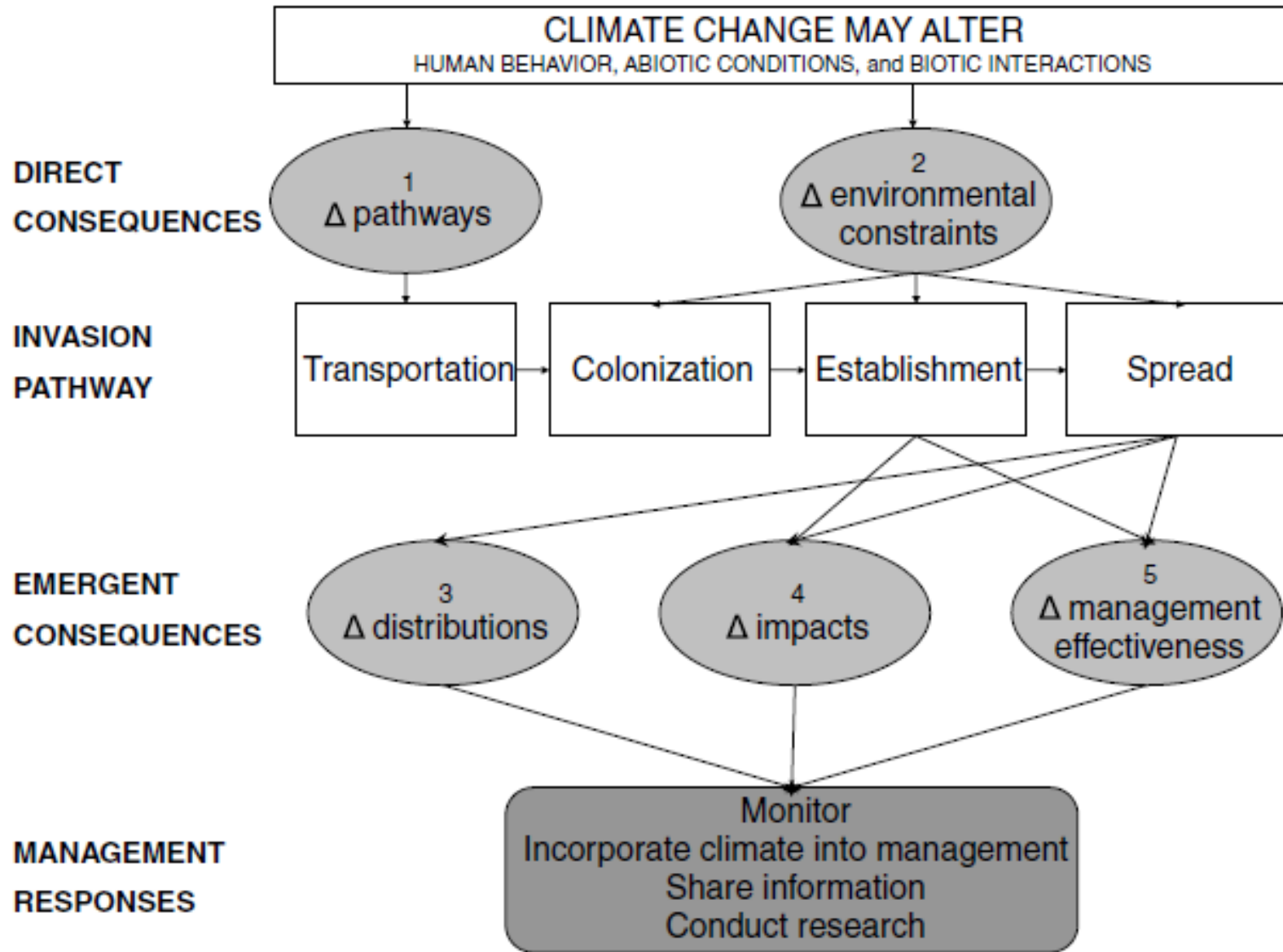


(Douglas and Smol)

Taken July 8 2014  
The Meretta Lake “sewage stream” is now a regular High Arctic Stream, as is also Meretta Lake = a typical High Arctic lake.

