Effects of watershed land use and geomorphology on stream baseflows in the southern Blue Ridge Mountains

Katie Price, C. Rhett Jackson, Albert J. Parker, Trond Reitan, John Dowd, and Mike Cyterski

The current understanding of watershed hydrology does not provide insight into prediction of low-flow response to land-use change in developing regions like the Blue Ridge of north Georgia and western North Carolina. To address this problem, three separate but complementary studies were conducted. In the first study, the hydraulic characteristics of soils underlying forest, pasture and turfgrass (lawn) land use were compared. Forest soils were shown to have substantially greater hydraulic conductivity, greater water holding capacity, and lower bulk density than lawn and pasture soils. These differences in soil characteristics associated with land-use change are of sufficient magnitude to alter watershed hydrology and decrease baseflows. In the second study, 35 watersheds representing the range of human impact in the study area were instrumented for continuous discharge measurement over a 16-month period, and multiple regression analysis was used to relate watershed geomorphic and land-use characteristics to baseflow metrics. Watersheds with greater forest cover were shown to have higher baseflow, counteracting the theory that forest cover reduces baseflows, due to the high evapotranspiration rates of trees. Watershed geomorphic characteristics of drainage density, slope variability, and colluvium were also shown to have significant impact on stream baseflows. In the third study, the distributed, GIS-based hydrologic model WetSpa was used to simulate 30 years of streamflow for four watersheds, under eight land use scenarios. More-developed watersheds were again associated with decreased baseflow magnitude, and less-developed watersheds demonstrated a higher proportion of baseflow to total streamflow. However, the model contained embedded theoretical assumptions about the importance of evapotranspirative losses from forest land use, without adequately accounting for the far greater hydraulic conductivities of forest soils in contributing to subsurface storage recharge and baseflow. Thus, the model had to be modified to account for the drastically higher infiltration rates associated with forest soils in this region, observed in the first study. This serves as an important caution against the use of rainfall-runoff models in the absence of empirical understanding of regional characteristics of watershed function. Overall, the results of these studies demonstrate that land-use conversion from natural forest to pasture, low-, and medium-intensity development are associated with reduced baseflows. Furthermore, factors of watershed geomorphology that correlate to subsurface storage capacity and the connectivity of stored water to the channel network are also important in explaining regional baseflow variability.