Effects of snowpack on thaw depth and growth of *Salix pulchra* at the Toolik Snowfence Experiment and a natural snowbed

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Introduction

It is unclear how tundra vegetation and ecosystem processes will respond to altered precipitation patterns as predicted by global change estimates (Walker et al. 1993). This snowfence experiment in the Alaskan Arctic is examining the short- and long-term effects of altered climate regimes on tundra vegetation and ecosystem processes. This poster focuses on the effects of increased winter snowpack (shortened growing season) on depth of thaw and growth patterns of *Salix pulchra* compared with a natural snowbed site. The experiment is part of the NSF-sponsored International Tundra Experiment (ITEX)(Molau and Mølgaard 1996) at Toolik Lake, Alaska.

Questions

Does increased snow effect the thaw depth of moist-tussock tundra, and how do the thaw depth patterns compare with those at the natural snowbed sites?

Does increased snow effect the growth of Salix pulchra,and are the patterns similar to the patterns seen at the natural snowbed sites?

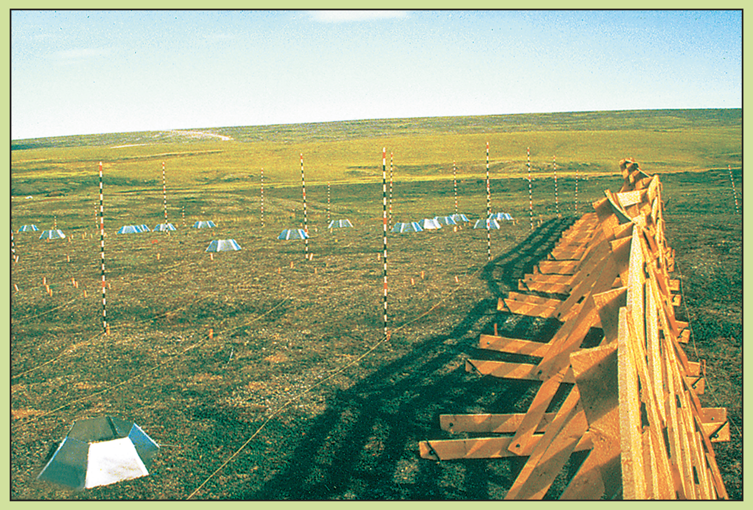

Figure 1. Snowfence at Toolik with ITEX cones in the foreground.

Experiment Location and Design

In the summer of 1994, two snowfences were erected at Toolik Lake, in order to manipulate the snowpack (Figs. 1 and 2). These snowfences are 2.8 m tall and 60 m long, and create approximately 50 m long drifts on the leeward side of the fences (Fig.3). Areas further than 60 m from the fences receive less than ambient amounts of snow.

At Toolik Lake, one of the snowfences is in a dry heath tundra site and the other is in a moist tussock-tundra site. Both fences are laid down during the summer as not to affect the ambient summer wind regimes.

This snowfence experiment uses a factorial design to examine the effects of increased snow and warming on the tundra vegetation. Half of the plots in the experiment are passively warmed during the summer using open top chambers (OTC's)(Marion et al. 1993, Fig. 1). These chambers warm the ambient air within the chamber between 2˚ and 3˚ C. These OTC's are used in the arctic as well as the alpine, at 24 other International Tundra Experiment (ITEX) sites around the world.

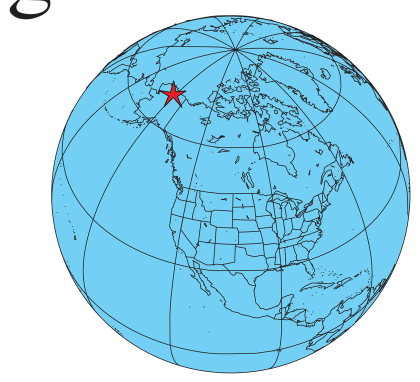

Figure 2. Star indicates the Toolik Lake, Alaska ITEX site (68˚ 38' N, 149˚ 38' W)

Permanent plots were established inside the snowfence grid as well as outside the effect of the snowfences. Several different types of permanent plots were established; non destructive OTC and control (CTL) plots for monitoring plant phenology,and plant growth; destructive OTCs and CTLs for monitoring thaw depth, soil moisture, soil mineralization, and decomposition; OTCs and CTLs to monitor carbon dioxide and methane flux; and NDVI plots to monitor changes in greenness.

