

Effects of Forest Management on Streamflow: A Meta-analysis of Paired Watershed Data Using Flow Duration Curves

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Abstract. The effects of forest management on runoff has long been a topic of scientific and public concern. Over the past 80 years paired watershed experiments have consistently shown an increase in annual water yield as result of forest harvest. A more recent focus is how forest harvest affects the size of peak flows and low flows, and the persistence of these effects over time. Individual paired-watershed studies have shown that forest harvest can increase, decrease, or have no significant effect on the size of peak or low flows, but differences in definitions and methodology have precluded rigorous comparisons between studies. To overcome this problem we compared flow duration curves from control and treated basins to determine both the absolute and percent changes in flow for specified flow percentiles. This allowed us to directly compare the changes from forest harvest for 26 paired-basin experiments, and test the extent to which the observed changes could be explained by either site characteristics or management practices.

The results showed a significant increase in flow for all percentiles, although there was considerable variability among individual studies. In absolute terms the median flow increases for the first three years after harvest ranged from $0.006 \text{ l s}^{-1} \text{ ha}^{-1}$ for the lowest flows (defined as the 1st percentile) to $0.21 \text{ l s}^{-1} \text{ ha}^{-1}$ for the highest flows (99th percentile). In percentage terms the median increase was about 50% for the lower flows and declined to 10-15% for the higher flows. Hydrologic recovery occurred within 4-8 years for most flows, but the increases in the higher flows were more persistent and still significantly different from zero after 10 years.

Mean basin slope and drainage density were weakly correlated with a larger increase in absolute flows, particularly for the lower flows. Larger changes in discharge were also associated with increasing percent area cut, increasing road density, and more disruptive silvicultural techniques. However, each of these relationships demonstrated a large amount of scatter and were usually dependent on a few influential points. The combined results suggest that careful forest harvest will have a relatively short-term effect on low flows and a more persistent effect on high flows, but the changes in flow are relatively small in absolute terms. The high variability between sites makes it difficult to predict the likely changes in flow without a more detailed analysis and understanding of the specific site conditions, hydrologic processes, and management practices.