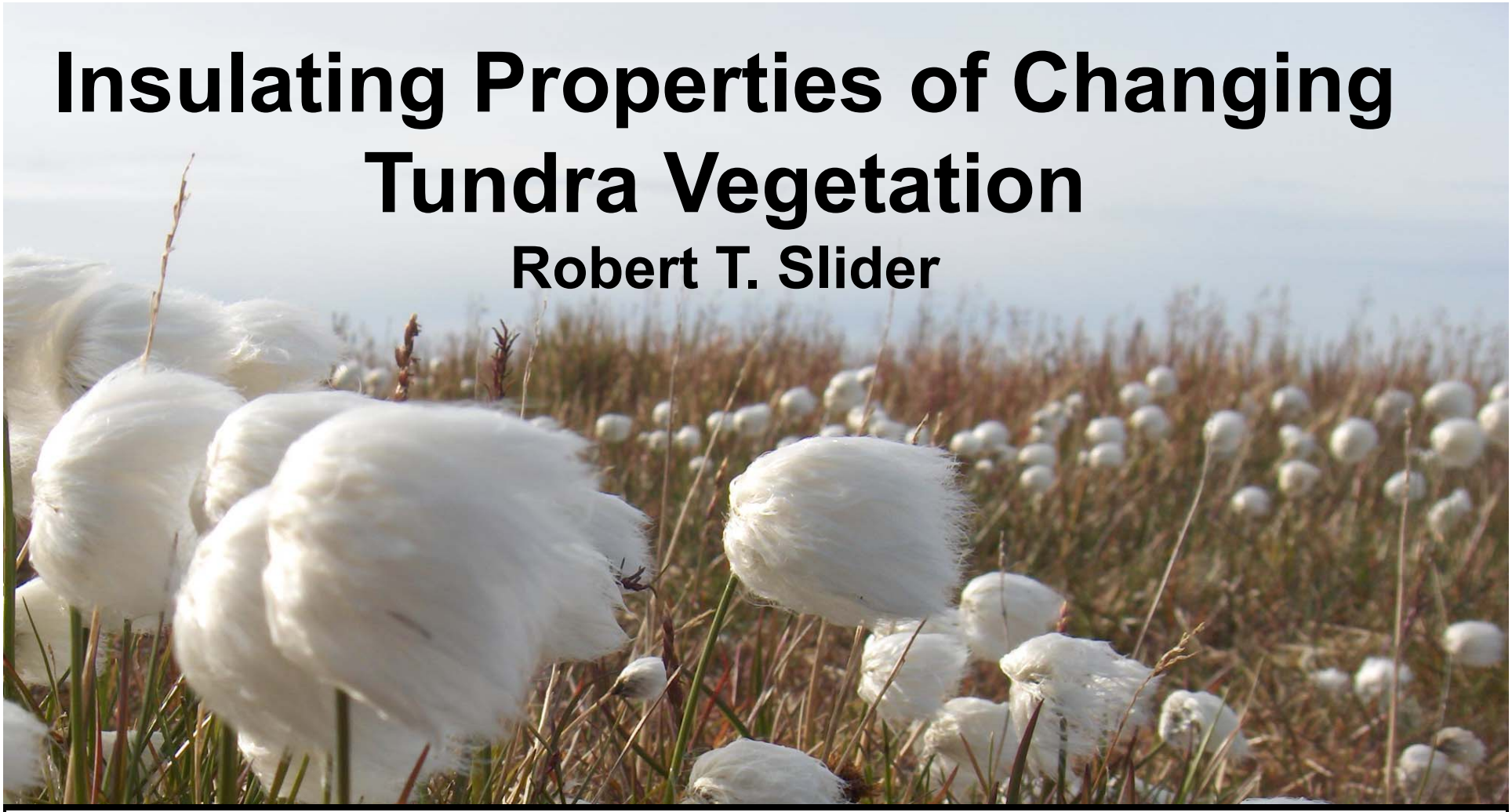
Insulating Properties of Changing Tundra Vegetation

