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BRITISH COLUMBIA

Coast Forest Region

Timber Harvesting Activities and Hydrology in Coastal British Columbia

To understand how timber harvesting activities may affect water, we need to understand the hydrologic cycle

by David Campbell, Thomas Millard and Denis Collins

WHAT IS HYDROLOGY?

Hydrology is the science of water and its movement over and under land surfaces – in rivers and lakes and as groundwater.

Hydrology includes understanding how water circulates from the atmosphere to the earth and back to the atmosphere. This movement of water is called the *hydrologic cycle* (Figure 1).

It is the hydrologic cycle that determines how much water is at a given location at any time. Understanding how the hydrologic cycle is affected by climate, trees and plants, soils, geology, topography, and land use is an important part of hydrology.

TRANSFER AND STORAGE OF WATER IN OUR ENVIRONMENT

The primary processes in the hydrologic cycle are the transfer and storage of water within the environment – usually within a watershed.

A watershed – also called a drainage basin or catchment – is the area of land that drains to a particular point on the landscape (Figure 2). It may include one or more rivers, lakes, springs, or any

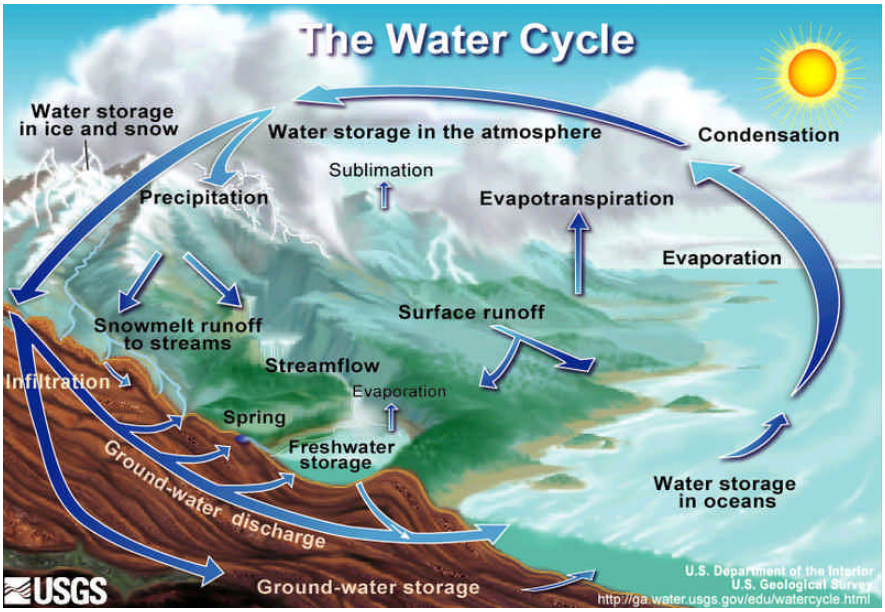

Figure 1. The hydrologic cycle, or water cycle (courtesy of the US Geological Survey).

combination of these features. Watersheds exist across the landscape, and some of them provide drinking water.

Precipitation

Precipitation occurs when water vapour in the air condenses. It is the mechanism that transfers water from the atmosphere to the earth's surface. Typically, precipitation occurs as rain or snow, but it can also come in the form of sleet, hail, dew, or frost.

Moist air masses form over the Pacific Ocean as they move east toward the North American continent. When a moist air mass comes in contact with the mountains along the western edge of the continent, the air is forced up and over the mountains. As the air rises, it cools and condenses to form precipitation.

Then, as the air mass continues to move east over the land and release its moisture in the form of precipitation, the moisture content of the air mass lessens. This leads to a "rain shadow" effect on the leeward side of mountain ranges – the leeward side is significantly drier than the windward side.

Regional influences: In Coastal British Columbia, fall and winter are the wettest periods of year (Figure 3), and precipitation can be extreme.

