Finding Grouping Schemes to Better Predict Tundra Plant Response to Warming

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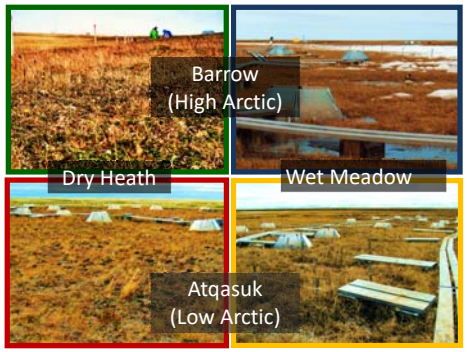
Introduction

Tundra plant species are well-adapted to the harsh conditions of the Arctic, but this environment is changing. Warming has been documented in the Arctic at rates higher than those in other parts of the world site (Arft et al 1999, Hinzman et al 2005, Walker et al 2006). These changes are expected to continue and increase. Boreal forest, the biome adjacent to tundra to the south, will slowly replace tundra (IPCC 2007).

Overall warming is known to cause an increase in biomass; the warmer conditions are initially beneficial to almost all species (Hollister 2005, May 2011). However, indefinite expansion of all plant species is not possible, and competition will begin to direct community change. Our objective is to identify those characteristics that could be used to predict species' responses to warming and the potential for a species to be successful in a more competitive environment.



Methods

Four long-term study sites were established in Northern Alaska in 1994-1996 (pictured above). Each of the four sites consists of 48 1m² plots, randomly designated as control plots or experimental plots. Experimental plots receive a warming treatment in the form of a passive open-topped warming chamber. Chambers raise temperature an average of 1-3°C during the growing season.

Cover data in the form of number of encounters per plot were used in this analysis. These data were collected using a point frame method in 2007-2008. Only encounters with live vascular plants were used. The number of encounters in control plots compared to the number of encounters in experimental plots represents the change in response to warming.

Grouping schemes were developed using information from the literature and from data from the sites. Each species was labeled according to the category in which it belonged within the grouping scheme being tested. The number of encounters of all species in each category was summed for each plot. Each category was analyzed individually using a t-test. If at least one category in a grouping scheme differed in direction of change (significant increase in cover, significant decrease in cover, or no statistical change in cover) then the grouping scheme was determined to be useful for predicting response to warming at that site.

Results

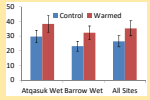
None of the grouping schemes we tested were found to be useful for predicting response to warming at all four sites. Four of the grouping schemes we tested are described to the right, with details about the categories within each.

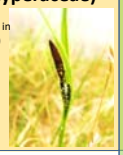
Below are descriptions of four abundant species found at the sites. The graphs show mean difference in cover between control plots and warmed plots at sites where species were present. These species showed the greatest change in response to warming. Often these species were members of categories that showed significant change, suggesting that overall community change is heavily influenced by the change of abundant species.

See boxes at lower right for details about these species in the different grouping schemes.

Carex aquatilis (Cyperaceae)

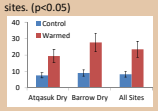
C. aquatilis showed an increase in cover at the wet sites. (p<0.05)





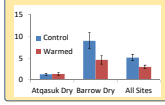
Cassiope tetragona (Ericaceae)

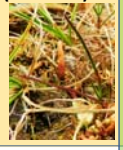
C. tetragona showed an increase in cover at the wet sites. (p<0.05)



Dupontia fisherii (Poaceae)

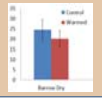
D. fisherii showed an decrease in cover at the Barrow Dry site. (p<0.05)

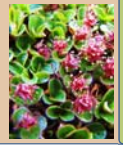




Salix rotundifolia (Salicaceae)

S. rotundifolia showed a trend to decrease in cover at the Barrow Dry site.

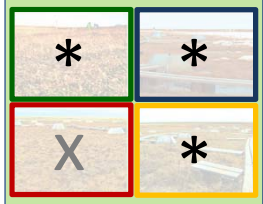




Circumarctic Distribution
Hultén 1968

This grouping scheme contains two categories:
- present throughout the Arctic
- not present throughout the Arctic

Species were assigned by looking at the distribution maps included Hultén's text (1968). See species boxes below.



This grouping scheme is useful at the Barrow Dry, Barrow Wet, and Atqasuk Wet sites.

* = useful x= not useful

C. aquatilis is categorized as present throughout the Arctic.

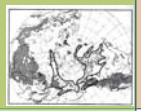
At the Barrow We t site this category shows an increase in cover, and *C. aquatilis* as a species increases in response to warming.

circumarctic

C. tetragona is categorized as present throughout the Arctic.

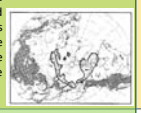
At the Barrow Dry site this category shows an increase in cover, and *C. tetragona* as a species increases in response to warming. Circumpolar species increase with warming

circumarctic



D. fisherii is categorized as NOT present throughout the Arctic.

At the Barrow Wet site this category shows a decrease in cover, and *D. fisherii* as a species decreases in response to warming. The Atqasuk Wet site shows the opposite.