In the summer of 1999, 21 new plots were set up in a natural snowbed on the west side of Toolik Lake (Fig. 5). These plots were set up along the snowdepth gradient in three rows (7 plots in each row). One row is in the "deep snow zone", one in the "mid snow zone", and the third in the "control zone". Plant phenology, Salix pulchra growth, and thaw depths were monitored at this site throughout the summer.

In this poster we only examine the effects of increased snow on the thaw depths and Salix pulchra growth patterns at the moist site snowfence and compare these patterns to those observed at the natural snowbed site.

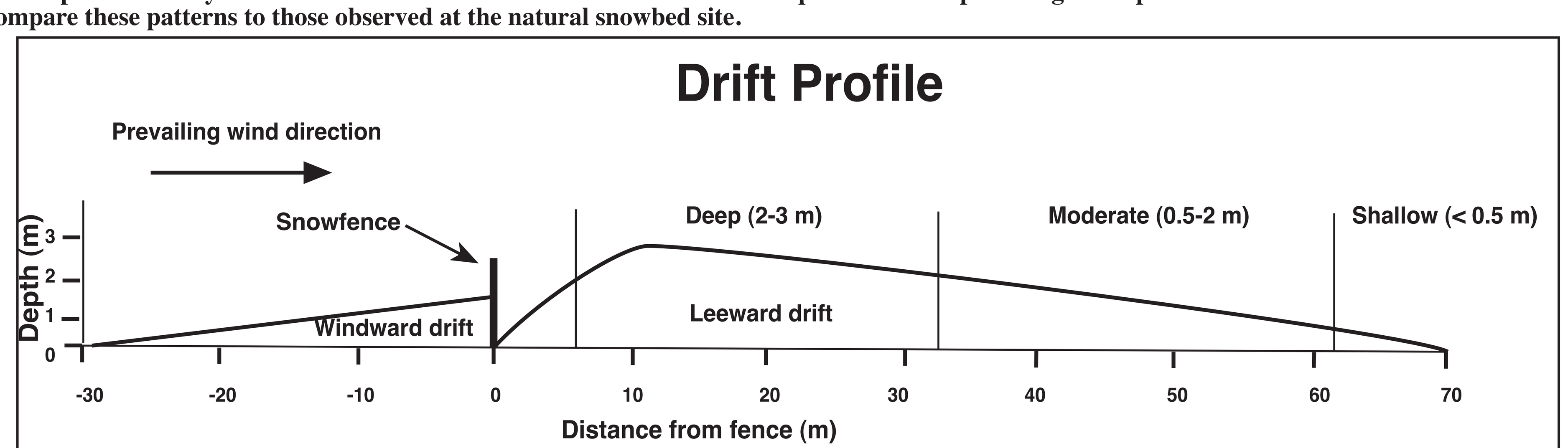

Figure 3. Experimental drift design.

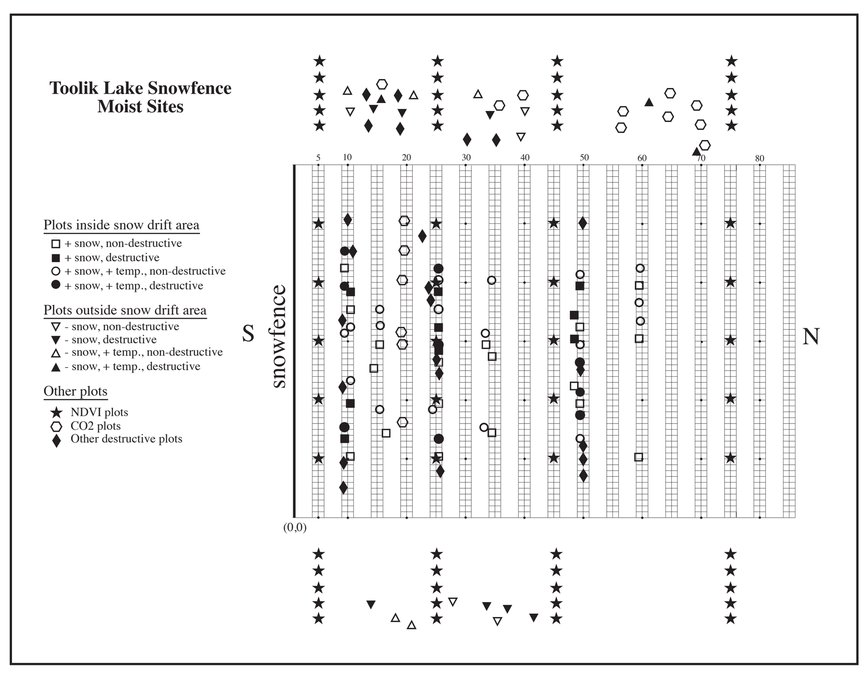

Figure 4. Plot map of moist site snowfence, Toolik Lake, AK.

