

Streamline

Watershed Management Bulletin

Volume 9 Number 1 Fall 2005

Snow Accumulation in BC's Southern Interior Forests

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Throughout most of British Columbia, snow is an important part of winter. We know that the amount and persistence of snow vary greatly from year to year and with location. Each year, data from snow surveys are used to predict the effects of snow accumulation and melt on transportation networks, recreational opportunities, length of winter logging seasons, flood hazards, reservoir management, and water supplies. We also know that vegetation affects how much snow accumulates on the ground at a particular location and when it disappears.

In forested areas, numerous studies have measured snow accumulation and melt under tree canopies relative to clearcut openings. In environments similar to those of the Southern Interior, 5 to 70% more water can accumulate as snow in clearcuts than in the forest.

Snow typically disappears up to two weeks earlier in clearcuts, depending on the forest type logged, aspect, elevation, and year (Winkler 2001; Pomeroy et al. 2002).

Only a few studies have investigated the effects of forest re-growth on snow accumulation and melt. In Montana, snow accumulation was 4% less in a 4-m-tall lodgepole pine stand, and 14% less where trees were 14 m tall, than in a clearcut. Melt rates in these stands were reduced by 6 and 36%, respectively, relative to the clearcut (Hardy and Hansen-Bristow 1990). In 8-m-tall coastal Douglas-fir stands with 45% crown closure measured using a densiometer, Hudson (2000) found that snow accumulation and melt were 75% "recovered," where recovery was defined as the return to pre-logging conditions.

In the Southern Interior, snow surveys in common forest types have been completed to learn more about the effects of forest growth on snow accumulation and melt as well as to improve estimates of snow "recovery" for watershed assessment

(Winkler et al. 2005a). Two detailed research projects are underway at Upper Penticton Creek and at Mayson Lake. At Upper Penticton Creek, snow accumulation and melt in clearcuts, regenerating stands, and under mature forest cover are being compared to learn how forest cover affects spring snowpacks and streamflow. At Mayson Lake, research is supplying information about snow accumulation and melt in clearcut, young, young-thinned, and mature forests (Winkler et al. 2005b), and about how these snow processes change as the stands age.

This article focuses on peak snow accumulation, which provides an indication of the maximum amount of water that may contribute to spring streamflow. We summarize differences in peak snow accumulation between clearcuts and:

- mature stands of lodgepole pine and of mixed Engelmann spruce, subalpine fir, and lodgepole pine at similar elevations;

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Published by:

**FORREX–Forest Research
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This publication is funded in part by the British Columbia Ministry of Forests and Range through the Forest Investment Account – Forest Science Program, the BC Ministry of Environment with funds from the Forests for Tomorrow (FFT) program, and by the USDA Forest Service.

ISSN 1705-5989

Printed in Canada

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- two mature pine stands at different elevations; and
- young pine and mature mixed-species stands.

The results of the stand comparisons presented in this article are the background to ongoing research at both Upper Pentiction Creek and Mayson Lake.

Study Areas

The Mayson Lake snow research area is located 50 km northwest of Kamloops, BC (Figure 1), in the dry Montane Spruce biogeoclimatic zone (Lloyd et al. 1990). This area receives about 700 mm of precipitation annually, of which about 60% falls as snow. From 1995 to 1997, four adjacent and relatively flat sites at an elevation of 1250 m were surveyed. One site was forested with multi-layered mature Engelmann spruce, subalpine fir, and lodgepole pine. Two sites were forested with 4- to 6-m-tall young lodgepole pine, one of which was thinned and pruned. A fourth site was a reforested clearcut with young lodgepole pine trees less than 1 m tall. These same stands are now being resurveyed as part of an ongoing study into changes in snow accumulation and melt associated with forest growth.

