The Response of Warming on the Flowering of Arctic Plants

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Abstract:

Organisms are limited by temperature in the Arctic. Summers in the Arctic are short and plants have little time for growth, development, and reproduction. Plant performance is therefore greatly affected by warming. We conducted an experiment to warmed the tundra using open-top chambers (OTC's) to estimate the impacts of elevated temperatures on plant flowering. The flowers were counted for each species and compared over five growing seasons. Flowering is an important sign of reproductive effort. Changes in flower timing or magnitude may lead to community changes. The number of flowers may also indicate the health of the community. In general, the responses to warming included an increase in the total number of flowers and earlier flowering times. However, these responses varied greatly among species as well as within the same species at different locations. For example, the number of flowers of *Cassiope tetragona* increased at Barrow, but decreased at Atqasuk in response to increased temperatures. These results are consistent with other studies which have found earlier increased flowering as a response to warming.

Introduction:

Plants living in seemingly harsh environments such as the desert or arctic often have synchronized flowering periods. Short growing seasons and cold temperatures constrain the ability of Arctic plants to grow and to reproduce. Among the activities restricted are pollination, pollen tube germination, ovule fertilization, nutrient absorption, and seed maturation (Totland, 1999). Thorhallsdottir (1998), indicated that the timing of flowering Arctic plants can be use to understand Arctic ecology and predict reproductive success. Studying the response of species due to anthropologenically enhance climate change has been an interest of study, especially in polar regions (Chapin et al, 2005). The tundra ecosystem may be replaced by shrubs and Northern movement of the boreal forest (Foley 2005). In this study, we used open-top chambers (OTC's) to evaluate the affect of warming on shrubs and sedges at two different locations.

Fig 1. A map of Alaska showing the location of the study sites.

Materials and Methods:

The plots were established at a wet and dry site in Barrow and Atqasuk, (Alaska, USA) between 1994 and 1996. Each of the study sites contained 24 control plots and 24 warmed plots. The average temperature of Barrow in July is 3.7 °C and 9.0 °C in Atqasuk. We used open-top, chambers (OTCs) made from fiberglass to warm the experimental plots. Chambers were installed shortly after snowmelt and removed at the end of the growing season. The OTC have been shown to warm the air temperatures an average 0.6-2.2 °C over the course of the summer (Hollister et al. 2005). Flowers were counted once a week throughout the growing season on the following plant species: *Carex stans* (sedge), *Carex aquatilis* (sedge), *Salix rotundafolia* (shrub), *Luzula confusa* (sedge), and *Cassiope tetragona* (shrub) . Their number of flowers and date of emergence were compared .

Fig 2: A researcher collecting data at the Barrow dry site

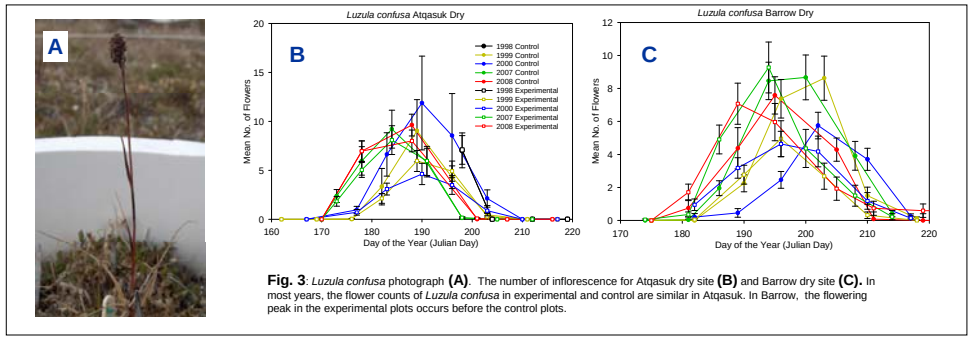

Fig. 3: *Luzula confusa* photograph **(A)**. The number of inflorescence for Atqasuk dry site **(B)** and Barrow dry site **(C).** In most years, the flower counts of *Luzula confusa* in experimental and control are similar in Atqasuk. In Barrow, the flowering peak in the experimental plots occurs before the control plots.

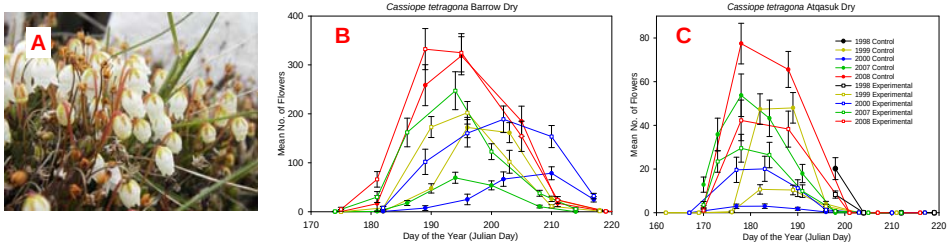

Fig. 4: Photograph *Cassiope tetragona* **(A).** The number of inflorescence for Barrow dry site **(B)** and Atqasuk dry site **(C).** Most years in Barrow, the flower number in experimental treatment had a significant increase than control, but *C. tetragona* showed a different response in Atqasuk. In Atqasuk, the flower counts decreased in the experimental plot and increased in the control plots.