Zone Descriptions

Zone 0 - Control zone, outside the effect of the snowfence (ambient snow conditions).

Zone 1 - Deep snow zone, approximately 10 m downwind of the fence.

Zone 3 - Moderate snow zone, approximately 25 m downwind of the fence.

Zone 5 - Moderate to ambient conditions, approximately 50 m downwind of the fence.

Figure 5. View of the natural snowbed site on the western side of Toolik Lake. The site was chosen because of its similar species composition, slope, aspect, drainage and snow duration as the snowfence experimental site.

Methods

At the moist site snowfence, thaw depth was measured in the destructive thaw depth plots in zones 0, 1, 3, and 5 using a stainless steel probe. Three measurements were made in each of the three CTL plots per zone. A mean thaw depth value was then calculated for each of the zones for every data collection date (n = 9 for each date and zone). At the natural snowbed site six measurements were made at each of the plots. A mean thaw depth value was then calculated for each of the zones for every data collection date (n = 42 for each date and zone).

Salix pulchra growth was measured three times during the season at each of the sites; once approximately two weeks after the onset of growth, once during the middle of the growing season, and a third time at the end of the growing season. There are six tagged plants per plot at each of the sites, and growth was measured from the terminal bud scale scar to the tip of new growth. The maximum value of growth for each plant was used to calculate a mean maxumum growth for each zone (n = 18 for the snowfence site and n = 42 for the natural snowbed site).

Results and Discussion

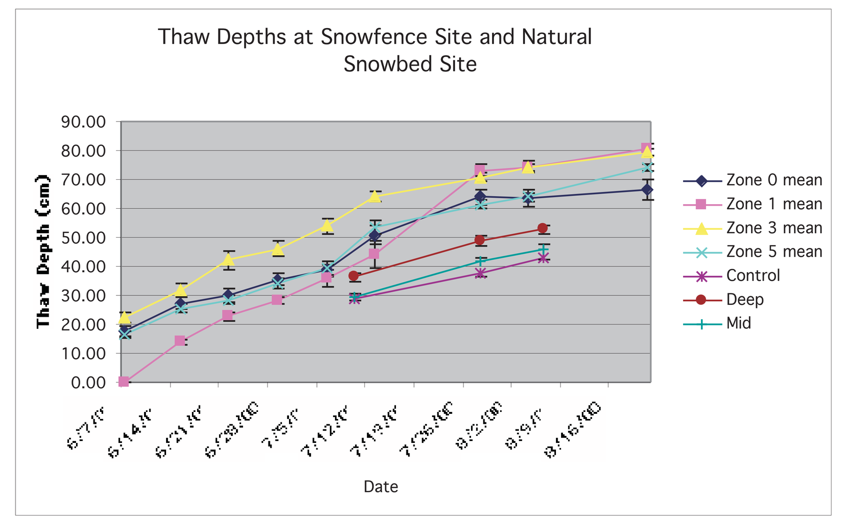

Figure 6. Mean thaw depths for zones 0, 1, 3, and 5 at the snowfence site and for control, mid and deep snow zones at the natural snowbed site. Depths are in centimeters (cm) and error bars display standard error.

At the snowfence site, even though zone 1 (deep snow zone) melts out about 3 weeks after the ambient snow zone, it ends up having the deepest thaw at the end of the growing season (Fig. 6). The thaw depth is approximately 17% deeper in zone 1 than in zone 0 (ambient snow zone).

At the natural snowbed site the deep snow zone also melts out about three weeks after the ambient snow areas. At this site the deep snow zones also end up having the deepest thaw depths at the end of the season; approximately 18% deeper than the ambient snow plots (Fig. 6).

