Predicting Streamflow Response to Increased Imperviousness in an Urbanizing Watershed using an Integrated Modeling Approach

Introduction and Objectives

- Hinkson Creek Watershed (HCW; Fig. 1) is an urbanizing watershed in central Missouri comprising an area of approximately 234 km² and encompassing roughly 59% of Columbia, a town of 113,225 residents. HCW is also the site of a nested scale watershed study, where stream characteristics such as flow variability and sediment loading are being examined (Hubbart et al., 2010).
- Hinkson Creek is listed as impaired under section 303(d) of the Clean Water Act and a TMDL plan to reduce surface runoff by approximately 40% was developed by the EPA and the Missouri Department of Natural Resources.
- To address this issue, a GIS-based model, the Imperviousness Change Analysis Tool (I-CAT; Sunde et al., 2014), was used to estimate future impervious surface growth in HCW. Predictions derived from I-CAT were then used in a hydrologic model, the Soil Water Assessment Tool (SWAT; Arnold et al., 1998), to quantify the possible effects of future impervious surface growth on Hinkson Creek’s streamflow.

Methods

- I-CAT was calibrated and validated for the Columbia area using data derived from a previous analysis of impervious surface cover in Missouri (Zhou et al., 2012). The receiver operating characteristic (ROC) curve method (Pontius & Schneider, 2001) was used to assess model performance.
- Area under curve (AUC) values derived from ROC analysis were 75 and 72 (Fig. 2) for the calibration and validation periods, respectively. After parameterization, the model was used to generate a percent impervious surface (PIS) grid for 2030 (Fig. 2).
- Percent impervious surface (PIS) grids for 2000 (baseline) and 2030 (future estimate) were then combined with NLCD land-cover data and extracted using the extent of HCW in order to create new land use layers for use in SWAT.
- Data from the Sanborn Field Weather Station, NRCS Soil Survey, and USGS (topography) were used in SWAT along with the combined PIS/NLCD land-cover data and simulations were run to compare differences in streamflow between the 2000 and 2030 land-cover datasets.

Results

- A previous study of impervious surface in Missouri showed that, in the year 2000, about 8.2% (19.1 km²) of HCW was comprised of impervious surface cover (Zhou et al., 2012). Preliminary urban growth modeling results from this study suggest that, at the current rate of growth, the amount of impervious surface cover in HCW will increase to at least 11.5%, or 26.8 km², by the year 2030 (Fig. 3). Preliminary stream discharge comparisons for Hinkson Creek using the future impervious surface cover estimates in SWAT suggest that discharge could increase by approximately 2.2% annually (Fig. 3) under the current urban growth trend.

Literature Cited


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Fig. 1. Study area - Hinkson Creek Watershed, Boone County, Missouri.

Fig. 2. I-CAT calibration/validation and 2030 imperviousness estimation for the Columbia area.

Fig. 3. Predicted impervious surface cover for 2030, along with baseline condition and estimated stream discharge increase.

Mean annual discharge +2.2%

2000: 19.1 km² (8.2%) impervious cover

2030: 26.8 km² (11.5%) impervious cover

SWAT simulations

Baseline condition

Stop the bleed, doctor.