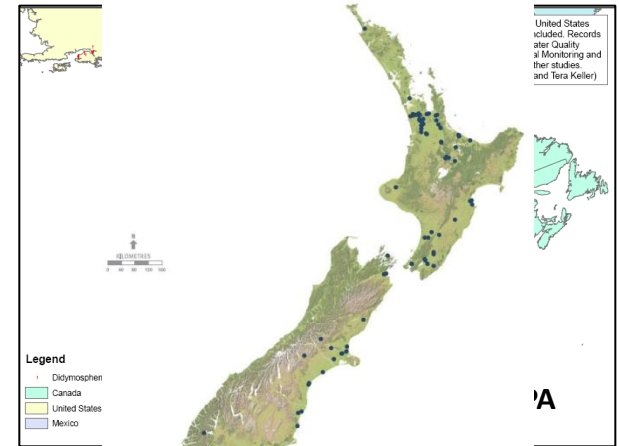






Nuisance freshwater algae (diatom)  
*e.g., Didymosphenia geminata*  
(aka “Didymo”)

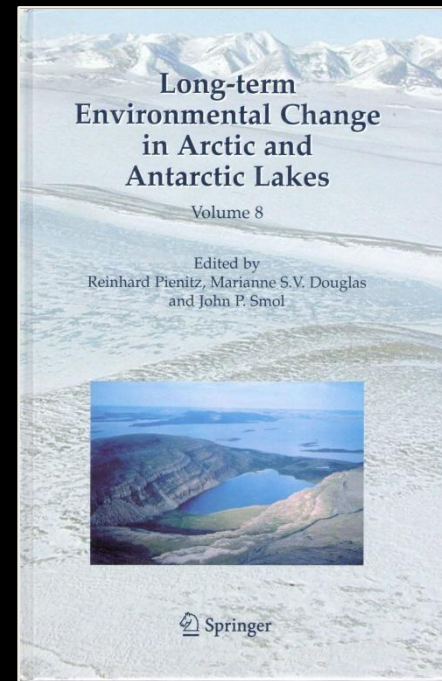
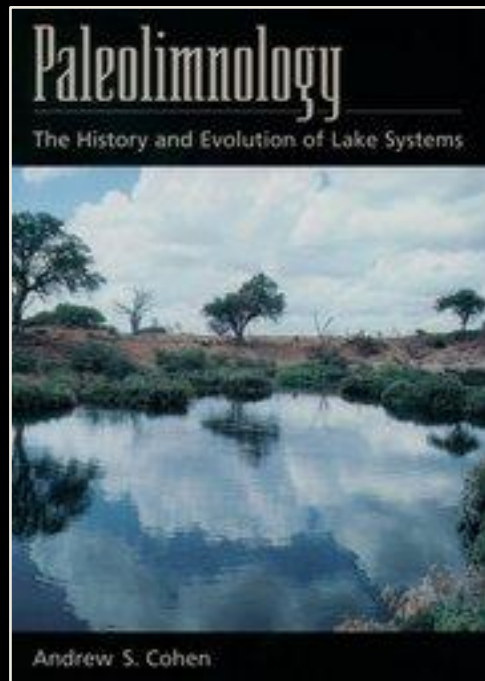
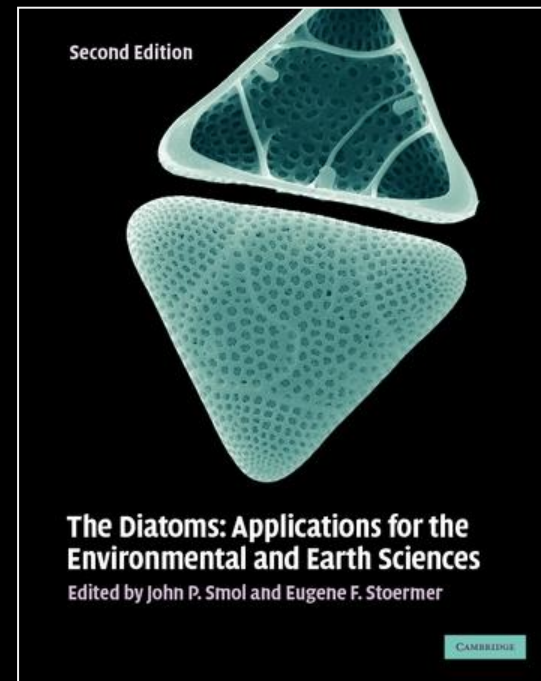
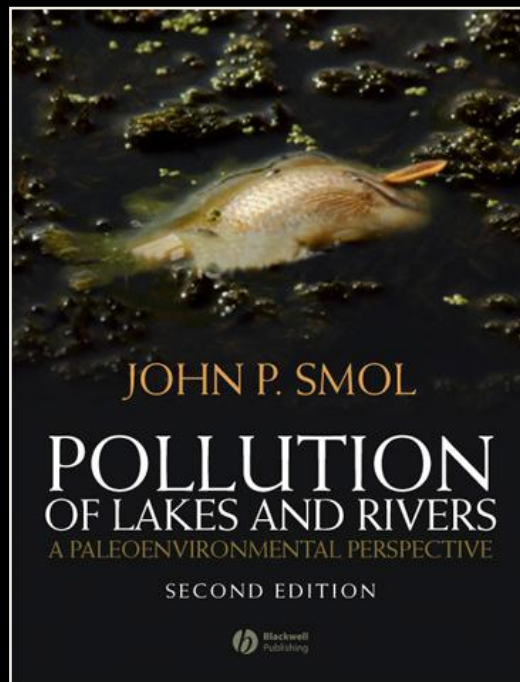
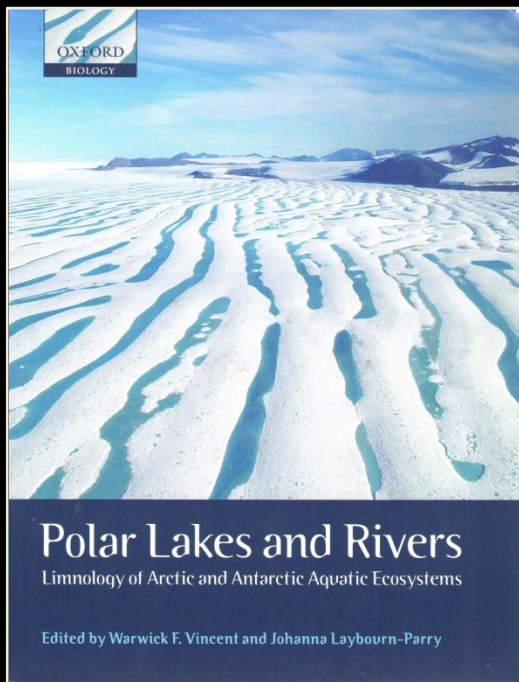
- *Occurrence*: usually oligotrophic streams and rivers throughout western NA, although spreading to east. Non-toxic
- *Threat*: harms aquatic ecosystems through microhabitat alteration in form of massive benthic mats.
- *Impacts*: reduced biodiversity  
nuisance blooms  
fish spawning, food web
- *Concerns*: spreading rapidly
- *Scope of project*: survey and monitoring of sites in Canadian Arctic (and elsewhere);  
➔ economic impact



# Global Significance of Polar Lakes

- Polar amplification → Experiencing rapid climate (and environmental change) change
  - Sentinels of climate change (next lecture)
- Carbon cycle complex and some additional lakes will become sources of greenhouse gases
- Important refugia for biological communities





**Thank you!**



# Impacts of (invasive) algae on aquatic ecosystems

- Livestock health (eg toxic blue-green algae)
- Fisheries (eg affects spawning habitats)
- Populations dependent upon harvests  
(esp. First Nations and Inuit)
- Increased pesticide usage
- Altered food webs
- Ecosystem services affected



# Lakes and ponds are a dominant feature of Arctic landscapes



Vary according to:

Size

Depth

Chemistry

pH

conductivity

nutrients

Ice cover

Biology

fish

fishless

Important for  
migratory birds



# Ice thickness varies



Implications for what kinds of organisms are present:  
planktonic (open water) vs benthic (bottom &/or  
attached to substrate)

