

Plant Community Changes In Northern Alaska Over The Past 12 Years

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Abstract:

Climate change effects all parts of the world, however these effects have been most pronounced in high latitude regions. This study follows community change over a 12 year period at dry heath and wet meadow plant communities near Atkasuk, a small native village on the North Slope of Alaska. Community changes were sampled using a point frame method by dropping a ruler down at each point on a 75cm X 75cm 100 point grid. Each contact was identified along with its live/dead status in order to estimate the cover of each species. The samplings were done in 1996, 2000, and 2007. Each sampling was conducted during the same 2 week period in order to minimize differences in cover due to phenological development. Changes in bryophyte, lichen, and forb cover differed between the 1996 to 2000 sampling and the 2000 to 2007 sampling, however changes in shrub and graminoid cover steadily increased from 1996 to 2007. The change in cover between 1996 and 2007 were as follows. Lichens showed only minor community changes in both sites (<10%). Bryophytes increased in the dry site (39%) and decreased in the wet site (10%). Forbs increased in the dry site (22%) and decreased in the wet site (40%). Shrubs and graminoids increased in both sites (15-45%). These results are consistent with a number of recent studies that have found a general increase in shrub and graminoid cover across the Arctic.

Introduction:

The effects of climate changes are felt throughout the world however these changes had the earliest and greatest effects in high latitude areas. The arctic is considered the global canary in the coal mine meaning that impacts of climate change are expected to be felt first in the arctic. Warming in the arctic has been well documented since the 1800s and has become more pronounced since the mid-20th century (Wahren et al. 2005). Changes in the biomes may affect many abiotic aspects of the region including precipitation rates, nutrient cycling, and soil moisture retention (Gornall et al. 2007).

Plant communities in these high latitude areas have adapted to survive under harsh conditions. The stresses that these communities are subjected to include short growing seasons, cold temperatures, low precipitation rates and high wind desiccation. Even small variations in this environment can have lasting effects on aspects of plant communities including growth rates, phenological development, and reproductive rates (Chapin and Shaver, 1985). These combined effects can change the overall structure and diversity of communities as species and growth forms often respond differently to changes in seasonal temperature.

Vascular plants often respond quickly to local increases in temperature with graminoids and shrubs showing the most increased growth rates (Arft et al. 1999; Kudo and Suzuki 2002; Hobbie and Chapin, 1998). These increased growth rates often allow a competitive advantage for these taller growth forms, as they are able to compete better for light resources. This can lead to lower lower strata plants (bryophytes, lichens and forbs) to be light deficient and over time lower in abundance (Epstein et al. 2004; Wahren et al. 2005). These changes are often more pronounced in wet meadows and are often marginal in dry heath environments due to dry heaths already being water stressed (Jaegerbrand et al. 2004).

The region is believed to have experienced a warming trend (Chapman and Walsh, 1993). This projects aims are to investigate how wet meadow and dry heath plant communities have responded to climatic changes over the past 12 years.



Figure 1: Photographs of the dry (A) and wet (B) sites in Atkasuk, and a map of Alaska showing the location of Atkasuk (C).

Methods:

Two study sites, one dry heath and one wet meadow, were established outside Atkasuk, Alaska in 1996 (Fig 1). Each site consists of 24 plots. Community data was collected using a point frame method in which a 100 point grid was leveled above the canopy layer (Fig 2). A ruler was lowered down at each point and all contacts were identified by species, live/dead status, and height. All measurements were done during the same two week periods in 1996, 2000 and 2007 in order to minimize differences in phenological development (Hollister et al. 2005). Species were then grouped by broad and narrow growth forms for analysis. Temperature ranges during the study period were between 7.5oC and 12.8oC (Fig 3).

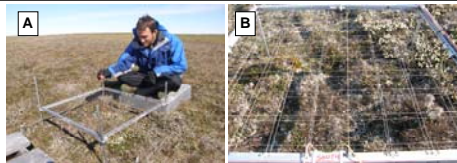


Figure 2: Photographs of point framing in Atkasuk (A) and point frame grid (B).

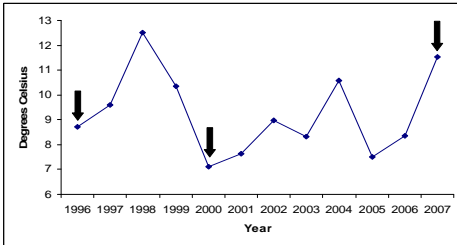


Figure 3: Mean July temperature change (°C) at Atkasuk in the years 1996-2007, arrows indicate years of samplings.

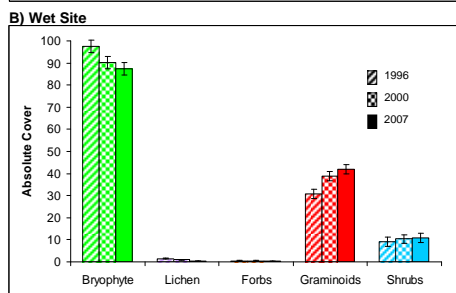
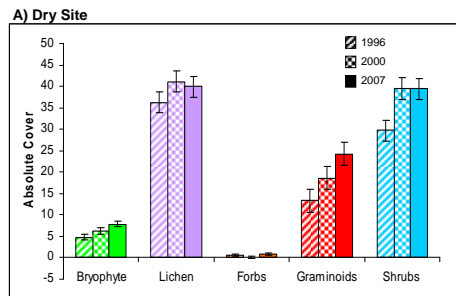


Figure 4: Plant cover of the major growth forms at the dry site (A) and wet site (B) in the years 1996, 2000, and 2007. For an example of each growth form see (Fig 5).

