Marshall Creek Soil Temperature Monitoring

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Introduction

The growth of young white spruce (*Picea glauca)* can be limited by a variety of different factors although few detailed studies have taken up this question in the Yukon. In British Columbia and Alaska numerous studies have examined the relationship between growth of white spruce and physical factors such as temperature, moisture, nutrients as well as key biotic factors such as competition, insects and disease (Coates 1994). White spruce grow very slowly in the southwestern Yukon and possible limiting factors include our cool, short summers (temperature), lack of moisture and nutrient shortages (especially nitrogen).

Soil temperature can have a major impact on tree growth because physiological processes in the roots (growth and water uptake) are temperature dependent (Stathers and Spittlehouse 1990). The soil temperature regime is often site specific and may vary with the ground cover and site preparation after logging activity. This report describes the preliminary results I obtained in 1999 on the shallow soil temperature regime in a logged area that has been planted with white spruce seedlings.

Background

During the summer of 1998 I worked with students from the Renewable Resources Management Program of Yukon College on a silviculture monitoring project at Marshal Creek. We began a study to examine the growth and survival rate of white spruce (*Picea glauca*) seedlings that had been planted during the summer of 1996 in a series of clear-cut blocks. We wanted to determine if there was a difference in growth or survival rate of seedlings that were planted in two different substrates.

There had been no special site preparation in the Marshall Creek cutblocks. Most of the logged area's forest floor was intact and covered with variable amounts of woody debris. In some defined areas there were ashpiles left from burning accumulated slash at the end of the logging activity. These ashpiles varied in diameter from small (perhaps 2m) to large (over 6m) and the substrate consisted mostly of mineral soil and residual ash. We set out permanent transects and marked seedlings in both ashpiles and unburned areas.

Although we did not find any differences in survival we did detect significant differences in growth and appearance. For example, we found that significantly more seedlings in the unburned areas had yellowish needles than the ashpile treatment and seedlings in ashpiles had leaders (terminal shoots) that averaged 2 cm longer than comparable seedlings in the unburned areas.

Physical parameters may differ between the unburned areas and ashpiles and in June of 1999 I installed a series of temperature probes to compare soil temperatures between adjacent areas where slash had been burned (ashpiles) or the ground cover left unburned. The goal of this study was to describe the soil temperature regime and make comparisons between the two microsites.

Methods

The monitoring sites are located in a cutblock (CB #4) that was clearcut in 1994-95 at Marshall Creek. There was no ground preparation done prior to planting and two sites, approximately 15m apart, were chosen. The *Unburned* site had a thick duff layer as well as fine and large woody debris scattered about the surface. Slash that had accumulated during the logging operation had been burned on the *Ashpile* site in 1995 and this left a thin layer of ash exposed on the mineral soil. There was no detectable duff layer or fine woody debris in the ashpile. Both sites are situated on a permanent transect that students established in 1998 and the ashpile site is also part of a silviculture plot established by DIAND Forest Resources in 1996 (Plot 3, CB#4). There is relatively little vegetation present on either site as succession is at an early stage so the ground receives little shading from the sun.

On June 3, 1999 I installed 4 temperature probes at each site using HOBO® 4-Channel External Data loggers and 6 ft temperature probes (TMC6-HA). Both dataloggers were set to take measurements every 30 minutes. A small soil pit (30 x 40 cm) was dug to install the temperature probes (Table 1). The actual probe sensors (about 3 cm long) were embedded in undisturbed soil along the face of the soil pit and then the excavated soil was replaced in the order it was removed. The temperature leads were run together from the soil pit just under the surface to the data logger about 1.7m away. The dataloggers are not weather proof so I nested them in a layer of cotton (to absorb any condensation), wrapped in plastic bags and sealed inside a tin can using silicone. The cans were then loosely buried and covered with plywood to keep moisture away. On June 7, I visited the site and found fresh moose and bear tracks on the soil pit I had excavated and backfilled although there was no disturbance to the site. On November 11 I retrieved the dataloggers and left the temperature probes (frozen) in the ground.

The raw data were imported to an Excel spreadsheet and transferred to an Access database. Temperature readings were available at 30-minute intervals and I reduced the size of the dataset by calculating the average temperature for each calendar day.

Table 1 Location of temperature probes.

