Effects of long term warming on vegetation in northern Alaska

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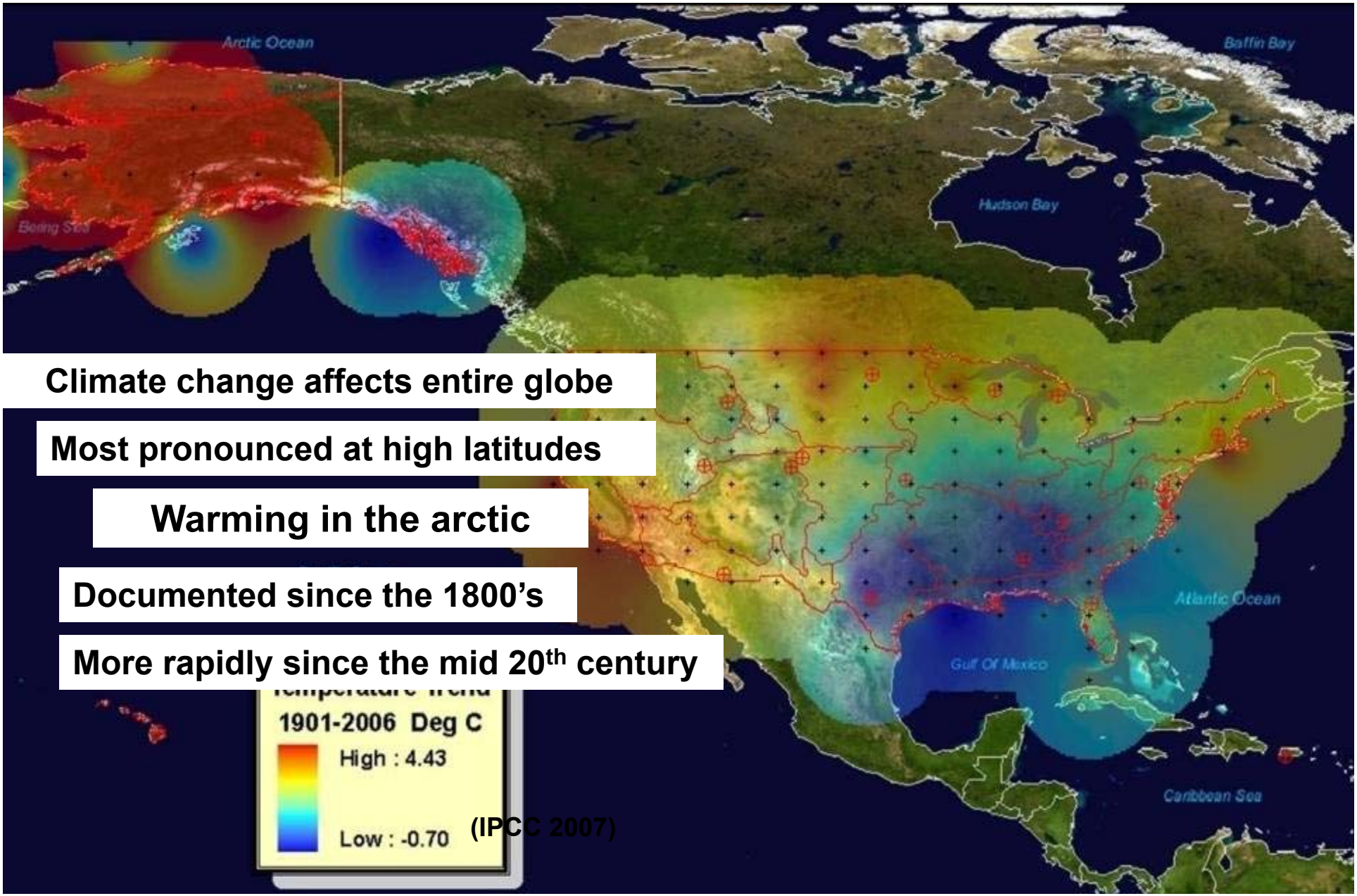
Climate Change and the Arctic



Climate change affects entire globe

Most pronounced at high latitudes

Warming in the arctic

Documented since the 1800's

More rapidly since the mid 20th century

(IPCC 2007)

Effects of Warming on Tundra Plants

Even small variations in the environment effect community function

Reproductive effort, growth rates, and nutrient cycling

(Chapin and Shaver, 1985)

Responses to warming are often within one growing season

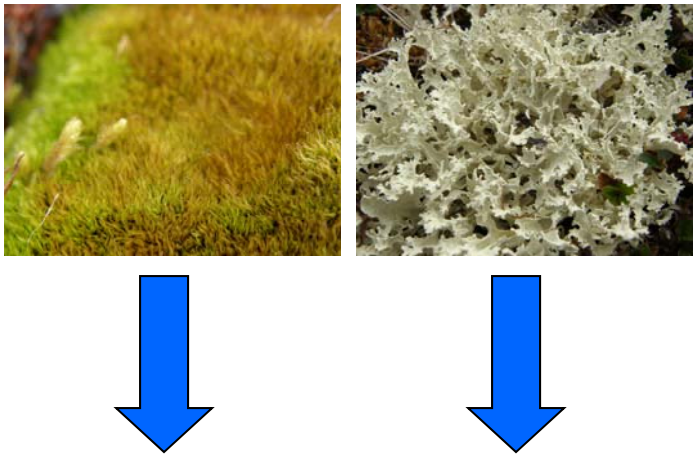
Graminoids and Shrubs often show the most increased growth

