UNIVERSITY OF MINNESOTA

Terrestrial Carbon Sinks:

how can they affect glacial cycles?

UMN Math Climate Seminar

Samantha Oestreicher

October 19, 2011

Contents

What is a Peatland?

http://maps.google.com

What is a Peatland?

Lääne-Viru National Park, Finland

http://dolecek.name/travelling/finland/index.htm

What is a Peatland?

Bog “islands” in sedge fen, Upper Red Lake Peatland, perfect “teardrops”,1961

What is a Peatland?

Central Borneo, Indonesia

http://www.panoramio.com/photo/45821483

What is a Peatland?

Hudson Bay Lowlands

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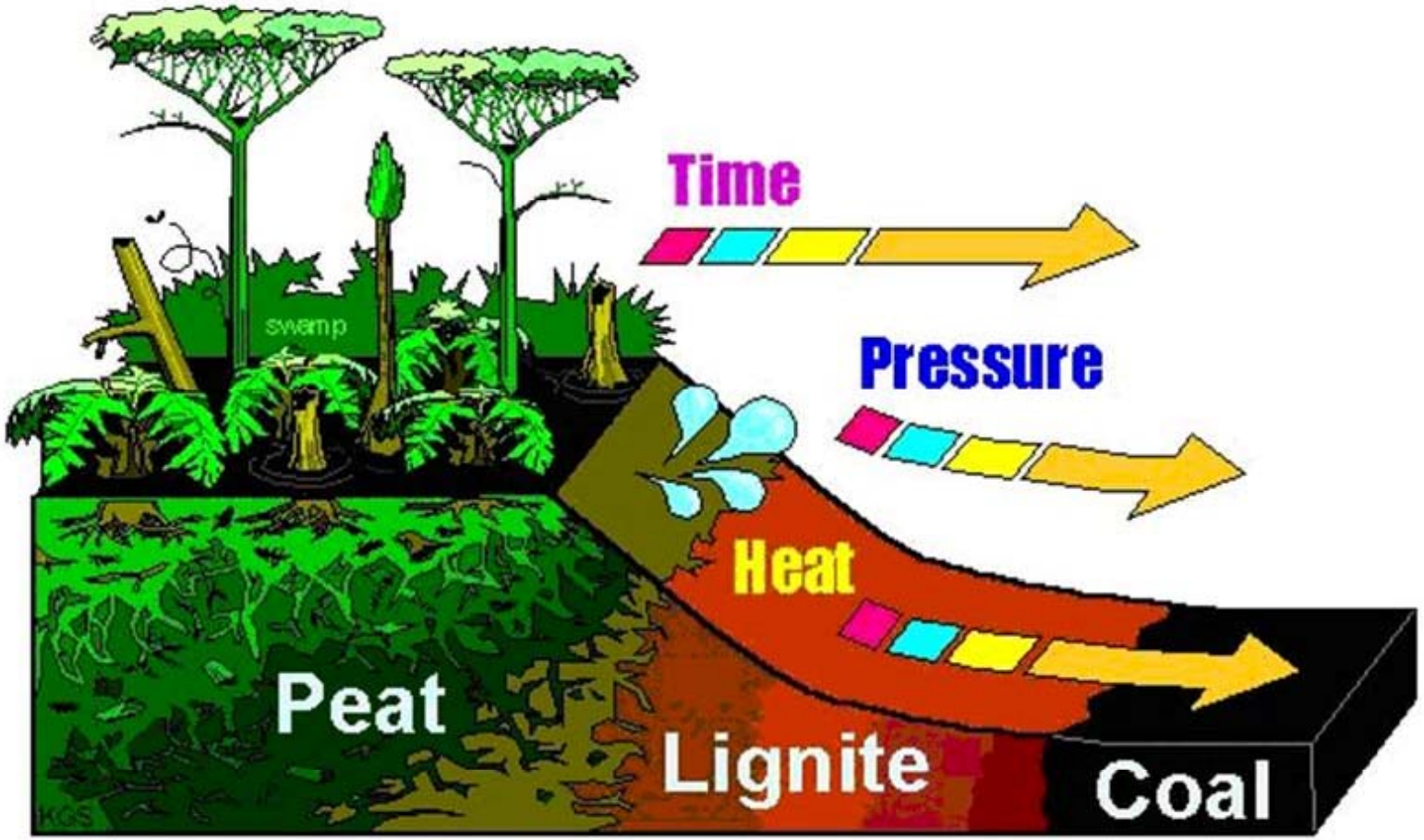
How do peatlands sequester carbon?

Although peatlands developed on “less than 3% of the terrestrial land surface, an estimated 455Pg of Carbon, approximately one-third of the terrestrial carbon pool, is currently stored in peatlands.” *(Keller 2004)*

In Minnesota peatlands cover 14% of the state but “hold 37% of its stored carbon, the highest of any land or vegetative form” and the Beltrami peatlands are part of this storage. *(McAuliffe 2009)*

How do peatlands sequester carbon?



Peatlands pull carbon out of the atmosphere to grow in the summer months (as every plant does), but the acidic soil does not allow the peat to decompose.

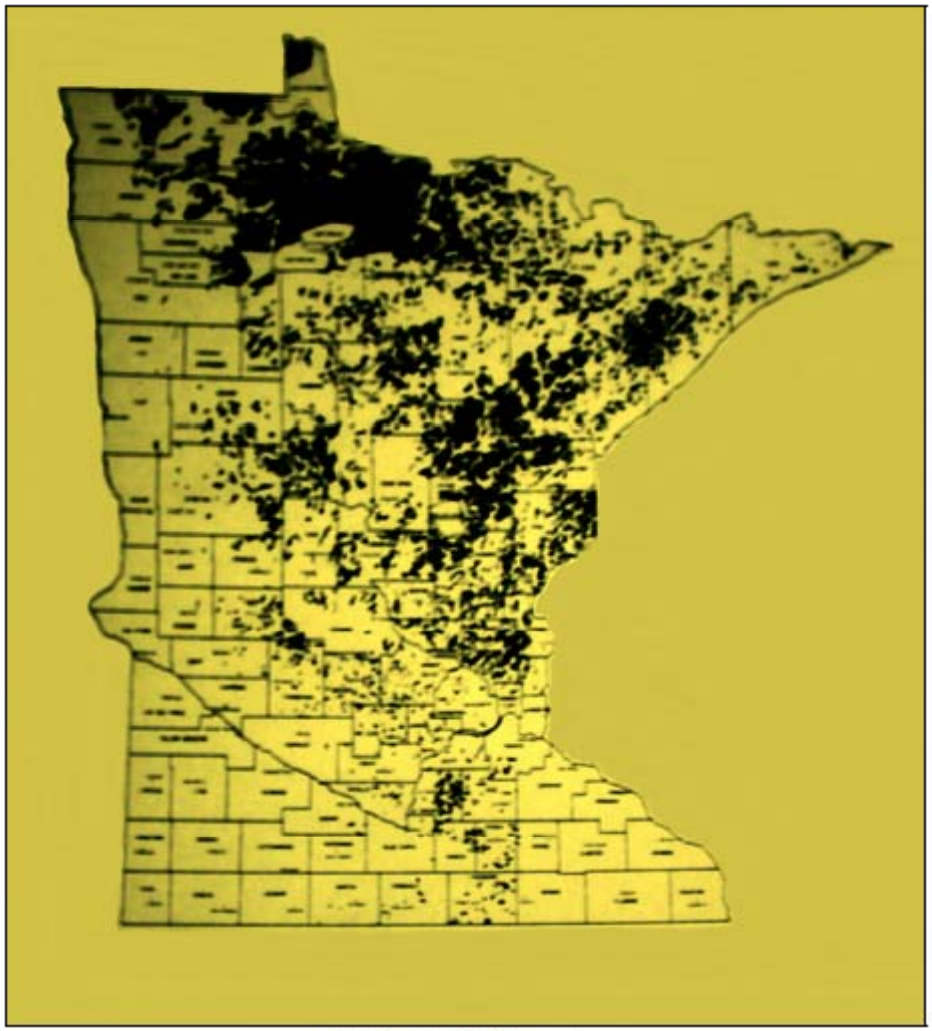
http://www.uky.edu/KGS/coal/coalform.htm

How do peatlands sequester carbon?

Core, Gander Bay, Nfld 1982

Slide by Clarence Lehman, University of Minnesota

How do peatlands sequester carbon?



Peatlands of Minnesota.

