Grand Valley State University REU Projects at Barrow & Atqasuk During the 2007 Field Season

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Background

Abstract

The AON Program of NSF/OPP has supported Research Experiences for Undergraduates (REU) at Barrow and Atqasuk in association with the ongoing GVSU ITEX research. These opportunities have allowed students to take a leadership role in the research and allowed the project to examine interesting auxiliary topics. During field season 2007 four students participated. Highlights of their projects are presented in the panels to the left.

The participants were selected from a campus wide solicitation. During the field season participants were expected to make rigorous routine daily measurements required for the long-term ITEX project and to carry out their own independent project. During the Fall and Winter the group met regularly to present and discuss their findings. They received credit towards their degree program for this activity. Participants were also paid an hourly wage to work on both their independent project and the overall project. During all stages of the process there was continual interaction with the Primary investigator Bob Hollister. The individual panels presented here are extracted from posters to be presented at the GVSU Student Scholarship Day to be held in April.

GVSU ITEX Project

The results presented here are in association with the Grand Valley State University (GVSU) International Tundra Experiment (ITEX) project. ITEX is a collaborative effort that seeks to examine the response of cold-adapted plant species to environmental change, specifically increase in summer temperature. ITEX researchers experimentally warm plant communities with open top chambers and examine the response of plants and ecosystem parameters. ITEX sites exist at many locations throughout the tundra biome (FIG 1). The project operates at four sites on the Northslope at Barrow and Atqasuk (FIG 2). The project was begun in 1994. The long-term nature and spatial coverage of the project maximizes the potential for more far reaching discoveries and student training.

FIG 1. Map of the locations of current and former ITEX sites. The Barrow and Atqasuk sites are shown in Blue and Red respectively.

FIG 2. The ITEX field sites operated by GVSU. Note that the sites span a hydrologic gradient from wet to dry and a latitudinal gradient from Barrow to Atqasuk. At each site 24 warmed and 24 control plots are monitored to detect possible changes in plant phenology, growth, and ultimately cover. Additional plots are also used to measure changes in temperature.

Acknowledgement

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Plant Community Changes in Northern Alaska in Response to Warming

Jeremy May

Jeremy has been working in the lab since the 2007 field season and plans on continuing with the project for the 2008 season and pursuing a masters degree in Biology after he graduates this semester. Ultimately he hopes to teach Biology at a college or university.

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.

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.

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)

The 2008 field season will conclude this aspect of the project as similar data is collected from sites in Barrow, AK. This will allow for complete comparisons to be drawn from past point framing samplings to determine changes in communities over extended periods of warming.

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.

TABLE 1. Change in mean plant cover between warmed and control plots in the Atqasuk 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) Atqasuk Dry Site

[illegible]

B)

[illegible]

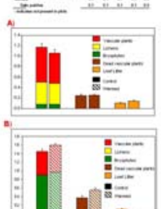

FIG 1. Change in Leaf Area Index between the warmed and control plots in the Atqasuk dry (A) and wet (B) sites.

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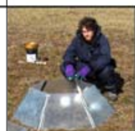
Insulating Properties of Changing Tundra Vegetation

Robert T. Slider



Rob has been working in the lab since last summer and plans to return to Barrow for the 2008 field season. He is pursuing a major in Biology along with minors in Earth Science and Chemistry and certification in Secondary Education. He plans to teach science at the middle or high school level.

An increase in global temperature is expected to dramatically effect arctic ecosystems. Warming may also release large stores of carbon from tundra soils into the atmosphere in the form of greenhouse gasses (IPCC 2007). Studies from the International Tundra Experiment (ITEX) have shown changes in plant communities under simulated warming conditions, including a general increase in plant cover (Walker et al. 2005). It has been proposed that this outcome may lead to a greater level of thermal resistance in the vegetation layer, altering the ability of warm air to effect vulnerable carbon stores (Hollister et al 2006).

To further examine the role of plants in heat transfer between air and soil, two new treatments were established at all four study sites in which vegetation was either removed down to bare ground or increased, using the plant material from removal (FIG 1). These treatments were compared to OTC and control plots established in 1998. Temperature was recorded for the duration of the growing season (June-August) at heights of 13cm, 0cm, and -10cm from ground level (FIG 2).

