

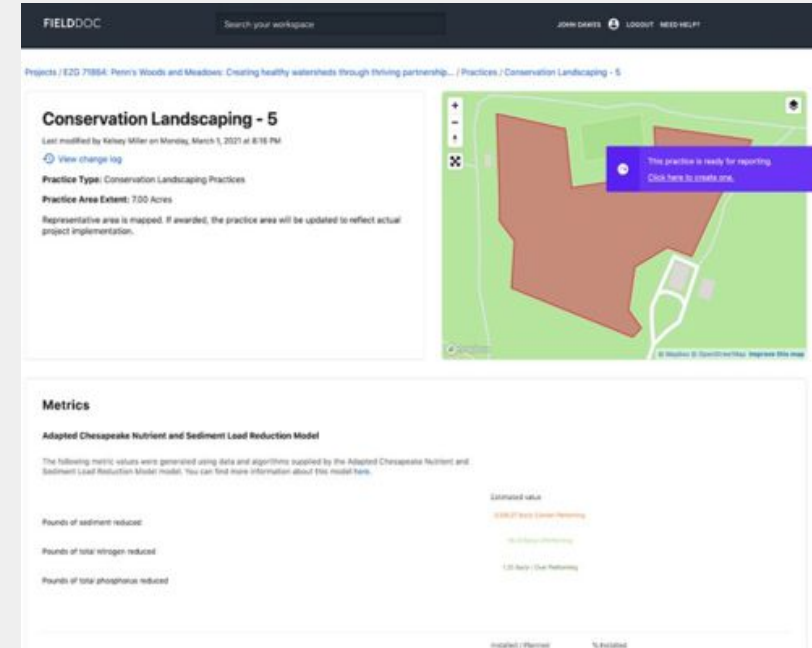


Relative Confidence Index: Modeling Localized Impacts of Management Practices

Chesapeake Bay Program 6-year Cooperative Agreement
Objective 3: BMP Planning and Reporting

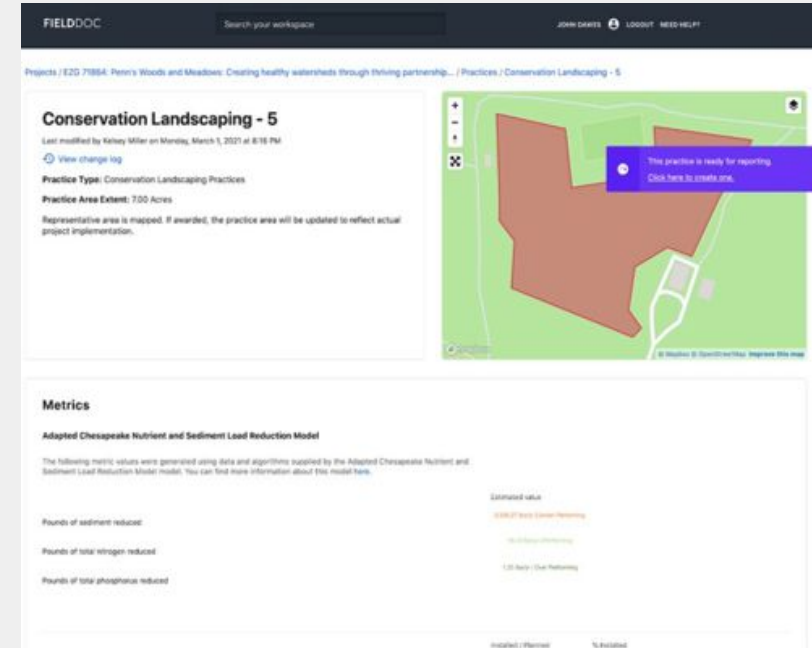
Relative Confidence Index

- RCI is a modeling effort to implement new site-level spatial modeling routines in combination with existing Chesapeake Bay modeling output and algorithms (e.g., established regional loading rates, BMP reduction coefficients, BMP reduction algorithms, etc.) in order to better estimate potential load reductions that might be achieved with “site-level” BMP implementation.
- The goal is to highlight projects that meet/exceed the modeled average to influence project planning towards higher performing projects and locations