Ashpile Site		
Probe	**Depth (cm)**	**Description**
1	5	mineral soil
2	10	mineral soil
3	20	mineral soil
4	Air Temp	about 120 cm off ground – probe not shaded
Unburned Site		
1	5	Fine woody debris- duff
2	10	Duff
3	20	in red stained soil 4.5 cm *below* the bottom of the organic layer
4	50	in gray soil - there is a red-gray transition at 27 cm

Results & Discussion

The soil profile of the two microsites being monitored shows significant differences (Table 1). The ashpile site had a thin layer of ash covering the mineral soil and there was no organic layer present. The unburned microsite had a thick organic layer so that the 5-cm deep probe was in fine woody debris and the 10cm probe was located in a layer of partially decomposed organic material such as spruce needles. The interface between the organic layer and mineral soil occurred 15.5 cm below the surface.

The ground was already thawed below a depth of 50 cm when the temperature probes were installed on June 3 (Figures 1 and 2). Peak soil temperatures occurred during the end of July and then began cooling with the ground starting to freeze in early October. I compared the difference in soil temperature between the ashpile and unburned microsite at three depths (5 cm, 10 cm and 20 cm) by taking the average daily temperature in the ashpile (for a given depth) and subtracting the average daily temperature in the unburned microsite (for the same depth). During the main growing season the ashpile microsite was consistently warmer than the unburned microsite by about 5 degrees Celsius (Table 2).

Table 2: Average daily temperature difference between microsites [daily ashpile temp-daily unburned temp.]

	5 cm depth	10 cm depth	20 cm depth
June	4.09 C°	5.18 C°	5.97 C°
July	4.49	5.84	7.01
August	3.51	5.16	6.67

Several studies in southern Canada have examined the relationship between soil temperature and root growth of spruce but there are no empirical data available for the Yukon (Coates et al. 1994). These studies suggest that root growth may be optimum between 10° C and 20° C although root growth may begin in soil temperatures as low as 1° C. Based on their literature review, Coates et al. (1994) inferred that the critical soil temperature threshold was 7-8° C for interior white spruce in British Columbia. For this preliminary analysis I calculated the number of degree-days above 5° C for both microsites at three comparable soil depths (Table 3).

Unfortunately the late installation of the monitoring equipment meant that the soil in the ashpile microsite had warmed above 5° C by June 3 and this limits the number of comparisons I can make. The end of the season, for degree-days above 5° C, occurred in mid-September at both microsites. The number of growing-degree days was much higher for the ashpile microsite; for example, at 20-cm depth the ashpile had 166 degree-days more than the unburned microsite.

Table 3: Summary of degree-day calculations for unburned and ashpile microsites

Degree-days > 5° C (DD)	Unburned	Ashpile
5 cm depth	470 DD	541 DD*
First day at 5° C	prior to installation	prior to installation
Last day at 5 ° C	Sept 19	Sept 22
10 cm depth	331 DD	471 DD*
First day at 5° C	June 7	prior to installation
Last day at 5 ° C	Sept 19	Sept 19
20 cm depth	198 DD	364 DD
First day at 5° C	June 15	prior to installation
Last day at 5 ° C	Sept 19	Sept 19

* DD represent minimum estimate as soil had warmed above 5° C at start of monitoring

Conclusions

The results from the 1999 season are somewhat tentative because the start of the growing season was missed. However there is convincing evidence that the soil temperature profile in the ashpile microsite is warmer than an adjacent unburned microsite. It would be useful to continue the monitoring during 2000 to obtain a complete set of data on temperature changes during the growing season.

Why was the ash microsite warmer than the adjacent unburned area during the growing season? It appears that the thick duff layer that was not disturbed during the logging operation is providing an insulating blanket (Draper et al.1985, Hungerford and Babbit 1987). Researchers have been investigating silviculture systems that favour rapid growth of white spruce seedlings and treatments that involve burning to remove the duff layer or scarification that physical overturns the duff layer seem successful (Densmore et al. 1999).

There are several outstanding questions:

1. What is an appropriate baseline temperature to use in calculating degree-days? In British Columbia the threshold is reported to be 7-8° C. Is 5° C appropriate for southwestern Yukon.
2. How do white spruce respond to increased soil temperatures? For example, does a difference of 150 degree-days (about 5° C) lead to significantly higher growth rates? It may be useful to collect measurements of leader growth in similar microsite over the 2000 season and compare this with soil temperature profile.

