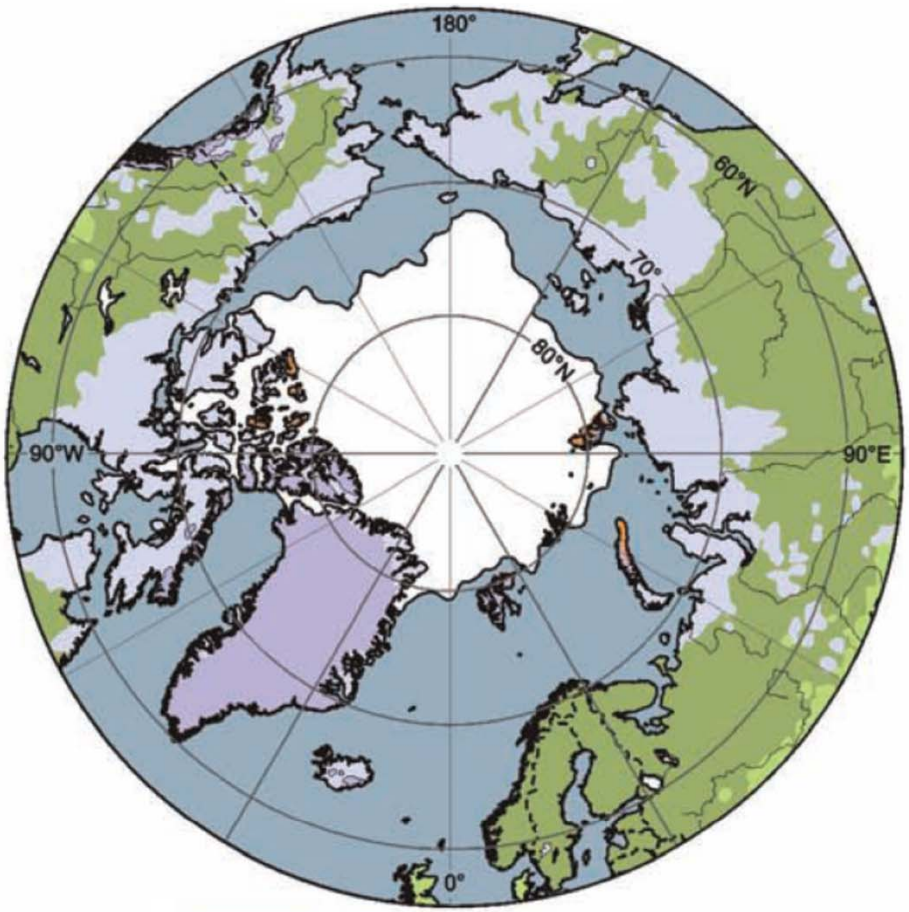
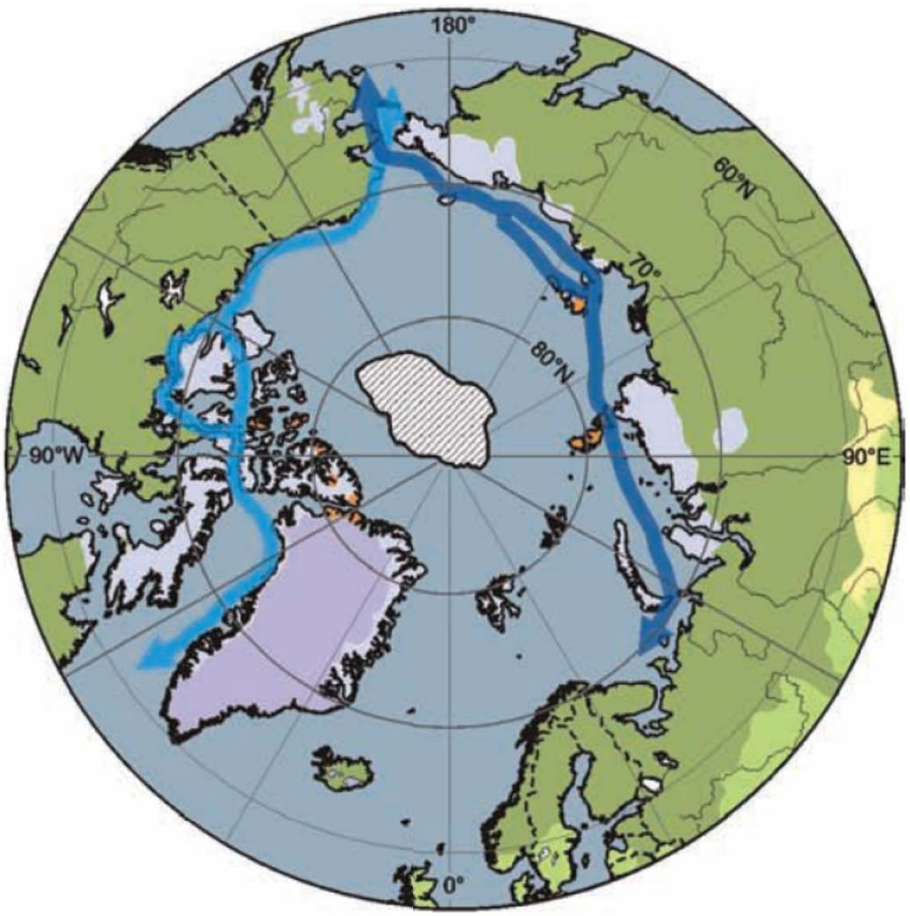
Exploring for traits that predict plant response to warming

Jenny Liebig

Current

Projected





Temperate forest

Grassland

Tundra

Boreal forest

Polar desert/ semi desert

Ice

Northwest Passage

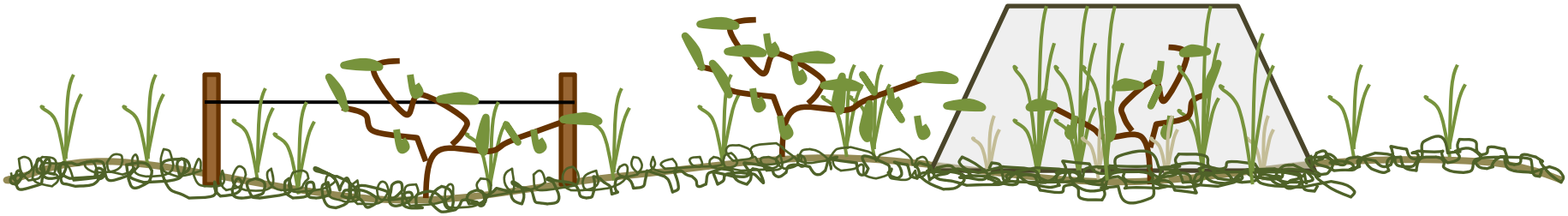
Northern Sea Route

Observed ice extent September 2002

Projected ice extent 2080 - 2100

IPCC (Intergovernmental Panel on Climate Change) 2007.

How does cover change?

