Investigating the Hydrological Effects of Permeable Surfaces on an Urban Watershed in Cobbs Creek, Philadelphia

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Abstract

Urban streams face a multitude of environmental issues today. Land cover change and anthropogenic pollution threaten urban streams and the ecosystems and the human populations they support. One of the biggest obstacles facing urban streams is the overbearing presence of impermeable surfaces like roads and sidewalks, which lead to more stream runoff, more polluted runoff, and more severe flooding events, detrimental to the health of already-fragile ecosystems. As part of the Urban Vegetation Community-Based Participatory Research Project (UrbVeg CBPR), this research aims to assess recent changes in urban vegetation and hydrological trends. Cobbs Creek is a roughly 12 mile-long Pennsylvania stream and tributary of the Delaware River that borders Philadelphia and Delaware counties. Cobbs Creek faces freshwater salinization which affects geochemical cycling, vegetation ecology, and microbial community health, all of which may be exacerbated by too many impermeable surfaces in the watershed. Water salinity is currently regulated by the PA Department of Environmental Protection and the EPA, but these guidelines do not reflect the salinization crisis affecting many urban streams today. The time between peak precipitation and peak discharge in a stream is called the lag time. Longer lag times are usually indicative of healthier watersheds, with plenty of permeable land cover to allow precipitation to percolate through the earth. This research attempts to analyze the relationship between permeable surface cover and lag time in the Cobbs Creek watershed. The following research questions are addressed in this project: 1) How has land cover and land use changed along with water quality in Cobbs Creek? 2) How does vegetation cover affect stream ecology in an urban environment? 3) Can streamside vegetation cover be used to effectively predict lag time? These questions will continue to be addressed through analysis of historical datasets, in-situ water quality monitoring, and remote sensing.

Methods

Google Earth Engine

- Developed both supervised and unsupervised classification models for land cover type
- Created time-series for NDVI values across specified reaches and all of Cobbs Creek
- Calculated total precipitation for Cobbs Creek over a 10-year period

