Module 2. SMALL WATERSHEDS - STREAMFLOW RESPONSE TO FOREST REMOVAL AND ROADS
[Julia Jones]

Responses of Peak Flows to Forest Harvest and Roads

The magnitude, seasonality, and duration of peak discharge responses to forest removal and regrowth and roads in five pairs of experimental basins in the Andrews Forest are consistent with fundamental water balance and routing concepts in hydrology. Effects of forestry treatments on evapotranspiration, snowpack dynamics, and subsurface flow interception vary predictably by season, geographic setting, amount of forest canopy removal, stage of canopy regrowth, and arrangement of roads in the basin. Post-treatment responses of selected subpopulations of matched peak discharge events were examined over 21-34 yr post-treatment periods in treated and control basin pairs in a range of geographic settings. Changes in evapotranspiration associated with forest canopy removal and regrowth apparently accounted for significant increases in peak discharges during the first post-harvest decade (Fig. 2.1). Changes in snowpack dynamics apparently accounted for significant increases (25-31%) in winter rain-on-snow events, but other types of winter events did not change in four of five basins at the Andrews Experimental Forest (Fig. 2.2).

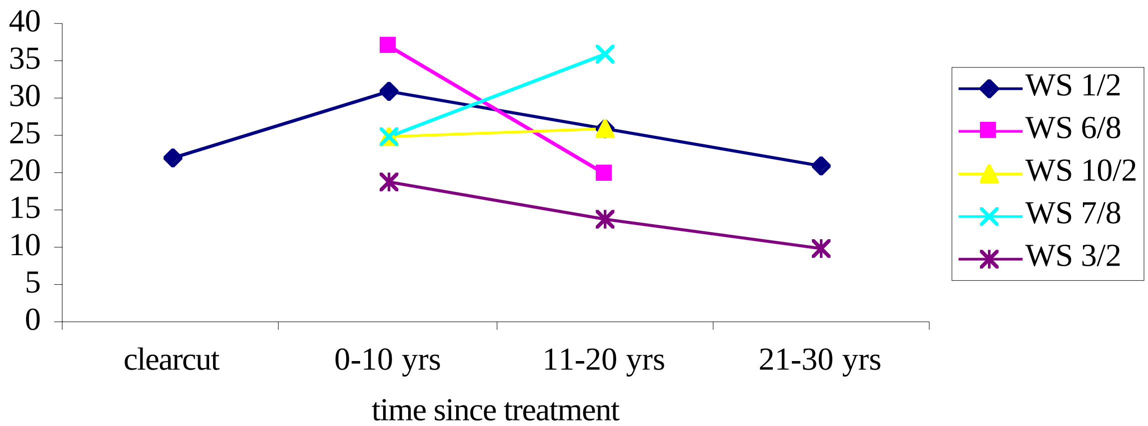

Figure 2.1. Statistically significant increases (%) in peak discharges of all event sizes by decade in different watersheds (WS) after forest harvest and road construction (from Jones, 2000).

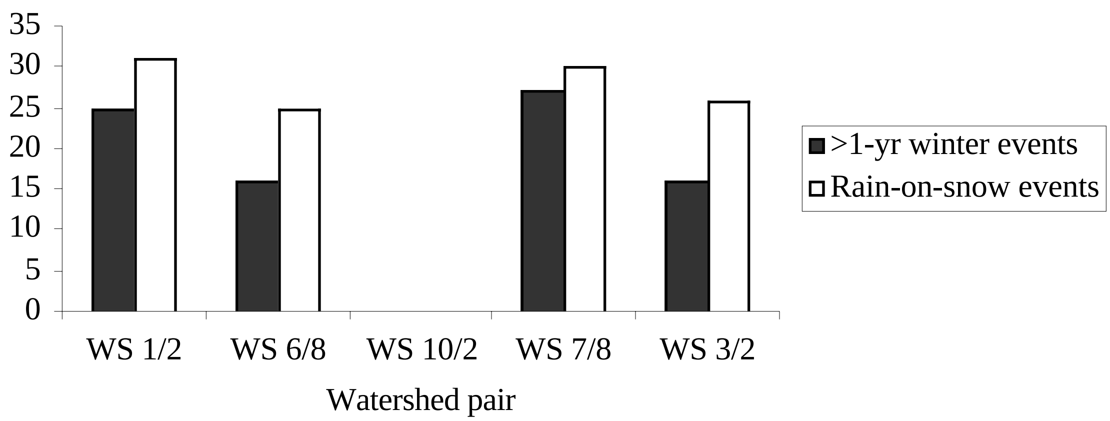

Figure 2.2. Statistically significant increases (%) in peak discharges of large and rain-on-snow events after forest harvest and road construction for all post-treatment years (from Jones, 2000).