Slide by Clarence Lehman, University of Minnesota

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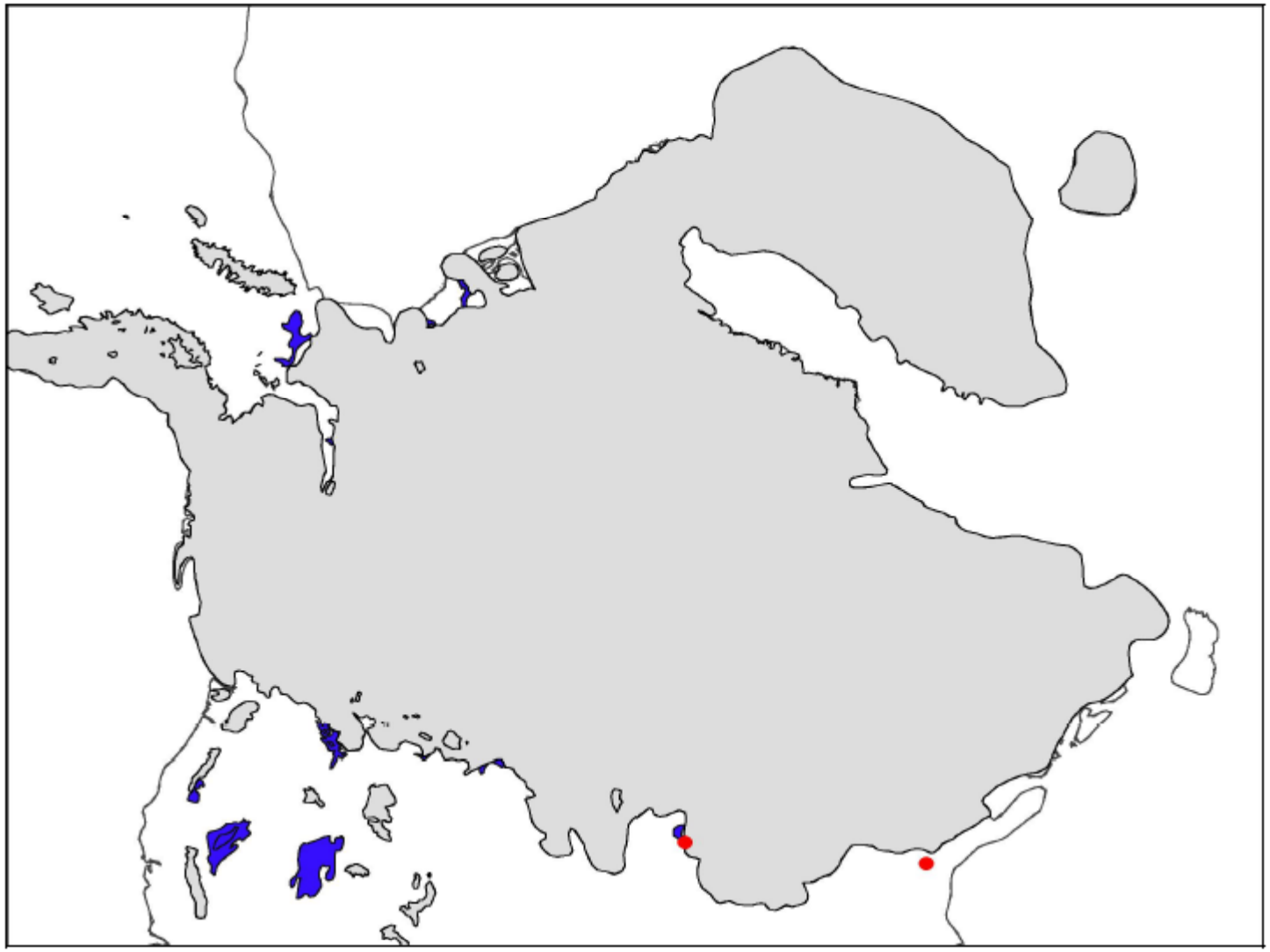
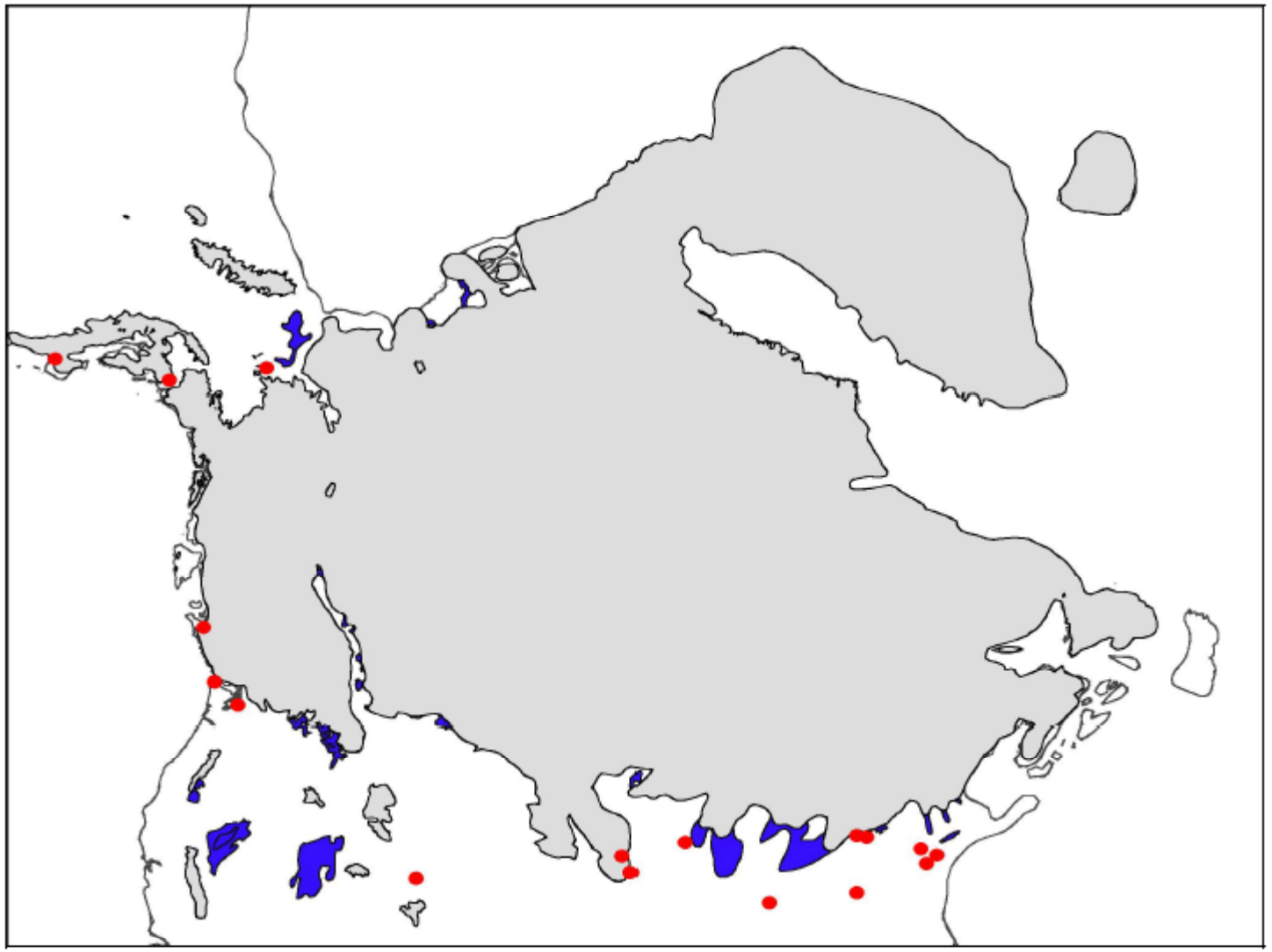
Developing Peatlands