The Upper Pentiction Creek study area is located 26 km northeast of Pentiction, BC (Figure 1), in the dry Engelmann Spruce–Subalpine Fir biogeoclimatic zone (Lloyd et al. 1990). Annual precipitation in this area is about 750 mm, of which approximately 50% falls as snow. From 1995 to 1997, snow surveys were completed at five sites: a mature lodgepole pine stand; a mature mixed Engelmann spruce, subalpine fir, and lodgepole pine stand; clearcuts with no young trees taller than 1 m located next to each of the mature forest sites; and a 4-m-tall stand of young mixed spruce, fir, and pine. These sites are all at an elevation of 1600 to 1700 m on level terrain. The mature lodgepole pine stand and adjacent clearcut continue to be surveyed and now provide 10 years of data.

Beginning in 1998, a second mature lodgepole pine stand, with lower stocking density, was also included in the study at Upper Pentiction Creek. This stand at 1650 m is located between the mature lodgepole pine stand and nearby clearcut. In 2000, two additional snow survey sites, a recently logged clearcut, and an adjacent mature high-elevation lodgepole pine stand were established at 1930 m. Five years of data have been collected at these sites.

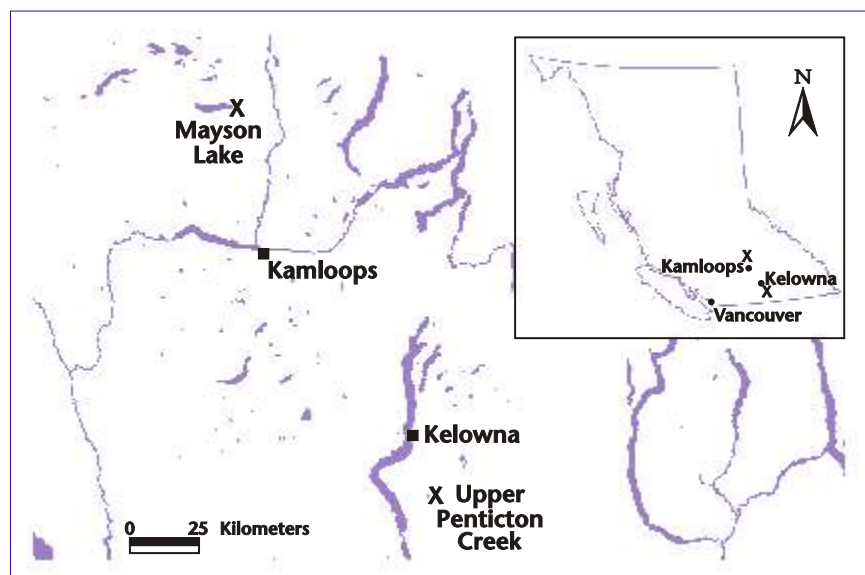


Figure 1. Location of the Mayson Lake and Upper Pentiction Creek snow research sites.

Detailed forest inventories have been completed for every study site. Variables measured included stand density, crown closure measured with a moosehorn (Bunnell and Vales 1989), stand basal area, average tree diameter, average tree height by canopy layer, and average crown length. Using these data, Winkler et al. (2005a) found that crown closure measured with a moosehorn best explained the largest proportion of the variability (> 68%) in snow accumulation among the study stands.

The response of SWE to forest cover, including regeneration, is not a simple matter — aspect, species mix, and elevation all play a role.

Snow Survey Methods

The amount of water in the snowpack, or snow water equivalent (SWE), was measured at all sites on or near April 1 using a standard Federal snow tube. At each site, snow survey sample points were spaced in a 15 × 15 m or 10 × 10 m grid pattern over approximately 1 ha. From 1995 to 1997, 64 sample points were surveyed in each stand. From 1998 on, snow has been surveyed at 32 points within each stand, a more manageable sample size that is still large enough to reflect the variability in snow accumulation expected in the forest types being studied (Spittlehouse and Winkler 1996).

Results

The SWE measured at Mayson Lake and Upper Penticton Creek on or near April 1 from 1995 to 2004, along with the attributes of each stand surveyed, are shown in Table 1. The percentage reduction in SWE under each forest cover type relative to that measured in the adjacent clearcut is also provided.

