MONITORING THE RESPONSE OF TUNDRA VEGETATION TO TEMPERATURE AT BARROW AND ATQASUK, ALASKA

Robert Hollister, Jeremy May, Robert Slider, Jennifer Liebig

Biology Department; Grand Valley State University (GVSU); 1 Campus Drive; Allendale, MI 49401. Contact: hollistr@gvsu.edu

ABSTRACT

The Arctic has warmed and is expected to continue to warm more than other region of the world. This study examines the potential effects of observed warming on the vegetation by observing the response of tundra plants to variation in temperature due to natural temperature gradients, interannual variability, and experimental warming at four sites experiencing modest warming in northern Alaska (PART A). The project couples long-term monitoring with experimental warming to determine if the changes observed in the region are due to regional warming or other causes. The four sites span a temperature gradient from warmer Atqasuk to cooler Barrow and moisture gradients from dry heaths to wet meadows. At each site 24 warmed and 24 control plots have been periodically monitored since the mid 90's. The most common response to warming observed thus far is earlier phenological development and increased growth of graminoids (PART B); however, the response of a plant species is individualistic and may vary among sites. The trajectories of species composition and cover change where not consistent across sites despite a more uniform response to experimental warming (PART C). This may reflect the influence of driving factors other than temperature or the resistance of the plant community to change. Overall the project is finding that warming is one of many factors likely responsible for the observed vegetation changes occurring in northern Alaska.

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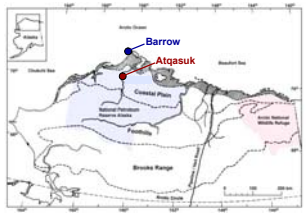


FIG 1. Map of northern Alaska. The region denoted with hashed marks is commonly referred to as littoral tundra because of the strong influence of the Arctic Ocean on regional climate.

PART A. The study sites are located near villages of Barrow and Atqasuk, Alaska (FIG 1). The Barrow Dry site begun in 1994 and the Wet site in 1995. Both Atqasuk sites begun in 1996. The project was established under the umbrella of ITEX (International Tundra EXperiment; a collaborative network researchers examining the response of tundra vegetation to warming) and the sites have been included in every major ITEX cross site synthesis [1,2,3,4]. The region has show a slight warming trend over the course of the project (FIG 2).

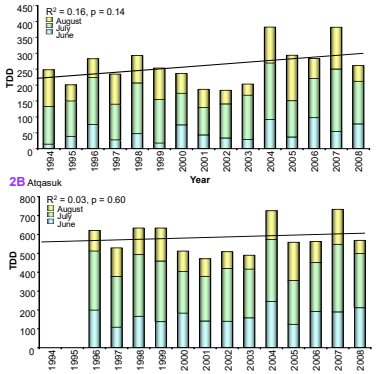
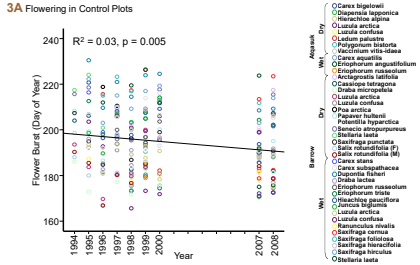


FIG 2. Thawing degree day accumulations (TDD) at Barrow (A) and Atqasuk (B). Measurements were made at screen height from snowmelt until mid August.



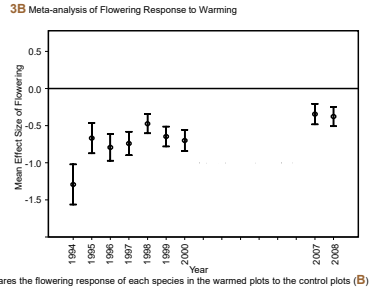
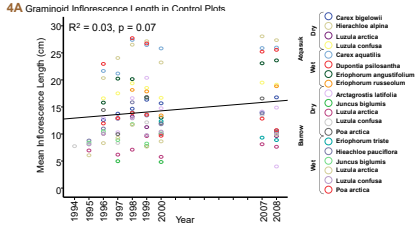
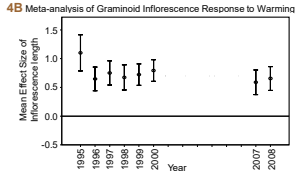


FIG 3. Change in flowering time of all species in the control plots (A) and a meta-analysis that compares the flowering response of each species in the warmed plots to the control plots (B) over the duration of the experiment.





