

Introduction:

Plant communities as a whole respond to changes within their environment. As conditions change so do aspects of the communities such as growth rates, phenological development, and fertility rates (Chapin and Shaver, 1985). One of the changes that has the most effect on plant communities in high latitude regions is temperature. These effects have been shown to also affect other non-plant biological processes such as nutrient cycling and soil moisture regulation (Gornall et al, 2007).

This project investigates how plant communities within established ITEX sites respond to experimental warming facilitated by open-top chambers.



Methods:

Community change data was collected using a point framing method. Each plot was sampled once over the summer and all of the data was collected within 2 weeks (mid July-early August) of previous samplings in order to reduce variability of data due to the phenological development of each plots species (Hollister et al, 2005).

The point frame is a 100 point grid that measures 70cm X 70cm with points at 7cm increments. The point frame was leveled above the highest point in the canopy and oriented using permanent cues in each plot to ensure accurate placing relative to previous samplings. At each point in the point frame grid a ruler was dropped down and each contact identified, along with its live/dead status and height. Some plants (i.e. bryophytes) are difficult to identify on site and therefore were grouped together in the nearest accurate taxon.

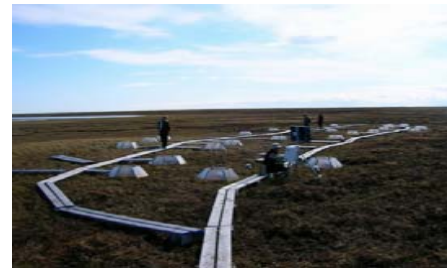
TABLE 1: Change in mean plant cover between warmed and control plots in the Atkasuk Dry and Wet sites. Cover was calculated for growth form and taxon. STE stands for the standard error of the mean and all sample sizes were 24. Diff is the difference between the warmed and control plots.

A) Dry Site

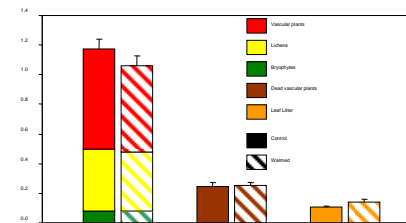
Growth Form	Warmed		Control		Diff
	mean	ste	mean	ste	
Bryophyte	7.2	1.0	7.9	0.7	0.6
<i>Achnanthes miss.</i>	4.4	1.7	4.4	0.9	0.0
<i>Lichnia viscaria</i>	-	-	2.6	0.6	-2.6
Lichen	37.9	2.3	39.9	2.4	-2.0
<i>Crustose</i>	2.3	0.5	2.1	0.4	0.2
<i>Foliose</i>	9.2	0.9	10.8	0.8	-1.5
<i>Frustrose</i>	26.3	1.8	27.0	2.2	-0.7
Shrub	29.7	2.1	28.4	2.3	1.3
Deciduous Shrub	0.5	0.2	0.6	0.4	-0.2
<i>Sax. phoenicifolia</i>	1.5	0.2	0.6	0.4	0.9
Evergreen Shrub	35.2	1.9	38.8	2.1	-3.6
<i>Calluna tetragona</i>	0.0	1.4	7.6	0.8	7.6
<i>Diapensia septentr.</i>	2.9	0.6	0.0	0.7	2.9
<i>Ledum palustre</i>	14.2	1.6	15.9	1.7	-1.7
<i>Vaccinium vitis-idaea</i>	7.7	0.7	11.4	1.5	-3.7
Forb	1.6	0.5	0.9	0.3	0.7
Erect Forb	0.7	0.3	0.6	0.3	0.1
<i>Polygonum bistorta</i>	0.7	0.3	0.6	0.3	0.1
Mat Forb	0.7	0.3	0.1	0.1	0.6
<i>Mimulus obtusifolia</i>	0.7	0.3	0.1	0.1	0.6
Rossette Forb	0.3	0.3	0.0	0.0	0.3
<i>Antennaria borealis</i>	0.0	0.0	0.0	0.0	0.0
<i>Antennaria borealis</i>	0.2	0.2	-	-	0.2
Graminoid	19.2	1.8	24.2	2.7	-5.0
Caespitose Graminoid	8.8	1.3	12.3	1.4	-3.5
<i>Luzula arctica</i>	0.3	0.1	0.3	0.1	0.0
<i>Luzula arctica</i>	8.5	0.9	12.1	1.4	-3.6
Single Graminoid	10.6	1.5	11.9	2.2	-1.3
<i>Carex ligulata</i>	1.0	0.4	3.8	1.8	-2.8
<i>Hierophyllum alpinu</i>	0.0	1.1	4.0	1.0	4.0
<i>Trisetum spicatum</i>	1.1	1.6	0.0	1.2	1.1
Dead	-	-	-	-	-
Bryophyte	0.0	0.0	0.0	0.0	0.0
Forb	0.2	0.1	0.2	0.1	0.0
Graminoid	20.1	2.4	19.6	2.1	1.5
Shrub	3.2	0.5	4.5	0.6	-0.8
Litter	-	-	-	-	-
Leaf Litter	13.7	1.5	9.9	1.2	3.8

