

Plant Responses to Temperature in Barrow and Atqasuk, Alaska

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Introduction

Under a changing climate the Arctic is expected to experience the greatest amount of warming of any ecoregion on earth (IPCC 2007). Because Arctic plants are adapted to thrive in cold temperatures their responses to warming is of interest to those seeking to predict the impacts of climate change. Numerous studies have shown, in general, that arctic plants respond to artificial warming with increased inflorescence length, and earlier flower burst (Artt et al. 1999, Hollister et al. 2005). By examining the responses of plants to artificial and natural temperature variations, this study seeks to find whether responses seen under artificial warming are also evident in annual temperature variation. This topic is becoming of increasing interest to those studying the effects of climate change on tundra vegetation as it may provide valuable insight into the rates of expected responses under a warming climate.

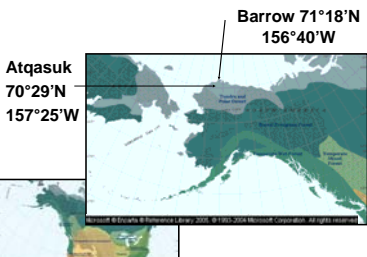


Figure 1: Location and scheme of Study sites in Barrow and Atqasuk, Alaska.

Results & Discussion

Differences between mean date of first flower burst in control and experimental treatments varied by species (Figure 2). For instance: In the Barrow Dry site, the species *Cassiope tetragona* consistently flowered significantly earlier in warmed plots than in controls while *Luzula arctica* did not display a consistent trend (Figure 2). Flowering trends in control plots at Barrow also followed a consistent trend of earlier flowering with higher mean July temperature (Figure 3) Differences between average maximum inflorescence lengths in each treatment also varied by species (Figure 4). While the general response of tundra vegetation to warming has been shown to be an increase in reproductive effort and earlier flowering, findings have also shown that response to warming varies from species to species (Artt et al. 1999, Hollister et al. 2005). This is shown in the inflorescence heights at the Atqasuk Dry Site (Figure 4) where there are multiple examples of inflorescences in experimental plots that are shorter than those in controls.

Analysis of relationships between mean July temperature and each developmental trait yielded r^2 values varying from 0.03 to 0.75 (Figure 5). 50% of the r^2 values obtained were categorized as medium while 7% were strong, and 43% were weak. This wide range of strengths suggests that while temperature significantly influences the development of some species, others are influenced more by other factors. r^2 values were generally higher in Barrow than in Atqasuk. This may be explained by the fact that Barrow is typically colder, and therefore Barrow plants would likely show a greater response to a heat source. Because mean July temperature does not account for the timing of snowmelt or heat experienced by the plants during the entire growing season, these trends may appear weaker or stronger than they actually are. Further analysis using thawing degree days may prove useful in explaining trends seen both in inflorescence height and date of flower burst.

Conclusion

Some significant differences were seen in reproductive timing and inflorescence growth between plants in control and OTC plots. Findings supported those of previous studies which showed a varied response to warming by species (Artt et al. 1999, Hollister et al. 2005). Evidence was found that some trends seen in artificial warming experiments, such as an increase in inflorescence length and earlier flower burst, are evident in annual temperature variation.

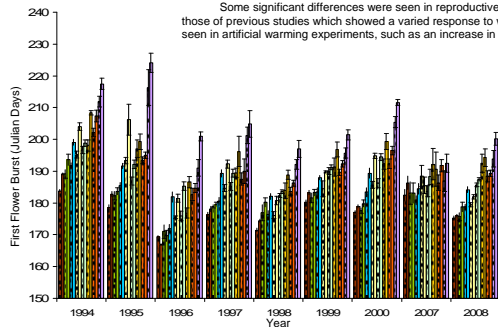


Figure 2: Average date of first flower burst by year and treatment. Error bars represent the standard error of the mean.

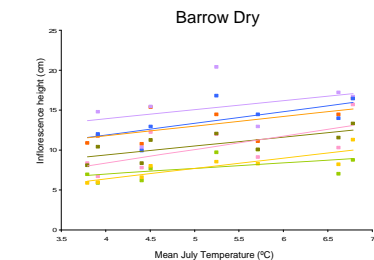


Figure 5: Average maximum inflorescence height in control plots compared to mean July temperatures.