Sample peatlands initiated as of 19,650 BP

Slide by Clarence Lehman, University of Minnesota

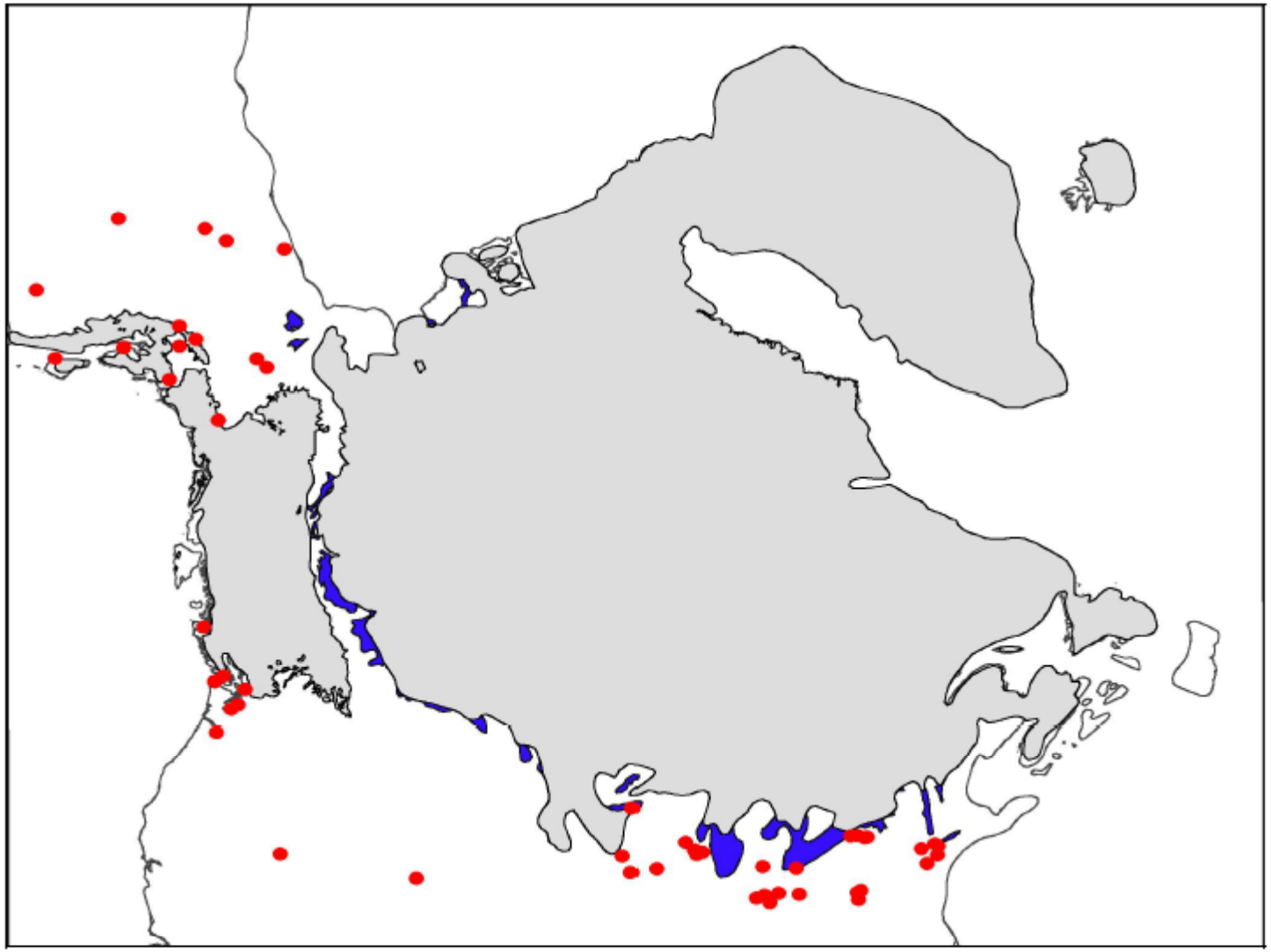
Developing Peatlands



Sample peatlands initiated as of 16,200 BP

Slide by Clarence Lehman, University of Minnesota

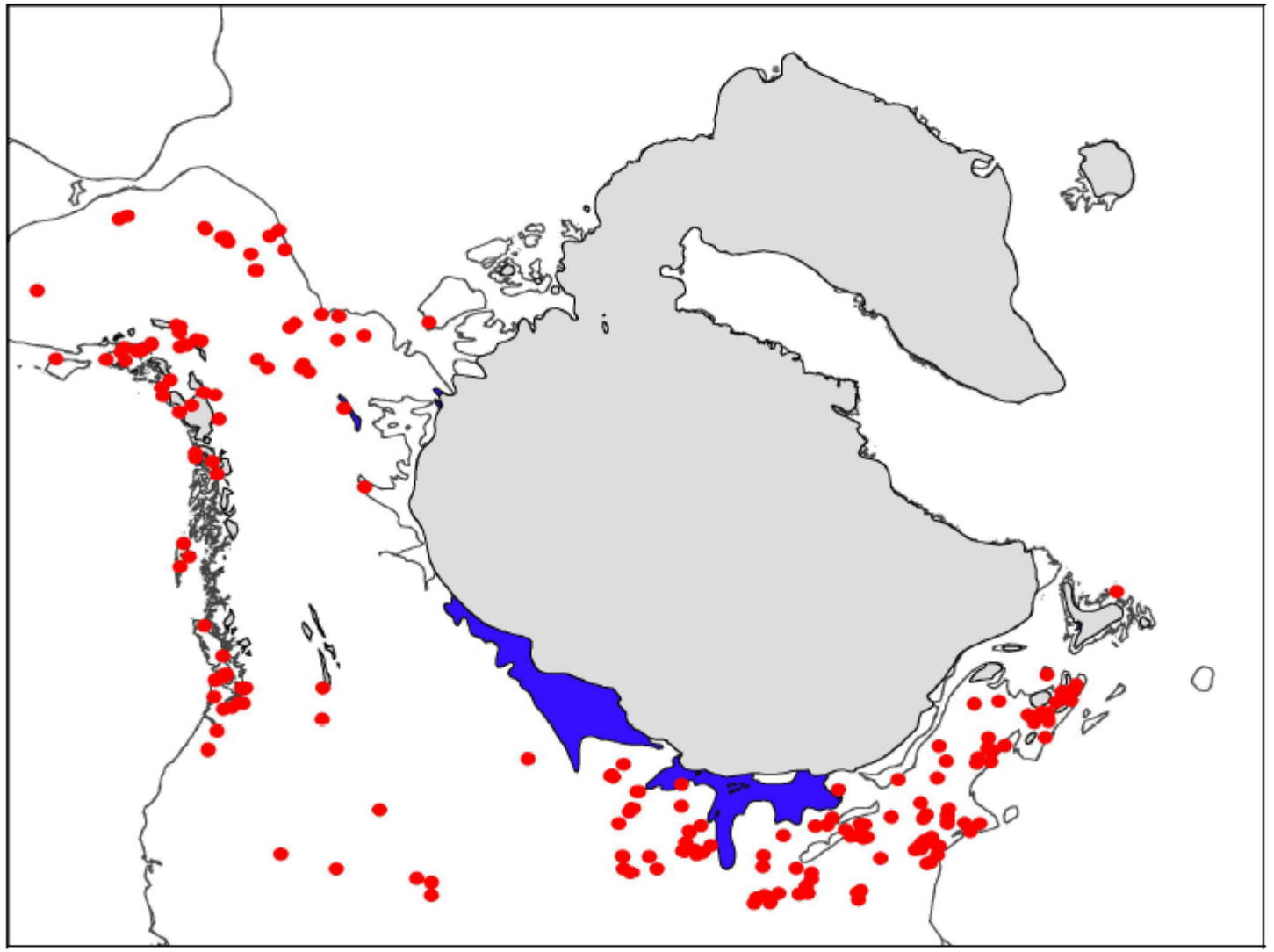
Developing Peatlands



Sample peatlands initiated as of 14,700 BP