Our results show some interesting differences in April 1 snow accumulation between stands. Average differences were smaller between the mature pine stands and adjacent clearcut (10% and 22%, respectively, at Upper Penticton

Creek) than between the mixed spruce stands and adjacent clearcuts (23% and 32% less SWE at Upper Penticton Creek and at Mayson Lake, respectively). At Upper Penticton

Creek, a young 4-m-tall mixed spruce–fir–pine stand with minimal crown closure accumulated slightly more snow (3%) than an adjacent clearcut. The increase in accumulation in the young stand may simply have been due to location or may have been a result of reduced sublimation losses. Although the increase was consistent from year to year it is also within measurement

error. In the 4- to 6-m-tall pine stands at Mayson Lake, SWE was 14% less than in the clearcut indicating a 43% recovery in snow accumulation at a canopy closure of 20 to 30%. On average, no difference in April 1 SWE was observed between the thinned and unthinned young pine stands at Mayson Lake, likely a result of the similarities in crown closure (21% and 28%, respectively) even though stem density had been reduced in the thinned stand. The difference

between stands varies from year to year and the range in SWE measured at each site is often larger than the differences among sites, highlighting the importance of sampling over a number of years.

Elevation

We also looked at the effect of elevation on snow accumulation. Unexpectedly, the April 1 SWE was 22% higher in the upper-elevation pine stand than in the adjacent clearcut. This finding is thought to be a result of increased snow sublimation losses and intermittent late-winter snowmelt in the southerly oriented high-elevation exposed clearcut. SWE in the high-elevation mature pine stand was 37% greater than in the lower-elevation pine stand, whereas the upper-elevation clearcut (1930 m) showed 13% less SWE than the lower-elevation SWE site (1650 m) on April 1. These results illustrate the spatial complexity of snow processes and are important in understanding how melting snow in different parts of a watershed contributes to streamflow.

Crown Closure

We also looked at the potential relationship between crown closure and the reduction in SWE measured

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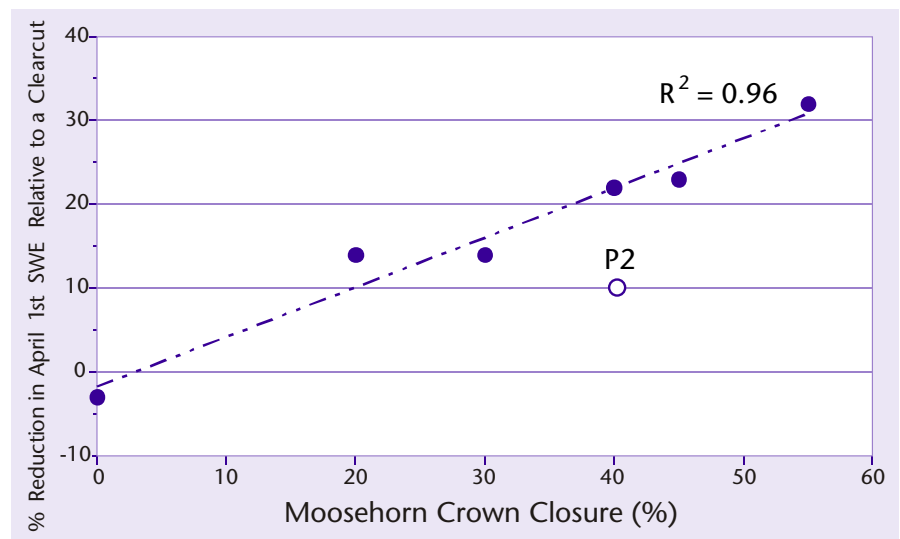


Figure 2. Reduction (%) in peak snow water equivalent (SWE), measured on or near April 1, under forest cover relative to a clearcut, in seven stands at Mayson Lake and Upper Penticton Creek.