Elevational influences: At low elevations in Coastal British Columbia, rain is the most common form of precipitation throughout the year. However, at higher elevations, snow is dominant during winter.

A transitional zone exists in the mid elevations (typically 300-800 m) where both rain and snow are dominant processes. In this transitional zone, rain-on-snow events-in which rain and accompanying weather conditions cause rapid melting of the snowpack-can be important.

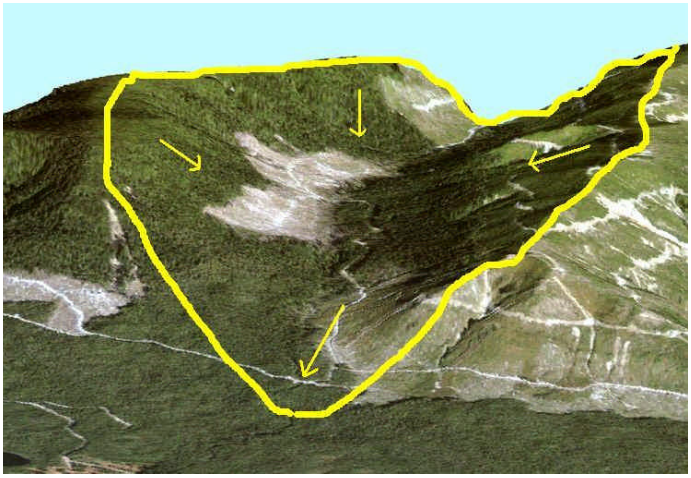

Figure 2. Image of a watershed (drainage basin). ©GeoEye.

At higher elevations, colder temperatures allow for snow to accumulate over the winter. This snowpack is water that is being stored on the land until it melts. In watersheds that receive snow, streamflow is strongly linked to the melting of the snow. The rate at which snow melts is determined by the weather, aspect, topography, and vegetation.