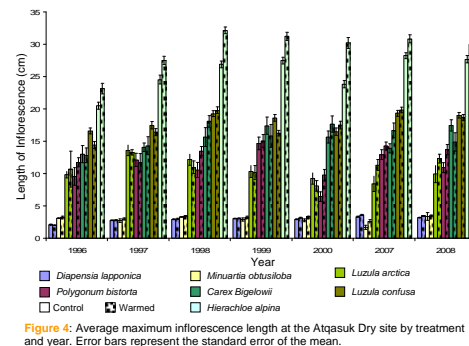


Figure 4: Average maximum inflorescence length at the Atqasuk Dry site by treatment and year. Error bars represent the standard error of the mean.

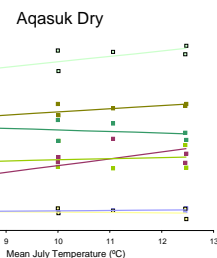
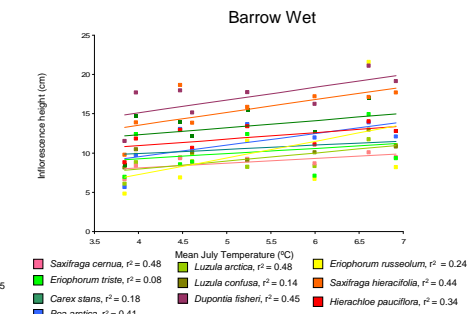


Figure 5: Average maximum inflorescence height in control plots compared to mean July temperatures.

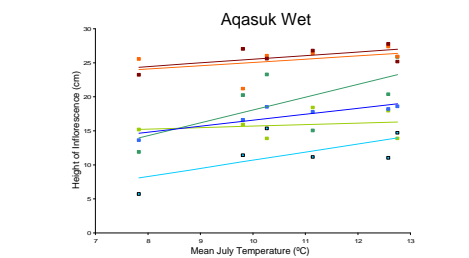


Figure 5: Average maximum inflorescence height in control plots compared to mean July temperatures.

Methods

Research was conducted at four sites in Barrow and Atqasuk, Alaska (Figure 1). Sites represented dry heath and wet meadow plant communities and are thus termed Barrow Dry, Barrow Wet, Atqasuk Dry, and Atqasuk Wet. Each site contains 24 control plots and 24 warmed plots. Open Top Chambers (OTCs) were used to warm tundra vegetation during the summer growing season (Mid-June through the end of August). OTC's act similarly to green houses by letting light pass through, but trapping infrared radiation. On average these chambers warm the plots by 2°C (Hollister, R.D., P.J. Webber 2000).

Growth of marked specimens was measured once each week and phenological developments were observed twice each week. Temperature at canopy height (13cm) was collected at 15 minute intervals by probes attached to Campbell Data Loggers. Temperatures were averaged and stored every hour for the duration of the year.

The maximum inflorescence length of marked individuals, and largest reproductive specimens, was averaged by plot and then by treatment at each site. Treatments were compared to examine differences in inflorescence lengths due to warming. Inflorescence lengths in control plots were compared to the mean July temperature, an estimation of heat energy experienced during the growing season, to investigate responses to natural temperature variation and compare these with responses to artificial warming. First date of flower burst was averaged by treatment type and compared to mean July temperature to examine responses to warming and natural temperature variation. Significant differences in inflorescence height and flower burst between warmed and control treatments were described as those beyond the standard error of the mean. r^2 values were found for correlations between both developmental characteristics and mean July temperature. r^2 values of less than 0.35 were considered weak, 0.35-0.70 were considered medium, and greater than 0.70 were considered strong.

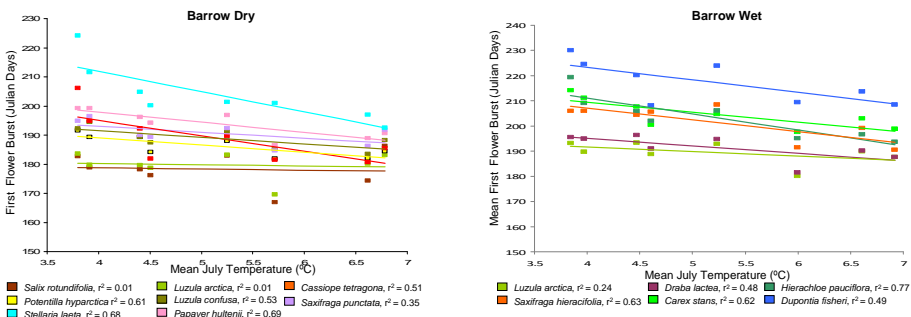


Figure 3: Average date of first flower burst in control plots compared to mean July temperatures.

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