Table 1. Stand characteristics and percentage reduction in snow water equivalent (SWE) measured on or near April 1 at Mayson Lake and Upper Pentiction Creek

Location	Site name	Stand type	Elevation (m)	Survey years	Sample sites	Main canopy tree height (m)	Basal area (m ² /ha)	Crown closure (%)	April 1 SWE (cm)		Reduction in SWE (%)
									Average	Range	
Mayson Lake	M1	Clearcut	1250	1995–1997	64	<1		0	22	20–26	
	M2	Young-thinned pine	1250	1995–1997	64	6	8	21	19	17–24	14
	M3	Young pine	1250	1995–1997	64	4	12	28	19	15–23	14
	M4	Mature spruce, fir (pine)	1250	1995–1997	64	23	62	55	15	12–19	32
Pentiction Creek	P1	Clearcut	1650	1995–2004	(64*)32	<1		0	31	23–42	
	P2	Mature pine	1670	1995–2004	(64*)32	18	58	40	28	17–37	10
	P7	Mature pine	1650	1995–2004	32	24	38	39	24	15–34	22
	P3	Clearcut	1600	1995–1997	64	<1		0	31	28–35	
	P4	Mature spruce, fir (pine)	1600	1995–1997	64	19	48	44	24	22–26	23
	P5	Young spruce, fir (pine)	1600	1995–1997	64	4	6	<10	32	29–37	–3
	P9	Clearcut	1885	2000–2004	32	<1		0	27	20–32	
	P10	Mature pine	1920	2000–2004	32	13	42	42	33	22–43	–22

*64 points were sampled each year from 1995 to 1997, subsequently 32 of these original points were sampled each year from 1998 to 2004.

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on or near April 1. Among most of the study sites, we found a strong relationship between the two variables (Figure 2). The exceptions were the upper-elevation pine stand (for reasons already discussed) and the lower-elevation pine stand P7. Stand P7 had similar crown closure to the second nearby pine stand (P2), but the length of live crowns was much shorter in P2 than P7. The difference in canopy structure resulted in only a 10% reduction in SWE from that in the clearcut at P2 compared with a 22% reduction at P7. These exceptions clearly illustrate the complex interactions between forest cover and snow accumulation. For most of the stands included in this study, our results indicate that on average about a 6% reduction in SWE may be expected for roughly every 10% increase in crown closure. This relationship will be tested across a broader range of stand types but is similar to the findings of Moore and

McCaughey (1997). This type of information would give a useful index to changes in snow accumulation as a result of logging and forest re-growth for watershed planning.

Operational Interpretations

- Average differences in snow accumulation from one year to the next can be greater than the difference between peak SWE in forests and openings in the same year.
- Clearcuts in mixed spruce–fir–pine stands may result in larger increases in snow accumulation than clearcuts in pine stands.
- Though snow accumulation generally increases with elevation in a watershed, other variables such as aspect and exposure may have a greater effect on peak SWE.
- More snow may accumulate in young forests than in a clearcut

during early stages of stand development.

- Measurable reductions in snow accumulation occur as crown closure increases, as shown by the 6% reduction in SWE with every 10% increase in crown closure in most of the stands studied.
- The results presented here illustrate that the response of SWE to forest cover, including regeneration, is not a simple matter — aspect, species mix, and elevation all play a role.

Continuing Work

Snow research in the Southern Interior of British Columbia is continuing to answer questions related to forest cover effects on snow accumulation and melt. The first set of snow accumulation and melt recovery surveys at Mayson Lake were completed in spring 2005 and these stands will be resurveyed beginning in



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2008 to learn more about the effects of forest growth on snow accumulation and melt. Ongoing work at Upper Penticton Creek will offer information linking snow processes to spring streamflow. New work in burned stands and areas affected by mountain pine beetle will add to our understanding of snow accumulation and melt in the Southern Interior.

Acknowledgements

The authors gratefully acknowledge the countless snow and stand measurements made by Laurie Lyons, Todd Redding, Dobson Engineering Ltd., and Skyline Forestry Consultants Ltd. The editorial suggestions by Dave Spittlehouse and three anonymous reviewers were helpful and appreciated. ~

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