Glaciers are also a primary component of water storage in

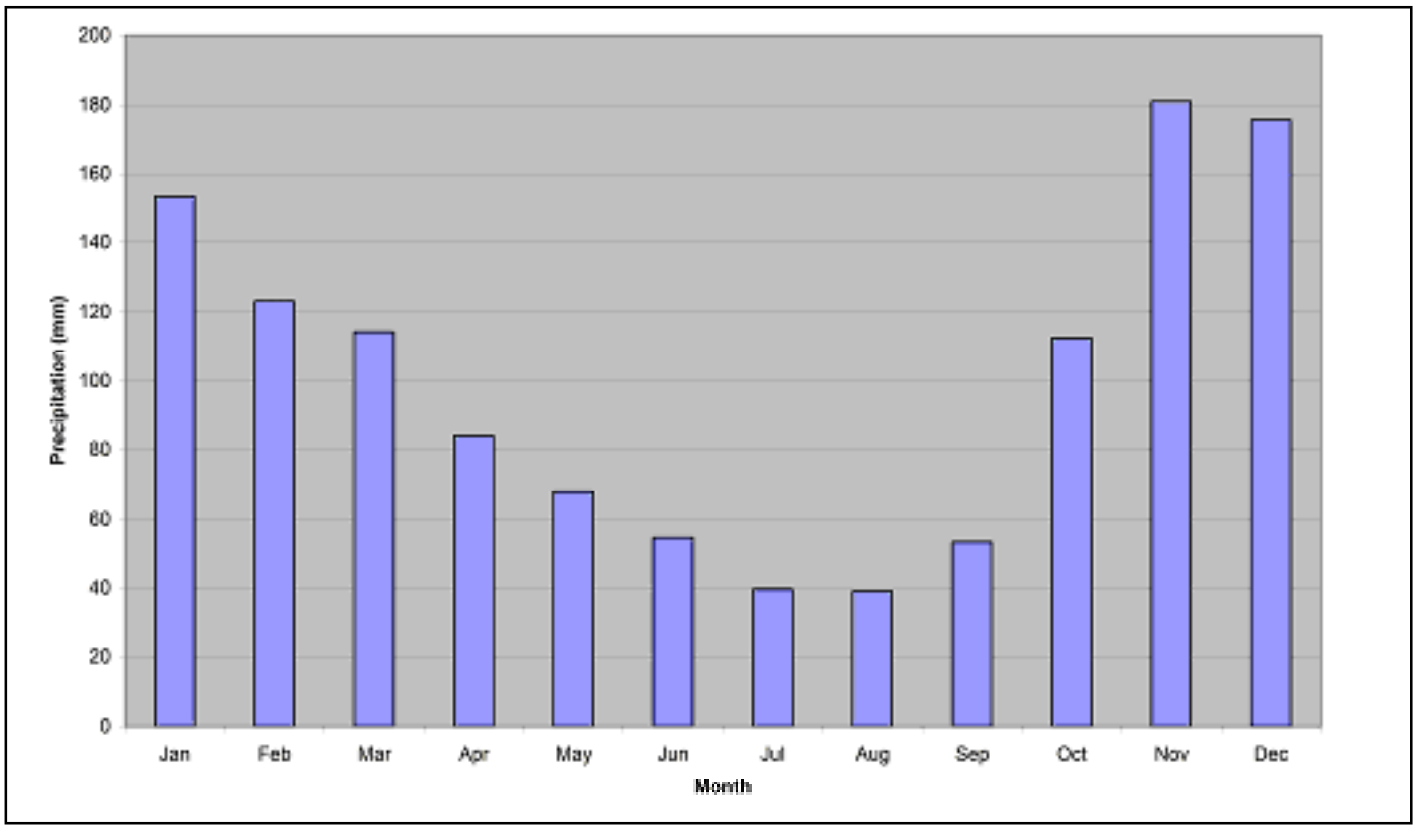

Figure 3. Average monthly precipitation for Vancouver International Airport, 1971-2000 (source: Environment Canada).

many watersheds. Changes in the patterns of glacier melt also affect streamflow.

Interception and infiltration

The branches and foliage of trees and plants can catch and retain the precipitation before it reaches the ground. This is called *interception*. It is an important process because it reduces the amount of precipitation that could be become streamflow.

Water that makes it to the land surface will either flow overland to a stream or river, or it will soak into the soil, which is called *infiltration*. Water that infiltrates the soil can remain in the soil, replenish deeper groundwater reserves, or it may flow below the surface to another location.

Evaporation, sublimation, and transpiration

Water is returned to the atmosphere by evaporation, sublimation, and transpiration.

Evaporation is the process by which water changes from a liquid to water vapour. This process removes water from the earth's surface, including from trees and plants, soils, rivers, lakes, and oceans.

Sublimation is the process by which water changes directly from a solid state (such as ice and snow) to water vapour.

Transpiration is the process by which water is withdrawn from the soil by plants and converted to water vapour through the plant's foliage.

Evaporation and transpiration are influenced by wind, temperature, soil moisture, humidity, and solar radiation. Transpiration is also affected by the species, age, and health of trees and plants, and by the season.

Runoff

Runoff is the portion of precipitation that actually reaches streams by flowing over or through the ground. Simply put, it is what remains after interception, evaporation, transpiration, and infiltration have taken place. Surface runoff flows away without penetrating the soil. Runoff from slopes within a watershed eventually collects in channels as streamflow. Groundwater runoff reaches streams by seeping through soils.

Groundwater

The storage and flow of *groundwater* includes both shallow and deep components.

The shallow component of groundwater occurs in the soil. Water flows through the pore space available within the soil matrix. Small underground pathways, such as former cavities of decayed roots, can develop for the water to flow, and these are efficient at rapidly moving water through the subsurface.

The deep groundwater component occurs in either bedrock or thick sediment deposits below the soil. Deep groundwater moves very slowly.

During periods of low flow in the summer and winter, streamflow generally originates from groundwater.

Streamflow

Streamflow refers to the amount of water flowing in a stream or river channel.