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Figure 1: Average Daily Temperature - Ashpile Microsite - 1999

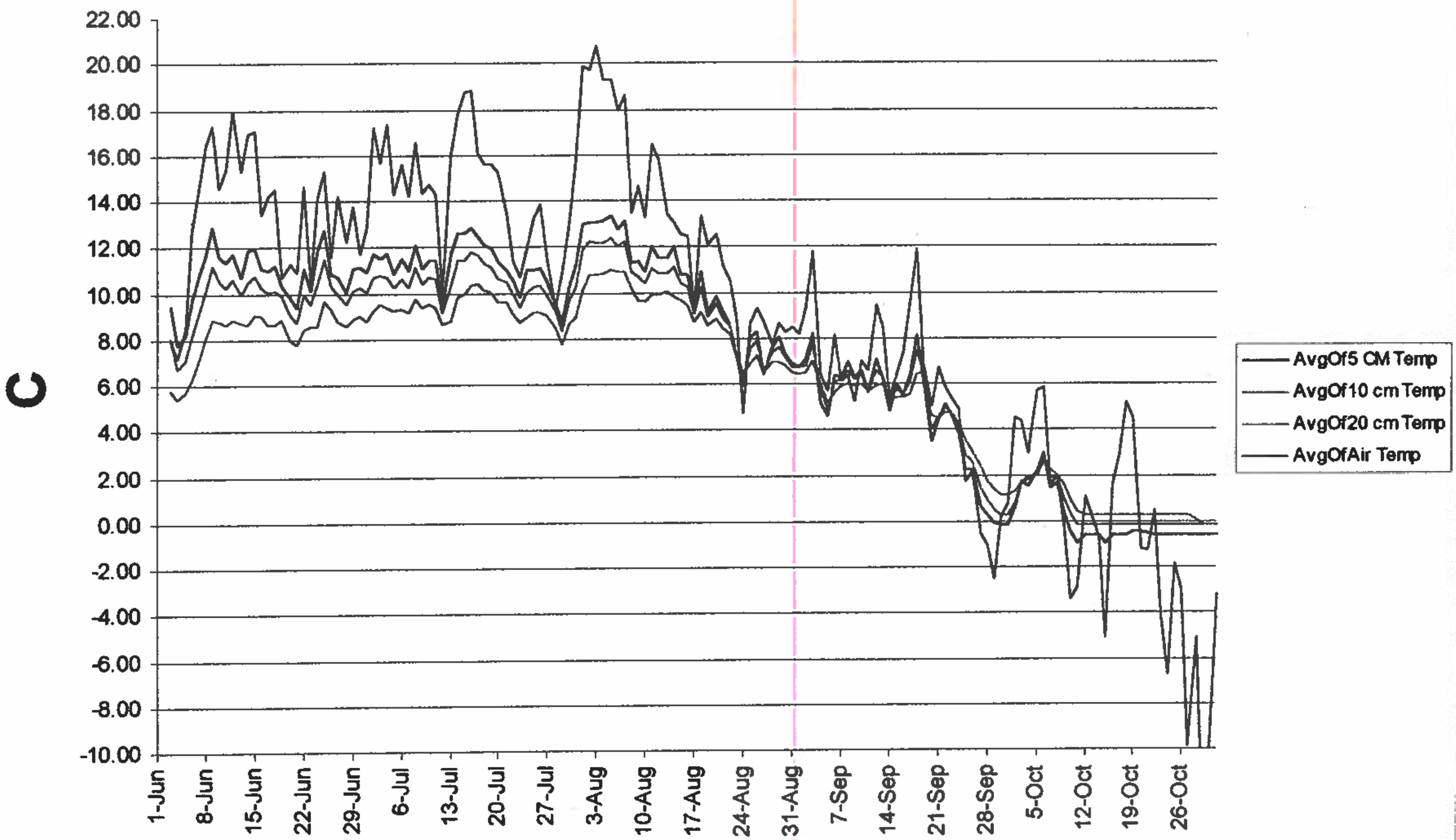

Figure 2: Average Daily Temperature - Unburned Microsite - 1999