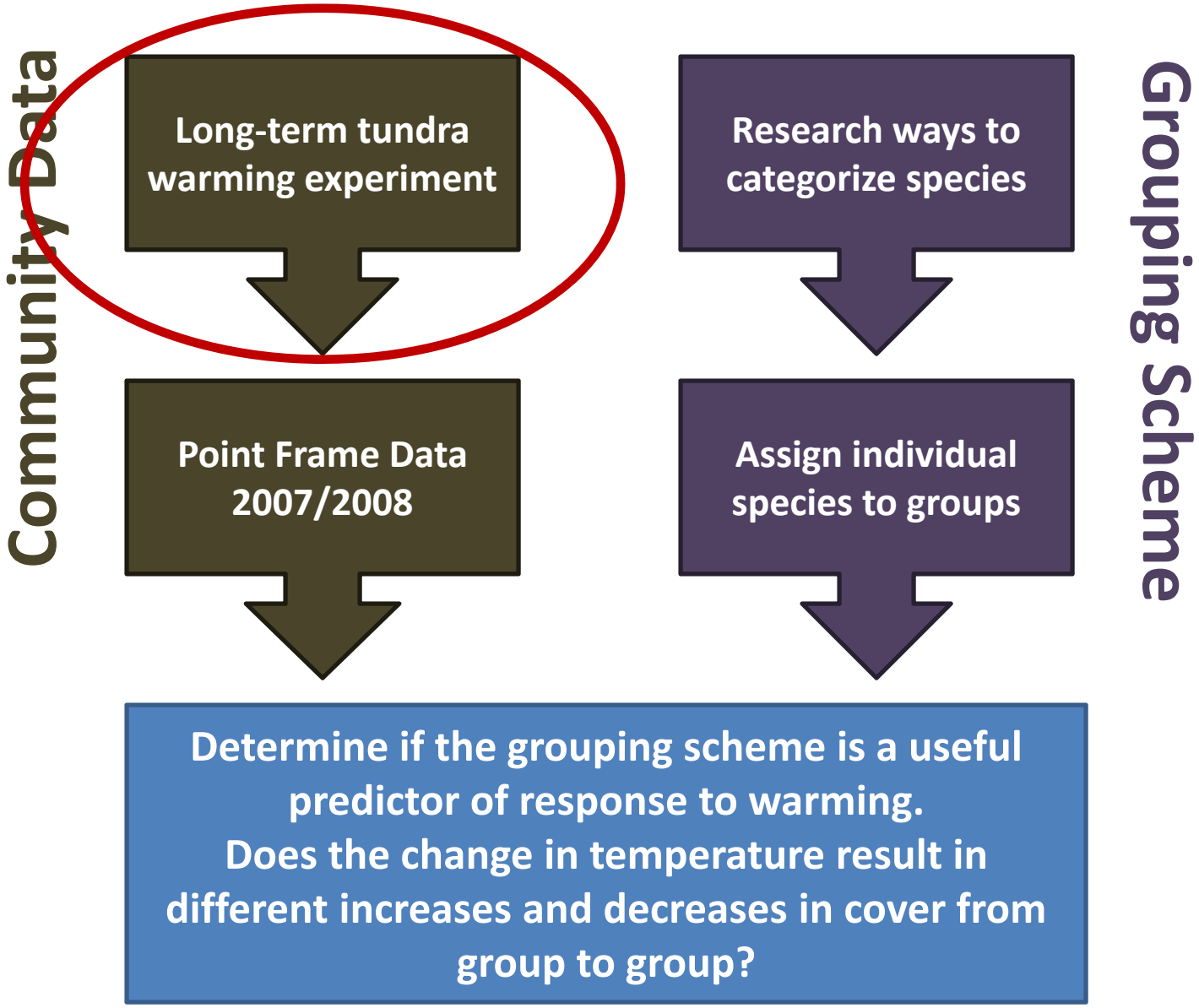


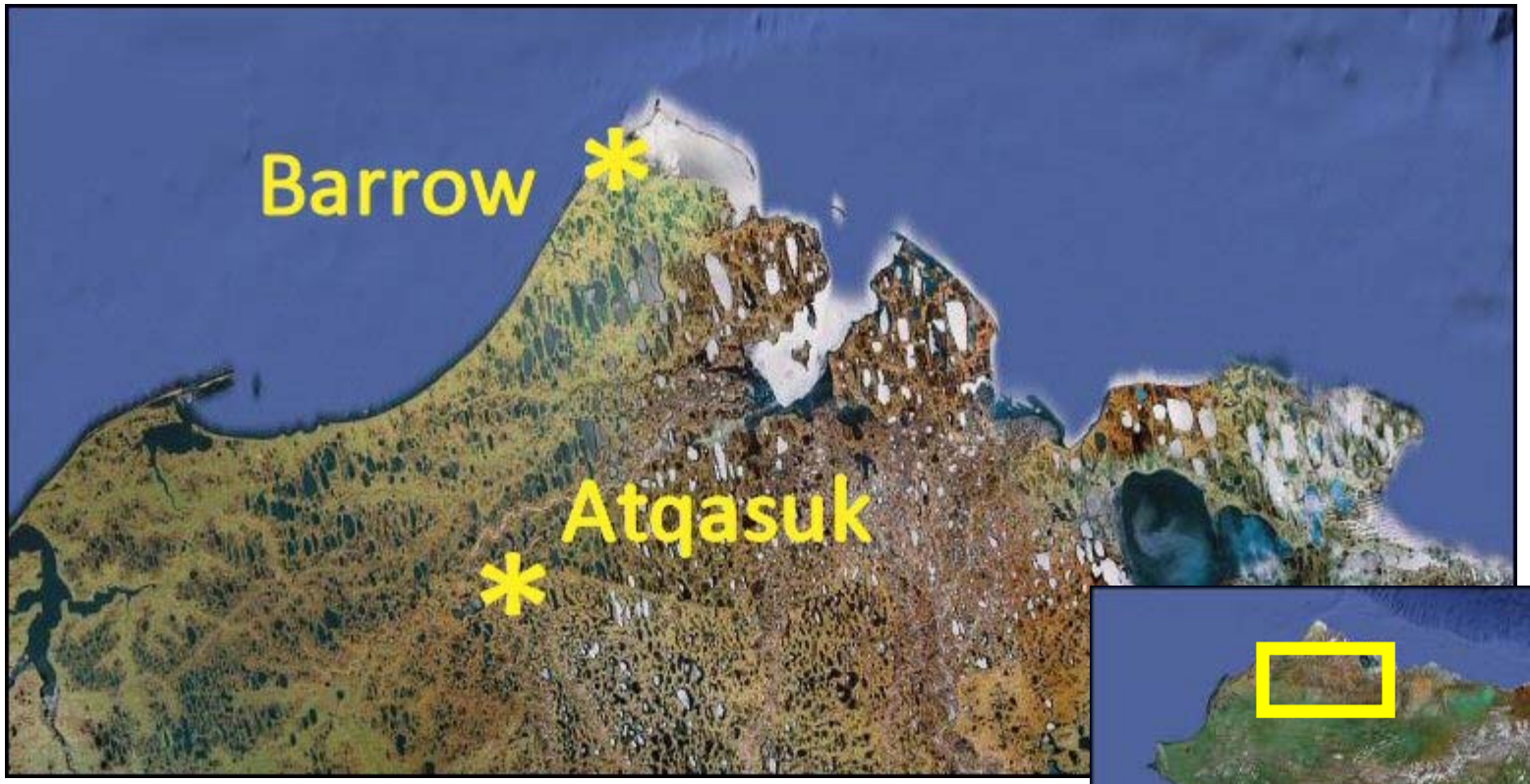
In general, warming causes:

- Increase in cover
- Increase in height
- Increase in litter and standing dead
- Decrease in mosses and lichens

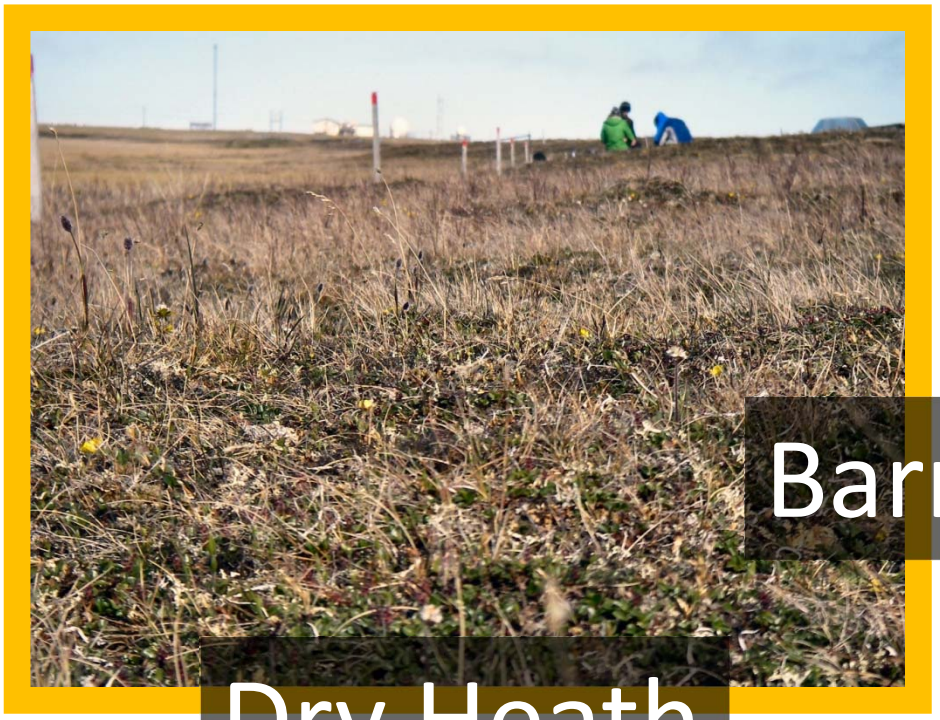
Even when a site does not respond as described above, there are increases and decreases in species within a growth form that cancel each other out

Which characteristics of tundra vegetation are most useful for predicting response to warming?


Community Data
Long-term tundra warming experiment
Point Frame Data 2007/2008
Grouping Scheme
Research ways to categorize species
Assign individual species to groups
Determine if the grouping scheme is a useful predictor of response to warming.
Does the change in temperature result in different increases and decreases in cover from group to group?



