The Cumulative Effects of Forest Management on Peak Flows During Rain-on-Snow Events

by

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Abstract

The Effects of Forest Management on Peak Flows During Rain-on-Snow Events

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Rain-on-snow (ROS) events occur when warm, windy rainstorms pass over a relatively ripe snowpack melting it partially or completely. In western Washington ROS events occur most frequently within the transient snow zone of the Cascade Range. The location of the transient snow zone varies locally, but in the middle Cascades the transient snow zone extends from roughly 300 m to 900 m in elevation.

The effects of clear-cutting on the rate and volume of water delivery to the soil during ROS events have been documented recently. The forest canopy affects both the accumulation and melting of snowpacks. While snow tends to accumulate in clear-cuts, it can be intercepted by the forest canopy where it melts and falls to the forest floor as water or in clumps of wet snow. Higher wind speeds in clear-cuts result in higher melting rates in clear-cuts than in forests during ROS events. The combination of greater snow accumulation and higher melting rates can result in higher rates and volumes of water delivery to the soil in a clear-cut than in the forest.

The main objective of this study is to investigate how forest management affects the size of peak flows from watersheds in the transient snow zone during ROS events. Observed meteorological data, an energy balance equation, and a conceptual watershed model were used to demonstrate how clear-cutting affects the size of peak flows from hillslopes ($\approx$ 16 ha) and how this effect varies over the

landscape during ROS events. A conceptual hydrologic model that has the ability to route water inputs through a linked hillslope and stream network was used to determine how harvest pattern and harvest intensity affect peak flows in a watershed (≈ 6400 ha) in the transient snow zone during ROS events.

The effect of clear-cutting on the size of hillslope peak flows during ROS events was shown to be dependent on the storm and the initial snowpack conditions under each forest cover. This effect varies over the landscape with aspect, elevation, and hillslope hydrological behavior. Hillslopes that produce a more peaked hydrograph response to soil water inputs experience greater increases in the size of hillslope peak flows following harvest than hillslopes that generate a more attenuated response. The increase in the size of peak flows following clear-cutting is greater on windier aspects. The increase in the size of peak flows following clear-cutting at different elevations depends on the snow conditions and the weather at each elevation. Since clear-cutting has a variety of effects on the size of hillslope peak flows in a watershed, harvest intensity alone is an inadequate index for forest harvest effects on peak flows during ROS events. The aspect and elevation and the hydrologic behavior of individual harvest units must also be considered.

The results suggested that harvest pattern has little inherent effect on the size of peak flows from watersheds with drainage areas (≈ 6400 ha), topography, and drainage networks similar to the study watershed. However, harvest pattern indirectly affects the size of peak flows to the extent that the different harvest patterns contain different aspects and elevations and hillslopes with different hydrologic behavior.

The results also suggested that harvest intensity has

a significant, inherent effect on peak flows from watersheds with drainage areas (≈ 6400 ha), topography, and drainage networks similar to the study watershed. For a particular ROS event, the ratio of harvested peak flow to forested peak flow increased with harvest intensity. However, there was significant scatter in the ratio among events for a particular harvest intensity. This suggests that there is a wide range of forest harvest effects on the size of peak flows during ROS events depending on the meteorological conditions during the storm and the initial snowpack conditions.