At all four sites, the greatest difference in temperature between canopy height (13cm) and soil (-10cm) was seen in plots with added vegetation (FIG 3). It was also noted that at each site the air to soil difference in OTC's with nine years of warming was within 10% of the OTC's with added vegetation, both of which were at least 20% cooler than treatments with bare ground.

Results indicate that vegetation acts as a significant insulator of tundra soils, and suggest that soil temperatures may initially be buffered from warming air temperatures by an increase in plant cover. However, it is not yet clear if this insulation will have an effect on permafrost thaw. Studies from Hollister et al (2008) indicated that OTC warming has not shown a significant effect on thaw depth, presumably due to the small size of the chambers, indicating that further examination of these interactions is needed.

FIG 1: Manipulations of warmed plots. Plots to the left show vegetation removed in a circle of 10cm diameter while plots to the right show vegetation added in a circle of 10cm diameter.

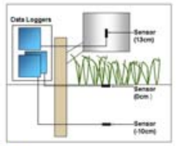


FIG 2: Diagram of study setup showing placement of temperature sensors relative to ground height.

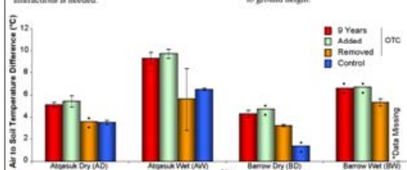


FIG 3: Temperature variation by manipulation and site for 2007 field season. Plots with added vegetation (Added), removed vegetation (Removed) and 9 years of treatment (9 Years) were warmed using Open Top Chambers (OTC's). Error bars show the standard error of the mean (n=2). A dot above and below a column indicates missing data due to instrument malfunction.

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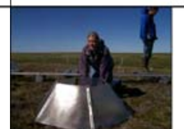
*Publication accepted pending changes

Overall Performance of *Cassiope Tetragona* in a Climate Changing Environment

Amanda Snyder



Amanda Snyder has been working for the lab since last summer. She will graduate in May of 2009 with a degree in Biology. She plans to enter the workplace before pursuing a graduate degree.

The effects of climate change are being examined on *Cassiope tetragona*, a dominant evergreen shrub of the arctic (FIG 1). *C. tetragona*'s leaves produced early and late in the season are shorter than the leaves produced in the middle of the season, allowing the annual growth increments (AGI's) of previous years to be measured (Havstrom et al. 1995). The length of the AGI reflects climatic conditions during the season they were produced (Molau 1997). Therefore, studying *C. tetragona* can help to determine climate changes, and the effects of them, over many years.

Data taken of *C. tetragona* during the growing season (June to August of 2007) include phenological changes, flower counts, and annual growth increments. The results show no difference in the length of annual growth increments between the control and experimental plots at each site, whereas at Atqasuk they are larger than at Barrow (FIG 2). There was no difference in the number of flowers between the control plots at Atqasuk and Barrow (FIG 3). At Barrow, the number of flowers was higher in the experimental plots than the control plots, while at Atqasuk there were fewer flowers in the experimental plots than the control plots. On average, flower opening, withering, and seed production occurred significantly later at Barrow. There were no significant differences between treatments but events were earlier on average in the warmed plots than the control at Barrow (FIG 4).

These results are consistent with the findings of Hollister et al. (2005) in which the number of inflorescences of *C. tetragona* at Barrow was greater in the warmed plots than the control plots, while at Atqasuk, there was little effect of warming, which could be due to water stress. The lack of growth shows that *C. tetragona* displays conservative growth strategies at these sites (Hollister 2005). The average annual growth was consistent with the findings of Havstrom (1995) in that growth was greater at Atqasuk than Barrow. However the small amount of warming was not enough to cause an increase in the growth at each site.

This suggests that with changing climate conditions, *C. tetragona* varies in the amount of effort put into reproduction at both locations, while keeping growth constant. These changes may have future impacts on community composition.

FIG 1. *Cassiope tetragona*, a circumarctic, ericaceous dwarf shrub present at both Barrow and Atqasuk, Alaska.

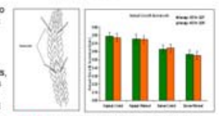


FIG 2. Left: Shoot of *C. tetragona* showing Annual Growth Increments (AGI's). Right: AGI's at the Barrow and Atqasuk sites in 2006 and 2007. Error bars represent standard error of the mean.

