High Arctic and Low Arctic Vegetation Responses to Climate Change

Jennifer A. Liebig, Robert D. Hollister, & Jeremy L. May
Grand Valley State University

ABSTRACT

High latitude regions have seen the most profound changes as a result of climate change. The village of Atqasuk on the North Slope of Alaska was the site of an ongoing study of the response of plant cover to experimental warming using open topped chambers. The experimental sites were established in 1996, and this study uses data collected in 2007. Plant cover was sampled using a point frame method. Previous studies have found that when compared to the control plots, the warmed plots show an increase in the cover of vascular plants. This study examines the differences between plants classified as high arctic and low arctic species. The prevailing wisdom is that low arctic species will respond faster to warming. We found that the warmed plots at the dry site showed a decrease in cover relative to the control plots. The warmed plots at the wet site showed a greater cover of high arctic species relative to the control plots. These findings were contrary to the prevailing wisdom.

INTRODUCTION

The poles see greater effects of climate change compared to mid- and low-latitude regions, and the severity of the climate dictates that tundra plants have adapted to these conditions in order to successfully colonize the region. This in turn dictates that small changes in climate could potentially have a large impact on the community. This study seeks to predict the behavior of certain vegetation species in response to climate change by investigating the difference between species that are exemplary of different vegetation zonation schemes. The International Tundra Experiment (ITEX) uses artificial warming to investigate the responses of plant communities by observing changes in growth and phenology. Previous studies have found that when compared to the control plots, the warmed plots show an increase in the cover of vascular plants (Hollister et al, 2005; Walker et al, 2006). The prevailing wisdom is that low arctic species will respond faster to warming as conditions change. This study uses a basic classification of high arctic vs. low arctic to categorize species at the existing ITEX research site in Atqasuk, AK (**Figure 1**) and determine if low arctic species are responding more quickly to warming.

Figure 1. The village of Atqasuk in Alaska, located at 70°28'40"N, 157°25'5"W

Figure 2. An OTC on an experimental plot

METHODS

The Atqasuk location consists of a dry heath site and a wet meadow site. In each site there are 24 control plots and 24 plots under Open-Topped Chambers (OTCs). The OTCs (**Figure 2**) provide insulation and warm the experimental plots between 1 and 5 degrees Celsius, depending on weather conditions (Hollister et al, 2006). Data about vegetation cover was collected using a point frame method. At each intersection of a 75cm x 75cm 100 point grid, a ruler was dropped (**Figure 4**). Every occurrence of a plant species was identified by species and recorded as alive or dead. This was done at each plot in both the wet and dry sites.

The species present were identifies as either high arctic species or low arctic species, using classifications outlined in Edlund and Alt, 1989, and Gould and Walker, 1999. Of the thirty-six species identified in Atqasuk, twelve were identified as high arctic species, meaning that they are present in higher latitudes than low arctic species, though they may also be present in the same communities as the species identified as low arctic. The list in **Figure 3** shows that the wet meadow site and the dry heath site share no species in common, though both high and low classified species are present in both. Defining "high" and "low" is necessarily relative, so for the purposes of this study, the division between the two categories is approximately the northern limit of erect dwarf shrubs such as *Salix pulchra* (Gould and Walker 1999).

Figures 5 and 6 show the average number of hits for each plot, with the data for all species classified as high combined and the data for all species classified as low combined. Average numbers of hits for the warming treatment are compared to the average number of hits in the control treatment within each site.

Wet Site Species **(A)**	
Arctophila fulva	High
Carex aquatilis	High
Carex aquatilis/stans	High
Dupontia fisheri/psilosantha	High
Juncus biglumis	High
Pedicularis sudetica	High
Polygonum viviparum	High
Salix polaris	High
Betula nana	Low
Calamagrostis sp.	Low
Carex rariflora	Low
Carex rotundata	Low
Eriophorum angustifolium	Low
Eriophorum angustifolium/triste	Low
Eriophorum russeolum	Low
Eriophorum scheuchzeri	Low
Luzula wahlenbergii	Low
Salix pulchra	Low

Dry Site Species **(B)**	
Arctagrostis latifolia	High
Cassiope tetragona	High
Luzula confusa	High
Trisetum spicatum	High
Vaccinium vitis-idaea	Low
Antennaria friesiana	Low
Armeria maritima	Low
Artemisia borealis	Low
Carex bigelowii	Low
Diapensia lapponica	Low
Hierochloe alpina	Low
Ledum palustre	Low
Luzula arctica	Low
Minuartia obtusiloba	Low
Pedicularis lapponica	Low
Polygonum bistorta	Low
Salix phlebophylla	Low
Salix rotundifolia	Low