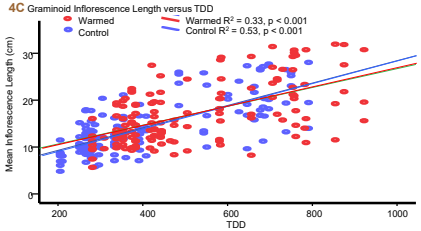


FIG 4. Change in the inflorescence length of all species in the control plots (A), a meta-analysis that compares the change in inflorescence length of each species in the warmed plots to the control plots (B), and a comparison of inflorescence length with thawing degree day sums (TDD) from snowmelt until mid August for each species (C).

PART B. The plants at Barrow and Atqasuk appear to be responding to regional warming. We say this because the observed changes occurring in the control plots are in many ways similar to the observed response to experimental warming. We have shown previously that the experimental warming is a reasonable analog of regional warming [5,6]. The timing of flowering appears to be advancing for the region as a whole (FIG 3A) and the response to experimental warming is consistently earlier flowering (FIG 3B). The observed trend for the region has been an increase in the length of graminoid inflorescences and leaves (FIG 4A; leaf data show the same trend but are not presented) and the response to experimental warming is increased graminoid growth (FIG 4B & 4C). Other responses to warming are less consistent across species and are difficult to generalize [7]. Since the response to experimental warming is similar to the observed trends for the region, we believe the underlying causal factor is the same –warming. Thus it appears that the plant species at Barrow and Atqasuk are responding to a the slight warming trend observed for the region with earlier flowering and increased growth of graminoids.

FIG 5. Photograph of vegetation sampling.

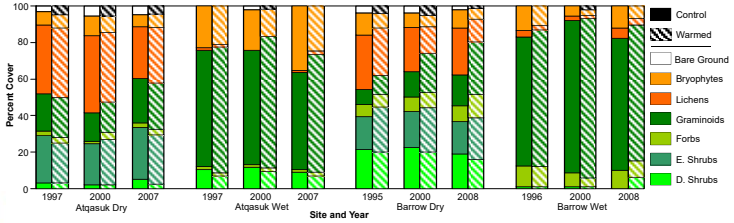


FIG 6. Change in the cover of vascular plants, bryophytes and lichens over time in the control and warmed plots at all sites.

PART C. Plant community change was monitored by point framing (FIG 5). The response to warming can be generalized as an increase in community stature due to an increase in growth and abundance of shrubs and graminoids at the expense of lichens and bryophytes which overall results in a decrease in species diversity (FIG 6, TABLE 1). These changes are consistent with earlier studies [2,8]. However the changes that have occurred in the control plots are much less consistent and do not show an obvious similarity to the response to experimental warming. Thus it appears that the factor driving community change is different at each of the sites.

TABLE 1. Change in the average canopy height and species diversity (richness and evenness) at the four study sites over time. Statistical significance was determined with a 2 factor ANOVA (n=24).

Site	Sampling 1		Sampling 2		Sampling 3		Significance		
	C	W	C	W	C	W	Warm	Year	W x Y
Atqasuk Dry	year 1997		year 2000		year 2007				
Canopy Height	1.93	1.82	1.73	1.65	1.25	1.36	ns	*	ns
Spp Richness	17.58	17.42	16.75	16.50	16.25	15.38	ns	*	ns
Spp Evenness	0.86	0.84	0.87	0.86	0.87	0.80	ns	*	ns
Atqasuk Wet	year 1997		year 2000		year 2007				
Canopy Height	7.61	8.20	7.07	7.94	5.41	7.97	*	*	*
Spp Richness	13.75	13.13	11.63	10.79	11.88	11.29	ns	*	ns
Spp Evenness	0.76	0.77	0.73	0.74	0.76	0.76	ns	ns	ns
Barrow Dry	year 1996		year 2000		year 2008				
Canopy Height	3.16	3.34	1.34	2.12	0.88	1.65	*	*	ns
Spp Richness	19.33	18.71	19.79	18.13	19.88	16.96	*	ns	ns
Spp Evenness	0.83	0.79	0.81	0.78	0.82	0.79	*	ns	ns
Barrow Wet	year 1995		year 2000		year 2008				
Canopy Height	3.19	3.97	4.01	4.53	2.94	4.04	*	*	ns
Spp Richness	18.67	17.96	15.96	15.83	16.38	14.79	ns	*	ns
Spp Evenness	0.81	0.80	0.81	0.77	0.83	0.79	*	ns	ns

* significant, ns not significant, C control plots, W warmed plots, W x Y interaction