(Arft et al, 1999; Hobie and Chapin, 1998)

Increased growth of these taller plants shift competitive advantage

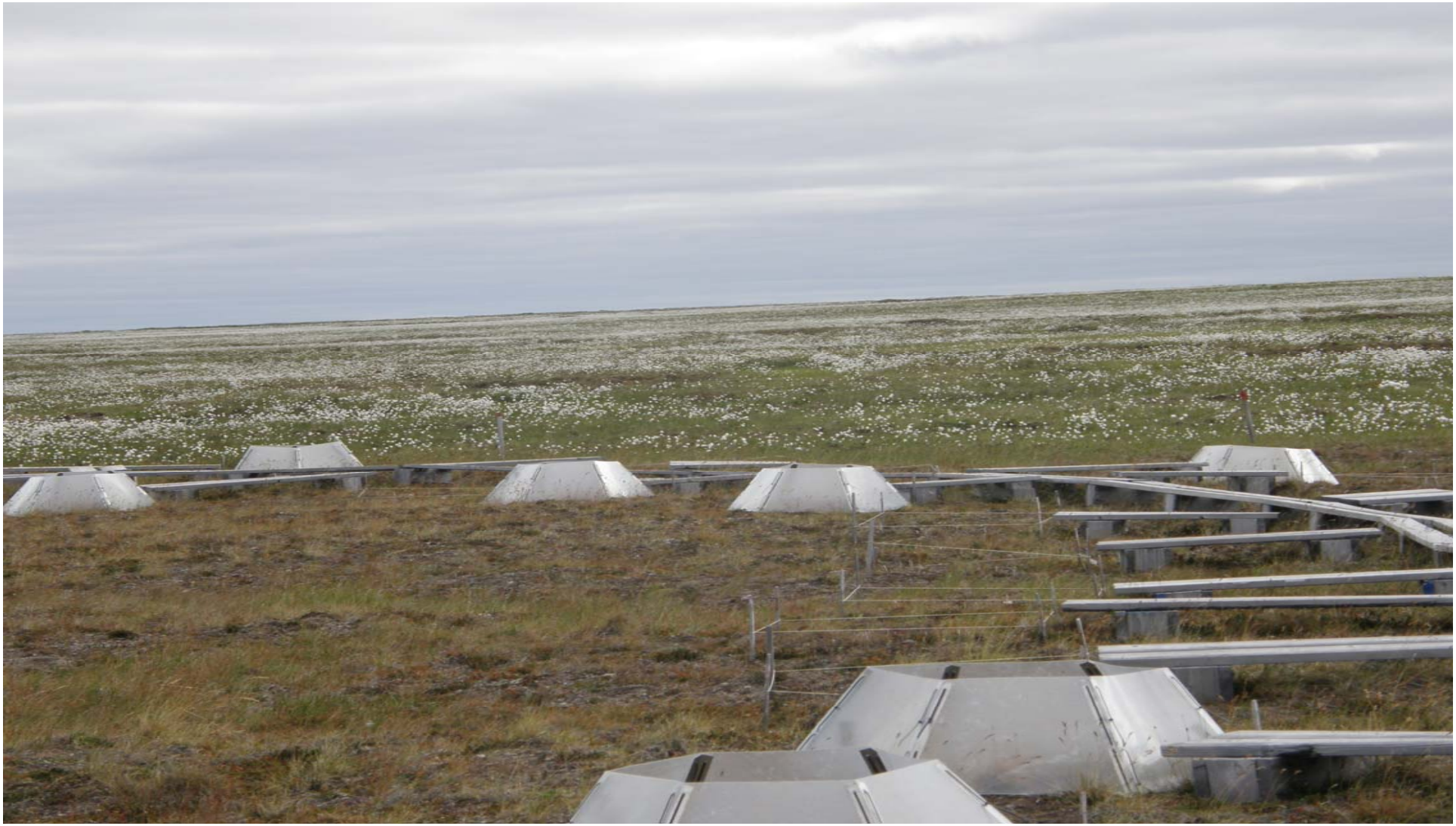
Bryophytes and lichens become light deficient and decline in abundance

(Epstein et al, 2004; Wahren et al 2004)



This Study

Investigated how 4 plant communities in Northern Alaska respond to experimental warming and between year variations