Relative Confidence Index

- RCI is deployed as a feature in FieldDoc to inform the user of the likelihood that a practice will achieve or exceed a CAST-based average load reduction for the land-river segment where the practice footprint is located.
- Practices included in first phase:
 - Riparian Forest Buffer
 - Riparian Forest Buffer with streamside exclusion fencing
 - Grass Buffer
 - Forest Buffer - narrow

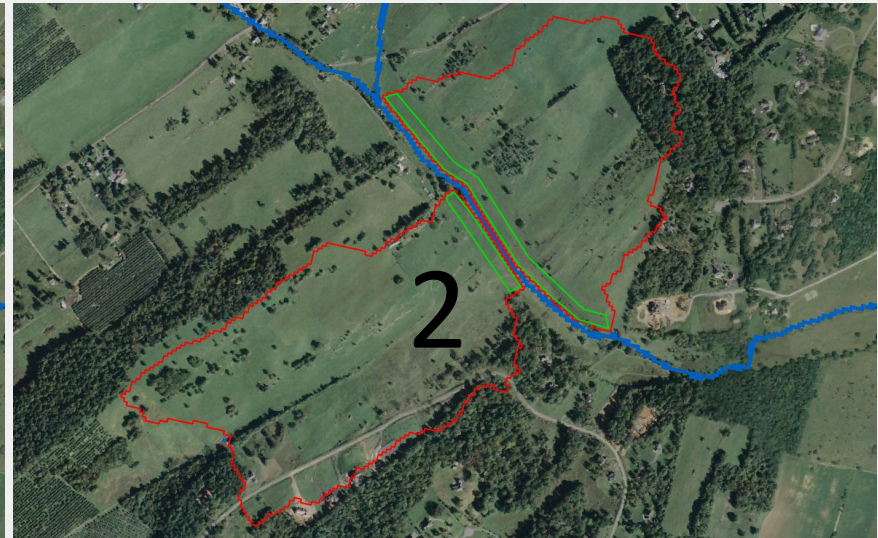
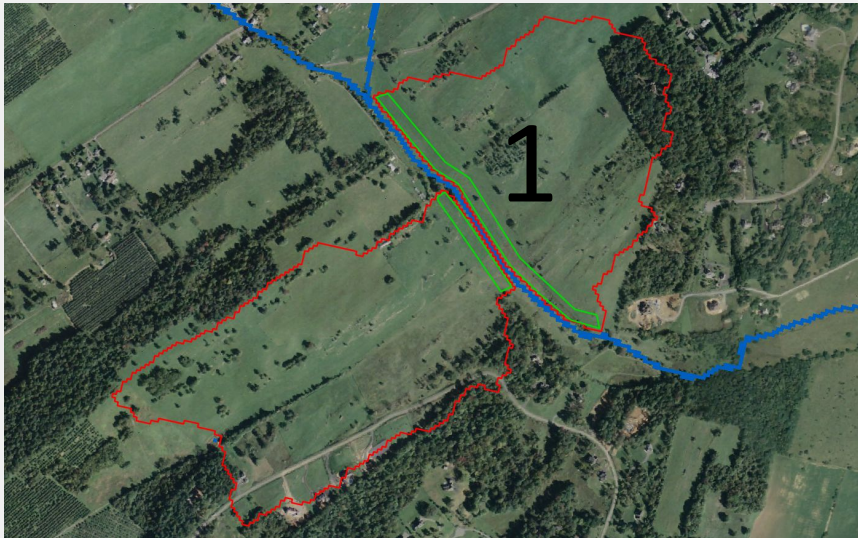


Who is the intended user audience?

- Overall intention to support local, state, and regional efforts to improve water quality throughout the watershed.
 - RCI is integrated into Commons' FieldDoc platform as a planning feature for users
 - Initial roll-out to grant program managers in FieldDoc (e.g. NFWF, MDNR, VEE)
 - Goal is to share to all FieldDoc users through a BMP planning sandbox environment after testing and feedback from initial roll-out

Example: Testing Two Riparian Buffers

- Two riparian buffers, 100 ft wide each
- Buffer 1 is roughly 0.5 miles long, while buffer 2 is roughly 0.2 miles long



