Forest Sciences

Prince Rupert Forest Region

Extension Note # 39

June, 1999

Basin hydrology and canopy interception in hypermaritime forests: Issues and approach[1]

Research Issue Groups:

Forest Biology

Forest Growth

Soils

Wildlife Habitat

Silviculture

Timber Harvesting

Ecosystem Inventory and Classification

Biodiversity

Ecosystem Management

Hydrology

Geomorphology

Extension

Forest Engineering

Introduction

Hypermaritime pattern, process, and productivity or HyP³ (pronounced "hip cubed") is an integrated forest research project initiated in the North Coast Forest District in 1997. This project is aimed at developing ecologically based guidelines for management of cedar-dominated forests that are mostly outside the current operable land base of north coastal B.C. Lower productivity cedar - hemlock forests dominate much of the outer coastal landscape. They contain significant amounts of wood including high value redcedar (*Thuja plicata*) and yellow-cedar or cypress (*Chamaecyparis nootkatensis*), for value added and specialty markets. Currently there is much uncertainty surrounding the feasibility and sustainability of harvesting these wet, slow growing forests. Using a combination of basic studies of structure and function as well as manipulative trials, HyP³ researchers are addressing four overall project goals:

- Assess the feasibility of managing lower productivity cedar – hemlock forests on the outer coast of B.C. for timber/fiber production.
- Define the extent of these sites and be able to readily identify the potentially operable portion.
- Develop ecologically based management guidelines for these forests.
- Document the ecology and hydrology of the blanket bog – upland forest complex of north coastal B.C.

This extension note introduces the basin hydrology component of the HyP³ Project and provides an overview of research objectives, study areas, and sampling methods. Future extension notes will provide more detailed descriptions of progress and results for each of the hydrological trials. An overview of the entire HyP³ Project is presented in Extension Note # 38.

[1]*Contribution #2 from the HyP³ Project.*

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The Issue

Excess moisture provided by abundant rainfall, cool temperatures, and high humidity is characteristic of British Columbia's north coast—it's a hypermaritime climate. The North Coast District receives 1,500 to >3,000 mm of rainfall per year. Such extreme conditions can result in shallow water tables and continuously moist soil conditions. Sites where water is not quickly shed become saturated and develop organic soils. Open bogs, bog forests, and low productivity upland forests cover more than 50% of the landbase, with productive forests being restricted mainly to steep slopes and floodplains. The hydrologic consequences of harvesting the lower productivity forests are unknown; before any harvesting begins, we need a better understanding of the hydrological fluxes operating at site and watershed levels.

Currently, there are very little hydrological data for north coast watersheds. While several agencies collect rainfall data, all current runoff data is limited to watersheds with reservoirs and glaciers. As a result we have an incomplete understanding of the role forests play in the water cycle. Previous site level research in the North Coast District indicates that the forests can intercept and evaporate up to 25% of fall and winter rainfalls (Beaudry and Sagar 1995). Although these findings were derived from models with assumed parameters, they suggest that harvesting will make more water available to soils already close to saturation. The potential consequences are elevated water tables, increased runoff, higher peak discharges, channel degradation, and increased organic soil development. The hydrology, geochemistry and ecological processes operating on the north coast are all interrelated. As a result there may be significant effects on soil nutrient and moisture regimes, vegetation development, and site productivity. Increased organic soil development, for example, can lead to elevated water tables, decreased soil aeration and nutrient supply to tree rooting zones, and lower tree productivity. Considering the lack of data and potential consequences of harvesting lower productivity sites on the north coast, it is necessary to explore the components of the hydrological cycle and how they would change if logging took place. The basin hydrology component specifically attempts to:

- Quantify hydrological fluxes at the site and watershed levels.
- Predict how these fluxes will be affected by forest harvesting.
- Predict how changes in hydrology will affect forest productivity, site regeneration, and streamflows.

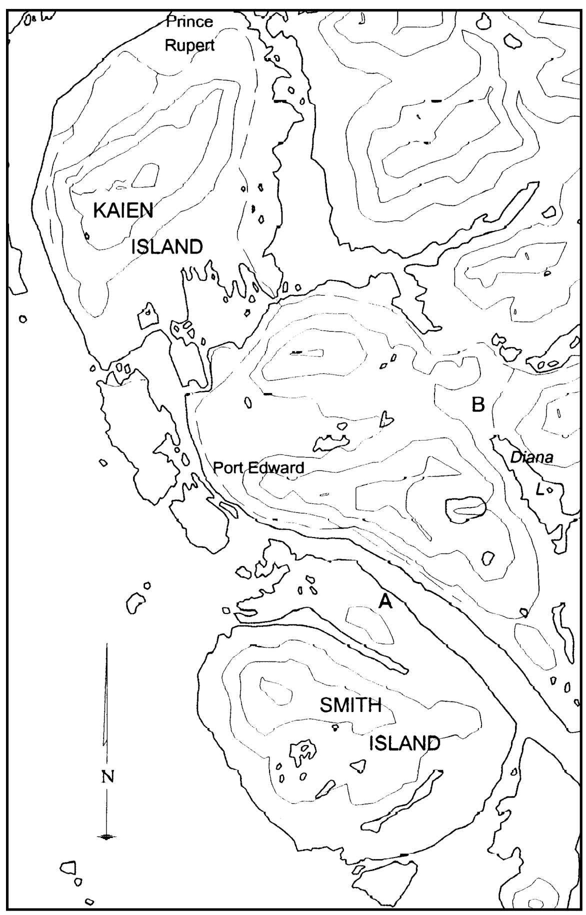

FIGURE 1. Study Area.

