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Hydrologic response to forest cover changes following a Mountain Pine Beetle outbreak in the context of a changing climate

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Over the last 15 years, there has been extensive mortality of pine forests in western North America associated with an outbreak of Mountain Pine Beetle, often followed by salvage logging. The objective of this study was to quantify the separate and combined effects of forest recovery and climate change over the 21st century on catchment hydrology in the San Jose watershed, located in the semi-arid Interior Plateau of British Columbia. Forest cover changes were simulated using a dynamic spatial model that uses a decentralized planning approach. We implemented management strategies representing current timber management objectives around achieving targeted harvest levels and incorporating existing management constraints under two different scenarios, one with no climate change and one under climate change, using climate-adjusted growth and yield curves. In addition, higher rates of fire disturbance were modelled under climate change. Under climate change, while productivity improves for some species (mainly Douglas-fir on better quality sites), on drier and poorer quality sites most species, especially Lodgepole Pine, become significantly less productive, and stocking is reduced to the point that those sites transition into grasslands. The combined effect of initial age classes (where the forest has been severely impacted by MPB), increased fire, and reduced stocking results in a greater proportion of the forest in younger age classes compared to a "Business As Usual" scenario with no climate change. The hydrologic responses to changes in vegetation cover and climate were evaluated with the flexible Hydrology Emulator and Modelling Platform (HEMP) developed at the University of British Columbia. HEMP allows a flexible discretization of the landscape. Water is moved vertically within landscape units by processes such as precipitation, canopy interception and soil infiltration, and routed laterally between units as a function of local soil and groundwater storage. The model was calibrated and tested on three stream gauges and on snow course data. A 'guided' GLUE approach was used to address the effects of parameter uncertainty and uncertainty in streamflow data on the uncertainty in future projections. Overall, the establishment and growth of post-disturbance forest stands result in a substantial reduction in snow accumulation and melt rates, and an increase in evapotranspiration, together resulting in a reduction in streamflow. The influence of projected climate warming was to advance the timing of spring melt, exacerbating the reductions in late-summer streamflow associated with forest recovery. In some climate scenarios, increases in precipitation helped to offset reductions in streamflow associated with forest recovery. Some challenges associated with linking output from the forest dynamics simulations and the hydrologic model are identified and potential solutions discussed.