Slide by Clarence Lehman, University of Minnesota

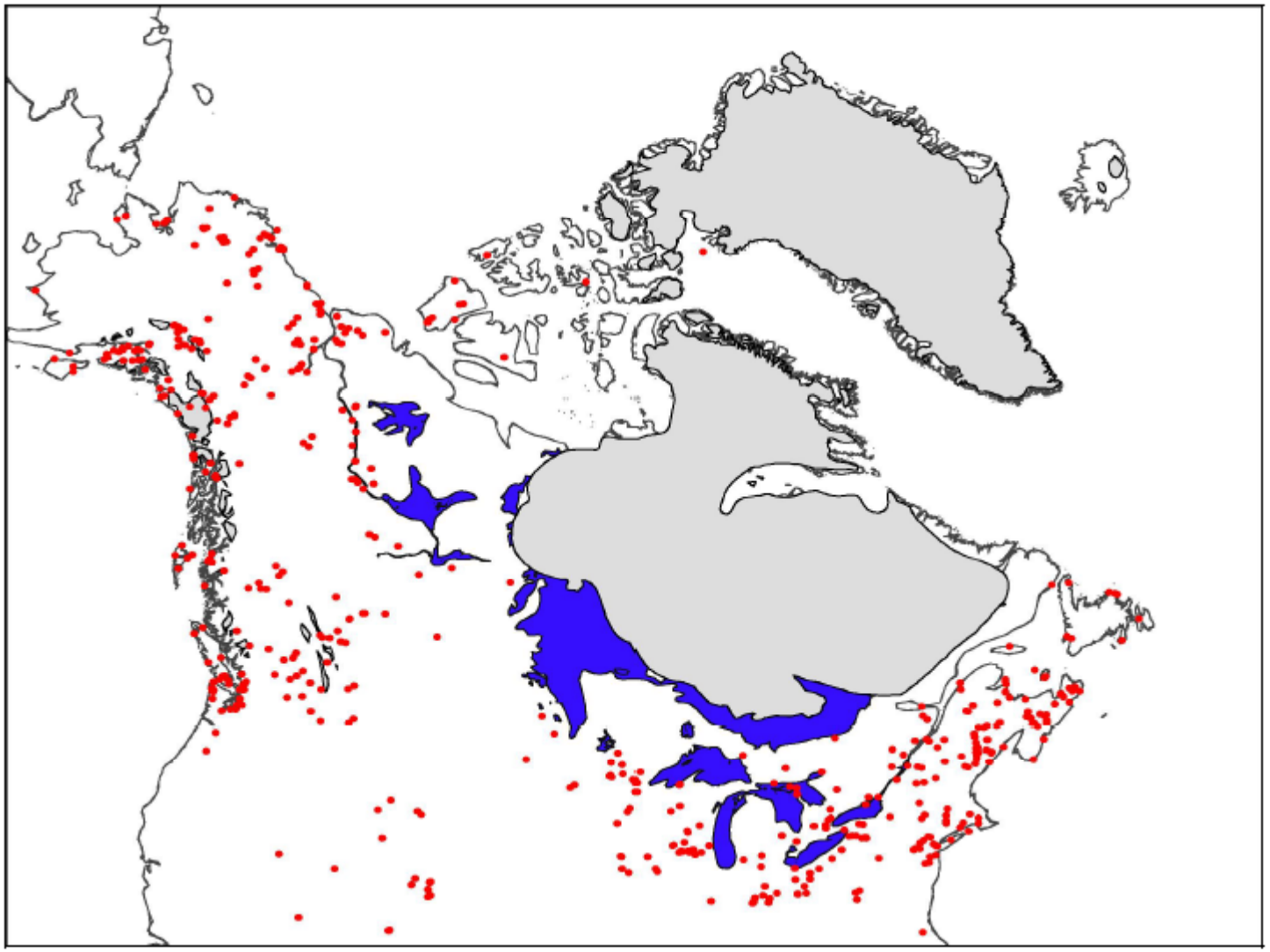
Developing Peatlands



Sample peatlands initiated as of 12,000 BP

Slide by Clarence Lehman, University of Minnesota

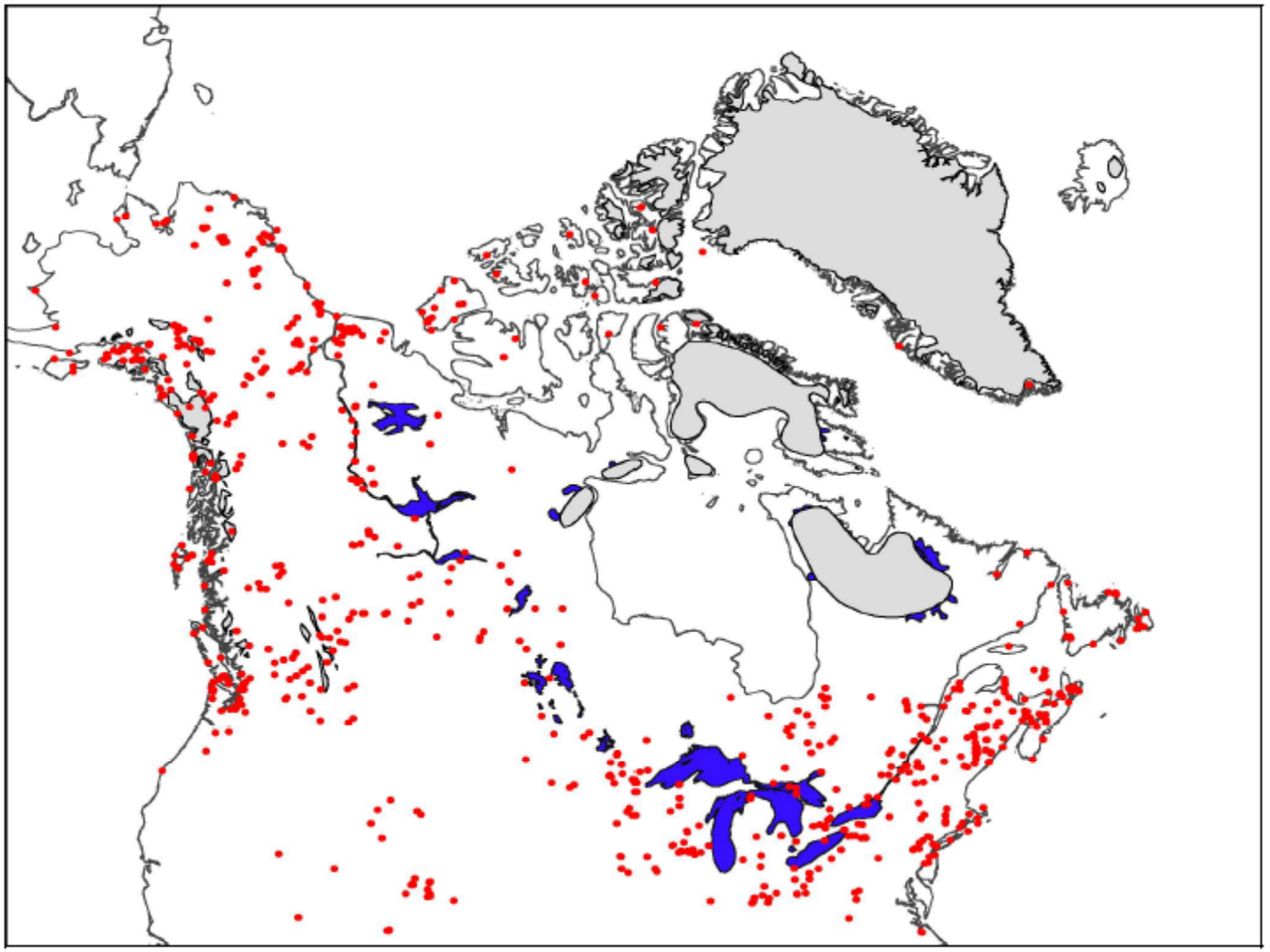
Developing Peatlands



Sample peatlands initiated as of 8,900 BP

Slide by Clarence Lehman, University of Minnesota

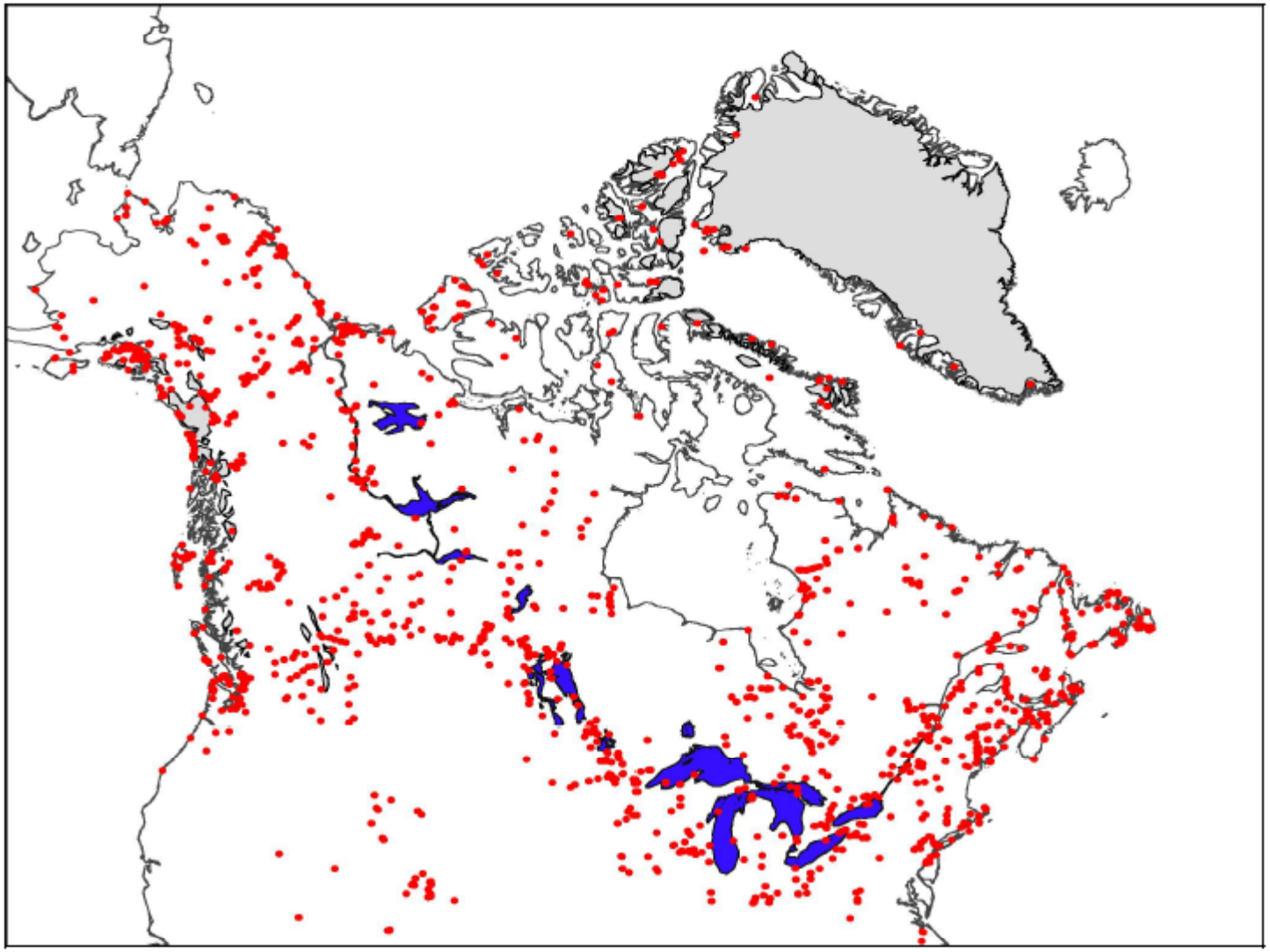
