Comparing snow accumulation and melt rates in different aged forest stands in the Rover Creek watershed

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Disclaimer

Abstract

This research study compares snow accumulation and snow melt rates in five forest stands in the Rover Creek watershed that are at different stages of regrowth after being logged. Snow accumulation and snow melt processes vary based on the canopy cover in each stand. The snow water equivalent, which is the depth of water in a snowpack was used to compare the snow accumulation in each site. The researcher found that a stand who had been logged recently who supported trees with an average height of two meters, could accumulate more than twice as much snow as a fully mature stand with trees averaging 25 meters in height. Although the total accumulation in the younger stand was much more, the ablation rate in the mature and younger stands were similar. The ablation rate is the rate at which snow dissipates from a site by process of snow melt and evaporation. The mature stand and the most open stands had very little range in the maximum and mean ablation rate. Contrary to other studies of similar scope, the solar radiation did not greatly influence the ablation rate: rather, the temperature was the main factor in driving snow melt.

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1. Introduction

North America experiences its largest run off events during the spring freshet (Pomeroy et al 1998). This is especially true in the Pacific Northwest where mountainous terrain accumulates large amounts of snow in upper elevations. Warming temperatures and the amount of solar energy that reaches the snowpack prompts snowmelt which results in this annual freshet phenomenon (Boon 2009). A thick forest canopy can intercept the solar energy or snow, successively slowing the process of melt and reducing snow accumulation (Pike et al. 2010). When forests are logged, the increase in solar energy that reaches the ground results in a more rapid melt period (Pike et al. 2010; Schnorbus and Alila 2004). Rapid melt causes changes in stream flows that can affect slope and stream channel integrity, potentially leading to landslides or mass destruction to downstream properties (Pike et al 2010).

Boon (2009) suggests that forest disturbance, such as industrial logging, may more greatly affect hydrological processes than climate change impacts. Sturm et al. (2009) acknowledges that monitoring snow water equivalent is the most fundamental metric to understanding global snow water trends. Since the forestry industry has been, and continues to be, a major driver in the

British Columbia (BC) economy, scientists are studying melt rate data to quantify hydrological recovery. This research would allow us to determine the period a forest returns to its natural snow accumulation and melt processes after it has been logged.

My research goal is to determine how canopy cover affects a forest's ability to capture, hold, and release snow in the Rover Creek watershed in the West Kootenay region of the BC Interior.

To address this goal, I will:

- Compare snow accumulation rates in the form of snow water equivalent (SWE) in five forest stands with various canopy cover
- Compare the rates at which the snow is melting with the average temperature in each forest stand

2. Methods

a. Study Area

The Rover Creek watershed is in the West Kootenay region of BC and can be accessed via Rover Creek Forest Service Road (FSR) from Blewett Road. Parking to access the site is located on Rover Creek FSR at 11U 466102E 5475422N. This watershed is in the Interior Cedar Hemlock zone (ICH), dry warm phase (dw) of the Biogeoclimatic Ecosystem Classification (BEC) System (MacKillop and Ehman 2016). Table 1 provides characteristics for each stand collected by Selkirk College forestry student, Thomas Weiszbeck in September 2019. The forest stands were named based on the average tree height. For example, Juvenile 10 refers to a stand whose average tree height is 10 meters. There are five tree species in these stands which vary from 972-1043 meters in elevation. The average tree heights range from 25 meters in the mature stand to two meters in the Juvenile 2.

Table 1. Site characteristics for Rover Creek snow study, September 2019.

Stand Name	Dominant Tree species			Mean Tree height (m)	Crown closure %	Aspect	Elevation (m)
Mature stand	60% western redcedar (*Thuja plicata*)	24% western hemlock (*Tsuga heterophylla*)	12% Interior Douglas-fir (*Pseudotsuga menziesii*)	25	40	Northeast	1043

Juvenile 10 North	63% western redcedar	27% western hemlock	5% western larch (*Larix occidentalis*)	11	48	Northeast	975
Juvenile 10 South	33% western redcedar	31% Douglas-fir	13% western larch	9	33	Northeast	984
Juvenile 5	57% western redcedar	27% western larch	16% Interior Douglas-fir	6	22	Northeast	1027
Juvenile 2	36% western larch	33% lodgepole pine (*Pinus contorta*)	16% Interior Douglas-fir	2	0	East	972

Project Design

Weather and SWE were collected from March 14 to April 28, 2019 as part of an ongoing hydrological recovery project organized by Dr. Kim Green who is working with the Applied Research and Innovation Centre (ARIC) at Selkirk College. A Hobo weather station was used to collect daily temperature data. With the weather data that was collected every hour, I calculated the average daily temperatures. A snow sampling tube was used to measure the snow depth and SWE. Snow water equivalent is an expression in cm of equivalent water per unit area of snow. Over the course of the study period, 14 snow courses were done in each stand. These were standard 10-point snow courses (approximately 10-meter intervals) that were spaced over 100 meters on a contour.