Changes in subsurface flow interception by road cuts apparently accounted for significant increases (16-26%) in large (>1 yr return period) events in four of five basins, of which three had roads. Increases in small peak discharge events decreased rapidly after the first post-treatment decade, but increases in large events persisted into the second and third post-treatment decades (Jones, 2000).

Streamflow Yield Responses—Annual Yield, Summer Yield

Immediately after forest canopy removal, annual streamflow increased by 400-500 mm (40%) at all three 100% harvested basins at the Andrews Forest (Fig. 2.3). Twenty-five to thirty years after forest canopy removal, basins at the conifer forest site had persistent annual increases of 200-450 mm at upper elevations (Watersheds 6/8), 200-350 mm at middle elevations (Watersheds 1/2), and 100-250 mm at lower elevations (Watersheds 10/2) (Fig. 2.3 from Jones and Post, in review).

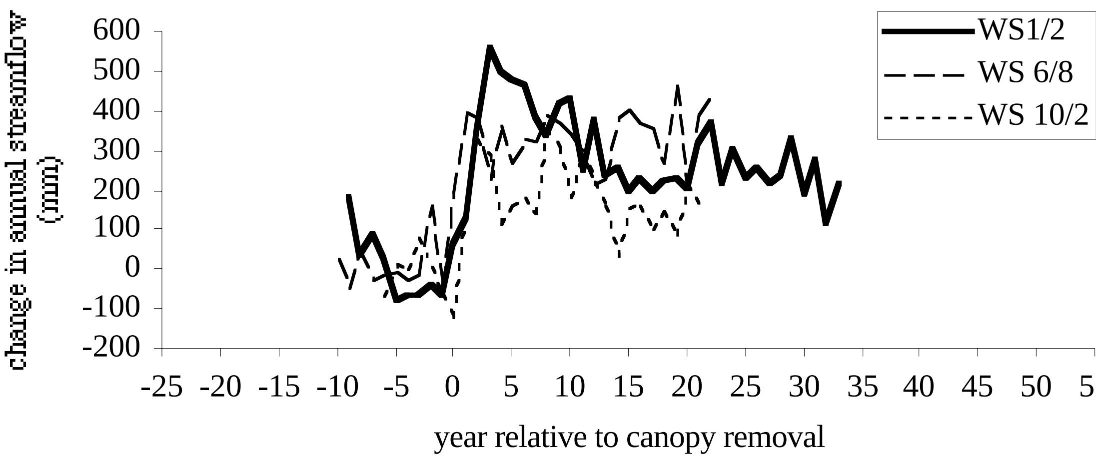

Figure 2.3. Absolute change in annual streamflow (mm at streamflow per unit area) over time after 100% canopy removal by watershed (WS) pairs.

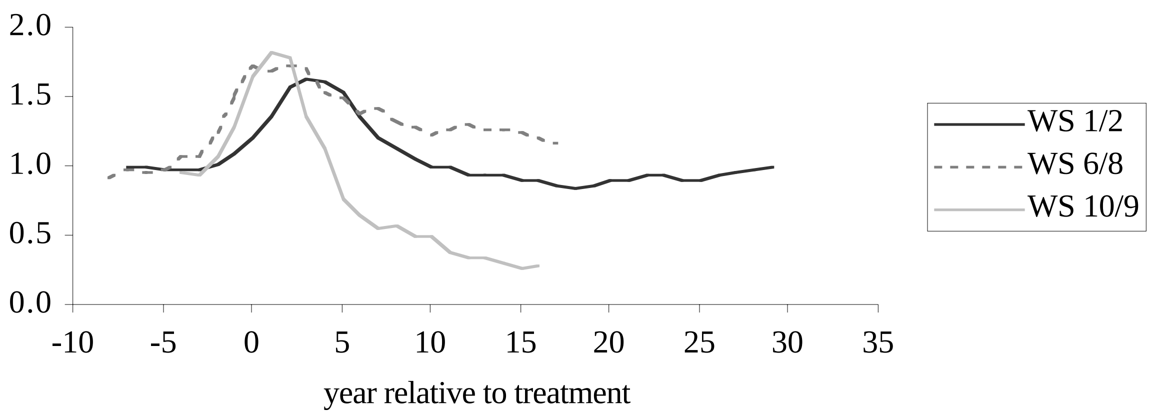

Figure 2.4. 5-yr smoothing of summer streamflow (June-September) responses to 100% forest harvest removal at the Andrews Forest, a fraction of pre-treatment flows by year relative to treatment Pre-treatment index = 1.