We believe these patterns are occuring due to the fact that the late-lying snowbeds are providing a thermal blanketing effect for the underlying tundra, thereby creating permafrost temperatures closer to 0˚ C. Permafrost temperatures closer to 0˚ C may allow deep snow areas to "catch up" and even exceed thaw depths of ambient snow areas.

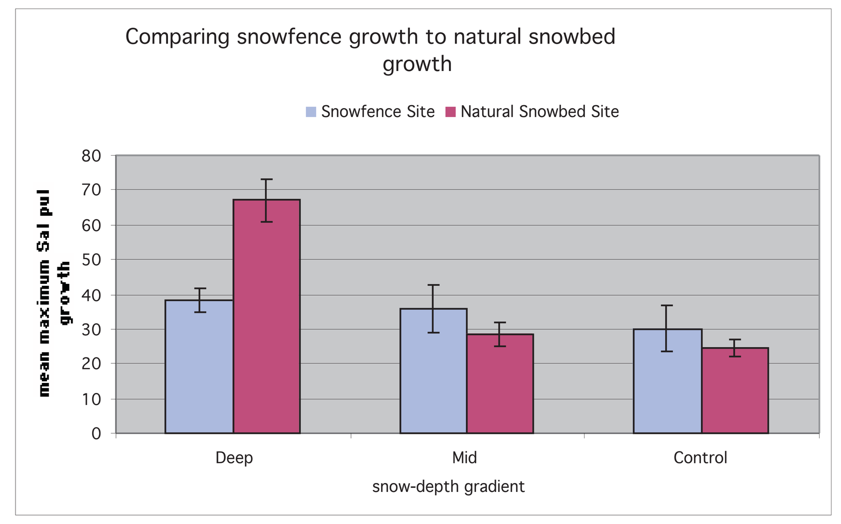

Figure 7. Mean maximum Salix pulchra *growth at the snowfence and natural snowbed sites throughout a snowdepth gradient during the summer of 1999. Growth measurements are in millimeters (mm) and error bars display standard error.*

Mean growth of *Salix pulchra* shoots at the natural snowbed site is approximately twice as large as in moderate and ambient snow areas (Fig. 7). There is no statistical difference between the growth in the mid and ambient snow zones at the natural snowbed site.

At the snowfence site, even though there is no statistical difference in growth between the control, mid, and deep snow areas, there is a trend toward increased growth of *Salix pulchra* with increased snowdepth (Fig. 7). We believe this trend is beginning to occur at the snowfence site because of a change in competition caused by increased snow. During the fifth summer of the experiment (1999) a large percentage of *Eriophorum vaginatum* did not green up after it was released from the snow in the deep snow areas of the snowfence. This decrease in plant density in the deep snow areas of the snowfence may be creating conditions of increased nutrient availability. Furthermore, dwarf shrubs have adapted a tolerance of increased snow conditions, and are able to increase vegetative growth under these conditions.

Future Plans

An increase in snow accumulation will have indirect impacts on plant species distributions through changes caused in nutrient availability, soil quality, and soil moisture. In order to address some of the questions that have arisen from the changes being seen at the snowfence experiment, next summer (2000) I plan to begin measuring the dissolved organic and inorganic nitrogen (DON and DIN) pools at the natural snowbed and snowfence sites by doing soil extractions, as well as the fluxes in and out of these pools using buried bag experiments, throughout the season. In the spring, at the beginning of the growing season, N that is trapped in the snowpack is released during snowmelt. N input into the nutrient-poor soils greatly increases during this time (Bowman 1992). It has also been found that during this period of snowmelt, there is a large crash in the microbial population, causing another large increase in available N and P in the soil (Lipson et al. 1999, Raab et al. 1999). By monitoring the phenology of nutrient availability in the soil along with the phenology of plant species throughout the season, I will be able to see if these flushes are available to the plants that are delayed in emerging from the snow.

Many of the indirect effects associated with late-lying snow cannot be well studied at the snowfence experiment because there is a time lag involved with developing decreased soil quality, decreased nutrient availability, decreases in soil organic matter, and changes in vegetation patterns. Therefore, comparing plant and nutrient availability phenologies in the snowfence experimental plots with plots containing similar species in natural snowbeds will allow us to better draw conclusions about how increased snow could effect plant communities in the Arctic under global warming scenarios. In addition, the data collected on nutrient cycling dynamics at the different sites will be very useful in parameterizing vegetation and global climate change models.

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