FIGURE 3. Species present in the sites, separated by wet site (A) and dry site (B) and identified as **HIGH** or **LOW**

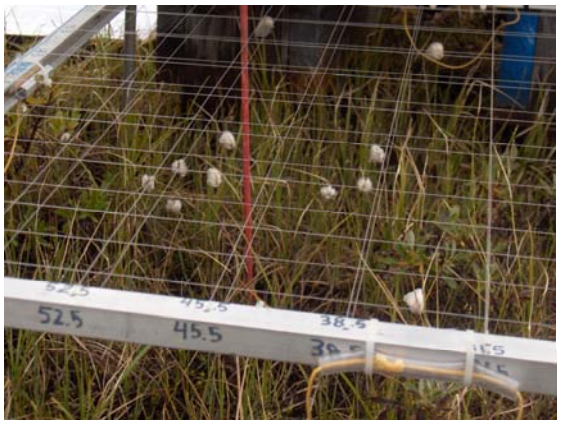

FIGURE 4. The point frame grid with a ruler dropping to the ground for the bottom hit

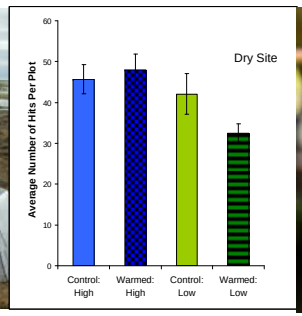

FIGURE 5. The Atqasuk Dry Site (A), where the difference between cover of high arctic species did not change between control plots and warmed plots, and the low arctic species showed a decrease in cover in the warmed plots (B). (C) shows *Cassiope tetragona,* an evergreen shrub that is common in the dry site.

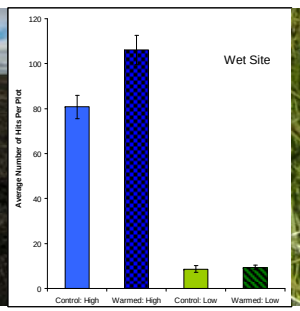

FIGURE 6. The Atqasuk Wet Site (A), where the cover of high arctic species showed an increase in the warmed plots, and the low arctic species showed no change (B). (C) shows *Eriophorum angustifolium,* a conspicuous graminoid that is common in the wet site.

RESULTS:

In the dry site the difference in cover of species classified as high arctic species between warmed and control plots was insignificant. The plants classified as low arctic species were found to have more hits in the control plots than the warmed plots, as seen in **Figure 5.** We found that overall the warmed plots at the dry site showed a decrease in cover relative to the control plots.

The warmed plots at the wet site showed a greater cover of high arctic species relative to the control plots, while the low arctic species, expected to increase as a result of the warming treatment, did not produce statistically significant differences (**Figure 6**). The trend shows an increase in warming, but the results are not significant.

CONCLUSIONS:

The findings of this study were contrary to the prevailing wisdom about high arctic and low arctic species. However, there was a significant increase in high arctic species cover in the warmed wet site plots and a trend towards an increase in low arctic species in those same plots. The most significant difference in cover was seen in the high arctic species of the wet site, which had more cover in the warmed plots rather that showing a predicted decline under warmer conditions. In the dry site the most significant change was a decrease in cover in the warmed plots, which also was not expected. It is possible that the dry heath site, already a dry environment, was further dried as a result of the warming treatment. Warming could have increased the water stress on the plants in the dry site, decreasing the cover for both high and low arctic species. In the wet site, the plants classified as high arctic are more likely to be graminoids than shrubs. These different functional groups do not reproduce and spread in the same way; graminoids are more likely to both produce new individuals and to have a matted layer of dead material that would be recorded in the point frame process. However, overall, the data show that shrubs and graminoids increase in both the wet and dry sites, and these preliminary findings indicate that the distinction between high arctic and low arctic plants is not significant.

ACKNOWLEDGEMENTS

Thanks to Robert Hollister, Primary Investigator for this project.

Also to the members of the Arctic Ecology Program in 2007-2008: Jeremy May, Robert Slider, Jean Marie Galang, Amanda Snyder, and Michael Lothshutz.

Thanks to the National Science Foundation for funding and the Barrow Arctic Science Consortium for providing logistics in Alaska.

REFERENCES

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.

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, and C. Bay. 2005. Plant response to temperature in northern Alaska: Implications for predicting vegetation change. *Ecology* 86(6): 1562-1570.

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.