I calculated the mean in the 10-point snow course points and found the average SWE per site for each survey day. The ablation rate was calculated by finding the difference in average SWE and dividing by total days. This allowed me to identify which stand was melting the fastest.

3. Results

The total snow cover disappeared from all study sites by the end of April. The mature stand was the first to be free of snow on April 4, and Juvenile 5 (J5) retained snow cover for the longest period. The SWE in the Juvenile 2 (J2) stand accumulated more than double that of the mature stand (Figure 1). Differences in SWE ranged from a maximum of 11 cm in the mature stand to

25 cm in the J2 stand. There was a 7 cm increase of SWE in the J2 compared to the J5. The highest melt rate of 1.6 cm/day was found in both the mature stand and in the J2 (Figure 2), and occurred when temperatures reached above 6 °C. The average melt rate in the J2 was 0.69 cm/day, similar to that of the mature stand (0.64 cm/day). Melt in the J5 and Juvenile 10 south (J10S) location and Juvenile 10 north location (J10N) ranged from 0.46-0.49 cm/day.

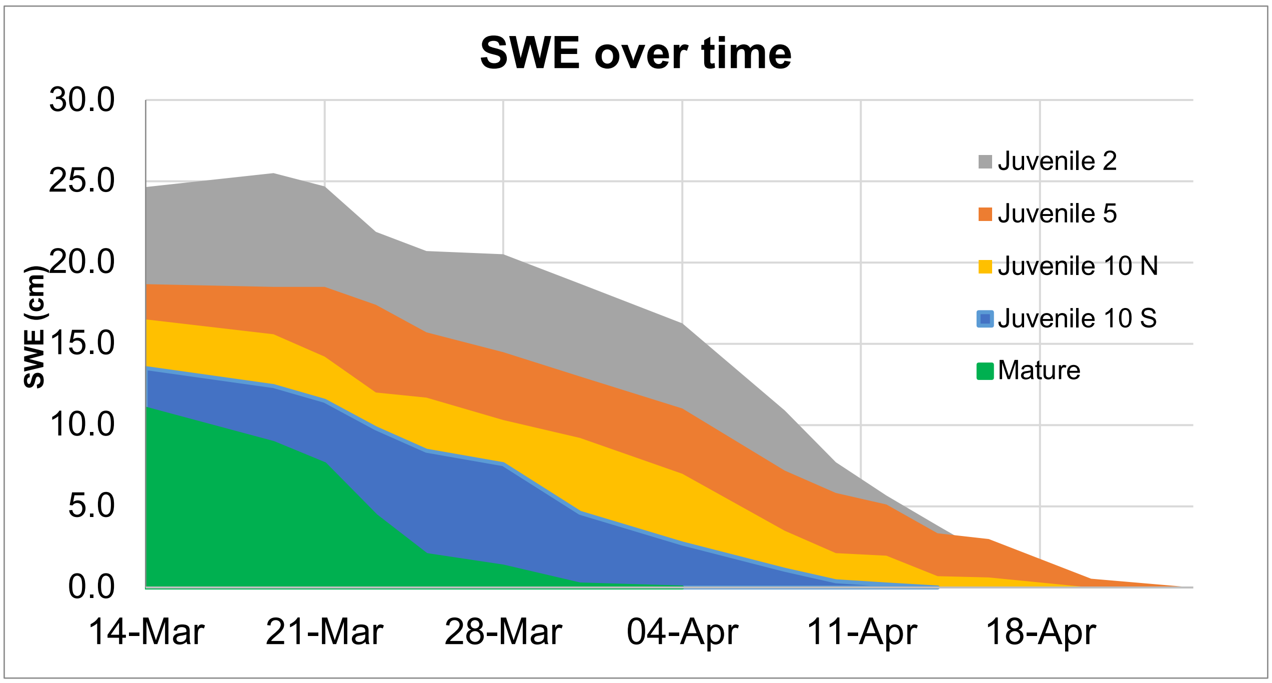

Figure 1. SWE over time in four forest stands from March 14to April 20, 2019, Rover Creek.