Table 1: Plant cover of growth forms and species (for vascular plants only) at the dry site (A) and the wet site (B) in the years 1996, 2000, and 2007.

A) Dry Site					
Growth Form	Taxon	1996	2000	2007	
Bryophyte	Acrocarpus moss	4.8	6.2	7.9	
	Leafy liverwort	2.7	3.2	4.4	
	Leafy liverwort	2.1	3.0	3.5	
Lichen	Crustose	36.3	41.1	39.9	
	Foliose	2.1	2.0	2.1	
	Foliose	9.9	11.2	10.8	
	Fruiteose	24.3	27.9	27.0	
Forb	Erreot Forb	0.7	0.2	0.9	
	Polygonum bistorta	0.6	0.3	0.8	
	Mat Forb	0.1	0.0	0.1	
	Minuartia obtusiloba	0.1	0.0	0.1	
	Rossette Forb	0.0	0.0	0.0	
	Antennaria friesiana	0.0	0.0	0.0	
	Artemisia borealis	
	Graminoid	Caespitose Graminoid	13.3	18.6	24.2
		Luzula arctica	6.7	8.9	12.3
		Luzula confusa	0.2	0.3	0.3
Single Graminoid		6.6	9.7	11.9	
Carex bigelowii		2.0	3.1	3.8	
Hierochloa alpina	2.9	4.0	4.5		
Trisetum spicatum	1.7	2.6	3.5		
Shrubs	Deciduous Shrub	29.7	39.5	39.4	
	Salix phlebophylla	0.5	0.6	0.6	
	Evergreen Shrub	0.5	0.6	0.6	
	Cassiope tetragona	29.2	38.9	38.8	
	Diapensia lapponica	5.4	7.5	7.6	
	Ledum palustre	2.7	4.5	3.9	
	Vaccinium vitis-idaea	12.2	15.4	15.0	
	Vaccinium vitis-idaea	8.9	11.5	11.4	
	

B) Wet Site				
Growth Form	Taxon	1996	2000	2007
Bryophyte	Acrocarpus moss	97.4	90.3	87.3
	Leafy liverwort	35.9	32.2	30.8
	Pleurocarpus moss	39.2	38.9	38.8
	Shalghum moss	13.7	11.2	10.0
	Thalloid liverwort	8.4	7.8	7.8
	Thalloid liverwort	0.2	0.2	0.1
Lichen	Foliose	1.5	0.9	0.3
	Foliose	0.9	0.8	0.2
	Fruiteose	0.6	0.3	0.1
Forb	Rossette Forb	0.5	0.5	0.4
	Pedicularis sudetica	0.5	0.5	0.4
Graminoid	Caespitose Graminoid	30.8	38.9	41.8
	Luzula wahlenbergii	0.0	0.0	0.0
	Single Graminoid	0.0	0.0	0.0
	Carex aquatilis	30.8	38.8	41.7
	Dupontia fisheri	21.6	28.8	31.3
	Eriophorum angustifolium	0.9	1.1	1.3
Shrubs	Eriophorum angustifolium	5.2	5.5	5.8
	Eriophorum russeolum	3.1	3.4	3.6
	Betula nana	9.1	10.4	10.8
Shrubs	Betula nana	0.5	0.7	0.7
	Salix polaris	2.0	2.4	2.8
	Salix pulchra	6.8	7.2	7.3
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Figure 5: The plant growth forms used in this project.

Results:

Both sites show community specific changes in growth forms and species absolute cover. Bryophytes had contradictory changes in the two sites with them steadily increasing in the dry site by 30% (Fig. 4 A) and decreasing in the wet site by 39% (Fig 4 B). Lichens increased overall in the dry site by 9% (Fig 4 A) while decreasing steadily in the wet site (Fig 4 B). Forbs showed a contradictory changes in the dry site between years with an overall small increase (Fig 4 A) and showed little change in the wet site throughout the study (Fig 4 B). Graminoids showed a steady increase in both sites with the dry site an increase of 45% (Fig 4 A) and in the wet site an increase of 26% (Fig 4 B). Shrubs increased steadily in both sites with the dry site increasing 25% (Fig 4 A) and in the wet site by 16% (Fig 4 B). Species in this study often followed the overall trends for the growth forms, however some species had changes that were contradictory to the changes of the overall growth form (Table 1 A and B).

Discussion:

Individual growth forms and species changed in fairly consistent way with previous studies (Hollister et al. 2005). Lichens showed little change in both sites, presumably due to their slow growth rates in which large changes in abundance could not be accurately modeled from this study. Forbs showed little change however the growth form was not dominant in either site at the beginning of the study so only minor changes in cover can be documented. Bryophytes changed over time in predictable ways in the wet site as their cover decreased possibly from being out competed for resources by more quickly growing forms. Bryophytes in the dry site, however, paradoxically increased despite suspected competitive disadvantage differing from the results of previous studies (Jaegerbrand et al. 2006). Shrubs and graminoids absolute cover changed in the expected ways as they are exposed to warming temperatures (Hollister et al. 2005). Both growth forms increased in cover over time. In the wet site the increased in cover were somewhat smaller in scale for both species.

Overall changes in species composition over time were consistent with observed responses to warming. Taller and more tolerant species increase in absolute cover as they out compete shorter and less tolerant species. If temperature in this region continue to rise we expect to see even more changes in species dominance in the region, as presumably graminoids and shrubs would be likely to become dominant and forbs and bryophytes would become less abundant.

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