Long Term Research Site Locations

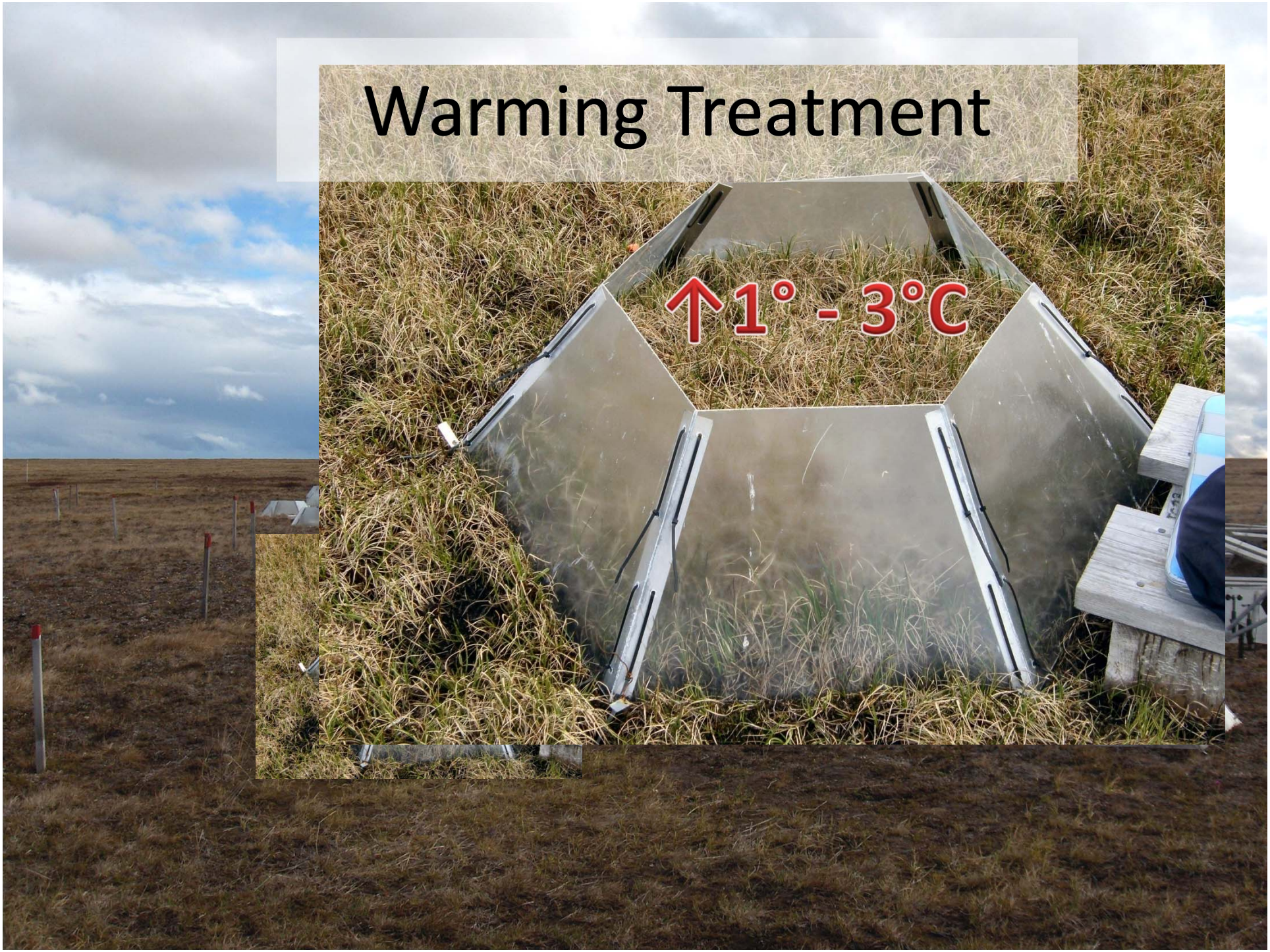

Barrow


Wet Meadow

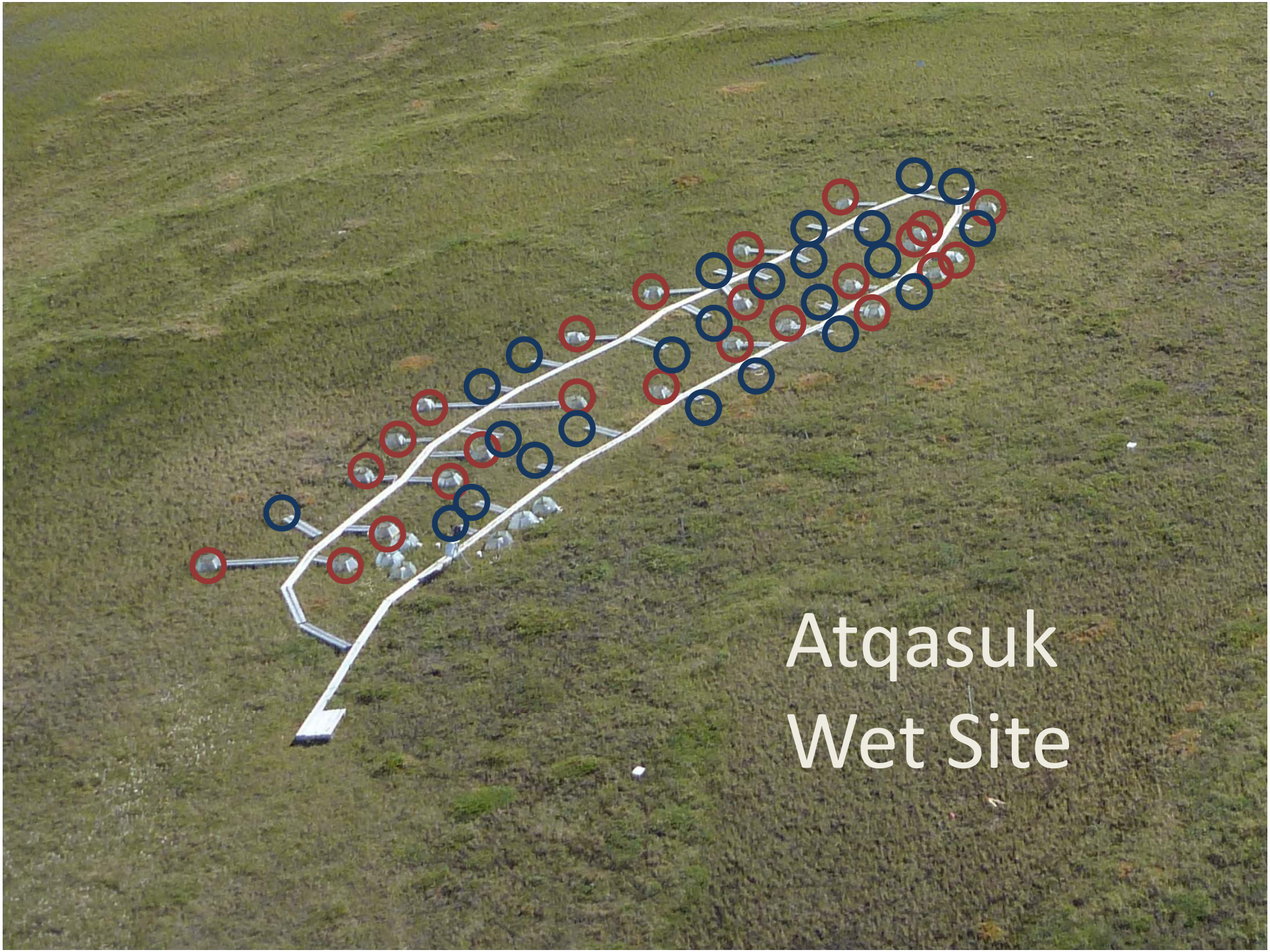

Dry Heath

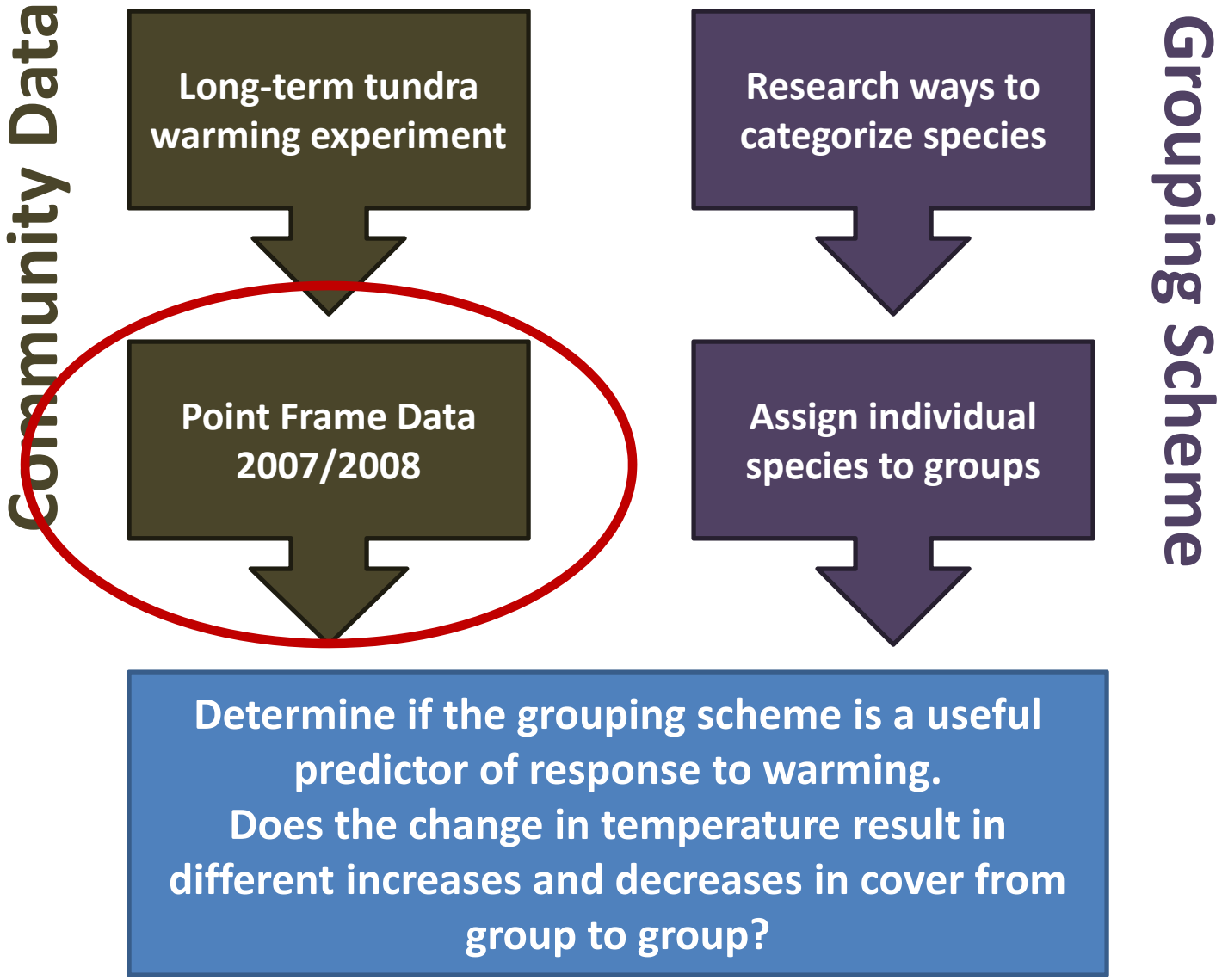

Atqasuk

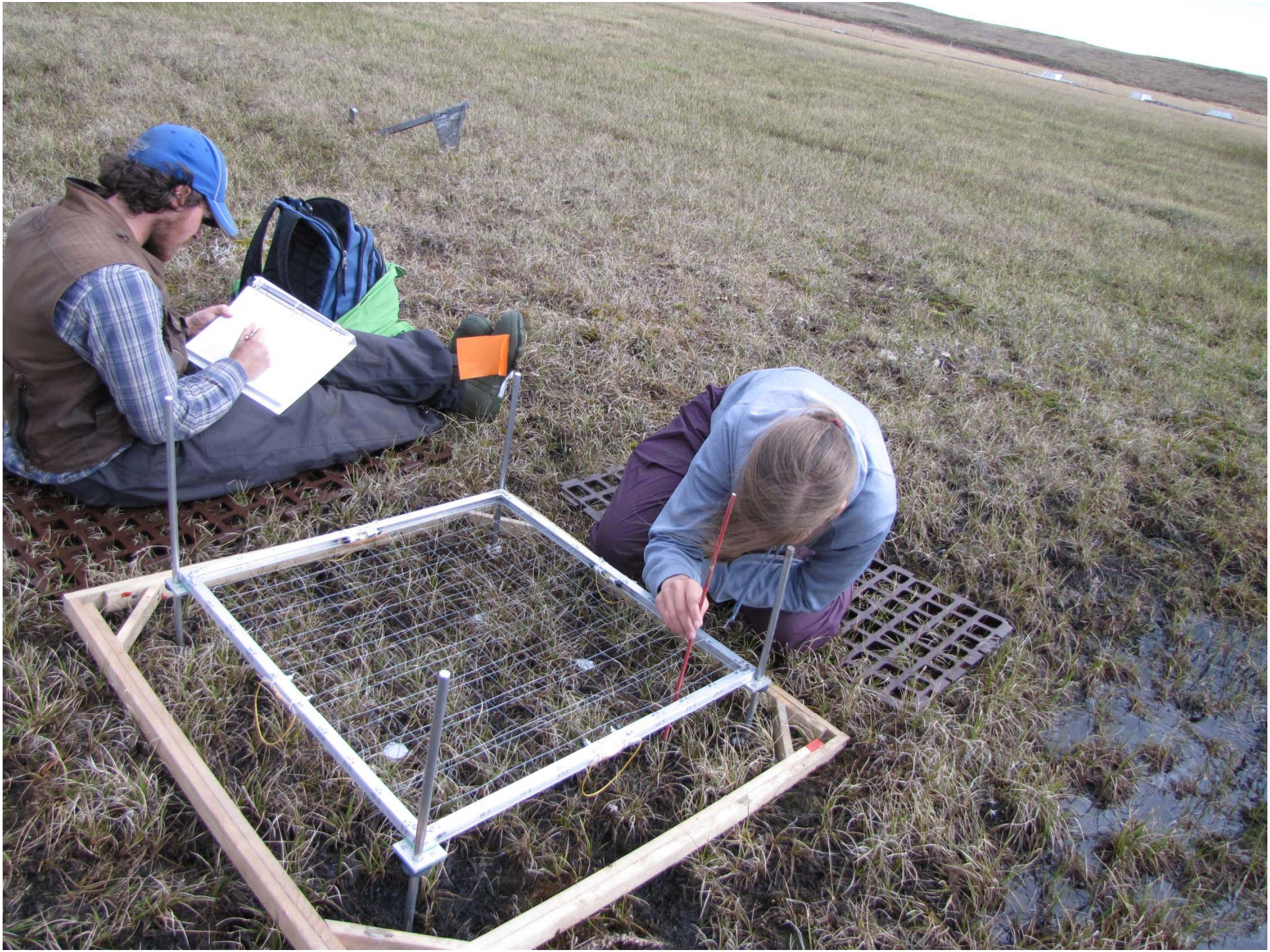
Warming Treatment



Atqasuk	Wet Site	CTL	x 24	
		OTC	x 24	
	Dry Site	CTL	x 24	
		OTC	x 24	= 192 plots
Barrow	Wet Site	CTL	x 24	
		OTC	x 24	
	Dry Site	CTL	x 24	
		OTC	x 24	