Hypotheses

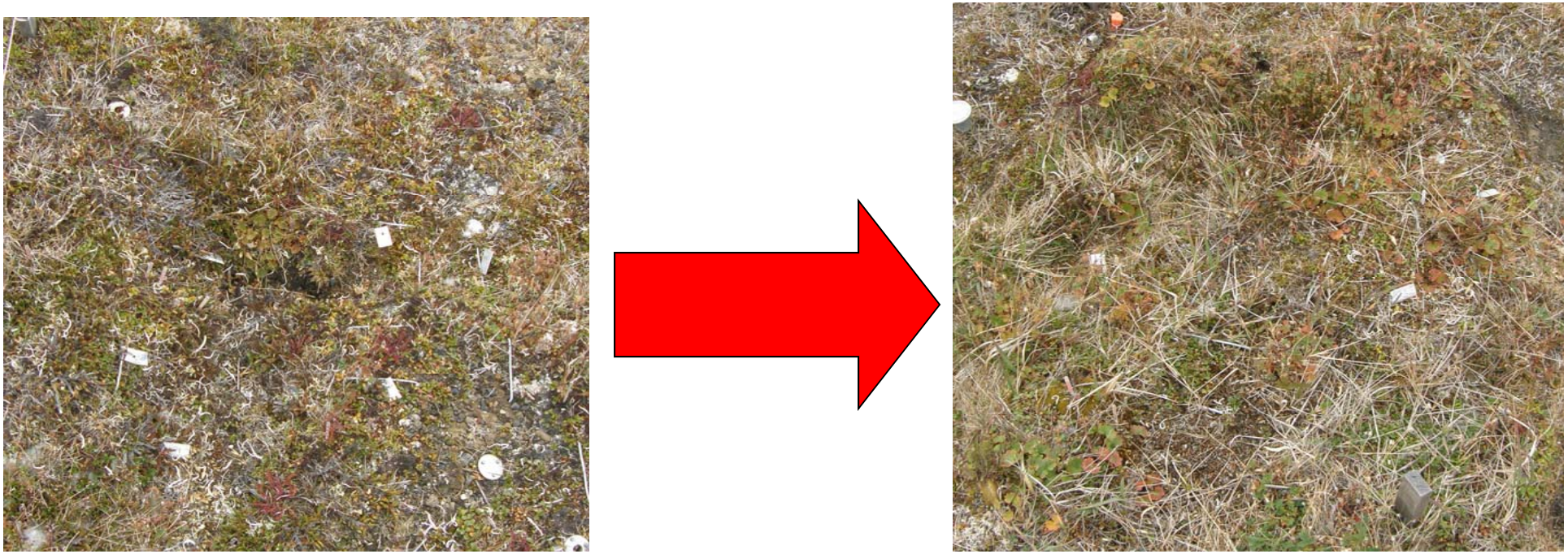
Increase in overall cover

Increase in tall plants (Graminoids and Shrubs)

Decrease in short plants (Forbs, Bryophytes, and Lichens)