Figure 4. Roads can influence flow pathways.

A *peak flow* is an extreme flow – a flood. A flood is typically caused by rapid snow melt, extreme rainfall, or rain-on-snow events.

A low flow occurs during a dry period.

Suspended sediment and water quality

Particles of sediment become suspended in stream water due to erosion. The particles generally come from the stream bed, stream bank, and landslides. The amount of sediment in a stream is affected by the rate of streamflow, amount of precipitation, and potential for erosion.

EFFECTS OF TIMBER-HARVESTING ACTIVITIES ON HYDROLOGY

Timber-harvesting activities-which includes tree removal and forest road construction-can change the role of forests in the hydrologic cycle.

- The removal of trees reduces interception and transpiration This leads to more runoff.
- The reduction in shade in harvested areas increases the amount of solar radiation reaching the land surface. This in turn increases air temperatures, evaporation, and snow-melt rates.
- At ground level, the effect of the wind may increase in areas where trees have been removed. More exposure of the land surface to wind can lead to increased evaporation rates, and accelerated melting of the snowpack.
- Road cuts and ditches can interrupt the underground flow pathways and cause concentrated surface flow (Figure 4).

Some timber harvesting activities have the potential to increase the total amount of runoff in a watershed, increase the frequency and size of floods, or change the timing of when floods occur. Timber harvesting activities can also affect water quality, primarily through increased sedimentation. Erosion from road surfaces and landslide scars are the main sources of

Figure 5. Alternative harvesting methods include partial cutting (left photo) and helicopter patch cuts (right).

increased sediment. The way in which a watershed responds to harvesting depends on the extent of the harvesting, the method of harvesting, and the sensitivity of the watershed.

Improved practices

Forest-management practices have evolved to reduce hydrologic effects from harvesting activities. Mitigating the potential effects of forest harvesting on hydrology is a high priority.

Some strategies for reducing the effects on hydrology include:

- Conducting detailed studies to examine how susceptible watersheds are to the effects of harvesting, and developing harvesting plans and forest management plans accordingly.
- Ensuring that the forest regenerates, either naturally or by planting. As forests regenerate, hydrologic functions recover.
- Limiting the size of cutblocks.
- Using alternative methods of harvesting, such as partial cutting (Figure 5).
- Reducing the amount of sediment entering streams to protect water quality.
- Constructing road-drainage features to reduce the ability for runoff to concentrate.
- Deactivating forest roads.

FREQUENTLY ASKED QUESTIONS

Q: How will climate change affect hydrology in British Columbia?

A: Projected climate change scenarios suggest that Coastal British Columbia will become warmer and wetter over the next century. The frequency of extreme weather patterns may increase, and therefore the frequency and size of floods may increase. In glaciated watersheds, shrinking glaciers will reduce the amount of water available for streamflow.

Q: Why has this creek dried up since harvesting took place in the watershed?

A: The tendency is for harvesting to actually increase the amount of runoff, although the water may not be visible because it is flowing through the gravel below the surface.

When a creek "goes dry" it is typically the result of excessive sedimentation rather than changes in the overall water supply. Land managers focus on reducing sedimentation by avoiding activities on terrain that is prone to erosion, and in other cases by leaving buffers around stream channels and riparian areas.

Q: Will harvesting increase the frequency of storms and increase precipitation?

A: Storm systems are not influenced by forest cover, and therefore are unchanged by harvesting. However, harvesting reduces interception, and therefore more precipitation makes it to the ground and becomes available for runoff.

Q: Is sediment caused by harvesting within the watershed?

A: Sedimentation of the water is caused by a number of erosion processes.

High concentrations of sediment in the water are often caused by certain geographic features or geologic conditions that naturally contribute a large quantity of sediment to the stream channel. Some examples include natural landslides and subsequent erosion of landslide scars, or stream bank erosion.

To minimize any increase in sediment, land managers and harvesting planners identify the potential sources of sediment in a watershed and address these in their harvesting plans.

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