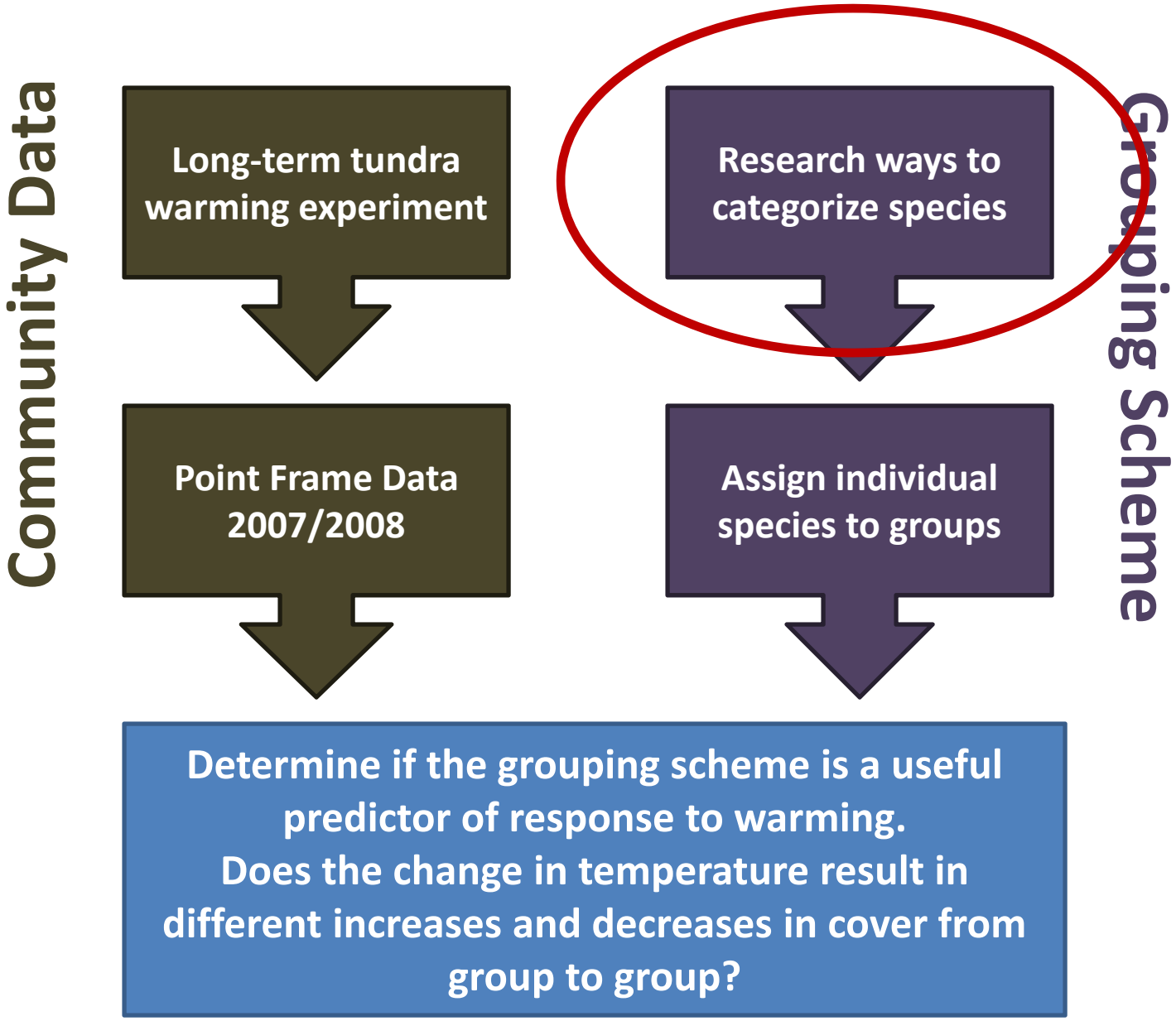

Atqasuk
Wet Site


Community Data
Long-term tundra warming experiment
Point Frame Data 2007/2008
Grouping Scheme
Research ways to categorize species
Assign individual species to groups
Determine if the grouping scheme is a useful predictor of response to warming.
Does the change in temperature result in different increases and decreases in cover from group to group?