Diversity should decrease

All trends should be consistent across time and in response to warming



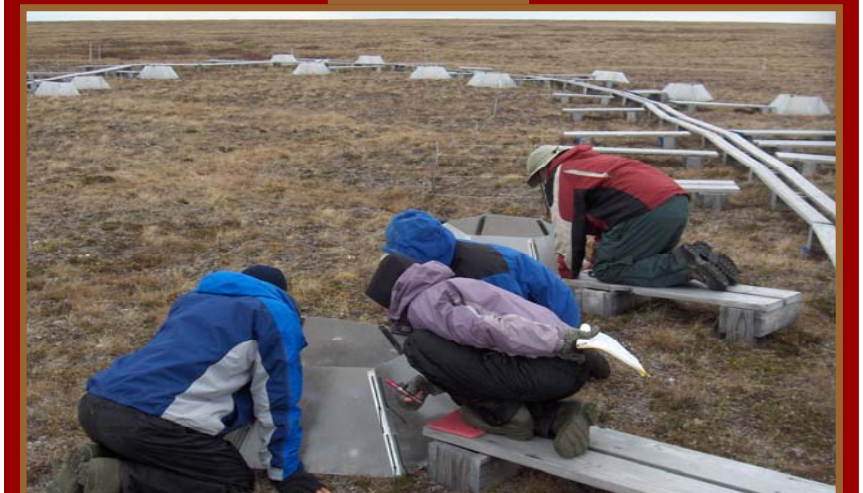
Site Locations

Barrow

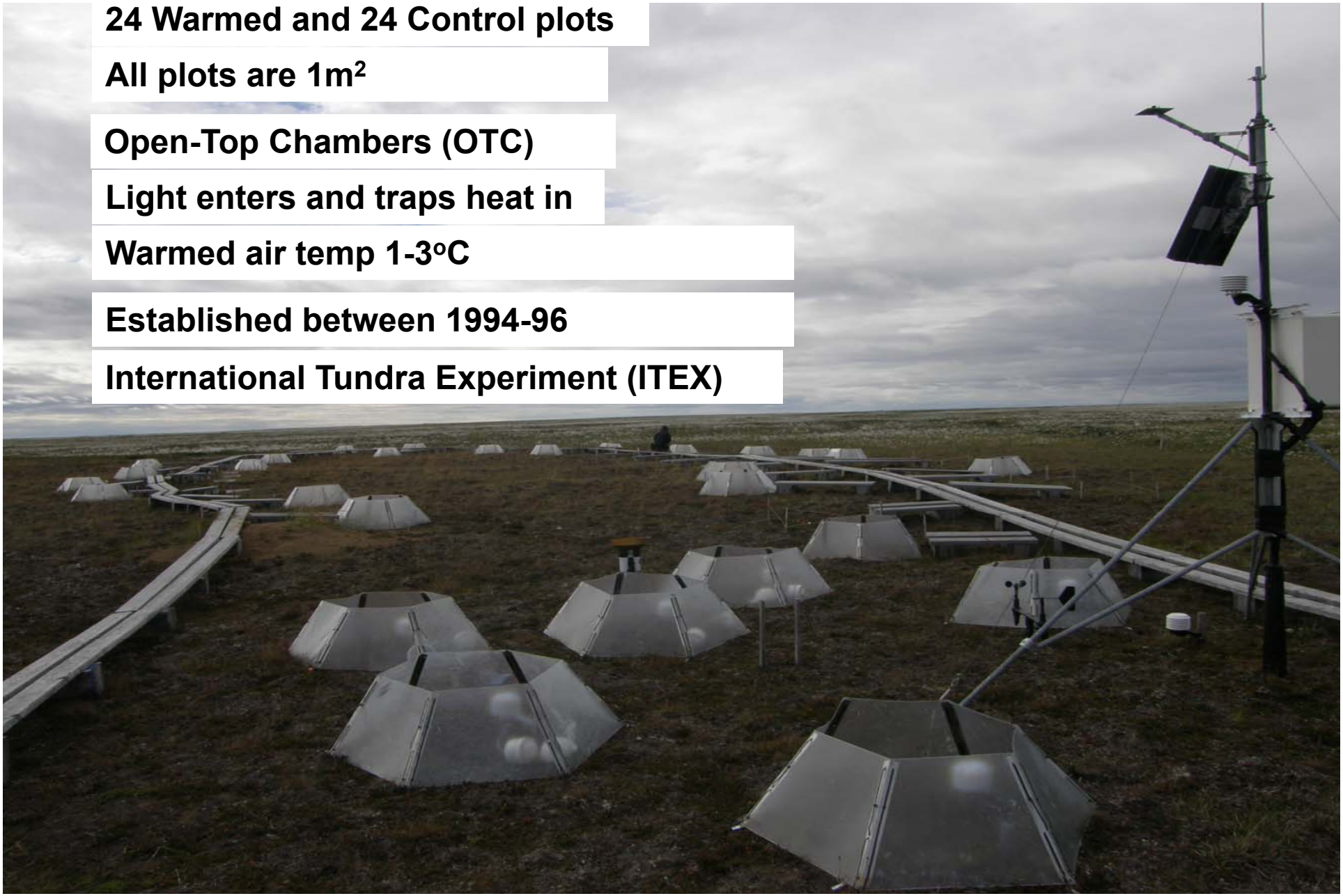
DRY

WET

Atqasuk



Site Setup and Warming



- 24 Warmed and 24 Control plots
- All plots are $1m^2$
- Open-Top Chambers (OTC)
- Light enters and traps heat in
- Warmed air temp 1-3^oC
- Established between 1994-96
- International Tundra Experiment (ITEX)