Developing Peatlands



Sample peatlands initiated as of 7,400 BP

Slide by Clarence Lehman, University of Minnesota

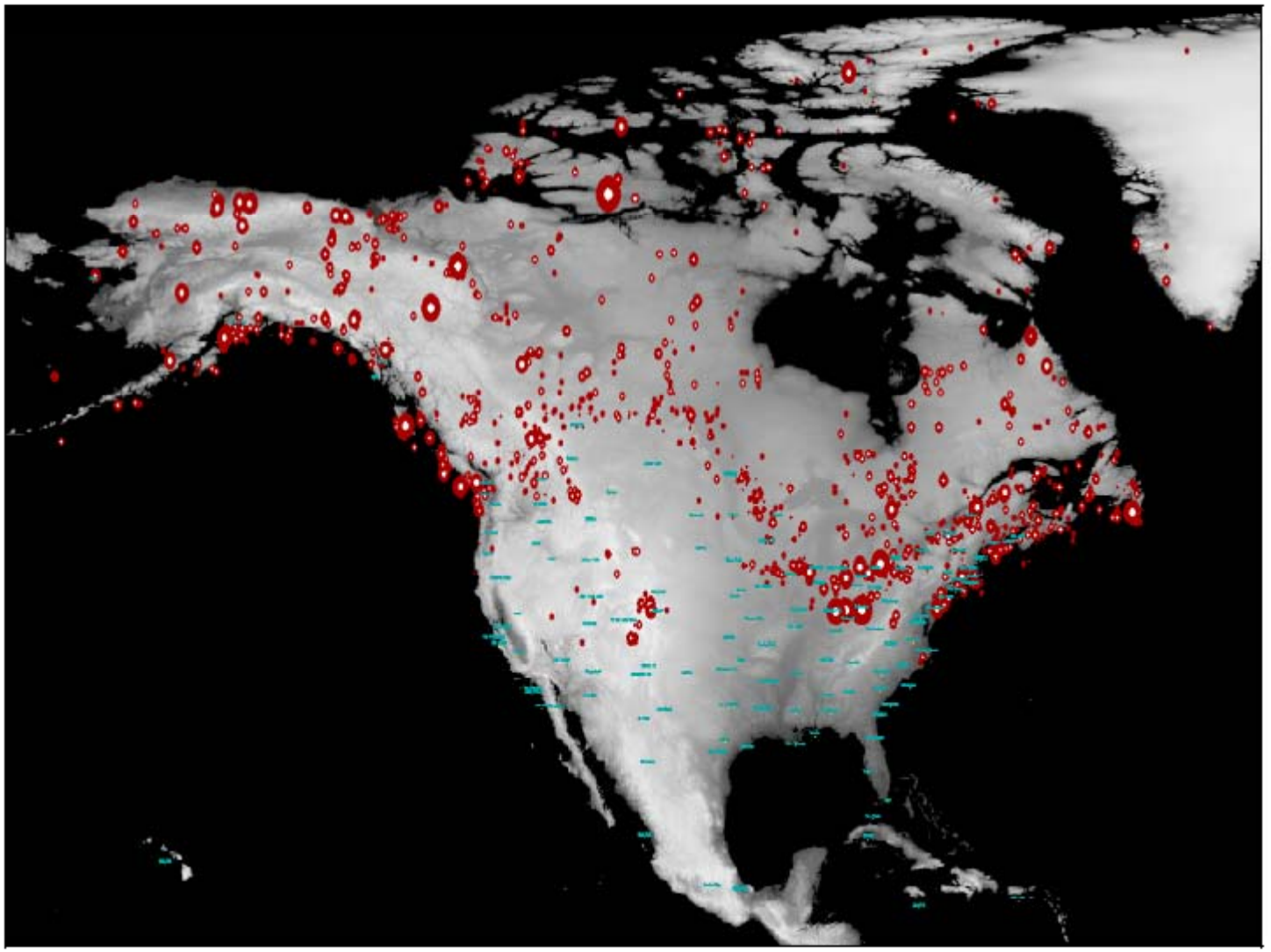
Developing Peatlands



Sample peatlands initiated at present

Slide by Clarence Lehman, University of Minnesota

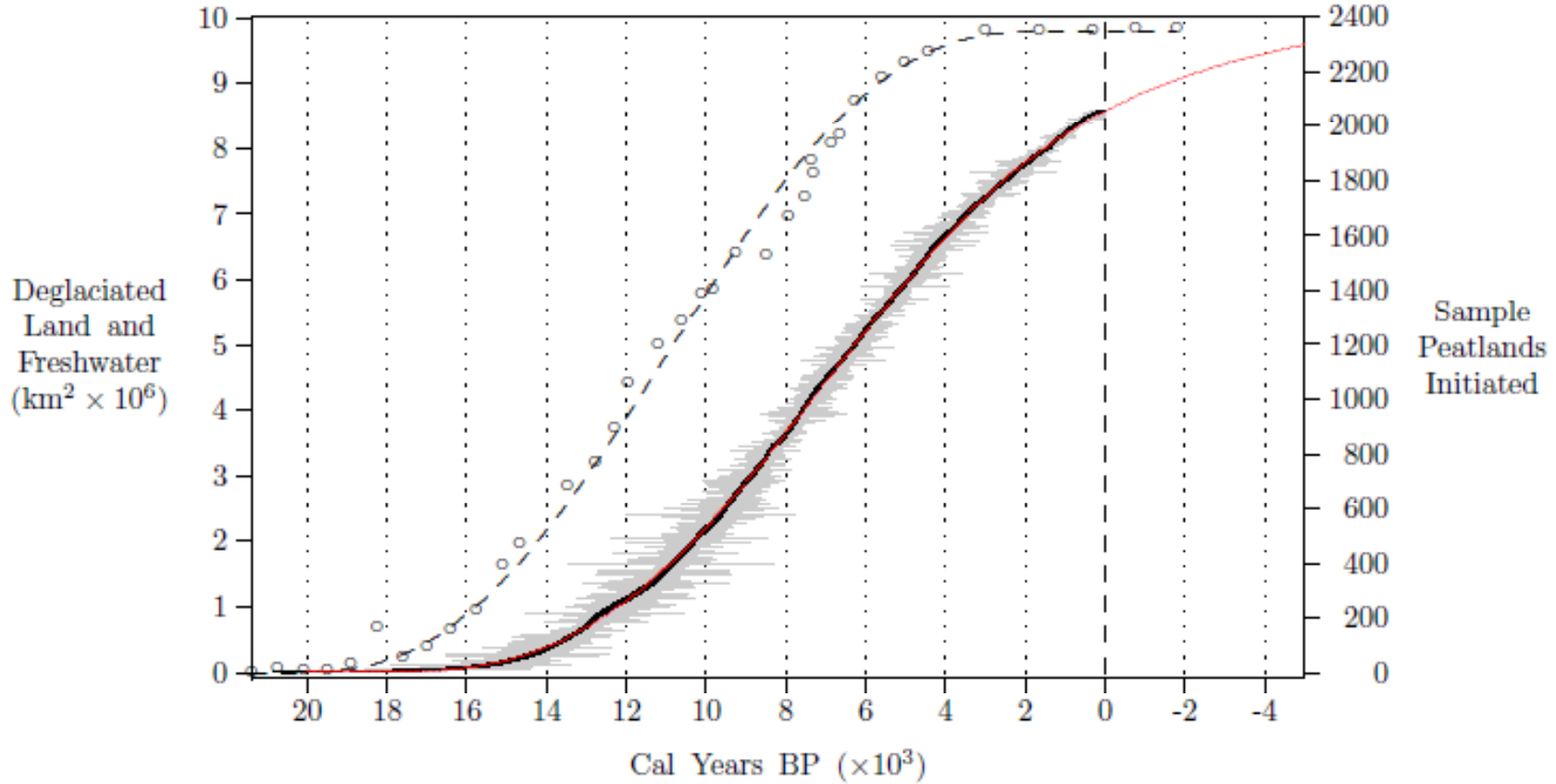
Developing Peatlands



NAmap.png

Slide by Clarence Lehman, University of Minnesota