Robert T. Slider



ITEX

ARCTIC ECOLOGY

GRAND VALLEY STATE UNIVERSITY

NATIONAL SCIENCE FOUNDATION

Climate Change & The Arctic

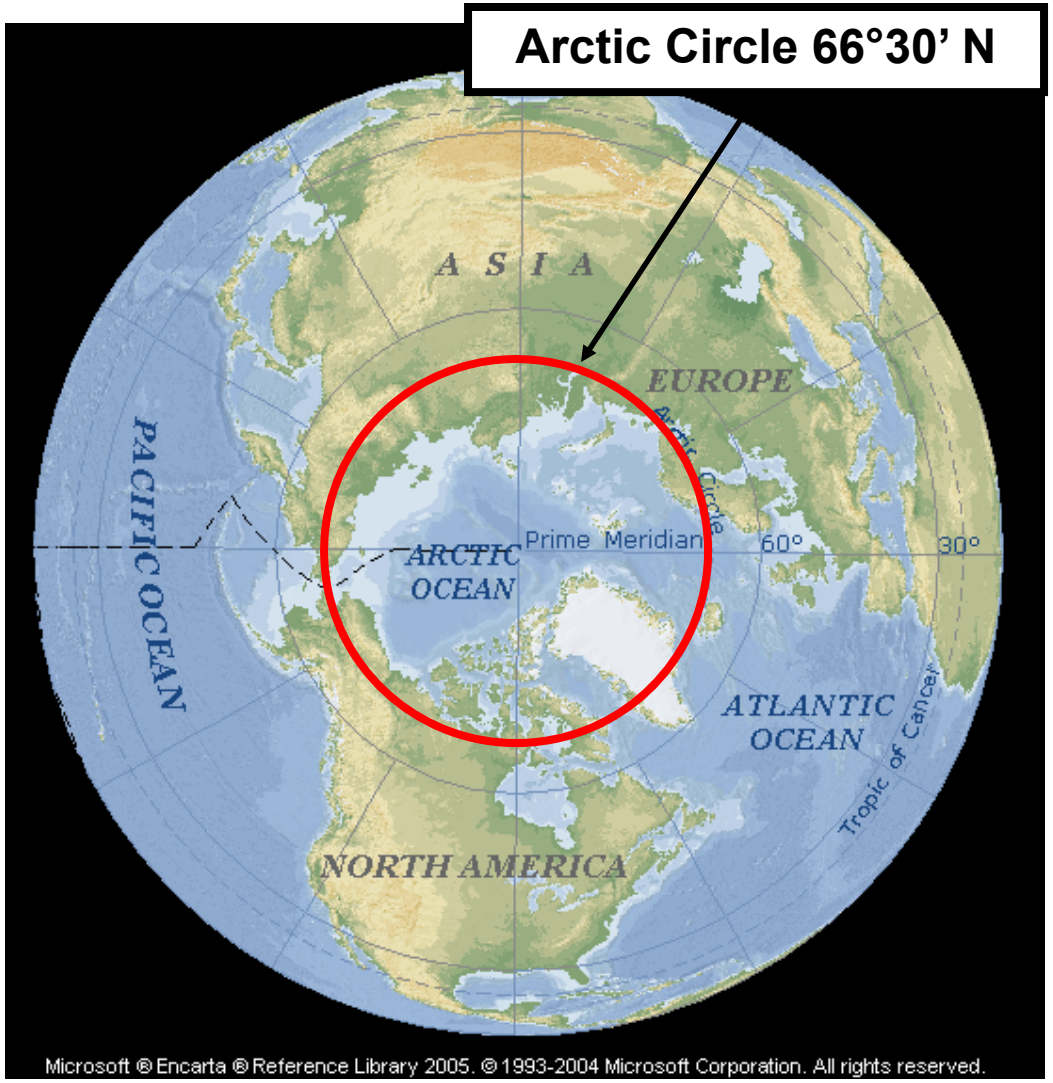
IPCC Report (2006)

-Arctic is greatly susceptible to change in climate

-Temperatures have increased and will continue to increase more in the arctic than in other regions

-Organisms adapted to cold face new competitors, diseases, parasites etc.

-Release of carbon from thawing tundra

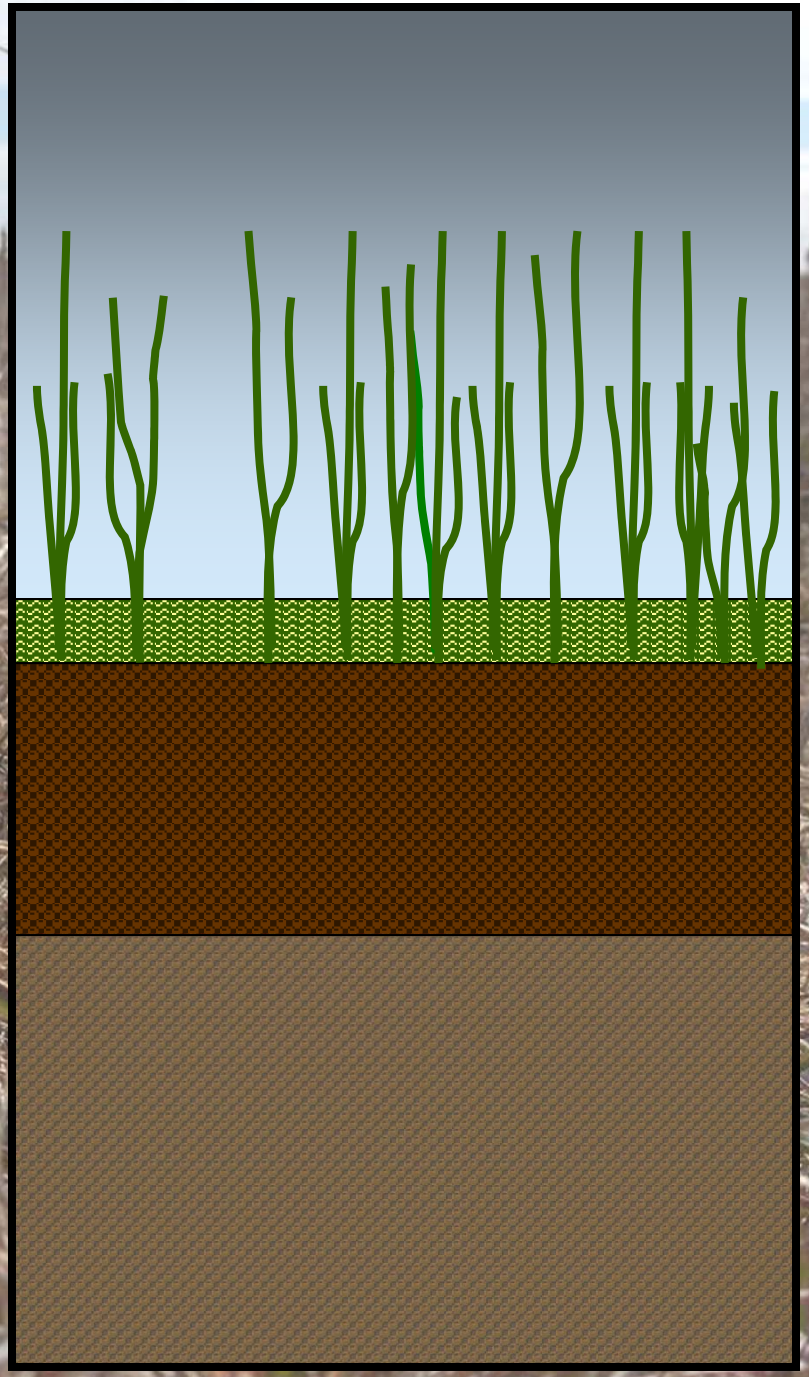


Tundra Cross Section

Vegetation Layer
(Mosses, Grasses, and Other Plants)