Point Frame Method

3 Samplings

Summers of 1995-96,
2000, and 2007-08

Same 2 weeks each year

Point Frame Grid
-75cm by 75cm
-100 points

Measurements

-At each point

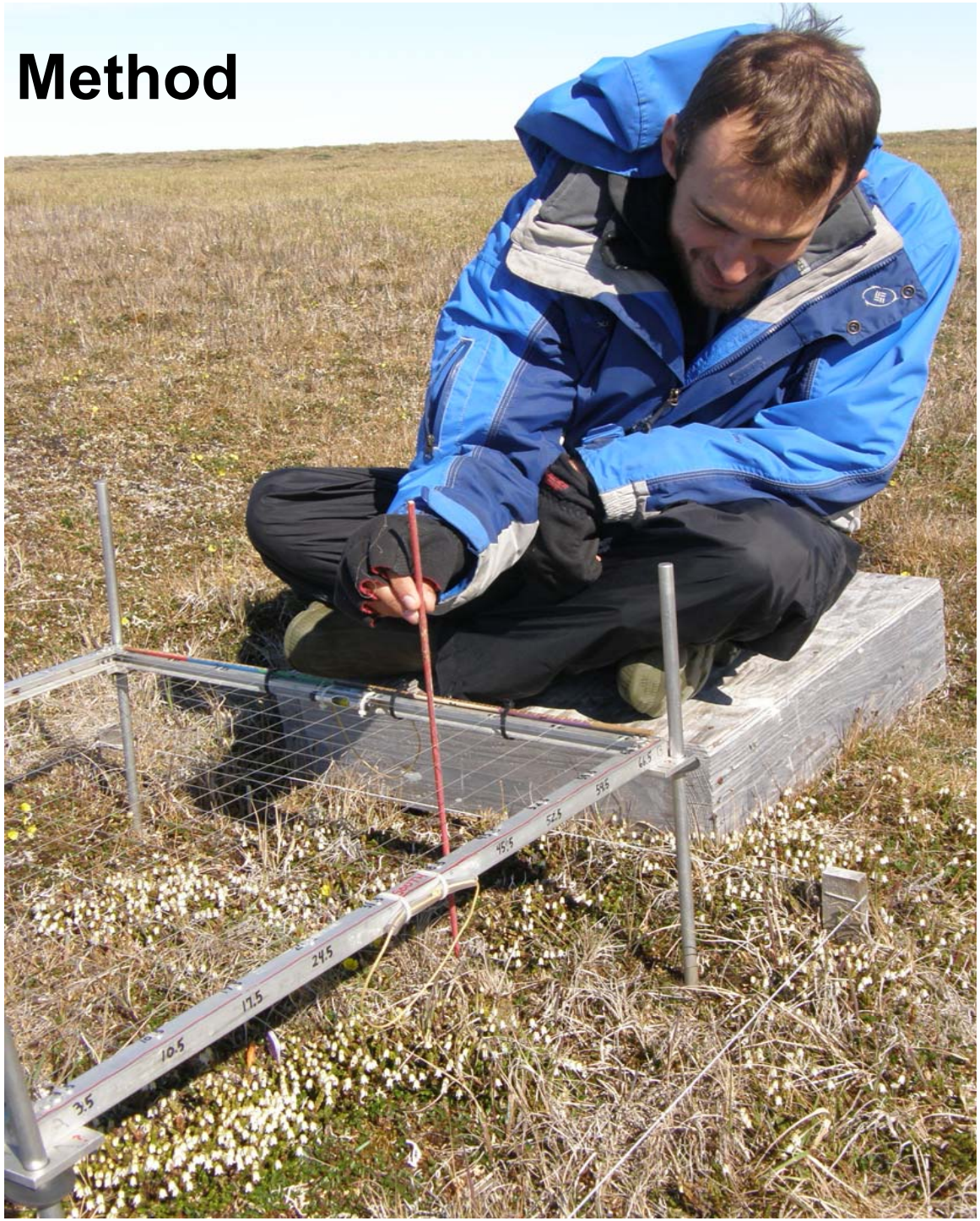
Top and Bottom contact

Species

Live/Dead Status

Height

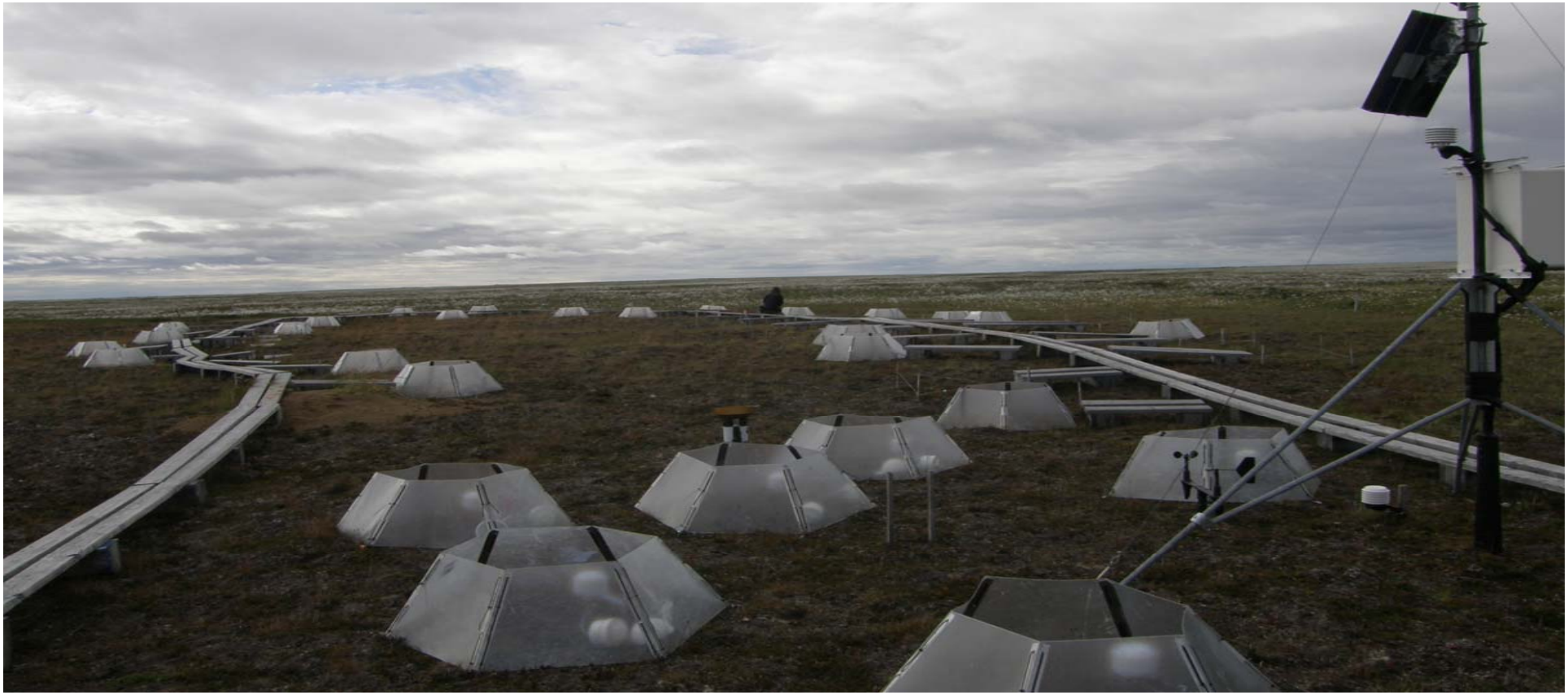
(Hollister et al, 2005)