# Research Gaps

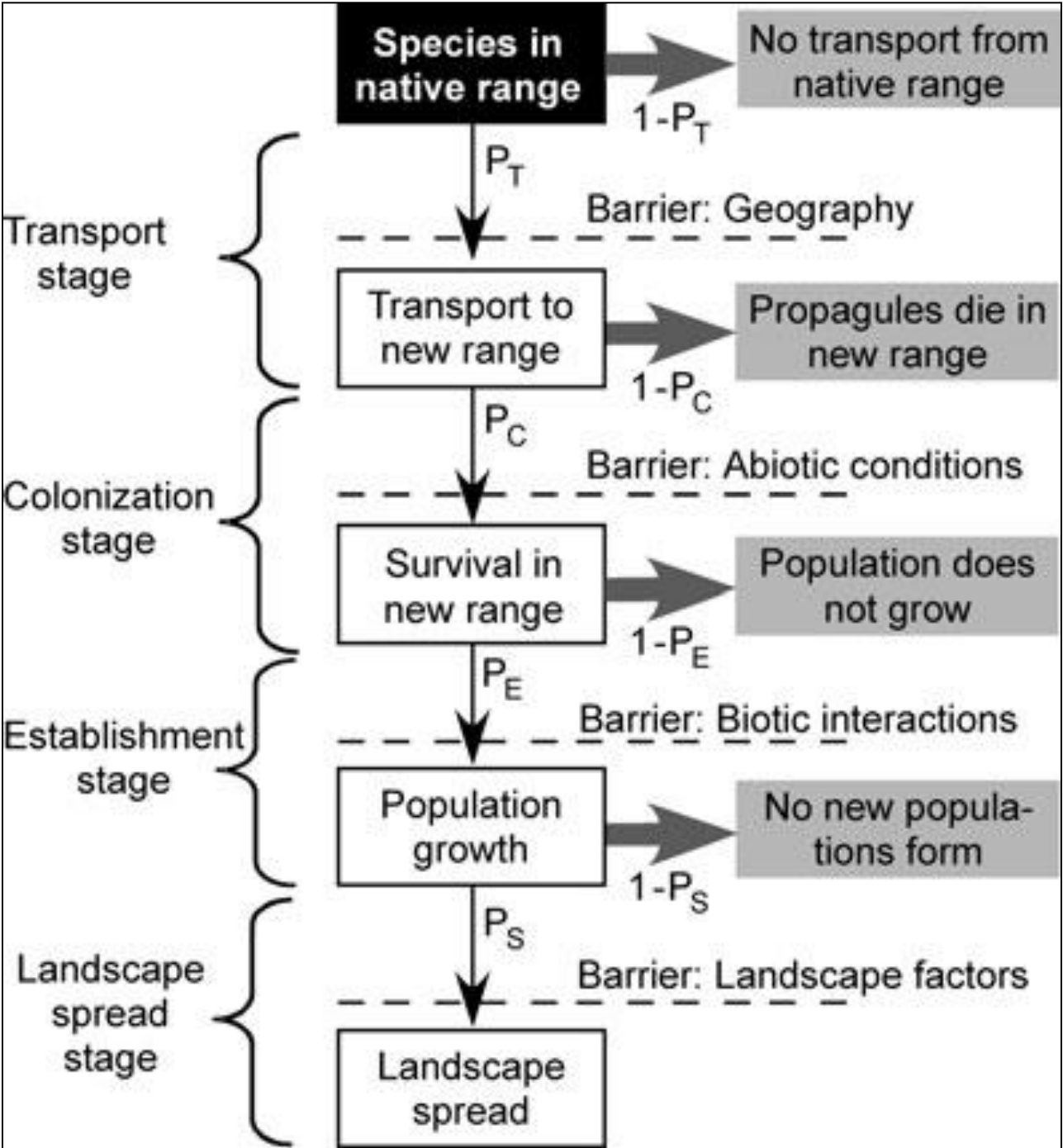
- Invasibility
- Water quality – climate change interactions
- Land-use changes