Active Layer
(Thawed soil)

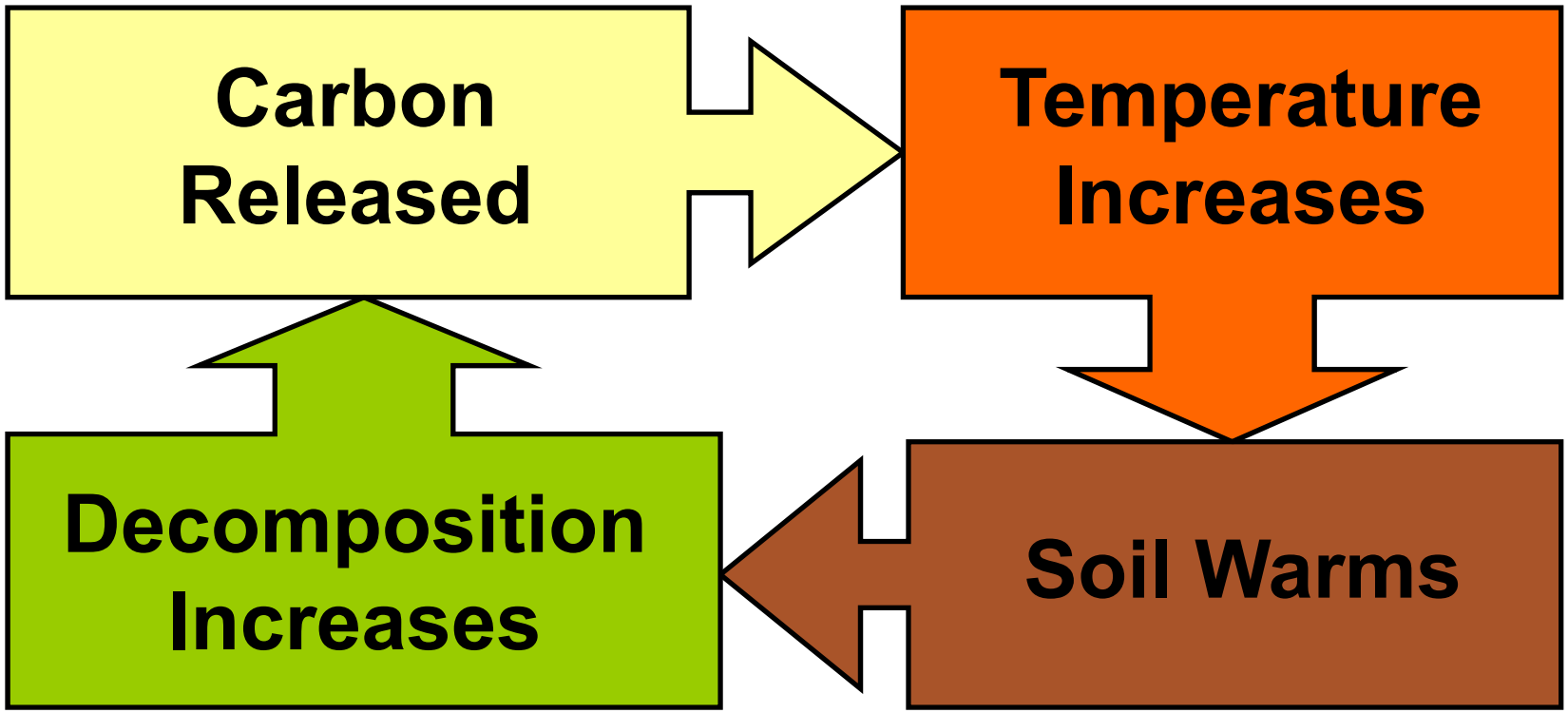
Permafrost
(Permanently frozen soil)