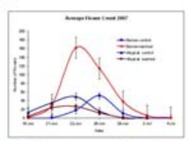


FIG 3. Average number of flowers for control and warmed plots at Barrow and Atqasuk in 2007. Error bars represent standard error of the mean.

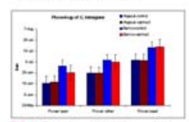


FIG 4. Phenology of *C. tetragona* between Atqasuk and Barrow, which include the average date of open flower, withered flower, and seed. Error bars represent standard error of the mean.

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Response of the arctic wet meadow sedge, *Carex aquatilis*, to changing temperature

Michael L. Lothschutz

Michael Lothschutz has been working for the lab since last summer. He will graduate in August of 2008 with a degree in Natural Resource Management. He plans to gain experience working in the field before pursuing graduate studies.

The objective of this study was to observe the changes of *Carex aquatilis* (FIG. 1) at Barrow and Atqasuk due to changing temperature. *C. aquatilis* was chosen because it is a dominant sedge and shows variation in size within its natural habitat (Chapin 1981). It is found in most wet meadows of the tundra implying changes in *C. aquatilis* will likely alter the characteristics of many plant communities along the north slope.

During the growing season phenological observations, inflorescence counts, and growth measures were collected to observe changes in the growth and reproduction of *C. aquatilis*. Phenological observations showed the average Julian day that green leaves, inflorescences, flowering, withering, and seeds occurred on. Events occurred earlier at AW than at BW. There were no changes that occurred due to warming at AW but warming did have an effect at BW (FIG. 2). There were no significant changes in number of flowers due to warming at AW. However, warming increased the flowering at BW (FIG. 3). The total number of inflorescences produced in the warmed plots at BW were similar to those produced in both the control and warmed plots at AW. Warming at BW increased the total number of inflorescences while at AW there was no effect (FIG. 4). The average length of leaves and inflorescences were greater at AW than at BW. Warming also increased the growth of leaves and inflorescences at each site (FIG. 5).

Warming has effected *C. aquatilis* by changing the phenological characteristics, growth, and reproduction efforts. *C. aquatilis* was larger and phenological events occurred earlier at AW but reproductive effort was not as large as warmed plots at BW. Warming at AW resulted in an increase in size only. At BW warming resulted in greater numbers of inflorescences and larger plants. Past studies done at the sites have shown significant positive results in growth and reproductive effort similar to these results (Hollister et al. 2005). Other research further shows the increase in aboveground biomass for *C. aquatilis* when warmed which can give it an advantage over other plants (Hollister & Flaherty). The results of the research indicate that an increase in temperature may change the existing tundra vegetation characteristics. The possible irreversible changes to the ecosystem make monitoring the changes in tundra vegetation due to climate change essential for understanding vegetation shifts.

FIG. 1. The arctic wet meadow sedge *Carex aquatilis*. It is commonly found in the moist areas of Barrow and Atqasuk.

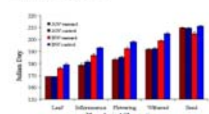

FIG. 2. Phenological observation comparison of *Carex aquatilis* per m^2 warmed and control plots at AW and BW. Error bars represent standard error of the mean (n ranges from 18 to 24 due to events not occurring).

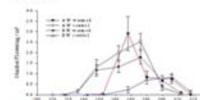

FIG. 3. Average number of plants in flowering comparison of *Carex aquatilis* per m^2 warmed and control plots at AW and BW. Error bars represent standard error of the mean (n=24).

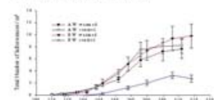

FIG. 4. Average number of inflorescences produced comparison of *Carex aquatilis* per m^2 warmed and control plots at AW and BW. Error bars represent standard error of the mean (n=24).

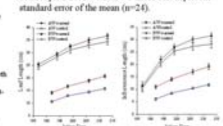

FIG. 5. Average seasonal change in leaf length and inflorescence length of *Carex aquatilis* in warmed and control plots at AW and BW. Error bars represent standard error (n=24 for leaf, n ranges from 12 to 24 for inflorescence due to event not occurring).

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