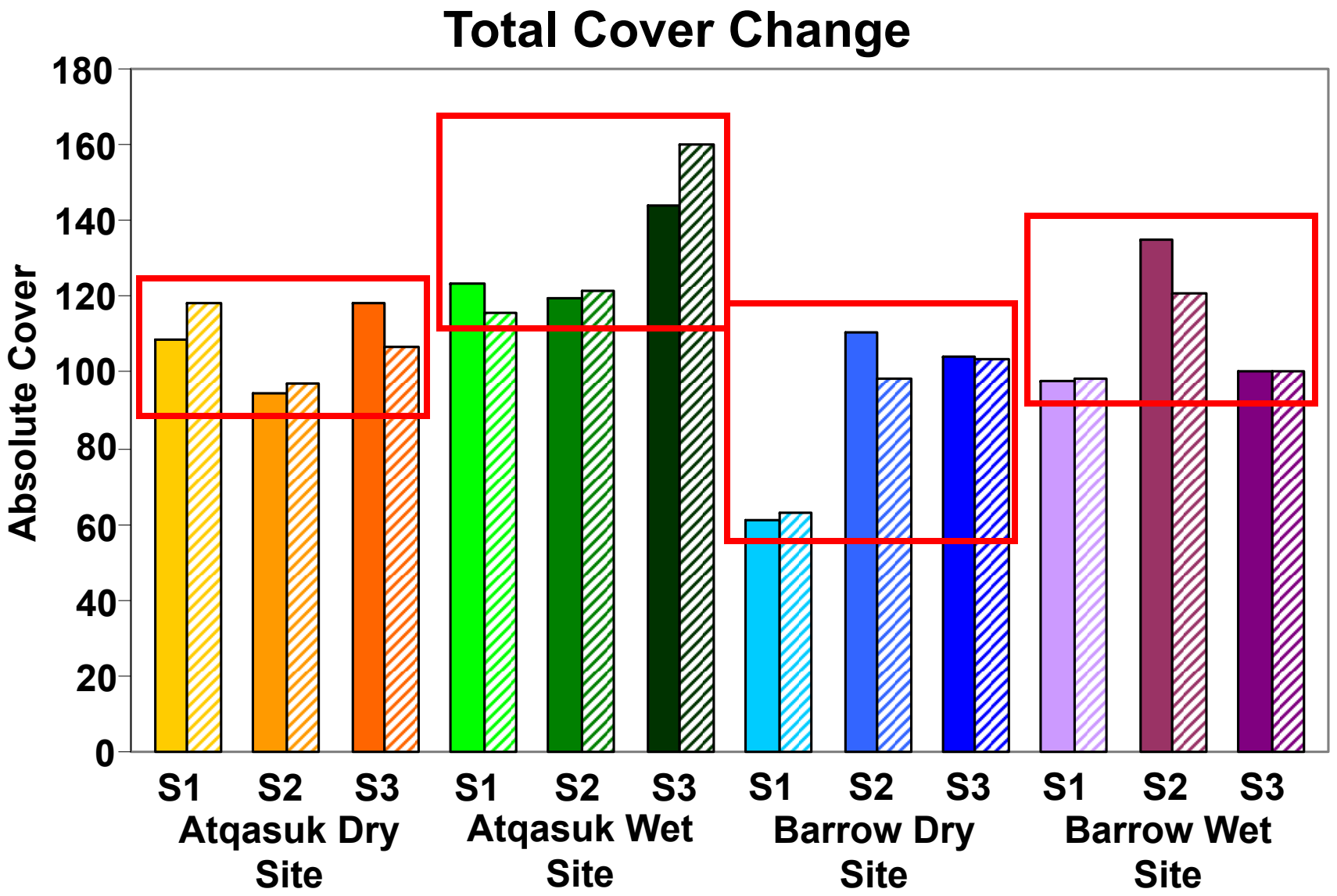


Analysis

Only live contacts were used for taxa and diversity analyses

Ran a mixed model repeated measures ANOVA





Initial changes were often not the same as secondary changes

Directional changes were site specific

	Sampling1			Sampling2			Sampling3					
	Ctl	OTC	Diff	Ctl	OTC	Diff	Ctl	OTC	Diff	W	Y	Int
Atqasuk Dry Site												
Deciduous Shrubs	3.3	3.0	-0.3	2.5	2.0	-0.5	5.0	2.8	-2.3			
Evergreen Shrubs	26.7	28.0	1.3	20.6	23.3	2.7	38.8	35.2	-3.6		*	
Graminoids	12.2	12.4	0.2	8.5	6.3	-2.2	24.2	19.2	-5.0		*	
Forbs	2.1	2.0	-0.1	1.0	2.7	1.7	2.8	3.9	1.2		?	
Lichens	55.6	62.1	6.5	51.4	52.8	1.4	39.9	37.9	-2.0			
Bryophytes	8.7	10.6	1.9	10.4	9.9	-0.5	7.9	7.9	0.0		?	
Atqasuk Wet Site												
Deciduous Shrubs	9.1	6.5	-2.7	10.3	7.8	-2.6	11.7	10.3	-1.4		?	
Graminoids	27.3	25.8	-1.5	18.3	22.3	4.0	41.8	50.9	9.1	*	*	
Forbs	1.5	1.6	0.1	1.6	2.0	0.4	1.7	2.0	0.3			
Lichens	2.1	2.1	0.0	1.3	3.0	1.7	1.0	1.7	0.7			
Bryophytes	83.5	79.7	-3.8	88.3	86.6	-1.7	87.7	95.0	7.3		*	
Barrow Dry Site												
Deciduous Shrubs	15.0	14.9	-0.1	28.5	24.3	-4.2	24.5	20.0	-4.4		*	
Evergreen Shrubs	11.3	15.2	3.9	20.4	24.8	4.4	19.5	27.7	8.2	*	*	
Graminoids	2.8	4.1	1.3	6.7	11.0	4.3	8.6	20.4	11.9	*	*	*
Forbs	4.0	4.0	0.0	6.6	6.0	-0.6	7.7	12.3	4.6		*	?
Lichens	19.6	19.2	-0.4	31.7	20.9	-10.8	32.5	15.9	-16.5	*	*	*
Bryophytes	8.5	5.6	-2.9	16.6	11.4	-5.3	11.7	7.1	-4.5		*	
Barrow Wet Site												
Deciduous Shrubs	0.0	1.6	1.6	0.0	3.2	3.2	0.0	10.5	10.5			
Graminoids	39.2	41.5	2.3	59.3	58.3	-1.0	50.6	51.3	0.7		*	
Forbs	15.6	12.5	-3.1	14.2	11.2	-3.0	15.2	16.5	1.3			
Lichens	5.1	4.7	-0.4	8.8	6.8	-1.9	9.8	5.9	-3.9			
Bryophytes	38.1	38.1	0.0	52.5	41.0	-11.5	25.0	16.1	-8.9	*		?