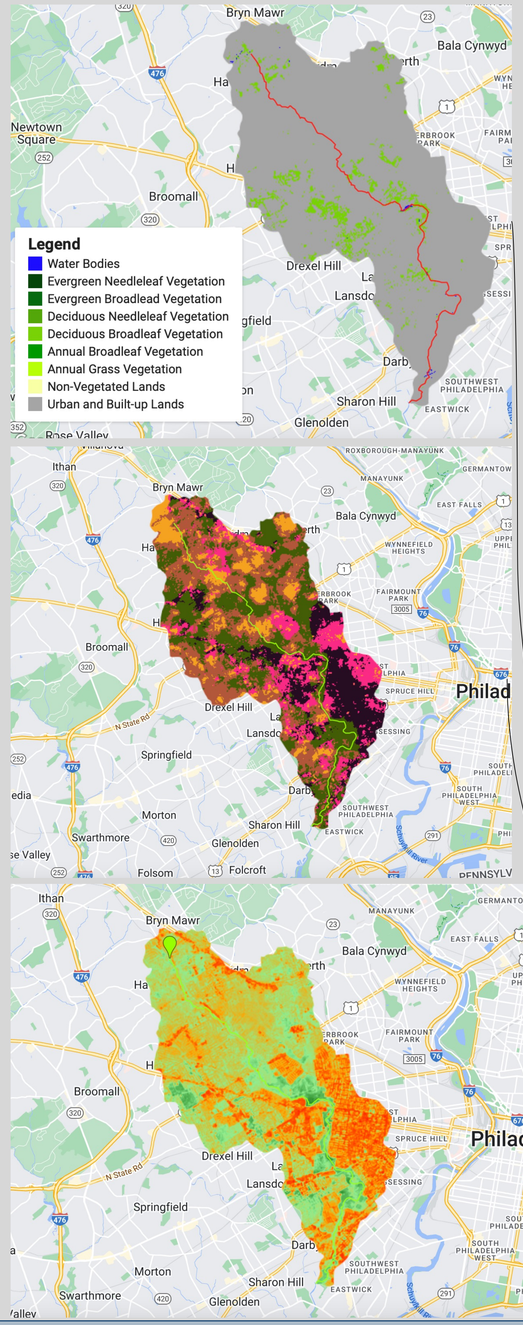
USGS Discharge Data

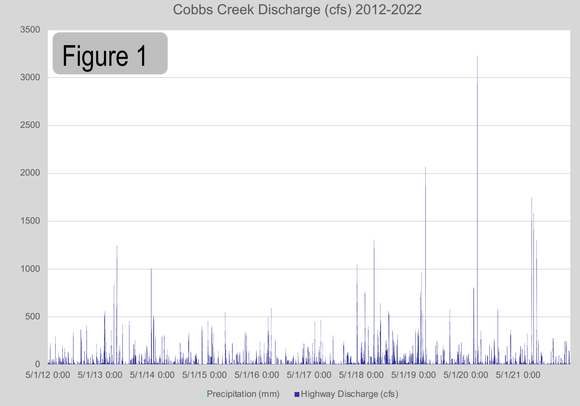
- Used existing discharge datasets from two water quality gauges on the Northern and Southern ends of Cobbs Creek

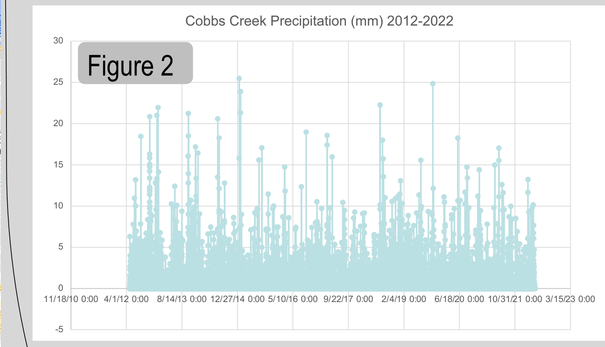
In-Situ Water Monitoring

- Measure dissolved oxygen, temperature, and specific conductivity using THERMO Orion Star Portable Water Meter

Results







A supervised classification of the Cobbs Creek Watershed using NASA's MODIS Land Cover Type Satellite

An unsupervised classification of the Cobbs Creek Watershed with 5 different classes

An NDVI map of the Cobbs Creek Watershed, where green indicates green vegetation and red indicates low or unhealthy vegetation.

Conclusions and Future Work

This research project is ongoing. However, early findings indicate that the Cobbs Creek Watershed exhibits excessively flashy behavior in response to moderate to severe precipitation events. It is hypothesized that this is due, in part, to the disproportionate area of impermeable surfaces in the watershed. In the future, I will generate a unit hydrograph for the watershed using historical USGS datasets. Then, using an autoregressive integrated moving average (ARIMA) analysis method, I will attempt to calculate average the average lag time for the watershed, More field work is needed to verify the results from Google Earth Engine, such as ground-truthing using NDVI cameras and comparing actual land cover types to what is found using the classification methods. Finally, due to the lack of extensive water quality data for Cobbs Creek before 2018, more in-situ measurements will be needed.

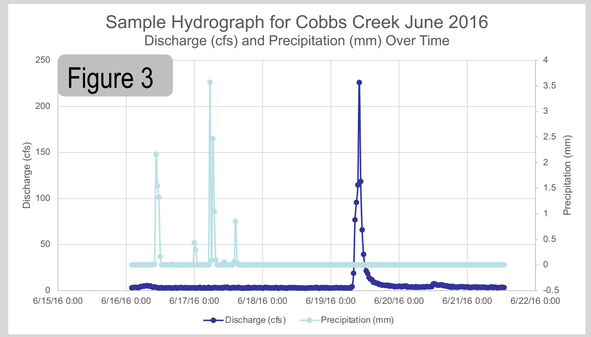


Fig. 1: Cobbs Creek Discharge 2012-2022 as measured by the USGS station at U.S. Highway No. 1 at Philadelphia, PA
Fig. 2: Precipitation in Cobbs Creek 2012-2022 as measured by the Global Precipitation Measurement (GPM) satellite mission
Fig. 3: Hydrograph for Cobbs Creek generated by the data presented in Figures 1 and 2

Project Limitations

This research project is limited by the spatial and temporal accuracy of Landsat data. In order to assess the impacts of freshwater salinization on Cobbs Creek, there must exist more extensive water quality monitoring from the USGS during times of heavy road salting, when the likelihood of high-salinity runoff is greatest.

References

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