The apparent more rapid recovery of streamflow at the lowest elevation site (Watershed 10) is especially marked in the behavior of summer flows (Fig. 2.4; Jones, unpub. data). Summer streamflow recovered slightly at the high elevation basins (Watersheds 6, 8), recovered completely at the mid-elevation basins (Watersheds 1, 2), and declined to well below pre-treatment levels at the lowest elevation basins (Watersheds 10, 9).

Hydrologic Responses to Forest Harvest and Regrowth by Day of Year

Forest harvest produced the biggest absolute increases in streamflow during the fall and spring at the Andrews Forest, based on the example of Watersheds 1/2 (Fig. 2.5). Streamflow increases were greatest in the fall, then the spring, and modest during the summer. Midwinter streamflow did not respond to 100% forest canopy removal in Watershed 1. Several alternative hypotheses have been proposed for the lack of response at this time of the year. First, interception, snow, and soil reservoirs may be full, hence transmitting all inputs, so removal of the canopy reservoir has no effect on streamflow. Second, losses of interception storage may be balanced by losses of cloudwater interception. Third, increased water delivered to the forest floor may be stored in a cooler more persistent snowpack, contributing to streamflow increases in the spring. Increases in summer streamflow disappeared within 5 yr after forest cutting, and increases of fall streamflow had mostly disappeared by 35 yr after it (Fig. 2.5). This recovery is probably due to increased summer and fall water use by regenerating vegetation. However, streamflow increases during the spring persisted with little decline for 35 yr after forest canopy removal.

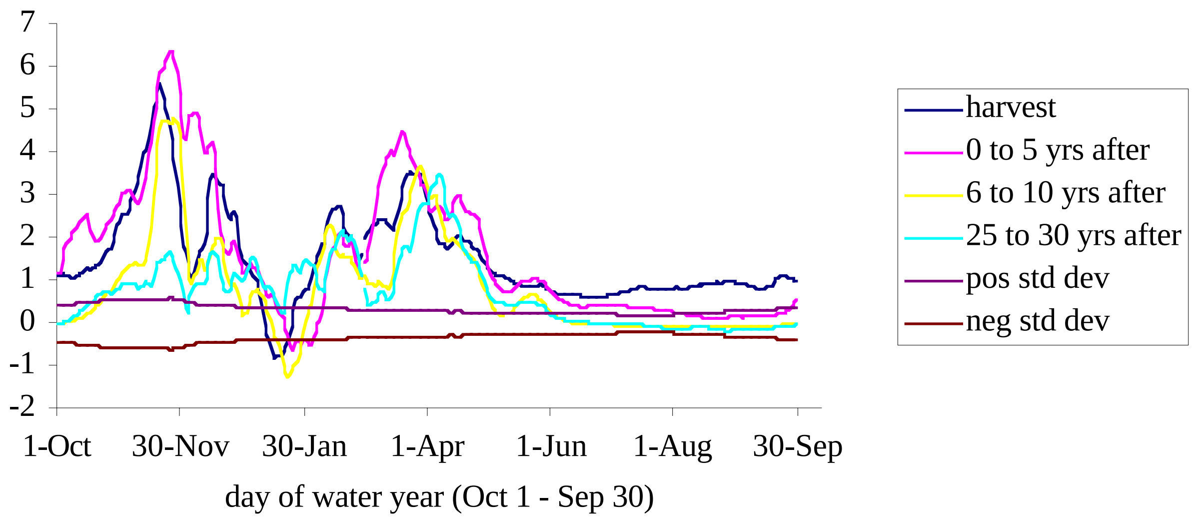

Figure 2.5. 15-day smoothing of absolute change (mm) in mean daily streamflow, Watershed 1 (100% harvest) v. Watershed 2 (control), for 5-yr periods after treatment. Standard deviation at control basin for period of record is shown for reference.