Upper Penticton Creek: How Forest Harvesting Affects Water Quantity and Quality

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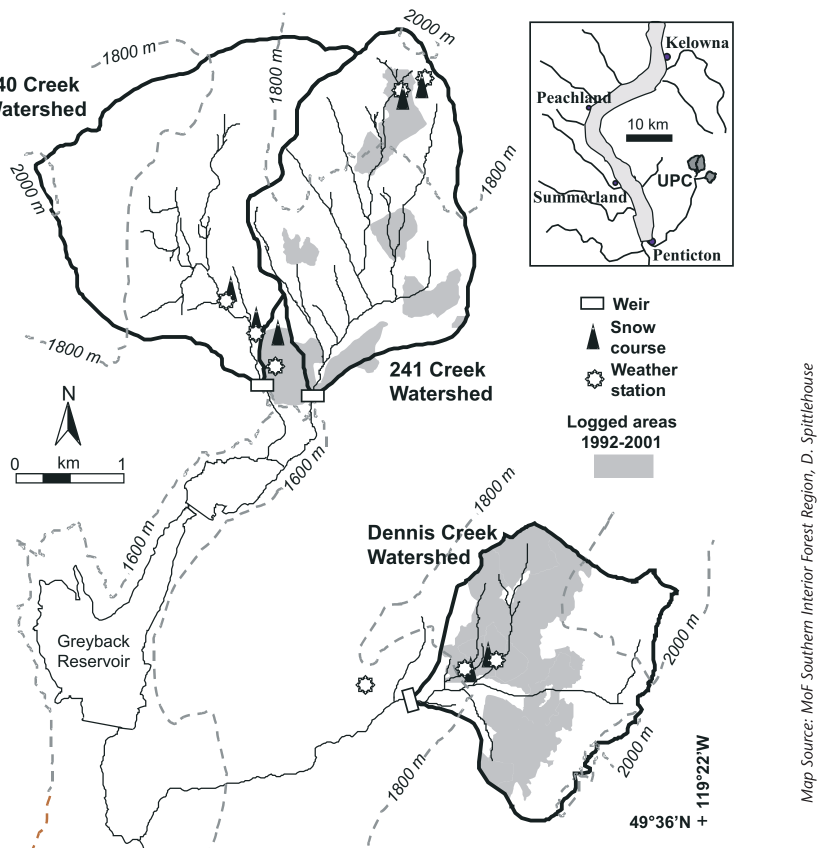
A continuous supply of high quality water is essential for domestic use, agriculture, industry, recreation, and aquatic life. Concerns about the sustainability of water supplies in the dry south-central Interior and the potential effects of forest land use on aquatic resources led to the establishment of the Upper Penticton Creek Watershed Experiment in 1984. From the initial streamflow and summer weather measurements, the experiment has grown to include a network of all-season weather stations, snow survey sites, channel monitoring sections, water balance installations, aquatic habitat surveys, and water quality measurements. Now an inter-disciplinary, multi-agency experiment with both control and treatment watersheds and pre- and post-logging measurements, it is the only experiment of its kind in the B.C. Interior and one of eight in Canada (Buttle *et al.* 2000).

At Upper Penticton Creek, researchers investigate the long-term effects of logging and forest regrowth on water quality and quantity, and on aquatic habitat. As well, they examine immediate operational questions related to changes in snow accumulation and melt with forest harvesting and regrowth, the effects of forest clearing on stream temperature, and modelling to predict potential changes in peak flows with increasing clearcut area. This article outlines the experiment and summarizes research results that were presented at a February 2004 workshop in Kelowna.

Upper Penticton Creek

The Upper Penticton Creek Watershed Experiment includes the watersheds of 240, 241, and Dennis creeks, three small headwater tributaries to Penticton Creek approximately 26 km northeast of Penticton, B.C. The watersheds are gently sloping, approximately 5 km^2 in size, and range in elevation from 1600 to 2150 m. The 240 and 241 Creek watersheds are oriented to the south while Dennis Creek flows to the west. The watersheds are forested with lodgepole pine (*Pinus contorta* Dougl.), and mixed Engelmann spruce (*Picea engelmannii* Parry) and subalpine fir (*Abies lasiocarpa* [Hook.] Nutt). During the last decade, annual precipitation has varied from 580 to 840 mm, of which approximately half fell as snow. Winter air temperatures occasionally drop to –20°C while summertime high temperatures can reach the upper 20s. From 0.8 to 3 million m^3 of water flow from each watershed annually, amounting to between 30 and 60% of the annual precipitation. The highest peak flows, which occur in May during mid- to high-elevation snowmelt, can reach



Upper Penticton Creek: Stream network, monitoring stations, and harvested areas in the 240, 241 and Dennis Creek watersheds.

Surveys of snow depth and water content in forest and clearcuts occur regularly during late winter and early spring.

1.5 m^3/s, about 0.1 million m^3 of water in a day.