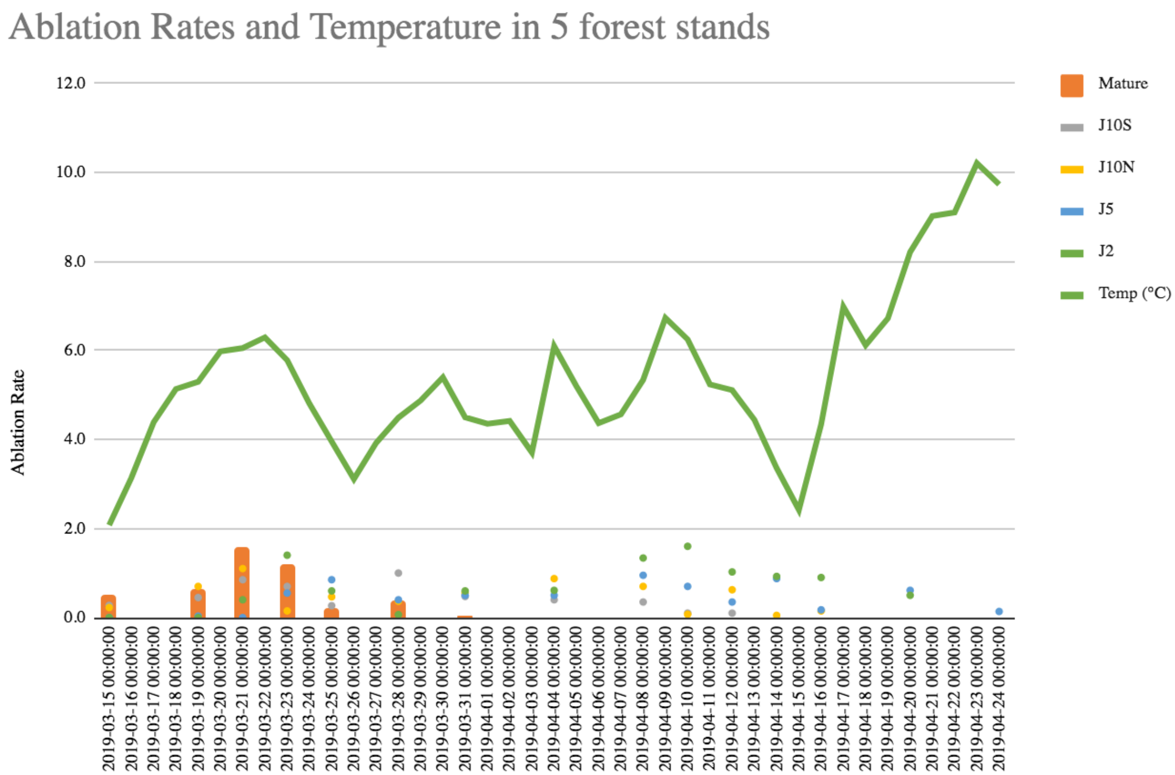

Figure 2. Ablation rate in cm per day and average temperature from March 13 2019- April 24 2019 in 5 forest stands in Rover Creek.

4. **Discussion**

The forest stands with the highest canopy cover (mature 40% crown closure and J10 48%) received less than half of the total SWE or, in other words, less snowpack, than the most open stands. These results indicate that there is less snow accumulation in forested stands because the tree canopies prevent snow build up on the soil surface. Hence, more snow accumulation would be expected with logged stands. However, although snowpack clearly was affected by degree of canopy closure, my analysis showed that the maturity of the forest stand did not result in notable differences in melt rates.

Studies have shown that differences in melt rates among the study sites correspond to differences in the energy available at the snowpack surface as a result of varying forest structures (Wrinkler 2005). In contrary, my snow melting data was likely initiated by warming temperatures rather than solar radiation because the different forest structures (J2 & Mature) had similar melt rates.

All sites would have been subject to similar precipitation and solar exposure because of their similar elevation and aspect. Likely, the similarities among the stands in terms of aspect and elevation caused the low variance in melt rates between sites.

5. Conclusion

In conclusion, melt rates did not vary among the stands but occurred, instead, at different times of the late winter due to snow accumulation differences. In other words, the rate at which snow melts and run-off begins appears to be more related to the warming late winter temperatures and not the depth of snow on the ground. In terms of snow accumulation, stands with less canopy closure has the potential of accumulating twice as much precipitation on the forest floor, therefore doubling the amount of water that will melt.

Measuring SWE equivalent is a very time consuming and additional research is underway to find new methods of measuring snow depth and ablation rates. Researchers are now using Lidar and recording with satellite imagery the melting period. Lidar is a surveying method that measures distance to a target by illuminating the target with laser light and reflected light with a sensor. This sure thing method is giving researchers the ability to receive very accurate data over an much larger area than could otherwise be done on foot. Using Lidar will allow scientists to quantifying the influence of forest regrowth on snow accumulation and melt. I am interested in the continued research on hydrological recovery and hope that new research findings will shed light on whether forest stands, and the BC logging industry in particular, contribute to more run-off resulting in downstream flooding, more landslides. Only when this information is quantified will we be able to change logging restrictions in our province.

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