Forest Harvest and Snowpack

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Introduction

Climate change is expected to alter snowpack. Increased air temperatures can shift the type of winter precipitation from snow to rain and may alter the amount or timing of snowpack. Long-term declines have been observed in the western US and Canada (Najafi et al. 2017; Mote et al. 2018). Understanding how forest management may alter snowpack in a changing climate is becoming increasingly important.

How does harvesting affect snowpack and water supply?

Snow accumulation generally increases in harvested areas

Opening the forest, whether by natural disturbance (e.g., fire, insect outbreaks) or harvesting is often associated with an increase in the amount of snow on the ground because there are fewer trees to intercept it (Varhola et al. 2010). When trees intercept snow, some of the snow on canopy surfaces can return directly to the atmosphere (sublimation) and will not reach the ground. Intercepted snow can also melt and may be transported to the ground below the canopy (as stemflow or throughfall) (Figure 1). The amount of snow accumulation on the forest floor generally increases with the size of the opening in the canopy (Varhola et al. 2010).

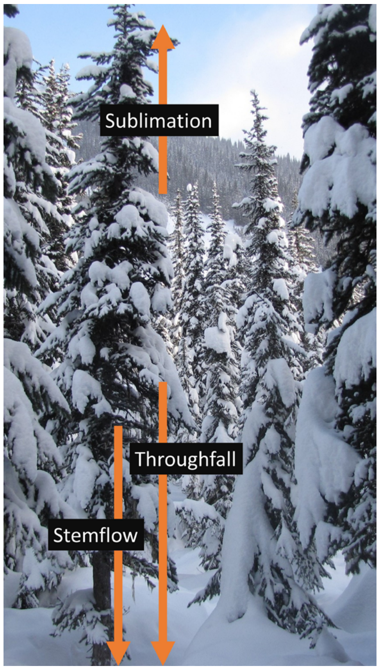

Figure 1. After snow is captured in the canopy it may either return to the atmosphere via sublimation or melted snow may be delivered to the ground as stemflow or throughfall.

Snow melt rates can also increase

While more snow may reach the ground in recently-harvested locations, snow melt rates often also increase (Varhola et al. 2010). Large (> 40%) increases in snow accumulation associated with canopy removal due to fire or harvest often have greater snow melt rates. In some cases, these higher rates of melt are associated with earlier snow melt, but later snow melt has also been observed in multiple locations. In northern Idaho, greater snow accumulation in clearcuts took 17 days longer to melt than in unharvested forest areas (Hubbart et al. 2015). Many of the site-specific microclimatic factors that affect snow melt (e.g., shading and solar radiation, wind sheltering, temperature) are not well understood and continue to limit our understanding of when and where snowpack may melt earlier or persist longer beneath canopy openings (Varhola et al. 2010; Hubbart et al. 2015).

How snowmelt relates to water supply during the summer low-flow season

The streamflow contribution that comes from groundwater (subsurface water storage) is called “baseflow” (Figure 2). During seasonally dry periods when precipitation events are limited, such as the summer low-flow season, baseflow

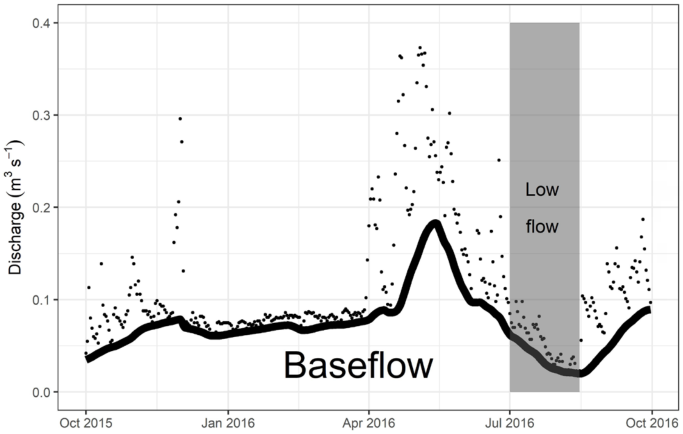

Figure 2. An example of an annual hydrograph from a British Columbia stream gage. The thick black line depicts the separation of baseflow. The grey shading indicates the seasonal low flow period in late summer.

sustains streamflow in streams that flow year-round. Snowmelt contributes to groundwater recharge of shallow and deep groundwater sources, which may affect late summer flow (Godsey et al. 2014), although these contributions may not affect baseflow in the same year. While the amount of snow is important, the rate of snowmelt and its timing may also have important effects on water availability during summer. For example, more rapid snowmelt has been associated with higher baseflow (Barnhart et al. 2016), with potential implications for baseflow later during seasonal low flow.

Sun et al. (2018) specifically examined the role of forest harvesting, snowmelt rates, and timing of snowmelt on summer low flow. They used a physically-based hydrological model in the eastern Cascades of Washington to explicitly model forest-snow interactions in canopy gaps following harvest.

They found that creating gaps (60 m diameter) equivalent to 24% of total watershed area increased seasonal low flows (late summer to fall) by 13.5% (0.26 m^3 s^{-1}) to 40% (1.76 m^3 s^{-1}). Their modelling results suggest that more small forest gaps may allow for longer snow retention than fewer larger gaps distributed throughout a watershed. It is likely that many region-, site-, and climatic-specific factors influence water availability due to snowpack dynamics, including snowmelt and summer low-flow responses.

References

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