Effects of Droughts on Two Indiana River Basins' Water Quality and Quantity

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This research provides information to understand how hydrological and water quality processes respond to climate change by incorporating six climate change scenarios (three General Circulation Models (GCMs) outputs under two Conservation Climate Change scenarios 4.5 and 8.5) for mid- and late century to Soil and Water Assessment Tool (SWAT) model simulations. Two Indiana study basins (White River Basin and Wabash River Basin) that contribute water to the Ohio River (Figure 1), and having areas of 29,000 and 42,700 km^2, respectively, were selected to investigate what makes watershed responses to climate change different. These two river basins represent a significant portion of the agricultural land of Indiana. We investigated future changes in availability and proportions of surface and groundwater and then how pollutants are transported to water bodies through different hydrologic pathways including surface runoff, tile drainage, and groundwater. Contributions of surface and groundwater flows to nutrients (N and P) loading and how each hydrologic component reacted to climate change scenarios was quantified through SWAT modeling studies. Recent climate change variations and extremes have created concerns about the future of agricultural and ecohydrologic systems. Heavy precipitation events with increased frequency can cause damage to crops and accelerate soil erosion. In drought-affected areas, land degradation, water stress and crop damage and failure can increase. In this study, drought effects on water quality and quantity through different hydrologic pathways were quantified as well as the effects of weather variability. The most vulnerable areas to drought were identified. We also investigated how projected climate change affects proportions of surface water and groundwater, as well as pollution transport through different hydrologic pathways (groundwater, tile drainage and surface water).

The two river basins in Indiana were selected as a pilot study to understand how drought events will affect the water quantity and quality in the US Midwest (Figure 1). We calibrated and validated simulated monthly flow, sediment, total N, total P, organic N loads, and nitrate N concentrations vs. observed data. Two representative concentration pathways (RCP 8.5 and RCP 4.5) and three Coupled Model Intercomparison Project Phase 5 (CMIP5) models among 31 CMIP5 models were downscaled at weather stations associated with the Wabash River and the White River Basins and utilized in SWAT simulations. The initial results indicated that the SWAT model could successfully simulate the observed annual crop yields, streamflow, and water quality variables for the current climate (1985-2014). Precipitation change and land slope appeared to be the main factors impacting changes in water flows and nutrient loads at the subbasin scale. The White River Basin was more vulnerable to climate change effects, considering loads from subbasins and the stream segments water quality values. Our results imply that projected changes are highly uncertain, and depend upon the GCM climate used in the simulations. Finally, nutrient loss under all climate change scenarios was predicted to increase and was more critical for the White River Basin; soybean yields showed greater predicted decreases in the Wabash River Basin.

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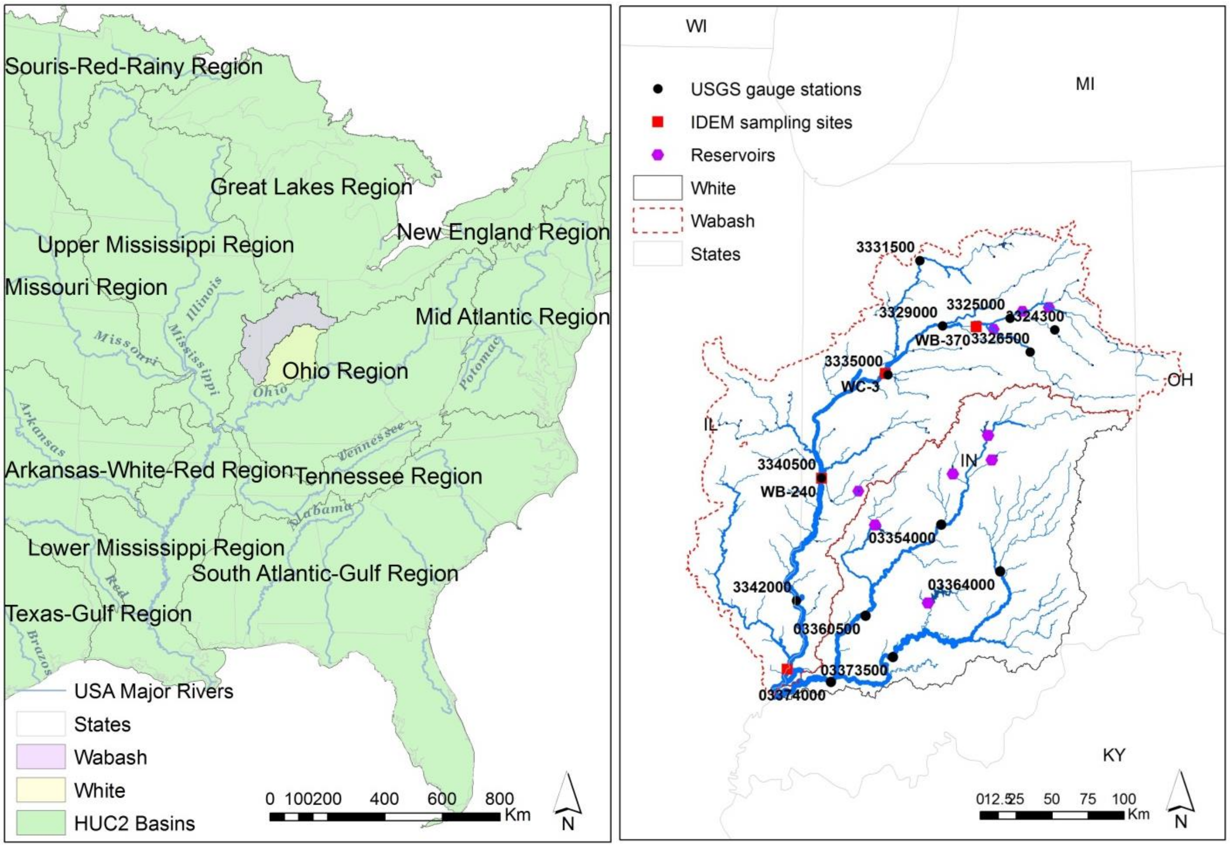

Figure 1. Location of Wabash and White River Basins, streams, major reservoirs, stream gauges and sampling sites.