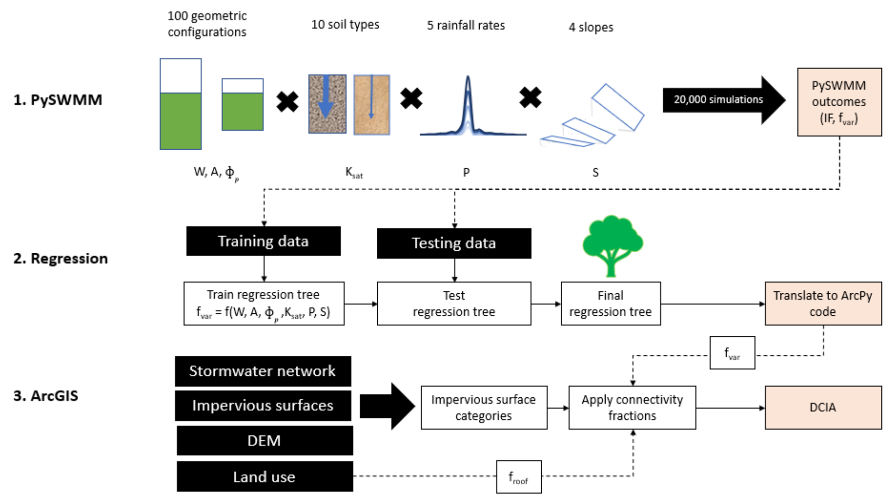
ReNUWIt Re-inventing the Nation's URBAN WATER INFRASTRUCTURE

October 2019 Project Spotlight

Connected or unconnected? A new method for estimating connectivity of impervious surfaces across variable soils, slopes, and rainfall scenarios

DESCRIPTION

For the purposes of stormwater modeling and planning, directly connected impervious area (DCIA) – the proportion of impervious areas that are directly connected to the stormwater drainage system – are reported to be a better indicator of hydrologic response, stream alteration, and water quality than total impervious area. Distributed stormwater technologies (best management practices (BMPs)), if sited appropriately, can help reduce DCIA and meet stormwater goals. However, most methods for quantifying DCIA require major assumptions regarding the definition of 'connection', potentially over-simplifying the role of variable climates, slopes, soil conditions, and heterogeneous flow paths on impervious surface connection. For example, it is common to assume that impervious surfaces that are physically connected to the drainage system are 'connected', that roof area connectivity depends on land use, and that impervious surfaces routed to pervious surfaces (A_{var}) are 'disconnected'. However, the degree to which A_{var} connectivity depends on soil type, slope, and rainfall is currently unknown and not accounted for in DCIA extraction methods.



Schematic overview of methods used to determine the relationship of landscape features to the connectivity of variably connected impervious surfaces (A_{var}) and coupling with methods for extracting DCIA at the watershed scale.

This study aims to: (1) determine the sensitivity of A_{var} connectivity to different landscape features; and (2) develop a transferable and semi-automated GIS-based method for estimating DCIA at the watershed scale that more accurately accounts for connectivity. We investigated the sensitivity of A_{var} connectivity to variability in soils, slopes, rainfall, and geometric properties of the impervious and pervious areas using PySWMM (python API for SWMM5). PySWMM input parameters and results were used to train and test a classification regression tree to predict A_{var} infiltration and connectivity. To enable diffusion of these methods into practice, we developed an ArcGIS model to extract the impervious surface categories, apply connectivity fractions, and summarize resulting DCIA by subcatchment.

The results to date show that for initially saturated soils, A_{var} connectivity is highly sensitive to soil saturated hydraulic conductivity (K_{sat}) and pervious fraction; however, this sensitivity is not constant across soil types. A_{var} connectivity with clay soils and low K_{sat} is more highly influenced by precipitation rate than by pervious fraction, while the opposite is true of sandy soils with high K_{sat}. The classification regression tree provides excellent fidelity with PySWMM outcomes and is incorporated into the ArcGIS script to determine A_{var} connectivity across urban watersheds. The methods developed in this study can be used to more accurately identify DCIA in urban watersheds, representing an important step forward for incorporating spatial heterogeneity in stormwater modeling and planning.

For more information, contact ReNUWIt (http://renuwit.org/contact/)

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INDUSTRY IMPACT

Accurate methods to predict impervious surface connectivity are needed to improve hydrologic modeling and inform efficient siting of distributed stormwater BMPs. Existing methods of predicting urban runoff in hydrologic models depends on accurately estimating 'directly connected' impervious areas. However, existing methods for predicting DCIA fail to account for potential variability due to soil types, slopes, and rainfall scenarios. This study presents a new method for extracting DCIA that explicitly considers the effect of landscape and storm variability.

ADDITIONAL RESOURCES

- Sytsma, et al., "An Integrated Approach for Estimating Directly Connected Impervious Areas in Ungauged Basins," State of the Estuary Fall Meeting Abstracts, October 2019.
- Sytsma, et al., "An Integrated Approach for Estimating Directly Connected Impervious Areas in Ungauged Basins and Implications for Stormwater Planning," AGU Fall Meeting Abstracts, December 2019.

PROJECT INFORMATION

Thrust:	U – Urban Systems Integration and Institutions
Theme:	U1 – Decision Support Systems for Utility Planning
No. & Title:	U1.7 Mapping connected impervious surface for distributed stormwater technology optimization
Team:	William Eisenstein (PI), Anneliese Sytsma, Terri Hogue, Colin Bell