Implications of Change

Melting of Permafrost and Increase in Active Layer Depth

Generation of a Positive Feedback System



Light Exposure

Active Layer Depth

Arctic Plant

Limitations

Temperature

Nutrient Availability

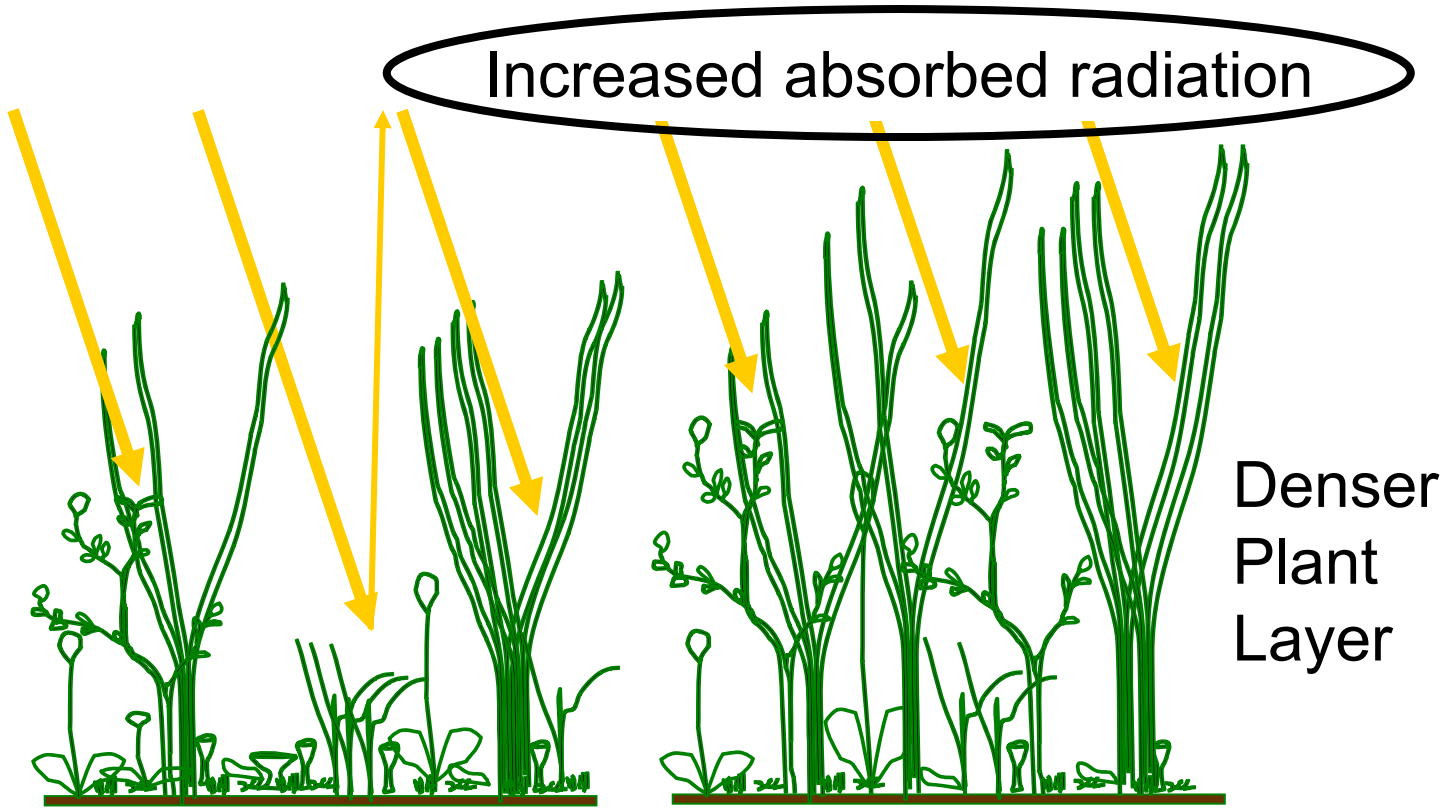
Plants, Soil, and Temperature

Changes & Interactions in the Arctic

Under simulated warming conditions we see an increase in vegetation cover (Walker et al. 2005)