Study Areas

Two watersheds have been selected for intensive study (Figure 1). One watershed is located on Smith Island near Port Edward (A), and the other is near Diana Lake Provincial Park (B). Both are 20 km southeast of Prince Rupert.

Site level studies within each watershed are being carried out along a transect that includes representative examples of the most common site series within the CWHvh2 (Banner *et al.* 1993). Site level questions focus on rainfall, interception, evapotranspiration, and soil moisture variables in the cedar–hemlock–salal lower productivity forest (site series 01). Watershed– level questions focus on the water balance within an entire basin.

The Diana Lake watershed is 31ha and rises from 70 to 365m above sea level. It has a southerly aspect and a mean channel gradient of 32%. The Smith Island watershed is 29 ha and rises from sea level to 396m, has a northeasterly aspect, and a mean channel gradient of 33%. Both are second order watersheds having at least one tributary stream (1:20,000). Neither main stem channel flows through wetlands or lakes.
Both sites experience oceanic climates, relatively mild temperatures, and heavy rainfall. Summers are cool and cloudy; winters are mild, very wet and only occasionally experience deep snowpacks. Mean annual temperature for Prince Rupert, 20 km to the northwest, is 6.9°C, with a mean temperature of 13.3°C in the warmest month (August) and 0.8°C in the coldest month (January). Mean annual precipitation at the Prince Rupert airport is 2,552 mm of which 94% is rain. Approximately 15.5% of annual precipitation occurs during the summer months (June to August) and 35.6% occurs during the fall months (September to November). Precipitation on the north coast is strongly controlled by topography. Within the Prince Rupert City area, for example, there is a 456 mm increase in precipitation between the airport at 34m above sea level and the city centre at 85m as a result of the orographic affect (Environment Canada 1998).

Soils at the study sites range from peaty organics to shallow mineral soils with thick surface accumulations of acidic forest humus. Mineral soils are derived primarily from colluvium and saprolite (decomposed bedrock). Plant rooting and most nutrient cycling occur near the soil surface. Old-growth western hemlock, western redcedar, and amabilis fir dominate the forests in both watersheds. Shore pine, mountain hemlock, yellow-cedar, and Sitka spruce also occur.

Bedrock geology in both watersheds is similar. It is part of the Coast Plutonic Complex, and composed primarily of schist and gneiss (Hutchison et al. 1979).

Study Methodology

The various pathways water can take within a watershed will be monitored using a water balance approach, whereby water inputs (rainfall and snowmelt) and outputs (evapotranspiration, channelized discharge, and soil and groundwater storage) are monitored. The water balance can be expressed as an equation:
$P = Q + Et \pm \triangle S$
Where P is precipitation (mm), Q is channel discharge (mm), Et is evapotranspiration (mm), and $\triangle S$ is the change in water table (mm). Researchers from the University of Waterloo are monitoring water table fluctuations as part of their soil hydrology and geochemistry studies.

Monitoring began in 1997. A calibrated tipping bucket connected to a datalogger monitors precipitation. Each datalogger is programmed for continuous monitoring and records total hourly precipitation. Tipping buckets are located in natural openings, away from the influence of surrounding structures. Rainfall recorded at these sites is representative of the amount of water falling on the forest canopy. Rainfall can make its way through the canopy to the soil surface either as direct throughfall, canopy drip, or stemflow. Throughfall and canopy drip are recorded by troughing 0.5 m above the forest floor. Each site has 5 troughs (5 m x 0.12 m) installed along a transect across the 01 site series. The troughs are positioned to monitor all forest conditions within the stand. These conditions include full canopy, partial canopy with standing snags, and natural gaps resulting from blowdown. The troughs are angled to direct water into a tipping bucket (Figure 2). Stemflow water is monitored using tree collars. The collars are rubber hoses circling the stem of a tree, directing stemflow water into a cumulative rain gauge. The volume of water collected by the gauge is manually recorded bi-weekly. The amount of water collected by the troughs and tree collars will be referenced to the amount of rainfall measured in the gaps. From these measurements, rainfall can be partitioned into throughfall, stemflow and evaporation. Basin discharge is measured periodically. Water depth (stage height) at each stream gauging site is monitored continuously by a pressure transducer and electronically recorded. Basin discharge and stage heights are correlated to produce a stage discharge curve for each watershed. The equation for the curve is used to calculate total hourly discharge from each watershed. Changes in groundwater storage are recorded by groundwater wells. Evapotranspiration will be determined using the water balance equation and checked through energy modeling. The variables necessary to run the models, such as air and soil temperature, relative humidity, wind speed and direction, total solar and net radiation, and ground heat flux are being recorded.

Expressing each component of the water balance equation as a depth of water will allow us to quantify the various water fluxes within each drainage basin. This will allow us to refine the water balance equation for north coast forests and assess potential site and watershed level consequences of forest harvesting in the 01 and 11 site series.

This project will run for five years to allow for a range in climatic conditions. Initial results will be presented in an extension note early in 2000.

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FIGURE 2. Troughing for monitoring throughfall and canopy drip.

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