Developing Peatlands



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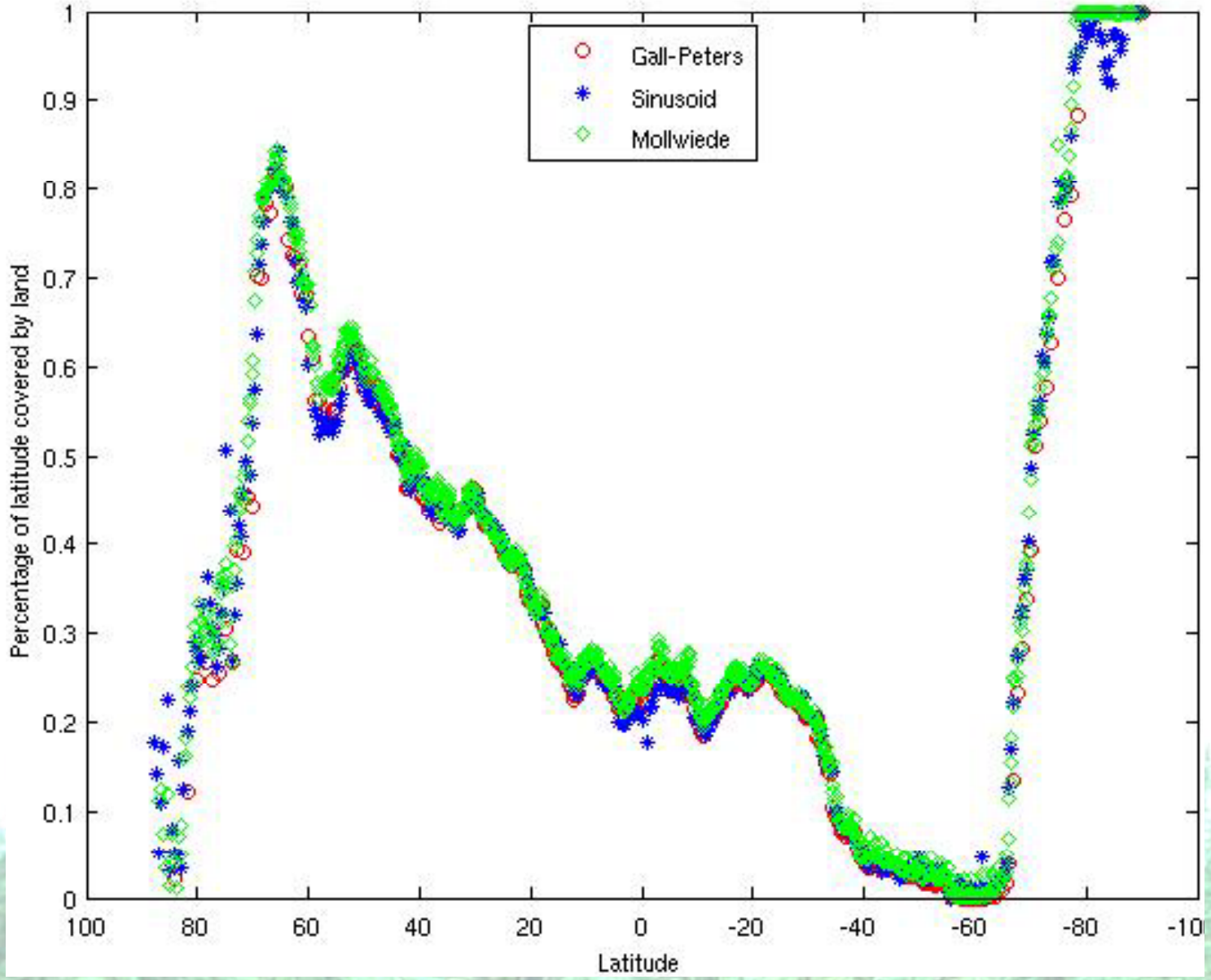
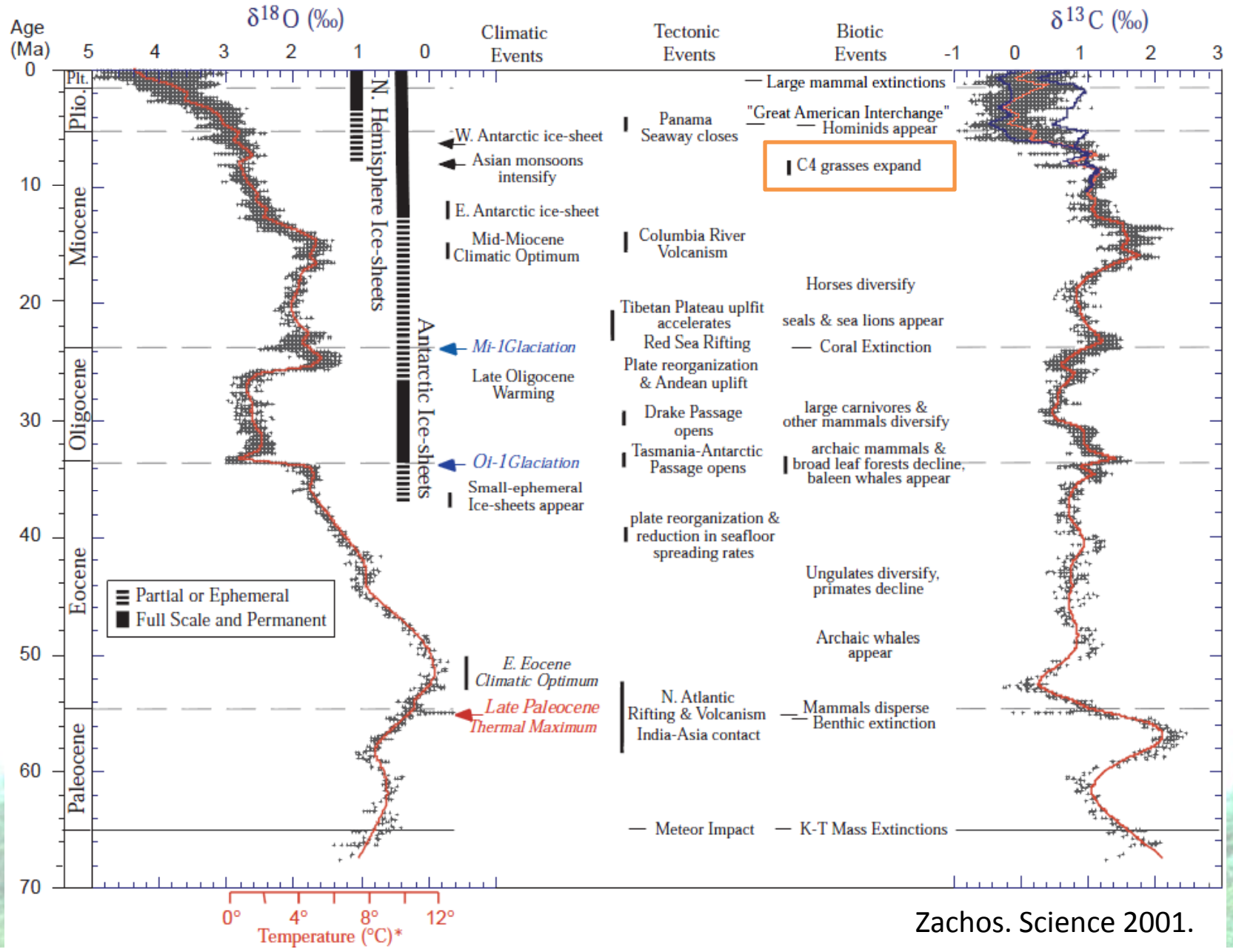
Terrestrial CO_2 has an impact



Oestreicher 2010

Terrestrial Effects?



Zachos. Science 2001.

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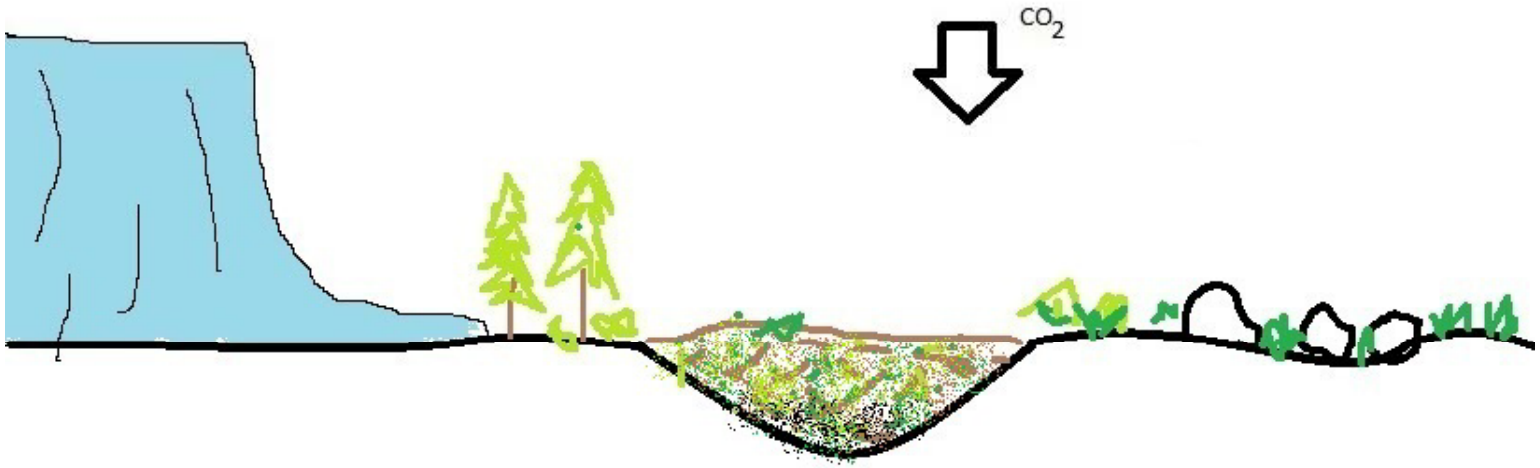
Glacial Cycle Proposal