Effects of Change

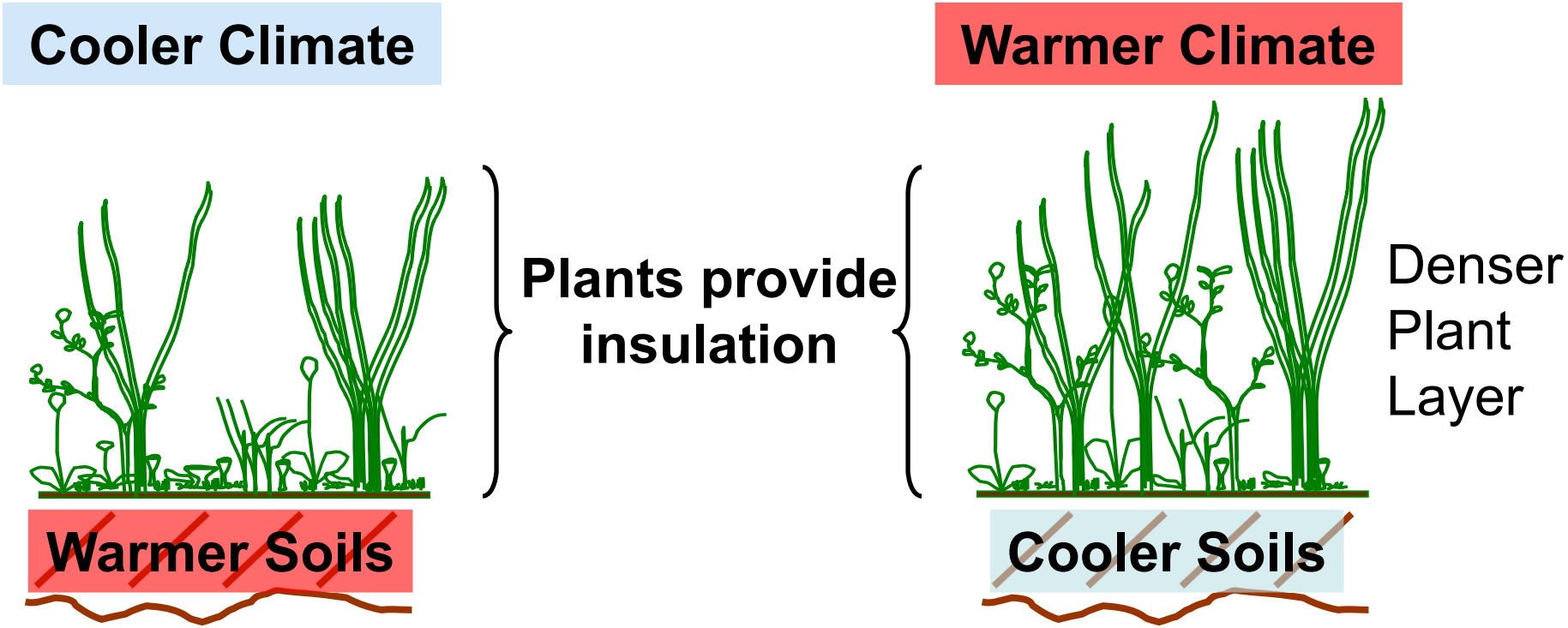
Less Albedo → Higher Temperatures



Plants, Soil, and Temperature

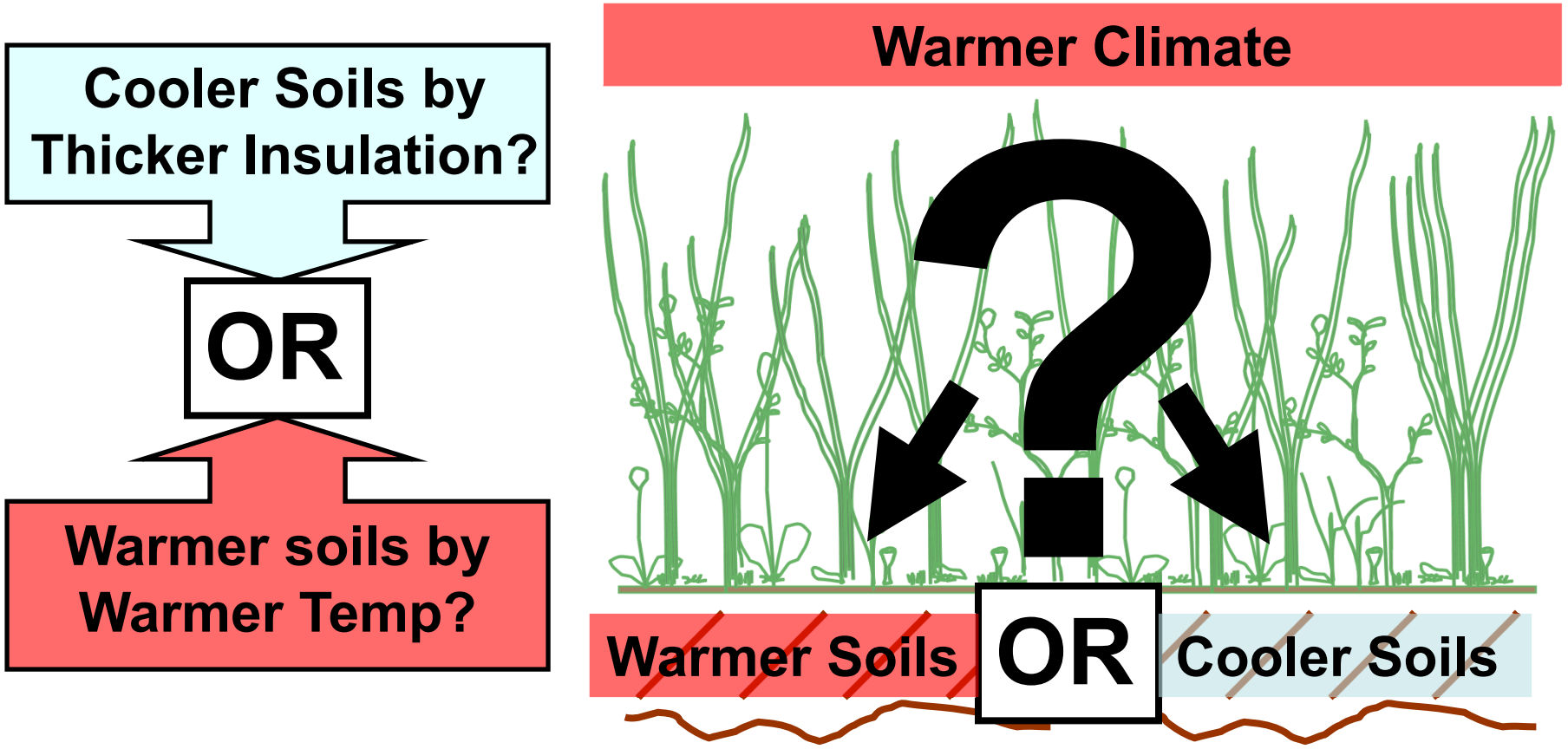
Changes & Interactions in the Arctic