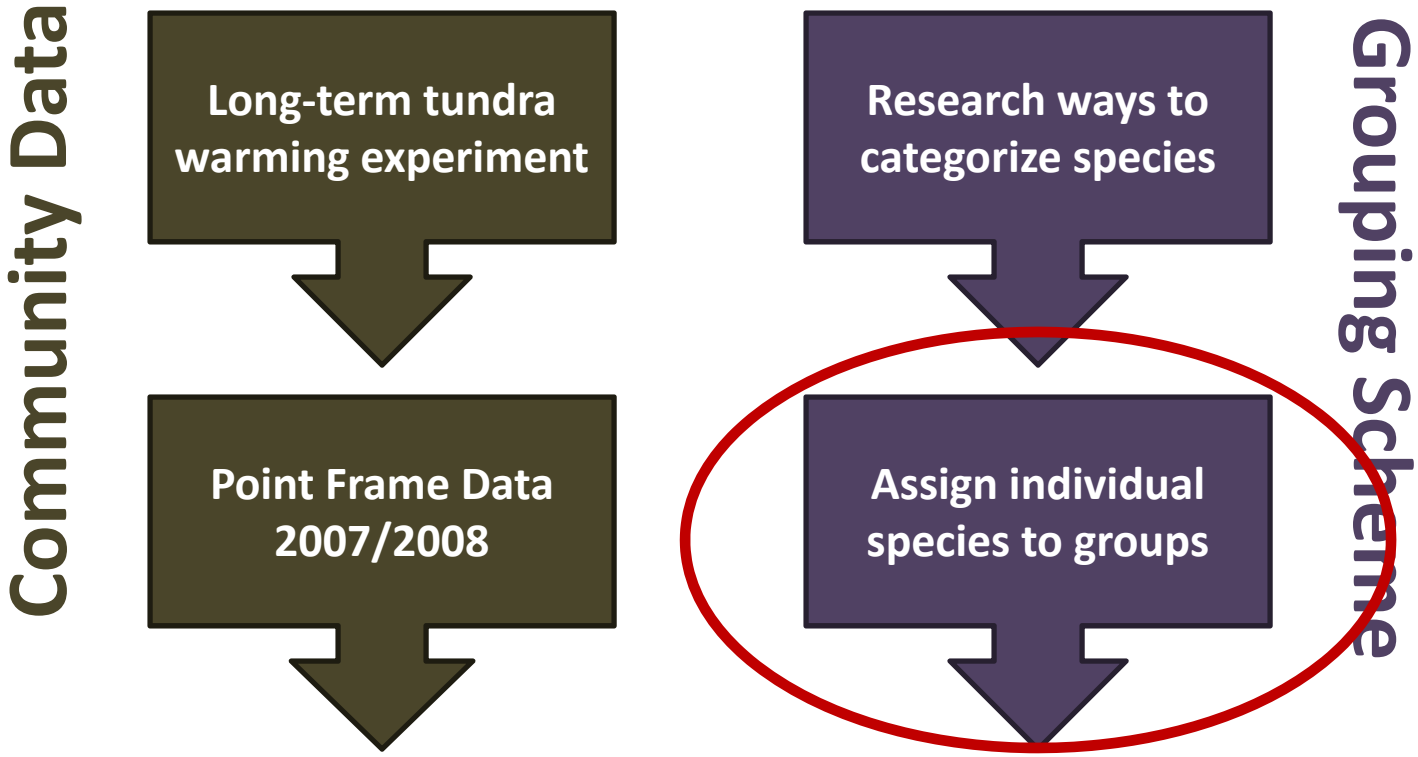
Comm Plot X
Stat Ht Hit Spp Stat Ht Hit Spp Stat Ht Hit Spp Stat Ht

Plot	Species	Live Hits
AW C 04	*Carex aquatilis*	44
AW C 04	*Eriophorum russeolum*	12
AW C 04	*Eriophorum angustifolium*	24
AW C 04	*Dupontia psilosantha*	13
AW C 04	*Salix pulchra*	5
AW C 04	*Salix polaris*	14
AW C 04	*Pedicularis sudetica*	2
AW C 04	*Betula nana*	4
AW C 04	*Polygonum viviparum*	3


Community Data
Long-term tundra warming experiment
Point Frame Data 2007/2008
Grouping Scheme
Research ways to categorize species
Assign individual species to groups
Determine if the grouping scheme is a useful predictor of response to warming.
Does the change in temperature result in different increases and decreases in cover from group to group?

Grouping Schemes

- Conventional wisdom and theories about ‘best adapted’ Arctic plants informed my research of ways to label the species
  - Geography
  - Morphology
  - Phenology


Community Data
Long-term tundra warming experiment
Point Frame Data 2007/2008
Grouping Scheme
Research ways to categorize species
Assign individual species to groups
Determine if the grouping scheme is a useful predictor of response to warming.
Does the change in temperature result in different increases and decreases in cover from group to group?

Raunkiær's Life Forms

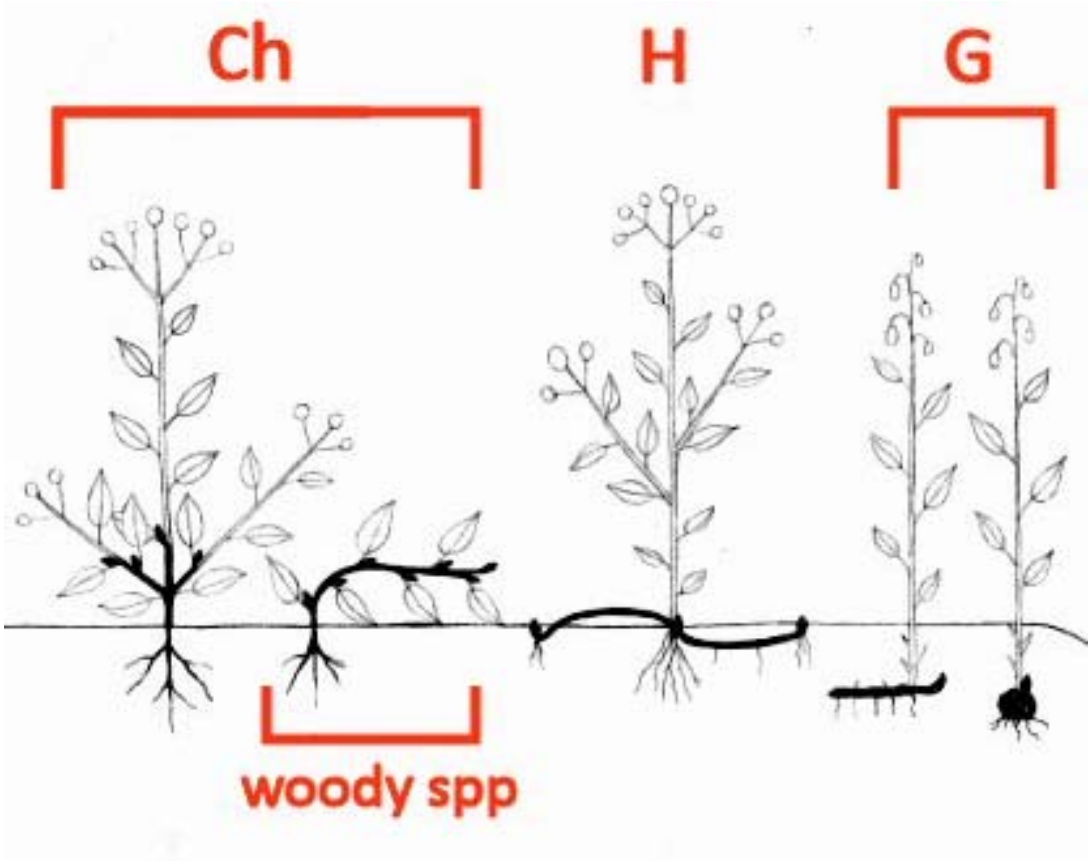
Sørensen 1941, Raunkiær 1934

Species divided into three groups .