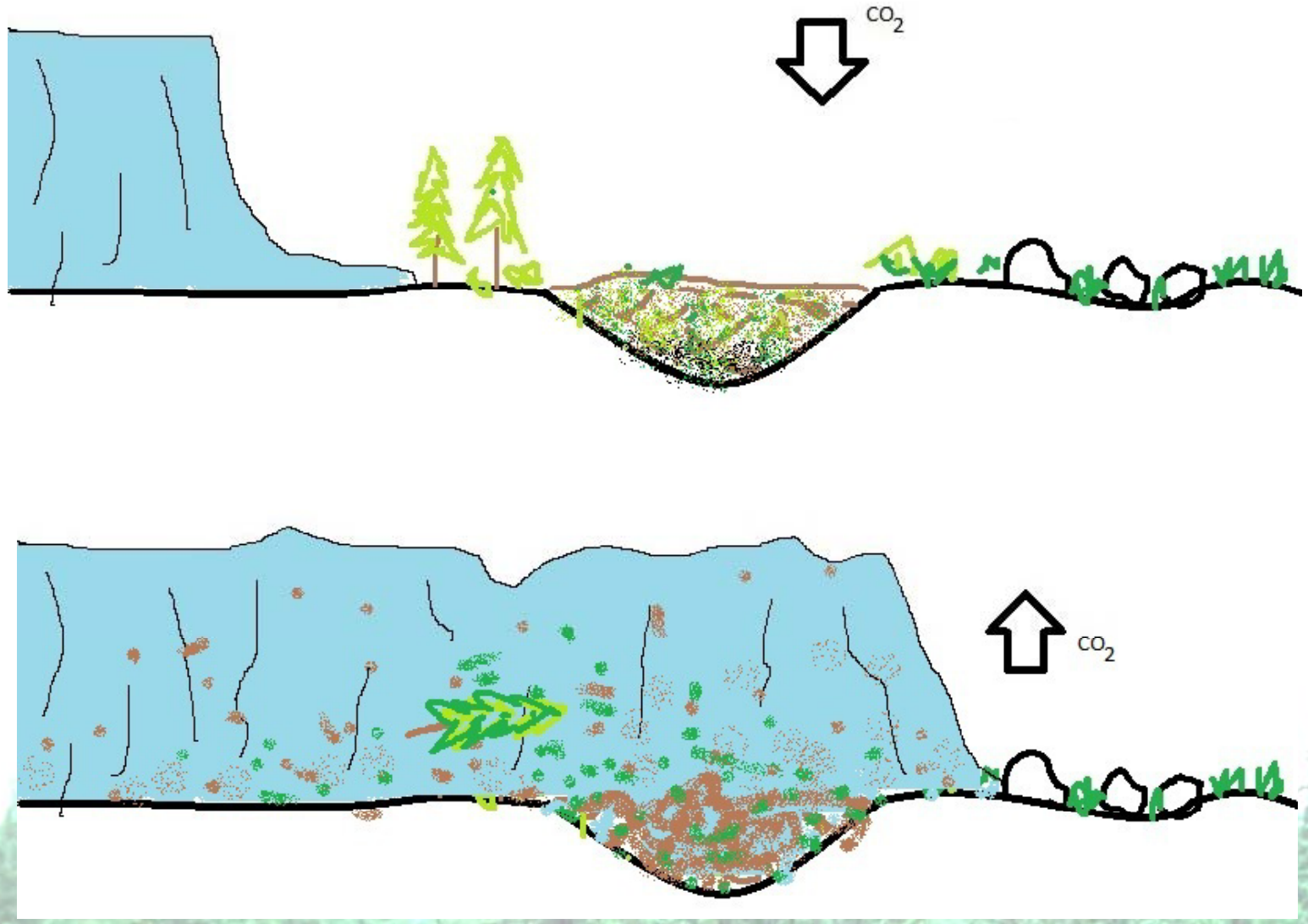
Then the glaciers begin to advance.

What happens to the forests and the peat?

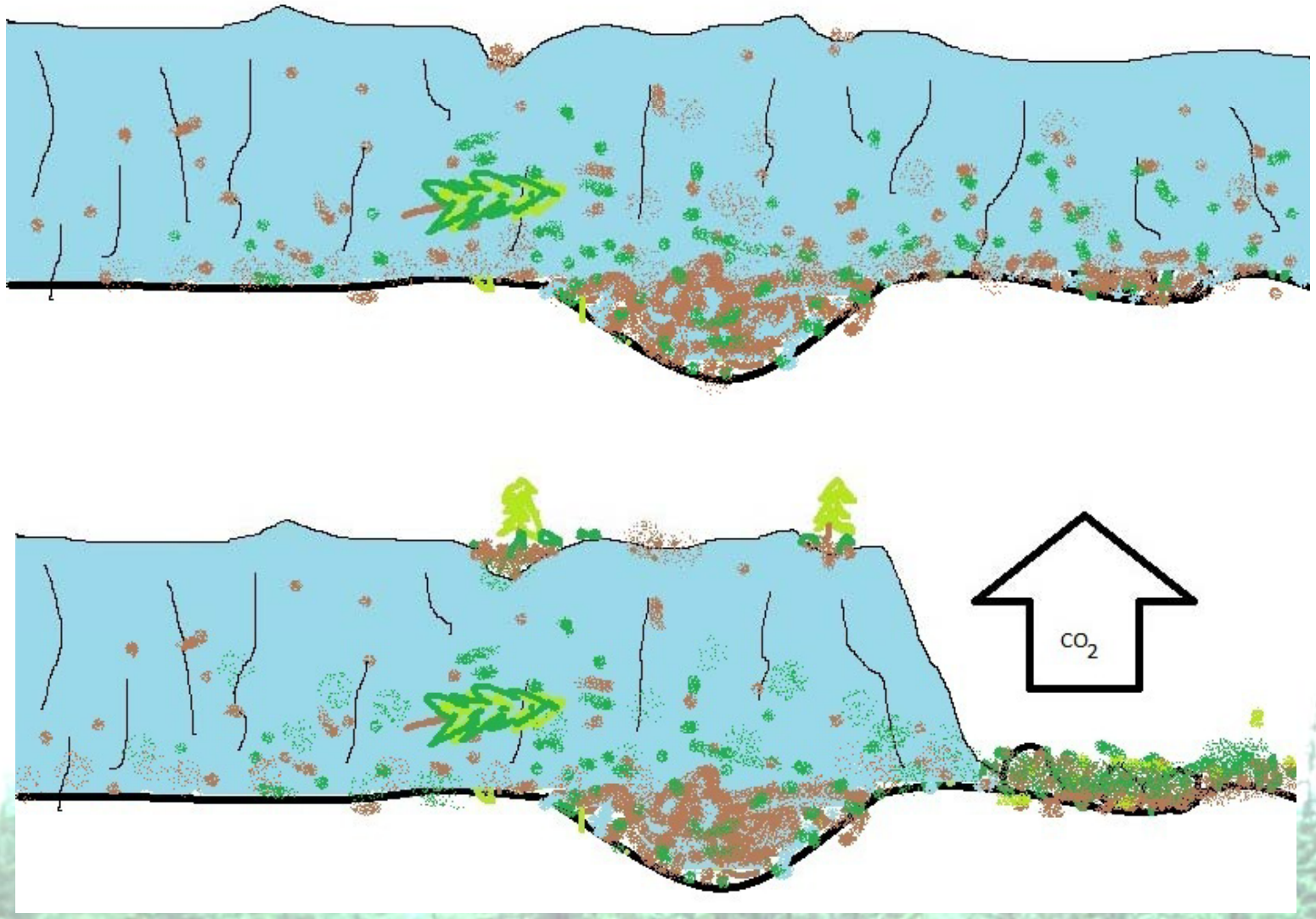
Glacial Cycle Proposal: Bulldozer or Snowpile?