The experiment follows a paired watershed design that includes pre-disturbance environmental monitoring in all study basins. Under this experimental design, one (or more) watershed is logged while another remains undisturbed as a control. Environmental monitoring continues in all watersheds throughout the experiment. This design enables researchers to separate post-disturbance changes related to the weather from those caused by logging. At Upper Penticton Creek, the 241 and Dennis Creek watersheds were logged in several passes, beginning in the winter of 1995, with four years between passes. Approximately 10% of the area in each watershed has been harvested in each logging pass, totalling 20% overall. Conventional feller-buncher and skidder logging techniques have been used throughout the experiment. The 240 Creek watershed has remained unharvested, as the control. By late 1999, a spruce beetle outbreak had killed many trees in the Dennis Creek watershed. These trees were subsequently logged in the winter of 1999 to 2000. At present, 30% and 53% of the 241 and Dennis Creek watersheds, respectively, have been logged. The effects of this level of cut will be measured for at least five years.

Water Quantity

Four years of post-20% logging streamflow measurements in 240 and 241 Creeks were completed in 2002. We have found that the 20% harvest in the 241 Creek watershed has had a minimal effect on peak streamflow and annual water yield. However, streamflow response to fall rains appears to have increased even at this low harvest level. Changes in daily peak flows as predicted by the Distributed Hydrology Soil-Vegetation Model (DHSVM) at 20% harvest were less than 5% for frequent events (i.e., those having a recurrence interval of 10 years or less for model output). Modelling results further suggest that increases in peak flows of up to 10% can be expected for infrequent events (i.e., those having a 50-year recurrence interval). Modelling of peak flow for more extensive harvesting indicates that the maximum increase expected is less than 50% regardless of the extent of forest cover removal. This result is thought to reflect hydrologic processes in gently sloping topography such as that in the 241 Creek watershed. The field measurements and analysis of streamflows post-30% and post-53% logging are continuing.

Water Quality and Aquatic Habitat

Water quality in our study streams remains high. Small increases in stream nitrate-nitrogen were measured during peak flows after the extensive spruce beetle salvage in the Dennis Creek watershed. All stream nitrogen concentrations were low (<0.5 mg/L) in comparison to the drinking water standard (10 mg/L). No significant change was measured in stream nitrogen in 241 Creek at the 20% harvest level. Other chemical water quality data are also being analyzed.

Visitors discuss forest hydrology during a tour stop at the 240 Creek weir.

Elevated concentrations of suspended sediment are observed each year when streamflow increases in spring. These sediments largely originate at road–stream crossings and from ditches. However, because of limited supply in the experimental watersheds, sediment concentrations peak well before maximum spring streamflows. Elevated sediment concentrations were also observed during fall rains, during and immediately after the extensive spruce beetle salvage in the Dennis Creek watershed. At no time did sediment concentrations exceed 20 mg/L and

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were most frequently lower than 5 mg/L.

Maximum, minimum, and mean 241 Creek stream temperatures in the clearcut reach were approximately 9, 2, and 6°C higher, respectively, than in the forest above the clearcut. Current research is comparing stream temperatures over a similar elevation gradient in the unlogged 240 Creek and downstream of the openings along 241 Creek.

The aquatic invertebrate communities of 240, 241, and Dennis creeks are dominated by Diptera (primarily chironomids). Following logging, aquatic biodiversity stayed constant or increased. Primary feeding groups changed from shedders to scrapers as the food supply changed from leaves to algae.

Interception and Evaporation

From 20 to 30% of the rainfall is intercepted by trees and evaporates, the percentage decreasing with increasing storm size. About 30% of the total summer evaporative water loss from the forest is by interception whereas 70% is by transpiration. Daily transpiration on sunny days during the summer varies from 5 to 50 L per day depending on tree size. There is about 30% less evaporation from recent clearcuts than from the forest. In the winter, forest interception of snowfall results in 15–30% greater accumulations of snow in the clearcuts relative to lodgepole pine and mixed spruce–fir stands, respectively. Snow in the open melts 1.3–1.5 times faster than in the forest. Snow surveys at high, mid, and low elevations have shown that clearcutting has synchronized melt runoff from high-elevation openings with melt from low-elevation forests. Once this change occurs over a large enough proportion of the watershed, changes in the pattern of spring runoff are expected.

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Weather station near the top of 241 Creek watershed.

Summary

The post-20% harvest data for Upper Penticton Creek demonstrate that any changes in water quantity and quality related to the treatment were small at the watershed scale. However, our results also illustrate that changes in forest cover at the stand scale can affect individual hydrologic processes and highlight the importance of protective riparian zones around small headwater streams. Maintaining riparian vegetation will reduce the potential for elevated stream temperatures and sediment delivery to stream channels. Locating roads away from channels and minimizing the number of stream crossings can further reduce sediment delivery to streams.

Post-20% harvest data for Upper Penticton Creek demonstrate that any changes in water quantity and quality related to the treatment were small at the watershed scale.

Although in its 20th year, the Upper Penticton Creek Watershed Experiment continues to evolve as more is learned about how Interior snowmelt-dominated watersheds function. Future work at Upper Penticton Creek includes assessment of 30%- and 50%-cut effects on streamflow and water quality. Other new studies will focus on hillslope processes and flow routing, hydrologic modelling, and the development of operational guidelines. More information about our research can be obtained from the lead author or at:

http://www.for.gov.bc.ca/rsi/research/Penticton/index.htm

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Reference

Buttle, J.M., I.F. Creed, and J.W. Pomeroy. 2000. Advances in Canadian forest hydrology, 1995–1998. Hydrological Processes 14:1551–1578.