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Modelling Impacts of Wildfire Disturbance and Tree Population Dynamics on Tree Throw, Sediment Transport and Microtopography

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This investigation is a followup to our earlier study analyzing tree throw and associated sediment transport in Hawk Creek Watershed, Canadian Rockies (Gallaway et al., 2009). Herein, we extend this earlier work by connecting it to LandMod (Martin, 1998; Martin, 2000; Martin, 2007), a numerical model of drainage basin evolution, to investigate spatial and temporal patterns in tree population dynamics, sediment transport and microtopography associated with tree throw events. LandMod incorporates an algorithm for wildfire occurrence across the model domain, with fire return intervals determined from stochastic rules based on a Weibull distribution. Our tree population dynamics model is incorporated into LandMod. Wildfire events initiate development of the forest, with the model cycling through generations of forest based on tree recruitment and mortality rules. Tree recruitment involves two types of cohort: (i) the fire cohort consists of trees that are recruited in the time period following a fire event; and (ii) the understory cohort consists of trees recruited thereafter, and generally has a lower recruitment rate. Mortality rates are specified for each cohort. Trees fall in accordance with an exponential rate based on time since tree death. Hence, there is a time lag between tree mortality and sediment upheaval resulting from tree throw. Algorithms define the size of the root wad associated with a tree throw event; this information is used to designate the pit dimensions and the amount of sediment involved in the upheaval. For the landscape surface defined in LandMod, we then create a pit having the given dimensions at the location of the tree throw event. The eventual disintegration of sediment from the root wad and its deposition on the land surface creates a sediment mound on the model landscape. The unique microtopographic expression created by the tree throw process is referred to as pit-mound topography. Microtopography has been shown to affect the development and connectivity of overland flow, and may also affect other sediment transporting processes. The new extensions to LandMod allow us to develop this pit-mound topography, which is then subjected to diffusive-type processes (such as soil creep). Over time, these diffusive processes act to diminish the topographic roughness created by the tree throw process. Changes in microtopographic expression of the landscape surface over time are examined, thus allowing the decay and longevity of pit-mound topography to be evaluated in relation to wildfire return intervals and tree population dynamics. For landscapes subjected to shorter wildfire return intervals, it is expected that a greater degree of microtopographic roughness will exist on the landscape at the time of the next wildfire disturbance, compared to situations of more limited wildfire activity.