Zeng 2003, Zeng 2007

Glacial Cycle Proposal



Glacial Cycle Proposal



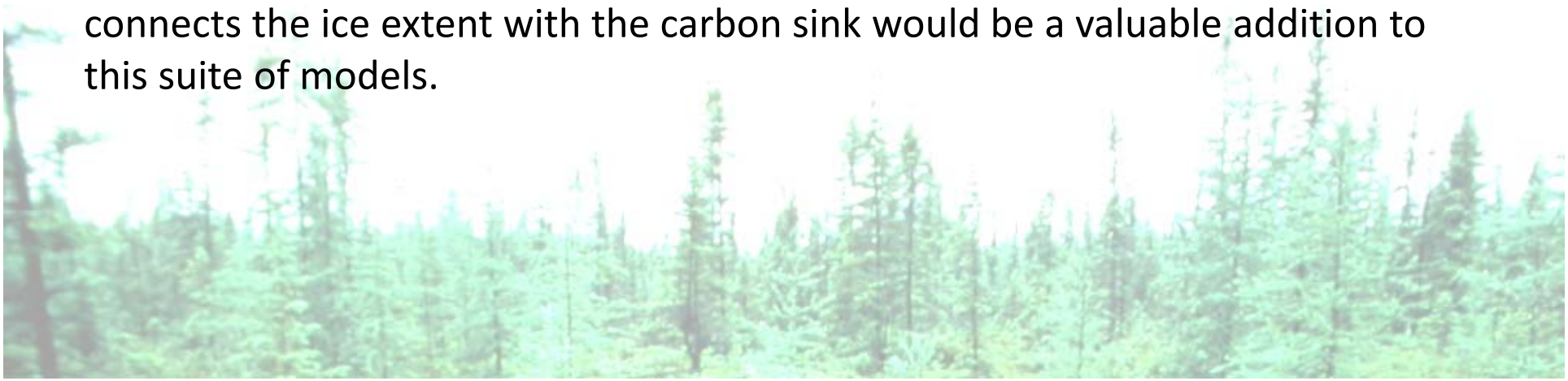
Glacial Cycle Proposal: Some Remarks

- Hogg's theory of a finite reservoir of carbon connects well to this theory.

- Every model with a dynamic carbon equation shows oscillation without the presence of Milankovitch forcing.

- Archer suggests that we do not have a complete understanding off all the processes to account for the rise and fall of atmospheric carbon. Perhaps this is part of the solution.

- No one has yet considered the implication of the terrestrially stored carbon with a simple dynamic model. (except PaleoCarbon!) Crafting a model which connects the ice extent with the carbon sink would be a valuable addition to this suite of models.



Glacial Cycle Proposal: A Model

I'm using the following system of equations

$$\frac{dT}{dt} = \left(\frac{k}{R}\right)(Q(1-a_0) - A - (B+H)T + H\overline{T})$$

$$\frac{d\eta}{dt} = \epsilon k(T - T_c)$$

$$\frac{dC}{dt} = k_3\overline{T} + k_0 + k_1\eta + k_2 C + h_\beta(e^{\frac{d\eta}{dt}} - .96)$$

Where

T = temperature.

η = ice line (1 is at the north pole, 0 is at the equator).

C = atmospheric CO_2 in ppm.

$k = 60 * 60 * 24 * 365$ is the seconds per year.

$R = 1.7e11$ is the Joules per m^2 per deg C.

Q = solar insolation.

$\overline{T}$ = the average global temperature.

$T_c = -10^oC$ the degree at which sea water freezes.

$a_0 = 0.5(0.32 + 0.62)$, the average of the ice free and ice covered ocean albedo.

$h_\beta = 0.5$, $k_0 = 0.12$, $k_1 = -0.1204$, $k_2 = 0.000084$, $k_3 = -1 \times 10^{-3}$.

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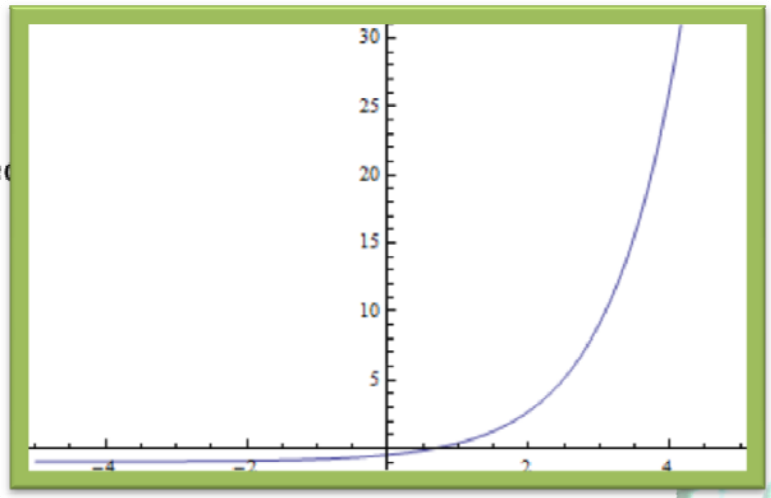

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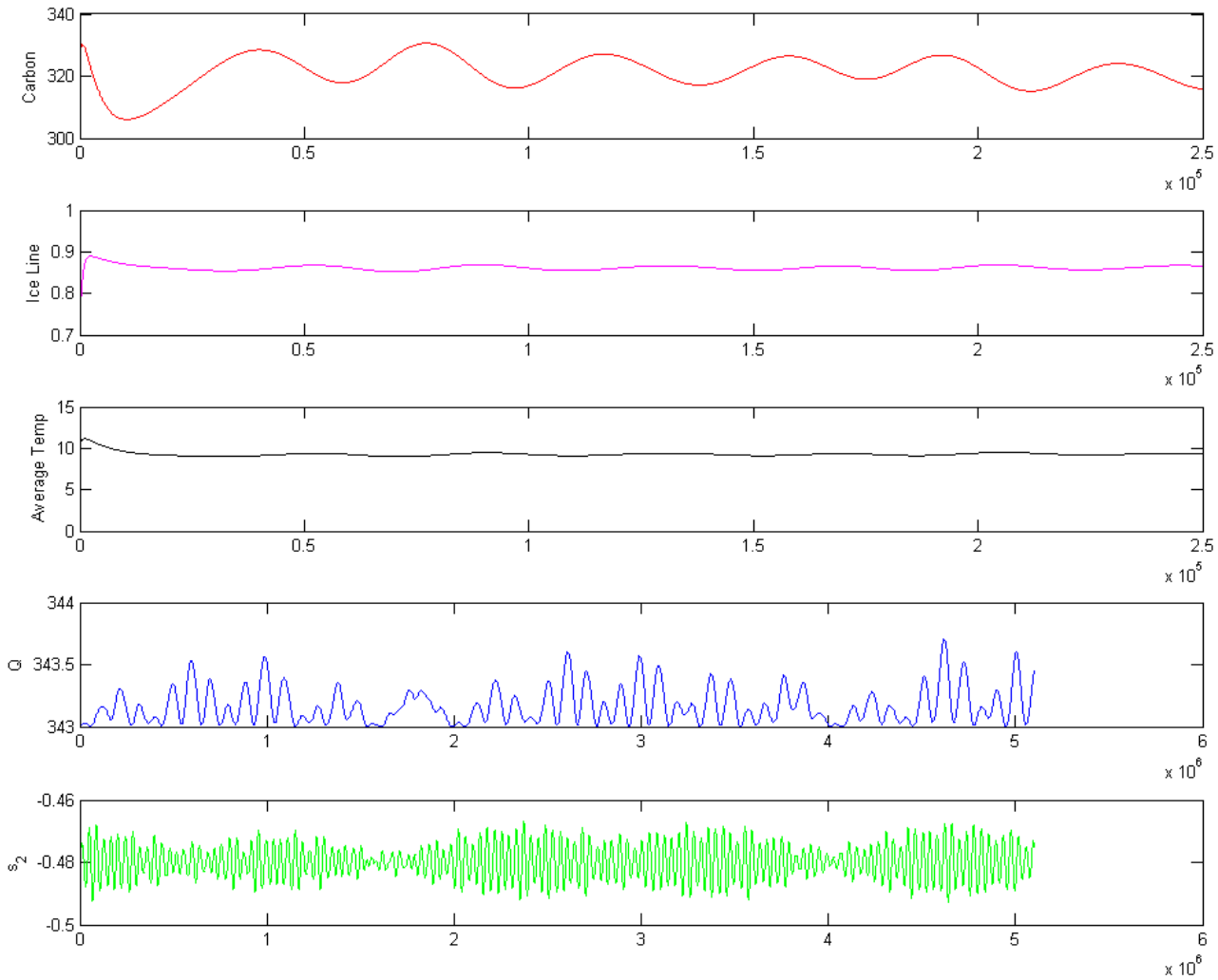

References

Keller, Jason K, Jeffrey R White, Scott D. Bridgham, John Pastors. *"Climate change effects on carbon and nitrogen mineralization in peatlands through changes in soil quality."* Global Change Biology. 2004. 1053-1064. Print.

Lehman, Clarence *"Carbon Sequestration in North American Peatlands"* Climate Change Seminar, Department of Mathematics, University of Minnesota, Minneapolis. 17 Feb 2010. Presentation.

McAuliffe, Bill "*Minnesota's peat bogs 'wild card' in global warming*" StarTribune.com. 2009. Print.

Wright, H.E. Jr, Barbara Coffin, and Norman Aaseng. The Patterned Peatlands of Minnesota. University of Minnesota Press, 1992. Print.