B) Wet Site

Growth form	Warmed		Control		Diff
	mean	ste	mean	ste	
Bryophyte	91.0	6.8	87.3	2.8	3.7
<i>Achnanthes miss.</i>	39.0	2.5	37.0	3.0	2.0
<i>Lichnia viscaria</i>	36.0	4.5	36.0	3.6	0.0
<i>Phycospora miss.</i>	17.0	2.5	10.0	1.9	7.0
<i>Leptogium miss.</i>	3.0	2.7	7.0	1.9	-4.0
<i>Thuidium svenen.</i>	0.0	0.0	0.0	0.1	0.0
Lichen	0.2	0.1	0.3	0.1	-0.1
<i>Foliose</i>	0.0	0.0	0.2	0.1	-0.1
<i>Frustrose</i>	0.2	0.1	0.1	0.1	0.0
Shrub	18.3	1.1	10.8	2.0	7.4
<i>Sax. nana</i>	1.1	0.5	0.7	0.5	0.4
<i>Sax. pilosa</i>	1.1	0.5	0.0	0.5	1.1
<i>Sax. pilosa</i>	6.0	1.0	7.0	1.4	-1.0
Forb	6.3	0.2	6.4	0.2	-0.1
Rossette Forb	6.3	0.2	6.4	0.2	-0.1
<i>Pedicularis vesicaria</i>	0.3	0.2	0.4	0.2	-0.1
Graminoid	06.9	2.7	41.9	2.1	35.0
Caespitose Graminoid	0.0	0.0	0.0	0.0	0.0
<i>Luzula arctica</i>	0.0	0.0	0.0	0.0	0.0
Single Graminoid	06.9	2.8	41.7	2.1	34.8
<i>Carex squarrosa</i>	04.4	1.4	11.3	1.4	-6.9
<i>Dryas octopet.</i>	1.4	0.4	1.0	0.5	0.4
<i>Empetrum angustifol.</i>	0.1	0.0	0.0	0.0	0.1
<i>Empetrum angustifol.</i>	0.0	0.0	3.0	0.8	3.0
Dead	-	-	-	-	-
Bryophyte	-	-	0.4	0.2	-0.4
Graminoid	64.0	4.0	36.4	4.5	27.6
Shrub	6.1	0.1	9.1	0.1	0.0
Litter	-	-	-	-	-
Leaf Litter	3.7	0.7	9.8	2.0	-6.1



A) Dry Site



B) Wet Site

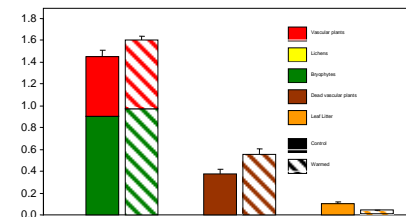


FIG 1: Change in Leaf Area Index between the warmed and control plots in the dry (A) and wet (B) sites.

Results:

The Dry site showed large decrease in graminoid relative cover while only a moderate decrease in lichens and shrubs in response to warming. Bryophytes within the site showed no changes. Leaf litter and standing dead graminoid plant matter both largely increased in the site. (TABLE 1 A)

The Wet site showed small decreases in relative cover in shrubs, forbs, and lichens. This is in contrast to the large increases of cover shown in both bryophytes and graminoids. Leaf litter decreased in the wet site however standing graminoid plant matter had a large increase in response to warming. (TABLE 1 B)

Leaf Area Index (LAI) also changed within the sites due to warming. The dry site showed a decrease in overall LAI from warming with most of the change coming from a decrease in vascular plant cover. Standing plant dead matter showed a small increase yet leaf litter increased moderately from warming. (FIG 1 A) The wet site LAI increased moderately due to warming with increases in both bryophytes and vascular plants. Standing plant dead matter also increased in warmed plots while leaf litter decreased. (FIG 1 B)

Discussion:

These results were similar to previous studies however some of the findings were contrary. Walker (2006) found that graminoids and shrubs cover increased with warming. We found that overall plant cover decreased in the dry site possibly due to water stress in warmed plots. There was increased cover, especially graminoids and shrubs, in the wet site where water stress may not be such a limiting factor.

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References:

Chapin F Stuart, Gaus Shaver. 1985. "Individualistic Growth Response of Tundra Plant Species to Environmental Manipulations in the field." Ecology. Vol. 66. No. 2. 564-567.

Gornall JL, Jondtitor IS, Woodin SJ et al. 2007. "Arctic mosses govern below-ground Environment and ecosystem processes". Oecologia. Vol. 153. No. 4. 937-944.

Hollister, Robert D.; Patrick J. Webber; Craig E. Tweedie. 2005. "The response of Alaskan arctic tundra to experimental warming: differences between short and long term responses". Global Change Biology. 11: 525-536.

Walker MD, Wahren CH, Hollister RD, Henry GHR, Ahlquist LE, Alatalo JM, Bret-Harte MS, Calef MP, Callaghan TV, Carroll AB, Epstein HE, Jonsdottir IS, Klein JA, Magnusson B, Moilan U, Oberbauer SF, Rewa SP, Robinson CH, Shaver GR, Suding KN, Thompson CC, Tolvanen A, Toland O, Turner PL, Tweedie CE, Webber PJ, Wookey PA. 2006. "Plant community responses to experimental warming across the tundra biome." Proceedings of the National Academy of Sciences of the United States of America. Vol. 103 Issue 5. 1342-1346.

Walker MD. 1995. "Effects of interannual climate variation on phenology and growth of 2 alpine forbs." Ecology. Vol. 76. 1067.