In 2006 Hollister et al. suggested that an increase in cover may yield a greater amount of thermal resistance



The Big Question

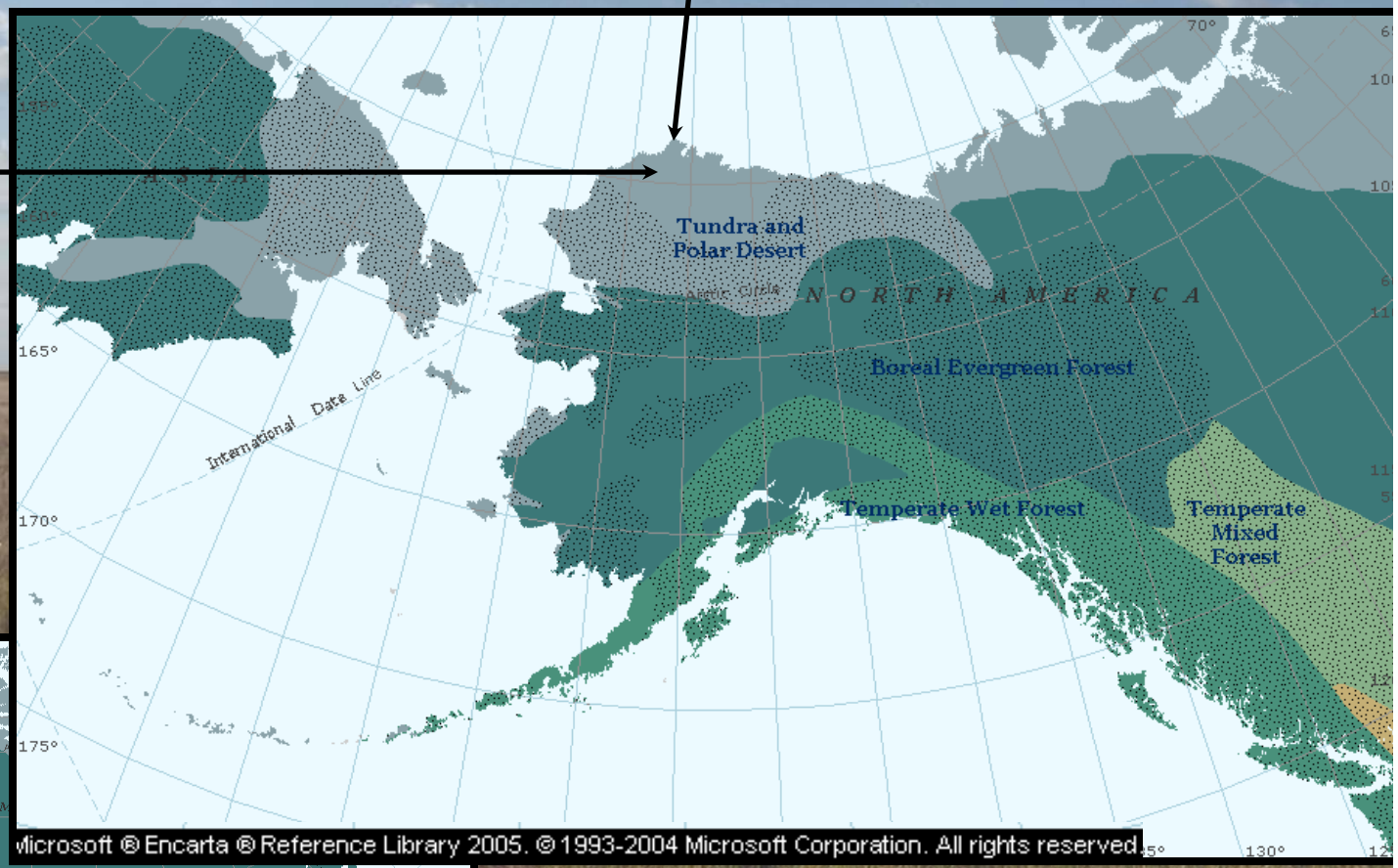
How does vegetation influence soil temperature in this system?