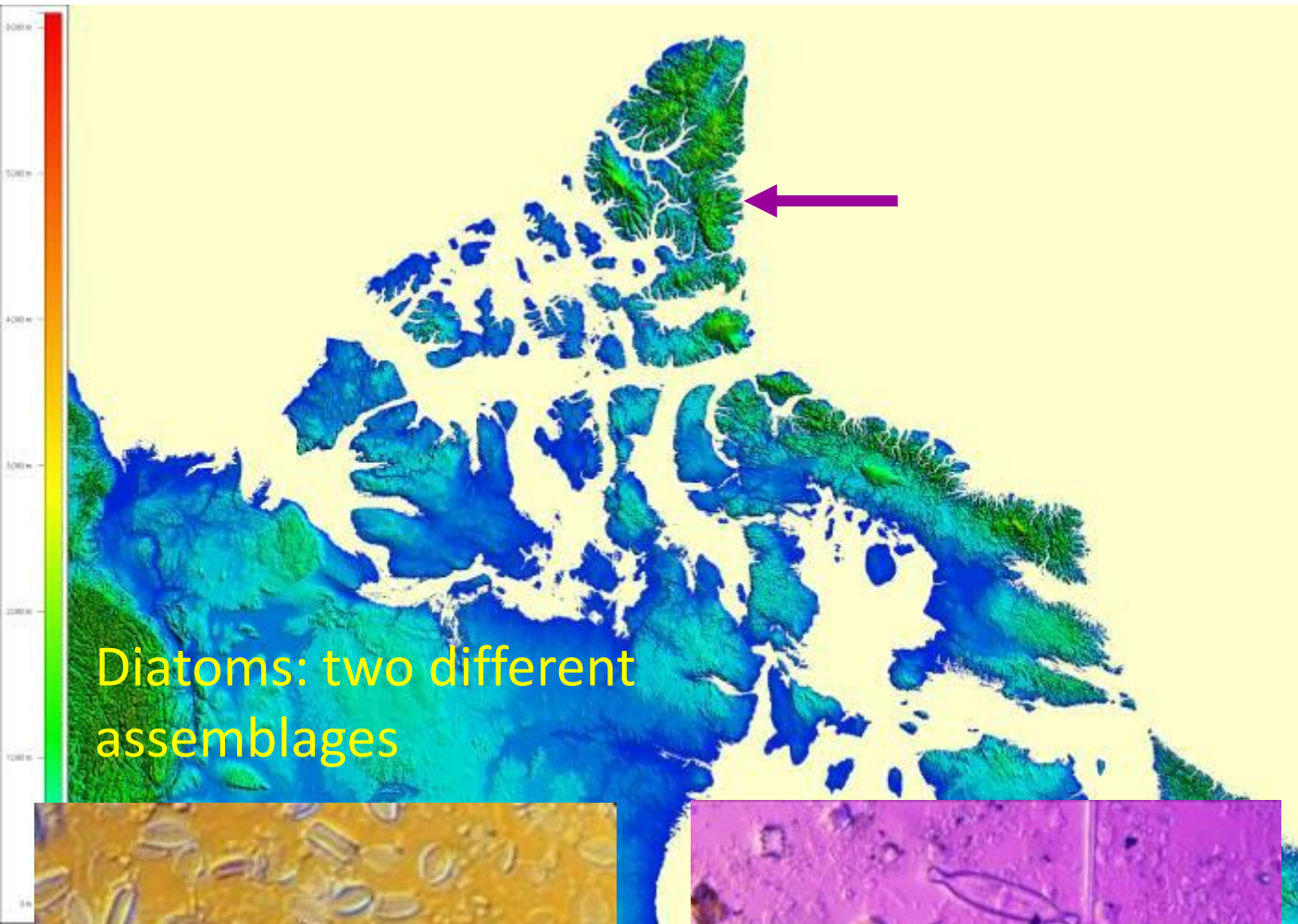
# Management Concerns

- Need to include climate change in management plans and goals.
- What are new conditions?
- Species expansions?
- Ecosystem services



# Invasion pathways and barriers





Diatoms: two different assemblages