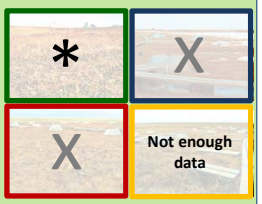
S. rotundifolia is categorized as NOT present throughout the Arctic.

At the Barrow Dry site this category shows a decrease in cover, and *D. fisherii* as a species decreases in response to warming. The Atqasuk Wet site shows the opposite.

Wintering State of Buds
Sørensen 1941

This grouping scheme contains three categories:
- A: active winter bud protection
- P: passive winter bud protection
- U: unprotected buds over winter

Species were assigned into groups in Sørensen's text (1941). See species boxes below.



This grouping scheme is useful at the Barrow Dry site only. The Atqasuk Wet site was analyzed.

* = useful x= not useful

C. aquatilis is in category P, passive bud protection.

At the Barrow Dry site this category shows a decrease in cover in response to warming. This means that the responses of other species are enough to mask the effect of *C. aquatilis* as an increasing species.

Passive

C. tetragona is in category A, active bud protection.

At the Barrow Dry site this category shows an increase in cover in response to warming. This means that the responses of other species are enough to mask the effect of *C. tetragona* as a decreasing species.

Active

D. fisherii is in category P, passive bud protection.

At the Barrow Dry site this category shows a decrease in cover in response to warming. *D. fisherii* also decreases in cover as a species at this site. Here this species responds in the same direction as the overall category it belongs to.

Passive

S. rotundifolia is in category A, active bud protection.

At the Barrow Dry site this category shows an increase in cover in response to warmingThis means that the responses of other species are enough to mask the effect of *S. rotundifolia* as a decreasing species. The change for this speices is not significant.

Active

Leaf Bud Burst
Phenology data from sites

This grouping scheme contains two categories:
- E: Relatively early greening species.
- L: Relatively late greening species.

Means were taken from observations of phenological responses collected since establishment of sites. Species were divided into either "early" group or "late" group if their average day of leaf burst was before or after the all-species mean. See species boxes below.

This grouping scheme is useful at the Barrow Dry, Barrow Wet, and Atqasuk Wet sites.

* = useful x= not useful

C. aquatilis is categorized as an early greening species.

At both wet sites the early greening category shows an increase in cover, as did *C. aquatilis* as a species.

Atqasuk Wet: Early
Barrow Wet: Early

C. tetragona is categorized as an early greening species in Atqasuk and a late greening species in Barrow.

This grouping scheme was not found to be significant at the Atqasuk Dry site. At the Barrow Dry site the late greening category showed no change.

Atqasuk Dry: Early
Barrow Dry: Late

D. fisherii is categorized as a late greening species in Atqasuk and an early greening species in Barrow.

At both wet sites the category that *D. fisherii* was in showed a decrease. However, *D. fisherii* shows no change at Atqasuk Wet.

Atqasuk Wet: Late
Barrow Wet: Early

S. rotundifolia is categorized as a late greening species.

The late greening species showed no change at the Barrow Dry site. *S. rotundifolia* shows a trend toward decreasing that is not statistically significant.

Atqasuk Dry: Late
Barrow Dry: Late

Polyploidy
Löve & Löve 1948

This grouping scheme contains three categories:
- No polyploidy: 2N
- Low : Greater than 2N, less than 8N
- High: 8n and greater(highest 16N)

Chromosome Numbers of Northern Plant Species gives chromosome numbers from a few sources. The estimations frequently varied, so we assigned species to one of three groups based on the approximate ploidy level. See species boxes below.

This grouping scheme is useful at the Barrow Wet, and Atqasuk Wet sites.

* = useful x= not useful

C. aquatilis is a high polyploidy species.

At both wet sites the category of species that is high polyploidy increased in cover, as did *C. aquatilis* as a species.

High polyploidy (8N and greater)

C. tetragona is a no polyploidy species (2n).

The polyploidy trait defined by this grouping scheme was not found to be a useful characteristic for predicting response to warming at the dry sites.

No polyploidy (2N)

Chromosome numbers for *D. fisherii* were not given in the text. Finding other sources for chromosome numbers will improve the analysis of this grouping scheme. Since the sources cited in the Löve & Löve (1948) text are often in disagreement, updated and accurate sources for this grouping scheme are needed.

Chromosome numbers for *S. rotunifolia* were not given in the text. Finding other sources for chromosome numbers will improve the analysis of this grouping scheme. Since the sources cited in the Löve & Löve (1948) text are often in disagreement, updated and accurate sources for this grouping scheme are needed.

Conclusions:

- Categories of plants respond differently at the different sites.
- Change may be driven by the increase or decrease in cover of a few abundant species, *Carex aquatilis* in particular.
- To identify traits that are useful for predicting response throughout the Arctic, grouping schemes need to be combined.

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