CH: Chamaephyte; buds on persistent shoots near ground

G: Geophyte; Buds resting in dry ground

H: Hemicryptophyte; Buds at or near soil surface



Plot	Species	Live Hits	Raunkiær's Life Forms
AW C 04	*Carex aquatilis*	44	G
AW C 04	*Eriophorum russeolum*	12	G
AW C 04	*Eriophorum angustifolium*	24	G
AW C 04	*Dupontia psilosantha*	13	G
AW C 04	*Salix pulchra*	5	CH
AW C 04	*Salix polaris*	14	CH
AW C 04	*Pedicularis sudetica*	2	G
AW C 04	*Betula nana*	4	CH
AW C 04	*Polygonum viviparum*	3	G

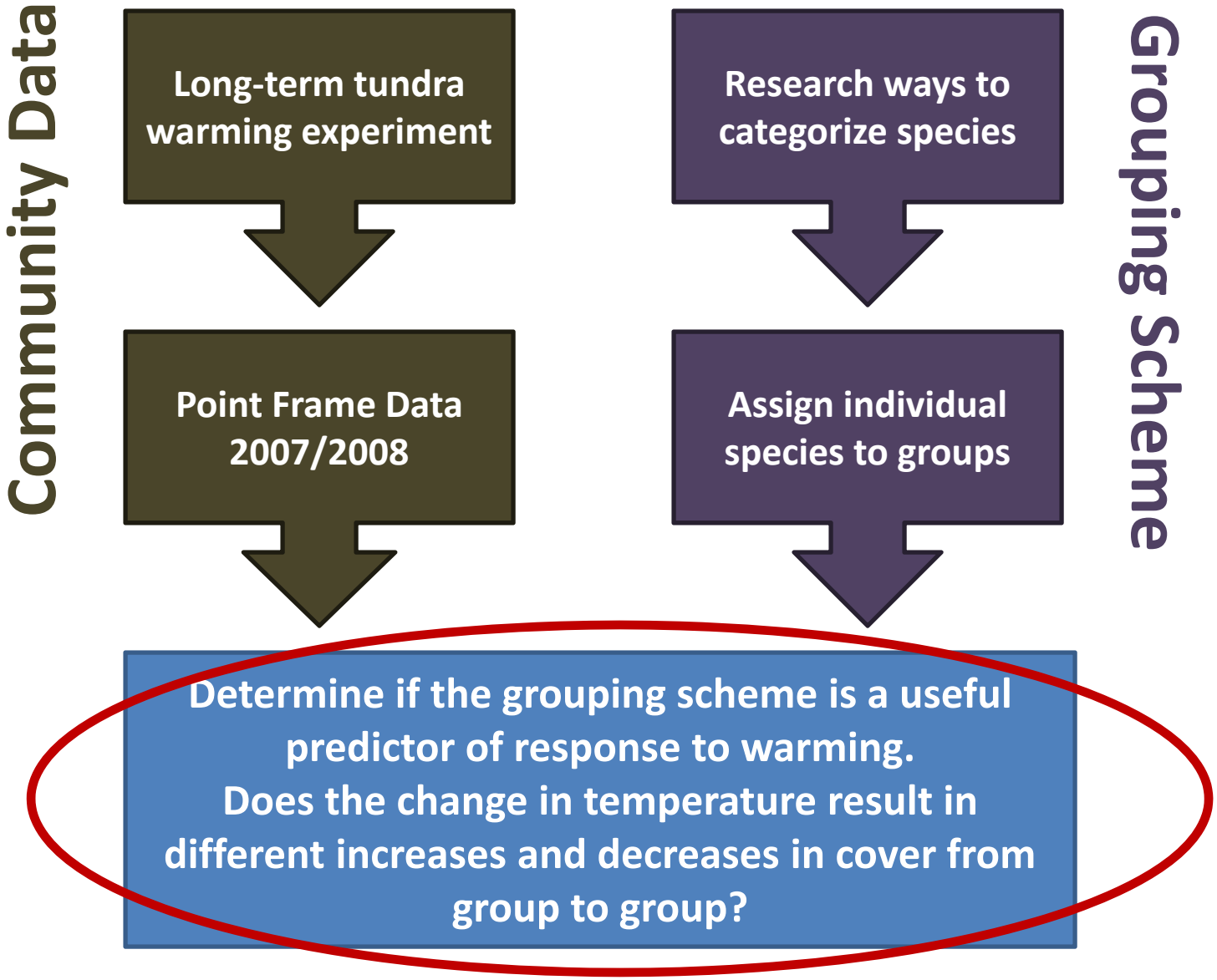
Plot	Species	Live Hits	Raunkiær's Life Forms
AW C 04	*Carex aquatilis*	44	G
AW C 04	*Eriophorum russeolum*	12	G
AW C 04	*Eriophorum angustifolium*	24	G
AW C 04	*Dupontia psilosantha*	13	G
AW C 04	*Salix pulchra*	5	CH
AW C 04	*Salix polaris*	14	CH
AW C 04	*Pedicularis sudetica*	2	H
AW C 04	*Betula nana*	4	CH
AW C 04	*Polygonum viviparum*	3	G

Chamaephyte total: 23

Geophyte total: 96

Hemicryptophyte total: 2

Grouping Scheme	Source	Number of Species
Growth Form	---	72/72
Family	---	72/72
Monocot/Dicot	---	72/72
TDDsm / Julian Day	Hollister 2003	72/72
Rainkiær's Life Forms	Sørensen 1941	41/72
Thawing Type	Sørensen 1941	41/72
Wintering State of Leaves	Sørensen 1941	41/72
Wintering State of Buds	Sørensen 1941	41/72
Floral Wintering Stage	Sørensen 1941	41/72
Early / Late Leaf Bud Burst	Phenology BRW & ATK	52/72
Early / Late Flower Burst	Phenology BRW & ATK	39/72
Response to Warming	Phenology BRW & ATK	72/72
Polyploidy	Löve & Löve 1948	35/72
Young Zones	Young 1971	42/72
High Arctic / Low Arctic	Gould and Walker 1999	40/72
Biome Distribution	---	54/72
Latitudinal Distribution	Hultén 1968	72/72
Longitudinal Distribution	Hultén 1968	72/72
Alaskan Distribution	Hultén 1968	72/72
Greenland Distribution	Sørensen 1941	41/72

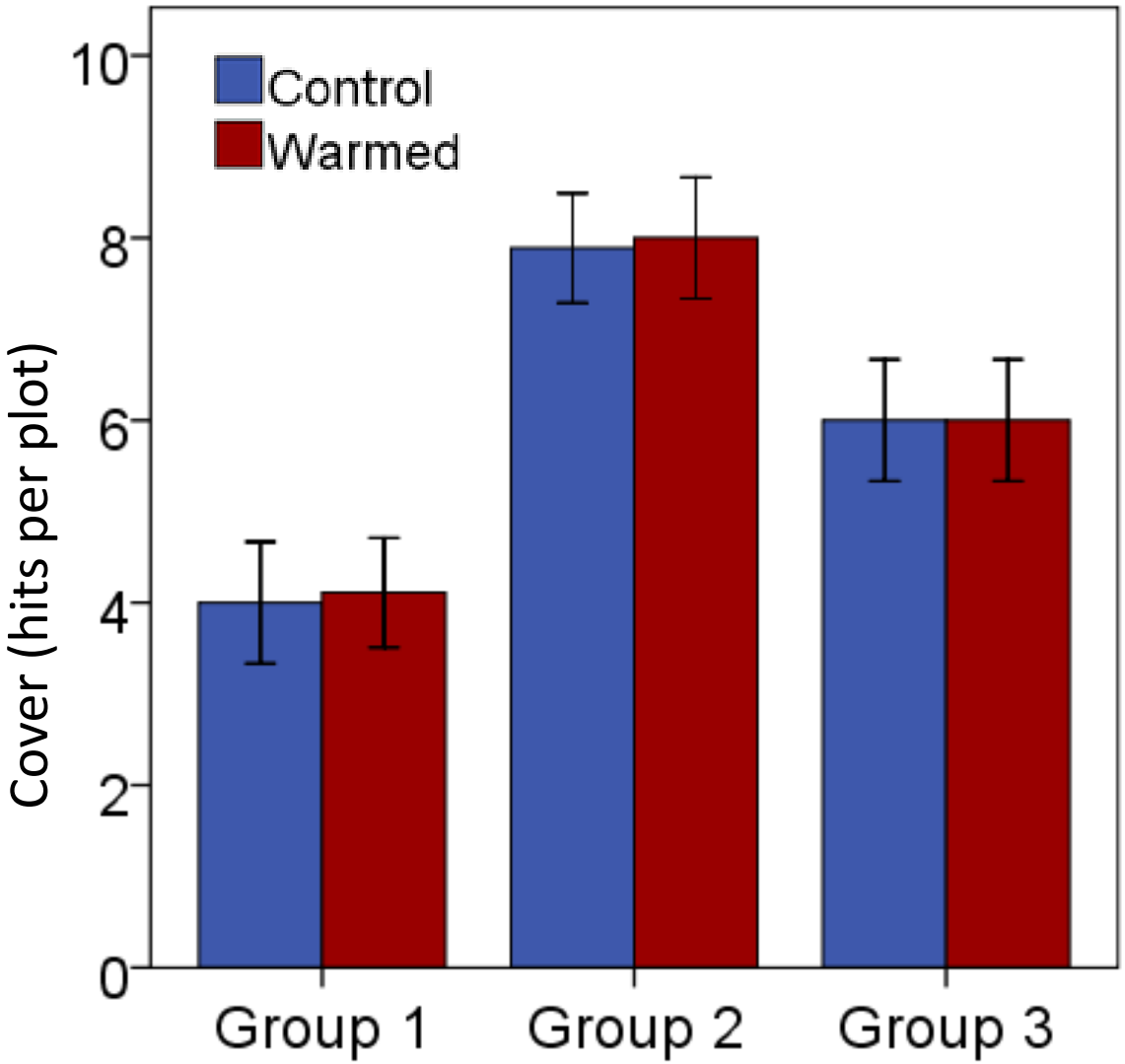

Community Data
Long-term tundra warming experiment
Point Frame Data 2007/2008
Grouping Scheme
Research ways to categorize species
Assign individual species to groups
Determine if the grouping scheme is a useful predictor of response to warming.
Does the change in temperature result in different increases and decreases in cover from group to group?