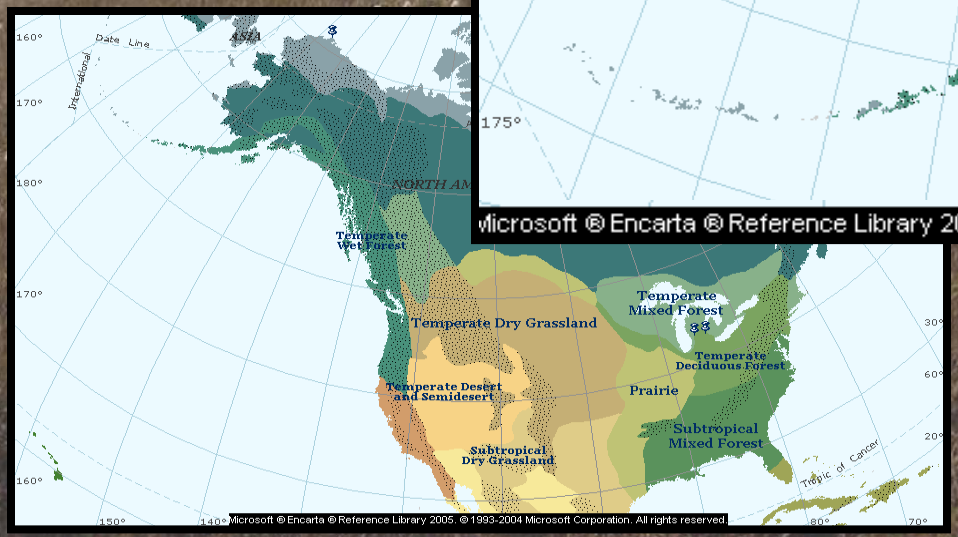


Study Sites

Barrow 71°18'N
156°40'W

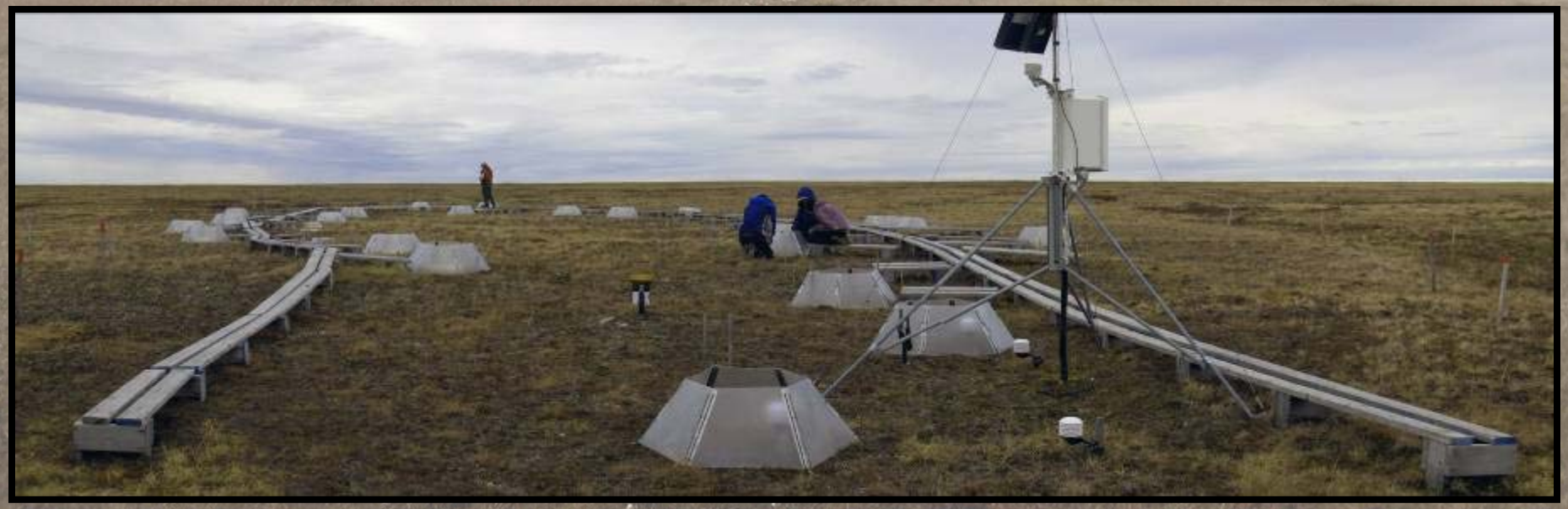
Atqasuk
70°29'N
157°25'W





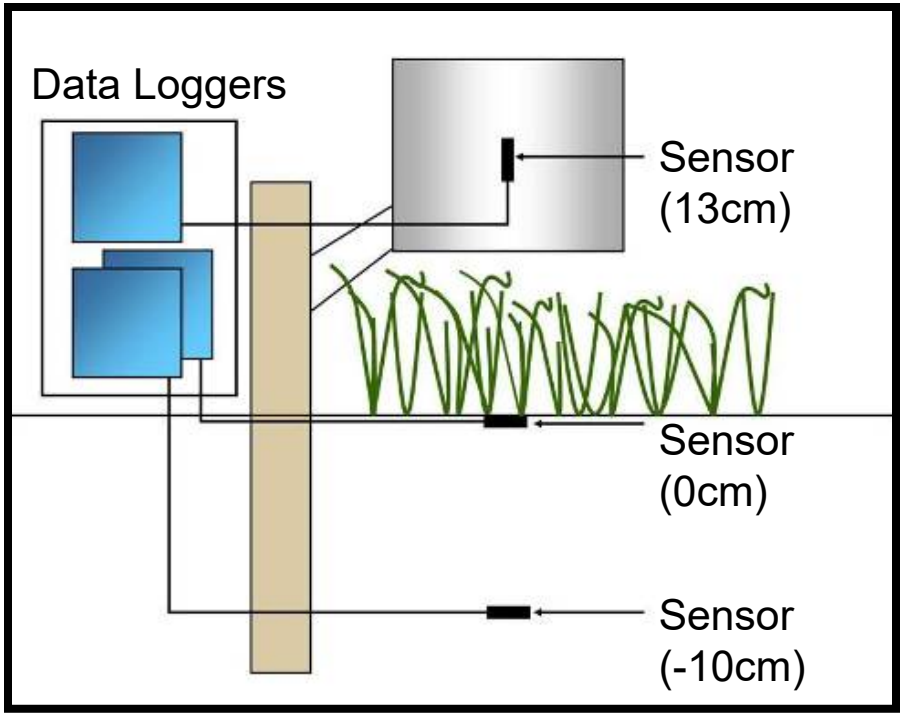
The Study

- Used Open Top Chambers (OTC's) to warm 1m^2 plots
- Plots from an ongoing study (OTC's & Control)
- Two new treatments were introduced



New Treatments

Temp. probes at 13cm, 0cm, and -10cm

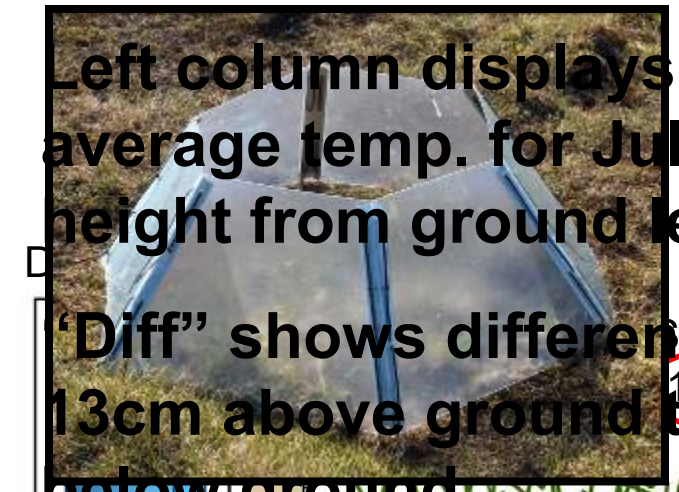


Vegetation <u>added</u> or <u>removed</u> in 10cm diameter

Findings and Discussion

Table Layout

"Warmed" are plots with OTC's on them



Left column displays average temp. for July at height from ground level

"Diff" shows difference from 13cm above ground to 10cm below ground

Separated by study site

	Control	Warmed		
		Bare	Added	9 Years
	Atqasuk Dry Heath (AD)			
13	12.5	13.4	14.3	14.9
0	14.4	12.8	11.1	15.6
-10	8.9	9.8	8.9	9.8
Diff	3.5	3.6	5.4	5.1
	Atqasuk Wet Meadow (AW)			
13	12.8	10.1	13.4	14.2
0	12.8	6.7	7.2	11.1
-10	6.3	4.5	3.8	4.9
Diff	6.5	5.6	9.7	9.3
	Barrow Dry Heath (BD)			
13	6.8	8.6	8.4	9.5
0	10.4	8.2	4.5	8.2
-10	5.4	5.4	3.1	5.2
Diff	1.4	3.2	4.7	4.3
	Barrow Wet Meadow (BW)			
13	6.8	8.9	9.7	11.0
0	---	10.3	4.6	11.5
-10	---	3.7	3.0	4.4
Diff	---	5.3	6.7	6.6

--- no data due to instrument malfunction

Temperature (°C) at height/depth (cm) from ground by site and treatment

Findings and Discussion

Active Layer

1) At -10cm Added treatments were cooler than Bare

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Temperature (°C) at height/depth (cm) from ground by site and treatment

Findings and Discussion

Active Layer

1) At -10cm Added treatments were cooler than Bare

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3) 9 Years and Added showed similar temperature differences

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Temperature (°C) at height/depth (cm) from ground by site and treatment

