Geophysical Research Abstracts
Vol. 15, EGU2013-1624-2, 2013
EGU General Assembly 2013


# Examining the effects of forest thinning on hydrological processes at different catchment scales in forested headwater

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We conducted field observation in nested headwater catchments draining Japanese cypress (Chamaecyparis obtusa) and cedar (Cryptomeria japonica) forests at Tochigi prefecture for examining the effects of forest thinning on hydrological processes at different catchment scales. 50% of the stems was removed with line thinning in catchment K2 (treatment catchment), while catchment K3 remained untreated as a control. We monitored nested catchment within K2-1 (17.1 ha) as K2-2 (10.2 ha), K2-3 (3.7 ha) and K2-4 (5.1 ha), and within K3-1 (8.9 ha) as K3-2 (3.0 ha). Runoff from the catchments was monitored during the pre-thinning (from April, 2010 to May 2011), and the post-thinning periods (from June 2011 to December 2012). Paired-catchment and hydrograph separation analysis were used to evaluate the effects of forest thinning on hydrological processes at different catchment scales. We developed the pre-thinning calibration equation for predicting post-thinning behaviors. Paired catchment analysis revealed that annual catchment runoff increased 648 mm in K2-1, 414 mm in K2-2, 528 mm in K2-3, and 566 mm in K2-4 during the post-thinning period. Greater increase of flow in largest catchment (K2-1) was be due to the contribution of increased delayed flow from infiltrated water, reappearing as surface flow (i.e. quick flow) in the lower parts of the catchment, caused by harvested activities (logging, road, skid trail). Because both quick and delayed flows increased significantly in the larger catchments of K2-1 and K2-2, while only delayed flow of smaller catchments (K2-3 and K2-4) increased significantly during the post-thinning period. Delayed flow also increased greater in K2-3 and K2-4, smaller in K2-2 but greatest in K2-1. Moreover, the increasing contributions to runoff from deeper groundwater sources that are recharged in upslope subcatchments caused increase amount of flow. This was explained when increase of annual base flow (i.e. bedrock flow) of zero-order catchments (K2-3; and K2-4) was 16, and 77mm, respectively; only 5 mm of first-order catchment K2-3 and up to 140 mm of second-order catchment K2-1. Our findings showed that changes in internal hydrological flow pathways and associated changes in runoff components due to forest harvesting differ depending on the catchment sizes.

Key words: Forest thinning, hydrological processes, hydrograph separation, paired-catchment analysis, scale effects.