Statistical Analysis

- Each grouping scheme analyzed by itself
  - 2-way ANOVA
    - Treatment x grouping scheme (2 x ?)
- Issues!

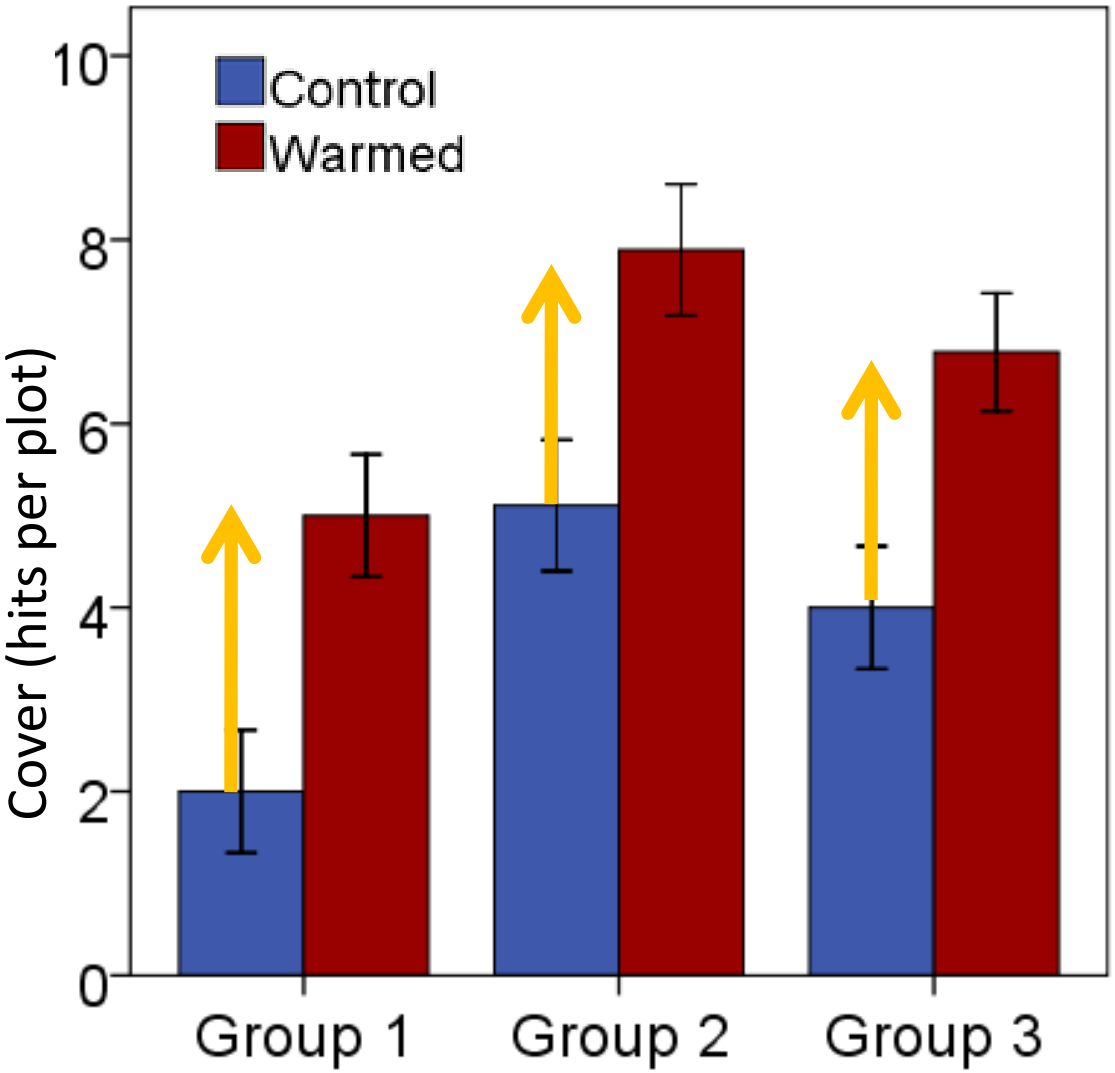
Grouping Scheme	Source	Barrow Wet	Barrow Dry	Atqasuk Wet	Atqasuk Dry
Growth Form	---		*	.	
Family	---	*	*		
Monocot/Dicot	---			*	
TDDsm / Julian Day	*Hollister 2003*			*	*
Rainkiær's Life Forms	*Sørensen 1941*	.		x	
Thawing Type	*Sørensen 1941*	*	.		
Wintering State of Leaves	*Sørensen 1941*			X	
Wintering State of Buds	*Sørensen 1941*		*	X	
Floral Wintering Stage	*Sørensen 1941*	*		*	
Early / Late Leaf Bud Burst	*Phenology BRW & ATK*	*	*	*	
Early / Late Flower Burst	*Phenology BRW & ATK*			*	
Response to Warming	*Phenology BRW & ATK*	*		X	X
Polyploidy	*Löve & Löve 1948*	*		*	
Young Zones	*Young 1971*	*			*
High Arctic / Low Arctic	*Gould and Walker 1999*		*		
Biome Distribution	---		.	*	
Latitudinal Distribution	*Hultén 1968*	*	*		
Longitudinal Distribution	*Hultén 1968*	*	*	*	
Alaskan Distribution	*Hultén 1968*		*	*	
Greenland Distribution	*Sørensen 1941*	*	*	*	
Species		*	*	*	

This grouping scheme is **not** useful.



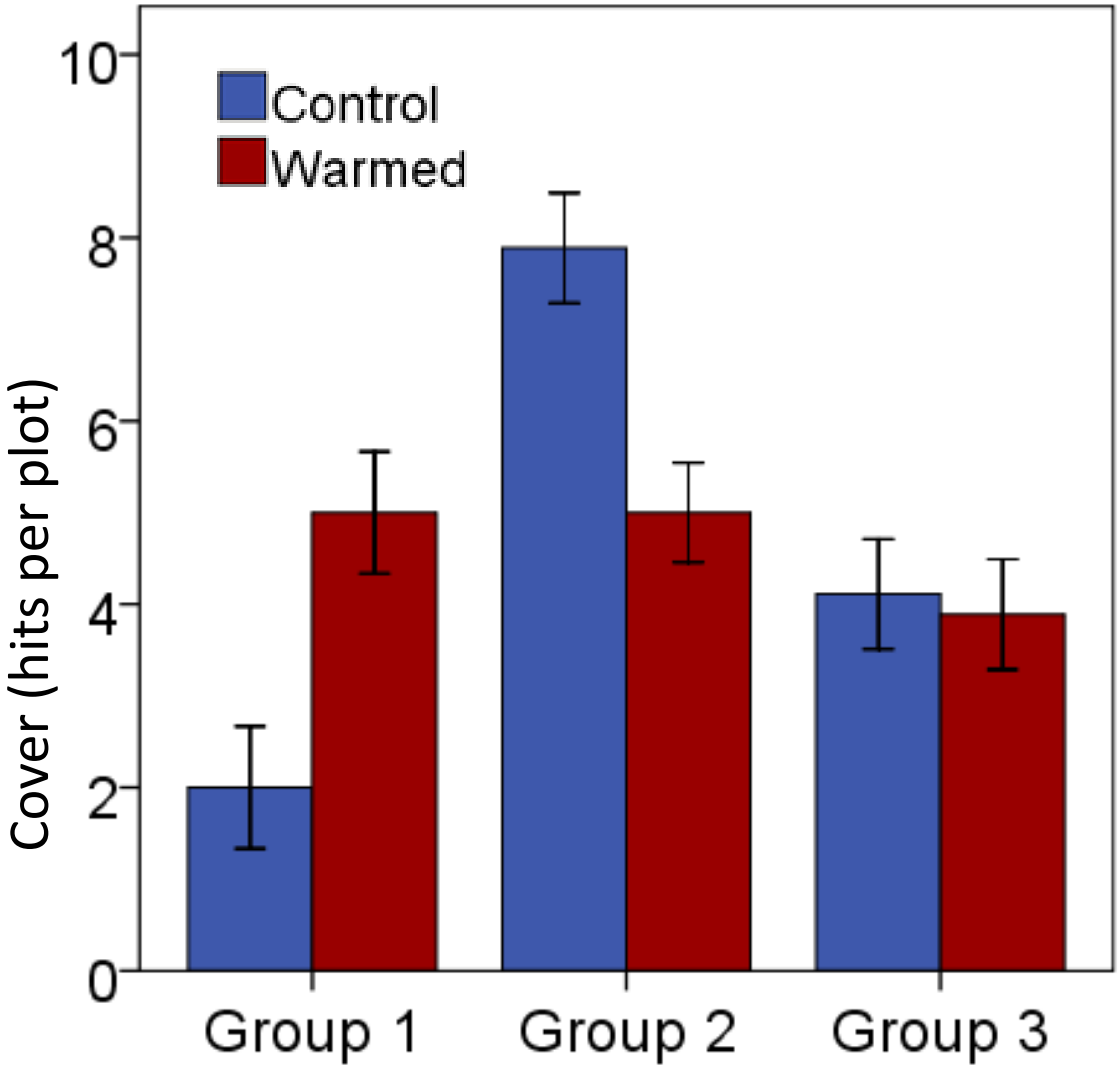
The categories are statistically different from each other, but there are no differences between treatments.