Between year variation had more influence than warming overall

Only Barrow Dry Site had a year/warming interaction

Shrubs and Graminoids responded positively overall

Short plants had mixed responses

Amplifying Effects of Taxa on Growth Form

Atqasuk Wet Site

	Sampling1			Sampling2			Sampling3					
	Ctl	OTC	Diff	Ctl	OTC	Diff	Ctl	OTC	Diff	W	Y	Int
Graminoids	**27.3**	**25.8**	**-1.5**	**18.3**	**22.3**	**4.0**	**41.8**	**50.9**	**9.1**		*	
Single Graminoids	**27.3**	**25.8**	**-1.5**	**18.3**	**22.3**	**4.0**	**41.8**	**50.9**	**9.1**	*	*	*
Carex aqualtilis complex	22.0	21.1	-0.9	13.5	16.7	3.2	31.4	37.7	6.3	*	*	*
Dupontia fisheri/psilosantha	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.1	-0.1			
Eriophorum angustifolium	3.2	2.8	-0.4	3.1	3.4	0.3	6.8	7.9	1.1			
Eriophorum russeolum complex	2.1	1.9	-0.2	1.7	2.1	0.4	3.4	5.2	1.8			

Best example is in second sampling

All taxa within the Graminoids respond positively and add to the change in the Growth Form

This example most difference driven by *Carex aquatilis* complex

Taxon Changes Cancelling Each Other Out

Atqasuk Dry Site

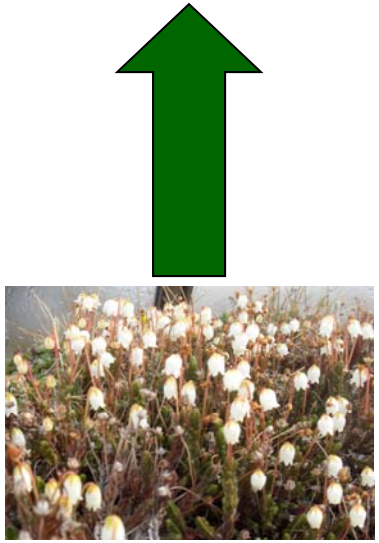
	Sampling1			Sampling2			Sampling3					
	Ctl	OTC	Diff	Ctl	OTC	Diff	Ctl	OTC	Diff	W	Y	Int
Evergreen Shrubs	**26.7**	**28.0**	**1.3**	**20.6**	**23.3**	**2.7**	**38.8**	**35.2**	**-3.6**	*		
Cassiope tetragona	6.5	8.9	2.4	4.7	7.8	3.1	12.6	13.2	0.6	*		
Diapensia lapponica	3.4	3.2	-0.2	2.5	2.0	-0.5	6.3	4.6	-1.7	*		
Ledum palustre	10.1	9.7	-0.4	8.1	8.3	0.2	10.7	9.5	-1.2			
Vaccinium vitis-idaea	6.7	6.2	-0.5	5.3	5.2	-0.1	9.2	7.9	-1.3	*	*	

Most pronounced in the first sampling

***C. tetragona* responds positively to warming**

Other evergreen shrubs respond negatively

Overall they mute the change for in Growth Form



Diversity

	Sampling 1			Sampling 2			Sampling 3			Effects		
	CTL	OTC	Diff	CTL	OTC	Diff	CTL	OTC	Diff	W	Y	I
Atqasuk Dry Site												
Richness	17.58	17.42	-0.17	16.75	16.50	-0.25	16.25	15.38	-0.88		*	
Simpson	0.88	0.87	-0.01	0.89	0.88	-0.01	0.90	0.89	-0.01		*	
Atqasuk Wet Site												
Richness	13.75	13.13	-0.63	11.63	10.79	-0.83	11.88	11.29	-0.58		*	
Simpson	0.80	0.80	0.00	0.76	0.76	0.00	0.77	0.79	0.02		*	
Barrow Dry Site												
Richness	19.33	18.71	-0.63	19.79	18.13	-1.67	19.88	16.96	-2.92	*		
Simpson	0.87	0.84	-0.03	0.86	0.84	-0.02	0.87	0.83	-0.04	*	*	
Barrow Wet Site												
Richness	18.67	17.96	-0.71	15.96	15.83	-0.13	16.38	14.79	-1.58		*	
Simpson	0.86	0.85	-0.01	0.84	0.81	-0.03	0.86	0.81	-0.05	?	*	