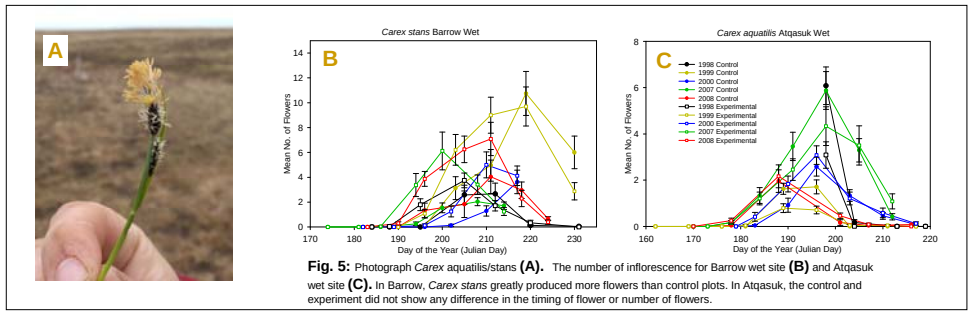

Fig. 5: Photograph *Carex* aquatilis/stans **(A).** The number of inflorescence for Barrow wet site **(B)** and Atqasuk wet site **(C).** In Barrow, *Carex stans* greatly produced more flowers than control plots. In Atqasuk, the control and experiment did not show any difference in the timing of flower or number of flowers.

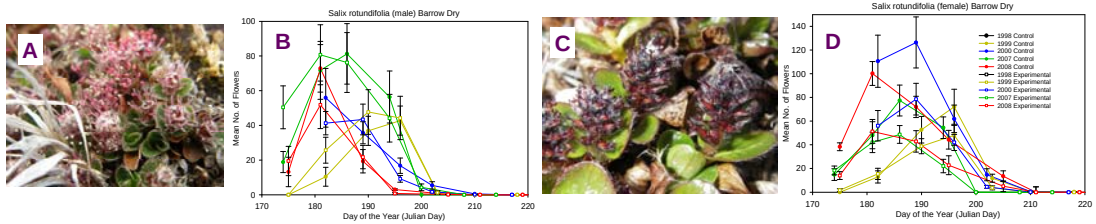

Fig 6 :Photograph of male *Salix rotundifolia* **(A)** The number of inflorescences for Barrow dry **(B).** In most years, the male *Salix rotundifolia* showed no consistent differences between control and experimental plots.

Fig 7: Photograph of female *Salix rotundifolia* **(C).** The number of inflorescences for Barrow dry **(D).** In most years, the female *Salix rotundifolia* have more flower counts in control plots than experimental plots.

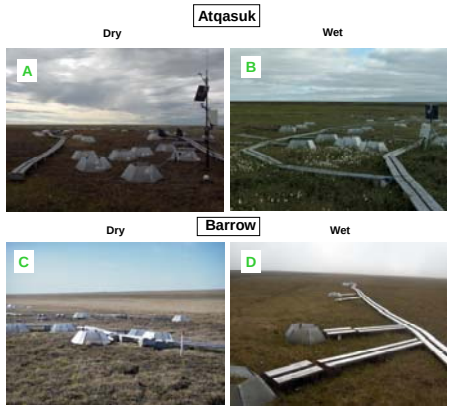

Fig. 8 : Images of the four study sites. Atqasuk dry **(A)** and Atqasuk wet **(B).** Barrow dry **(C)** and Barrow wet **(D).**

Discussion:

The response of plant flowering to warming varied between species and across sites. For example, in response to warming the number of *C. tetragona* flowers increased at the Barrow dry site and decreased at the Atqasuk dry site. We believe the decrease in flowering at Atqasuk is due to the drying in the chambers. Female *S. rotundifolia*, plants also decreased in flowering in the experimental site at Barrow. Both *S. rotundifolia* and *C. tetragona* are prostate woody shrub may be over topped by graminoids (*L. confusa, C. stans,* and *C. aquatilis*). Interestingly, *S. rotundifolia* male counterpart did not show any difference between control and experiment. *Carex* showed little response to warming at Atqasuk but flowering increased and was earlier at Barrow. The flowering of *L. confusa* was earlier in response to warming at the Barrow but did not change in Atqasuk. Arft et. al (1999), found that reproductive response of graminoids responds more consistently than woody forms and it may be due to their capability of nutrient absorption and flexible morphology to respond to warming (Arft 1999). In general warming resulted in greater and earlier flowering. However, the results from the experiment showed that different species responded differently to warming and that the same species my have had a different response in different years or at different sites.

References:

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Acknowledgements:

Dr. Robert D. Hollister,Jeremy May, Robert Slider, Jenny Liebig, Amanda Snyder, National Science Foundation, and Barrow Arctic Science Consortium.