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SPECIAL SECTION

APPLICATIONS OF THE SWAT MODEL

Effects of Urbanization and Climate Change on Stream Health in North-Central Texas

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Estimation of stream health involves the analysis of changes in aquatic species, riparian vegetation, microinvertebrates, and channel degradation due to hydrologic changes occurring from anthropogenic activities. In this study, we quantified stream health changes arising from urbanization and climate change using a combination of the widely accepted Indicators of Hydrologic Alteration (IHA) and Dundee Hydrologic Regime Assessment Method (DHRAM) on a rapidly urbanized watershed in the Dallas-Fort Worth metropolitan area in Texas. Historical flow data were split into pre-alteration and post-alteration periods. The influence of climate change on stream health was analyzed by dividing the precipitation data into three groups of dry, average, and wet conditions based on recorded annual precipitation. Hydrologic indicators were evaluated for all three of the climate scenarios to estimate the stream health changes brought about by climate change. The effect of urbanization on stream health was analyzed for a specific subwatershed where urbanization occurred dramatically but no stream flow data were available using the widely used watershed-scale Soil and Water Assessment Tool (SWAT) model. The results of this study identify negative impacts to stream health with increasing urbanization and indicate that dry weather has more impact on stream health than wet weather. The IHA-DHRAM approach and SWAT model prove to be useful tools to estimate stream health at the watershed scale.

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Urbanization may cause hydrologic alteration of a basin as the hydrologic circulation between surface and subsurface water gets disconnected with increased impervious cover. A large number of streams are impaired in the United States. In Texas, about 44% of the 37,898 km of rivers and streams and 38% of the 1461,996 acres of impoundment water bodies are on the 2010 State of Texas 303(d) list of impaired or threatened waters. They are included for not providing adequate support to aquatic life (USEPA, 2011). Alteration of river hydrology by flashy urban stormwater generally increases the vulnerability of an ecosystem. Recent studies indicate that the health of stream biota is closely related to the surrounding hydrologic environment at the catchment scale (Wang et al., 2001; Nagy et al., 2011; Schoonover et al., 2006).

The health of stream biota such as aquatic habitats, macro- and micro-invertebrates, and fishes is often quantified using the Index of Biological Integrity (IBI) because it reflects the ecological complexity of an aquatic community based on statistical analysis. Indicators of Hydrologic Alteration (IHA) is a method that provides the most comprehensive hydrologic indicators from daily stream flows using statistical analysis (Richter et al., 1996). Recent studies suggest that hydrologic indicators, such as those listed in IHA, show a variable degree of correlation with IBI. DeGasperi et al. (2009) found that eight indicators (low pulse count and duration, high pulse count duration and range, flow reversals, flashiness index, and time), among which two flashiness indices were non-IHA indicators, were found to be highly correlated to IBI in several urbanizing streams of the United States. At the catchment scale, other factors (e.g., human population density, road density, flashiness, and urban land use) were reported to have a high potential for influencing the attainment of aquatic life (Bressler et al., 2009; Dow, 2007).

Hydrologic alteration of the environmental system in urban communities is a complex and interactive multiplication of anthropogenic activities, hydro-systems that connect locality to regions, and global environmental changes at a larger scale. Often, the impact of climate change is overshadowed by dramatic changes in the local environment driven by urban development,

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Abbreviations: DHRAM, Dundee Hydrologic Regime Assessment Method; IBI, Index of Biological Integrity; IHA, Indicators of Hydrologic Alteration; SWAT, Soil and Water Assessment Tool; UWRC, Upper White Rock Creek.