Findings and Discussion

Active Layer

1) At -10cm Added treatments were cooler than Bare

2) Greatest difference in temp. from 13cm to -10cm was seen in Added treatments

3) 9 Years and Added showed similar temperature differences

4) Thicker vegetation did not always lead to cooler temperatures at -10cm

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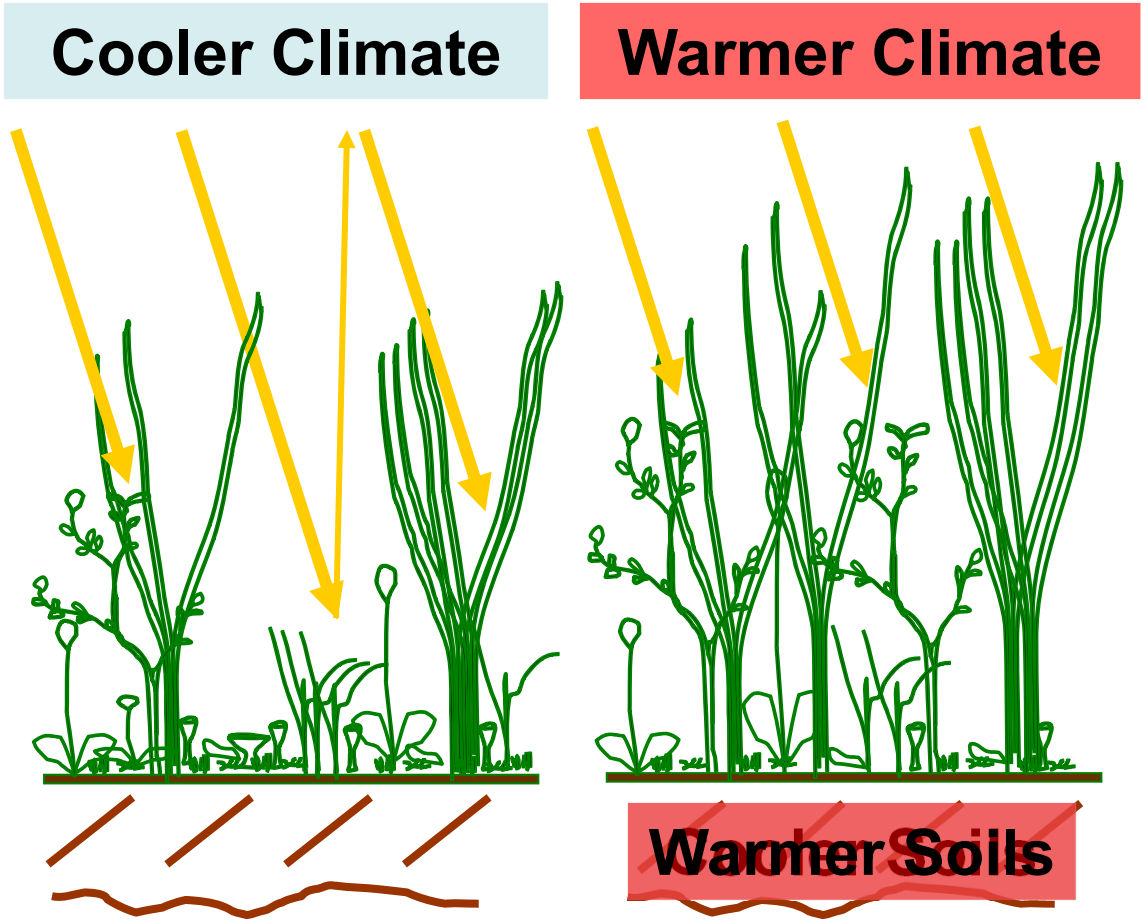
Temperature (°C) at height/depth (cm) from ground by site and treatment

How does vegetation influence soil temperature in this system?

1) At -10cm Added treatments were cooler than Bare	**Plants have the ability to cool the soils**
2) Greatest difference in temp. from 13cm to -10cm was seen in Added treatments	**More vegetation yields greater amount of insulation**
3) 9 Years and Added showed similar temperature differences	**Added treatment is analogous to predicted changes**
4) Thicker vegetation did not always lead to cooler temperatures at -10cm	**Warmer air temp. may increase soil temp. despite insulation**

Predicted Changes Under Warmer Climate



- Warmer temp. will cause an increase in plant cover

-Denser plants will absorb more radiation and warm the air

-Increased cover will reduce heat transfer between air and soils

-Despite insulating effects we will likely see eventual increase in soil temp.

Acknowledgements

Organizations
- National Science Foundation (NSF)
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- International Tundra Experiment (ITEX)

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Jeremy May
Amanda Snyder

Questions?

Resources

- **Hollister, R.D., P.J. Webber, F.E. Nelson, C.E. Tweedie 2006. Soil thaw and temperature response to air warming varies by community: Results from an open-top chamber experiment in northern Alaska. *Arctic Antarctic and Alpine Research* 38: 206-215.**

- **Hollister, R.D., P.J. Webber, R.T. Slider, F.E. Nelson, C.E. Tweedie *2008. Soil Temperature and Thaw Response to Air Warming Varies with Changing Vegetation.**

- **IPCC (ed) 2007. *Climate Change 2007: The Scientific Basis. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press*. Cambridge, United Kingdom. 230 pp.**

- **Walker, M.D., C.H. Wahren, R.D. Hollister, G.H.R. Henry, L.E. Ahlquist, J.M. Alatalo, M.S. Bret-Harte, M.P. Calef, T.V. Callaghan, A.B. Carroll, H.E. Epstein, I.S. Jónsdóttir, J.A. Klein, B. Magnusson, U. Molau, S.F. Oberbauer, S.P. Rewa, C.H. Robinson, G.R. Shaver, K.N. Suding, C.C. Thompson, A. Tolvanen, Totland, P.L. Turner, C.E. Tweedie, P.J. Webber, P.A. Wookey 2006. Plant community responses to experimental warming across the tundra biome. *Proceedings of the National Academy of Sciences of the United States of America* 103: 1342-1346.**

***Publication accepted pending changes**