This grouping scheme is **not** useful.

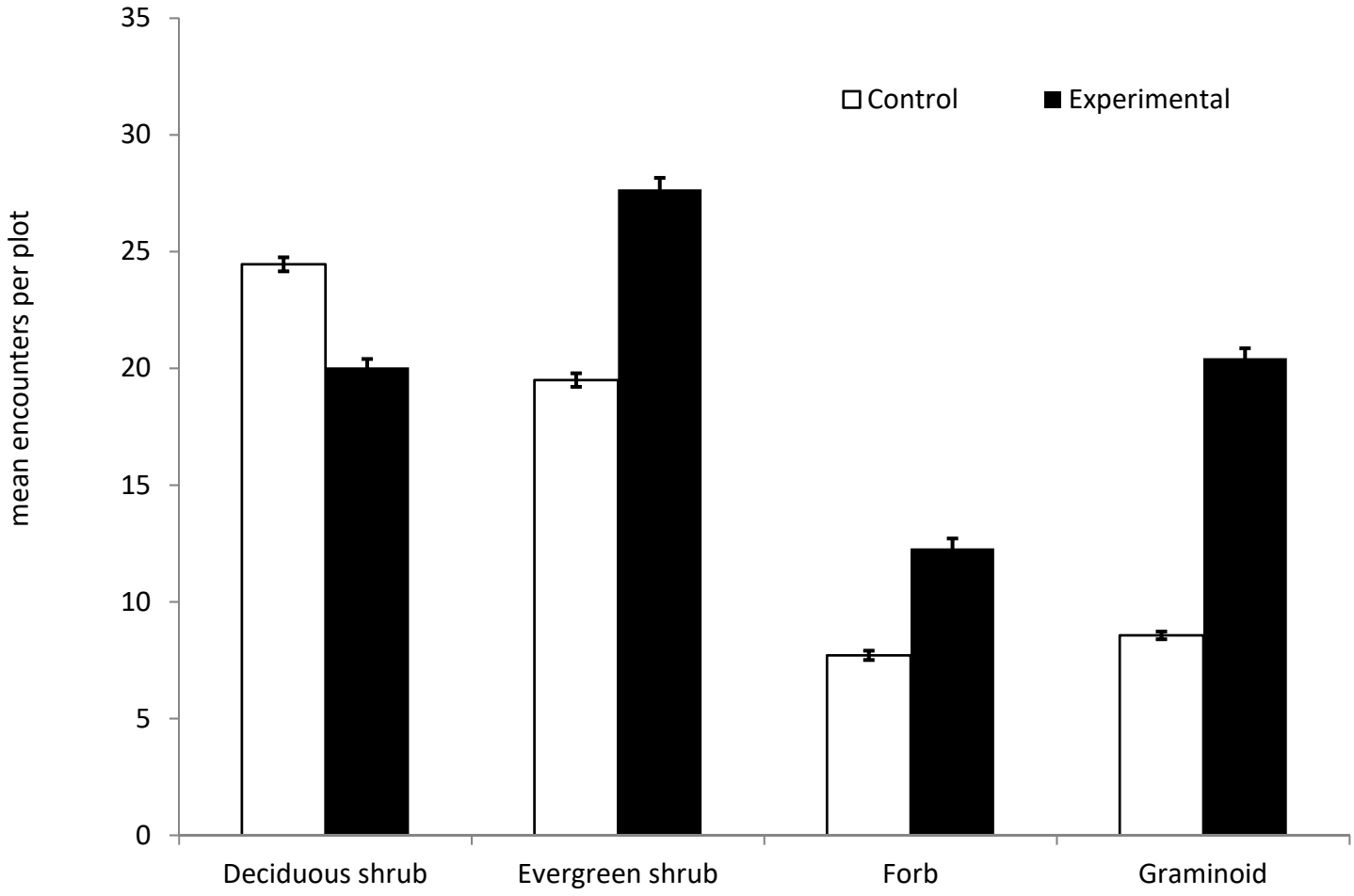


There is a response to warming, but the effect is the same for all groups.

This grouping scheme **is** useful.



This grouping scheme could be used to predict how plants assigned to each group may respond to warming in the future.


35
30
25
20
15
10
5
0
mean encounters per plot
Control
Experimental
Deciduous shrub
Evergreen shrub
Forb
Graminoid

Conclusions

- More appropriate statistical analyses are needed
- Once “useful” grouping schemes are identified then a meaningful way of combining them will be needed

References

Arft, A.M., M.D. Walker, J. Gurevitch, J.M. Alatalo, M.S. Bret-Harte, M. Dale, M. Diemer, F. Gugerli, G.H.R. Henry, M.H. Jones, R.D. Hollister, I.S. Jónsdóttir, K. Laine, E. Lévesque, G.M. Marion, U. Molau, P. Mølgaard, U. Nordenhäll, V. Raszhivin, C.H. Robinson, G. Starr, A. Stenström, M. Stenström, ø. Totland, P.L. Turner, L.J. Walker, P.J. Webber, J.M. Welker, and P.A. Wookey. 1999. Response patterns of tundra plant species to experimental warming: a meta-analysis of the International Tundra Experiment. Ecological Monographs 69(4): 491-511.

Edlund, S. A. & Alt, B. T. 1989. Regional congruence of vegetation and summer climate patterns in the Queen Elizabeth Islands, Northwest Territories, Canada. *Arctic* 42 (1): 3-23.

Gould, W. A. & Walker, M. D. 1999. Plant communities and landscape diversity along a Canadian Arctic river. *Journal of Vegetation Science* 10 (4): 537-548.

Hinzman, L.D, N. Bettez, F. S. Chapin III, M.B. Dyurgerov, C.L. Fastie, B. Griffith, R.D. Hollister, A.S. Hope, H.P. Huntington, A. Jensen, D.L. Kane, A.H. Lynch, A. Lloyd, A. D. McGuire, F.E. Nelson, W.C. Oechel, T.E. Osterkamp, C.H. Racine, V.E. Romanovsky, D. Stow, M. Sturm, C.E. Tweedie, G.L. Vourlitis, M.D. Walker, P.J. Webber, J.M. Welker, K. Winker, and K. Yoshikawa. 2005. Evidence and implications of recent climate change in terrestrial regions of the Arctic. Climatic Change 72(3): 251-298.

Hollister, R.D., P.J. Webber, and C. Bay. 2005. Plant response to temperature in northern Alaska: Implications for predicting vegetation change. Ecology 86(6): 1562-1570.

Hollister, R.D., P.J. Webber, and C.E. Tweedie. 2005. The response of Alaskan arctic tundra to experimental warming: Differences between short- and long-term responses. Global Change Biology 11(4): 525-536.

Hollister, R.D., P.J. Webber, F.E. Nelson, and C.E. Tweedie. 2006. Soil thaw and temperature response to air warming varies by plant community: Results from an open-top chamber experiment in northern Alaska. Arctic Antarctic and Alpine Research 38(2):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.*In Ninth International Conference on Permafrost*. Institute of Northern Engineering, University of Alaska, Fairbanks. 729-734 pp.

Hollister, R.D. and K.J. Flaherty. 2010. Above and belowground plant biomass response to experimental warming in Northern Alaska. Applied Vegetation Science13(3): 378–387.

Hultén, E. 1968. *Flora of Alaska and Neighboring Territories.* Stanford University Press, Stanford, California, USA, 1008 p.

Raunkiær, C. 1934. *The Life Forms of Plants and Statistical Plant Geography.* Clarendon Press, Oxford, United Kingdom, 632 p.

Sørensen, T., 1941, Temperature relations and phenology of northeast Greenland flowering plants: *Meddelelser om Gronland*, v. 125, p. 1-305.

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. Magnússon, U. Molau, S.F. Oberbauer, S.P. Rewa, C.H. Robinson, G.R. Shaver, K.N. Suding, C.C. Thompson, A. Tolvanen, Ø. Totland, P.L. Turner, C.E. Tweedie, P.J. Webber, and P.A. Wookey. 2006. Plant Community Responses to Experimental Warming Across the Tundra Biome. Proceedings of the National Academy of Science of the United States of America (PNAS) 103(5): 1342-1346.

Walker, D. A., Raynolds, M. K., Daniëls, F. J. A.,Einarsson, E., Elvebakk, A., Gould, W. A., Katenin, A. E., Kholod, S. S., Markon, C. J., Melnikov, E. S., Moskalenko, N. G., Talbot, S. S., Yurtsev, B. A. & the CAVM Team 2005. The Circumpolar Arctic Vegetation Map. – *Journal of Vegetation Science* 16 (3): 267-282.

Webber, P.J. and R.D. Hollister. 2001. Vegetation research and global Change at Barrow. In Fifty More Years Below Zero. Arctic Institute of North America. 303-312 pp.

Young, S.B. 1971. The vascular flora of St. Lawrence Island with special reference to floristic zontation in the arctic regions. *Contributions from the Gray Herbarium of Harvard University* 201: 11-115.