Year effects had more influence than warming did overall

Richness decreased in all sites across all samplings

Simpson's Diversity decreased in all sites across all samplings

Differences were most pronounced in Barrow sites

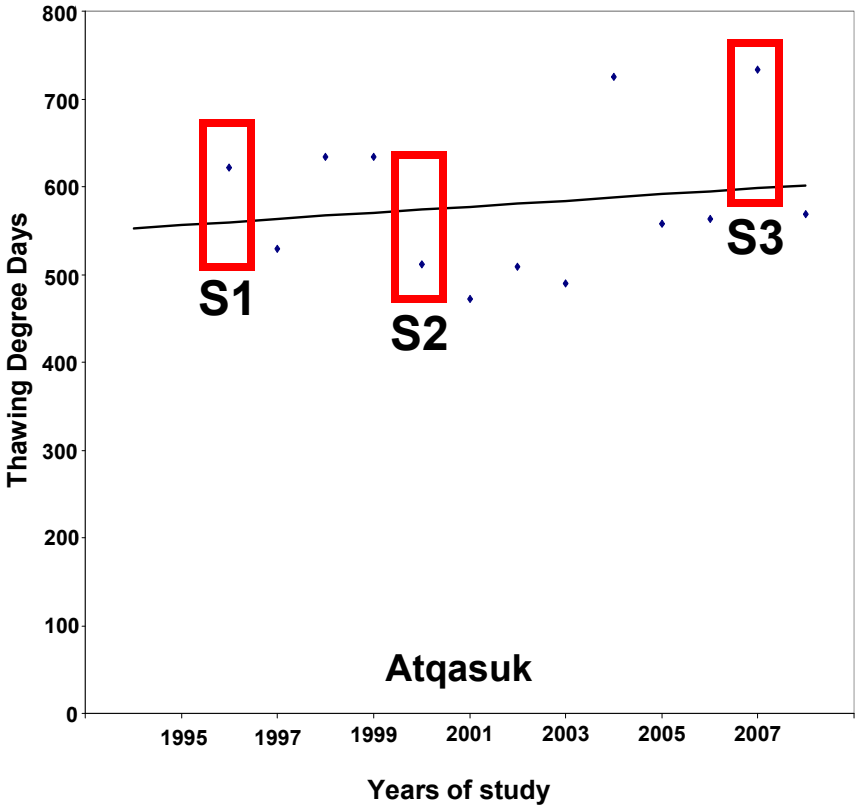
So why does Year effect make so much of a difference?

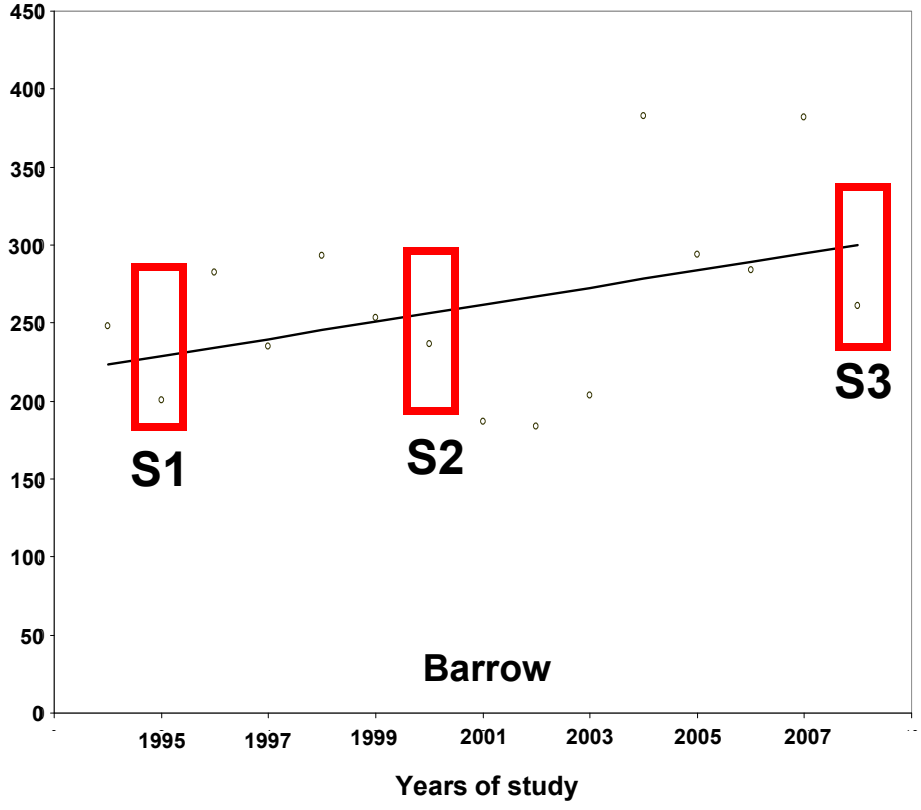
Yearly Differences In:

Winter snow cover and depth

Summer precipitation amounts

Temperatures increasing





Conclusions

There was a larger difference between years than between treatments

Tall plants (Shrubs and Graminoids) increased in cover over time but had mixed responses to treatments by site

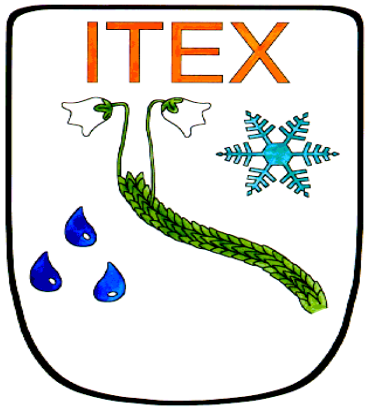
Short plants (Forbs, Lichens, and Bryophytes) were often site specific in responses and were resistant to change over time

Some taxa within groups respond differently and mute overall Growth Form change

Richness and Simpson Diversity decrease over time (except the Barrow Dry Site) and in response to warming

Acknowledgements

Rob Slider, Jennifer Liebig, Amanda Snyder, Jean Galang, and Mike Lothshultz



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Questions?