Relative Confidence Index

Method

- Create a ratio of the CAST ISO Reduction Estimate over the Practice Specific Reduction Estimate
- The ratio is scaled from 0 to 2, with any over-performing practice being capped at 2, and any under-performing practice measured as a percentage.
- This would be visualized with a gradient color bar for any practices receiving a ratio score of:

0 = potentially underperforming

1 = potentially performing as expected

2 = potentially performing better than expected

Confidence Index =
CAST Isolation Reduction /
Spatially Explicit Reduction

BMP Load Reduction API Origins

- Delaware River Watershed Initiative
- Developed specifically to assess project impact of NFWF Delaware River Restoration Fund capital investments
 - Ag BMPs
 - Urban Stormwater Management
- FieldDoc used for project planning and implementation tracking

BMP Load Reduction API - Data Sources & Models

Chesapeake Bay Watershed (CBW)

- USGS NHD+ High Resolution (10m)
- Digital Elevation Model (DEM)
- Flow Direction Raster (FDR)
- CBW High Resolution Land Cover (2013) (10m re-sample)
- Chesapeake Bay Watershed Model
- Chesapeake Assessment Scenario Tool (CAST) BMP Efficiency Coefficients
- Phase 6 BMP Methods Documentation

Delaware River Basin (DRB)

- USGS NHD+ High Resolution (10m)
- Digital Elevation Model (DEM)
- Flow Direction Raster (FDR)
- National Land Cover Dataset (NLCD, 2011)
- Generalized Watershed Loading Function – Enhanced (GWLF-E)
- CB Program and PADEP BMP Efficiency Coefficients

Best Management Practice (BMP) Load Reduction API

Models reductions in TN, TP, and TSS for each practice in FieldDoc

- Currently 8 BMPs modeled in the Chesapeake River basin within 2 archetypes
- Modeling approach for each BMP was established
 - Met with CBP modelers
 - BMPs were grouped into archetypes that all have similar methodology



7 Major Archetypes

Models reductions in TN, TP, and TSS for each practice in FieldDoc



Use "polygon drainage" routine to calculate acres of different land cover types to the feature (buffer or wetland), apply upland loading rates to estimate the total loads, and then reduce these loads using fixed reduction coefficients

7 Major Archetypes

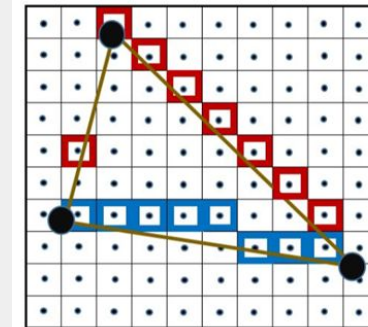
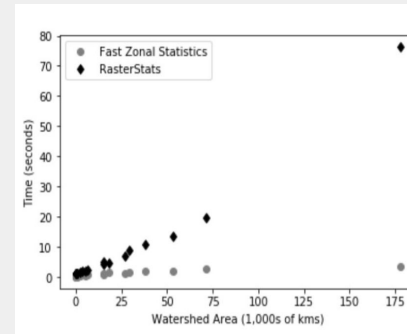
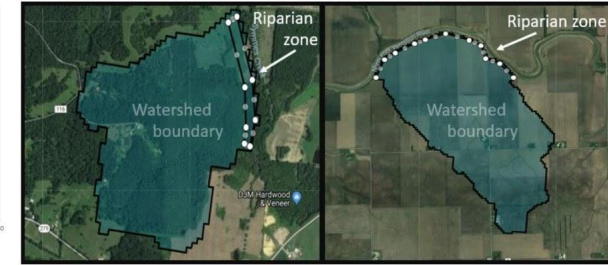
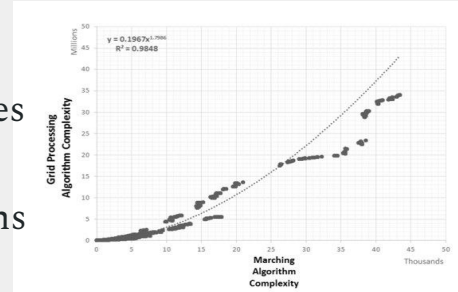
Models reductions in TN, TP, and TSS for each practice in FieldDoc



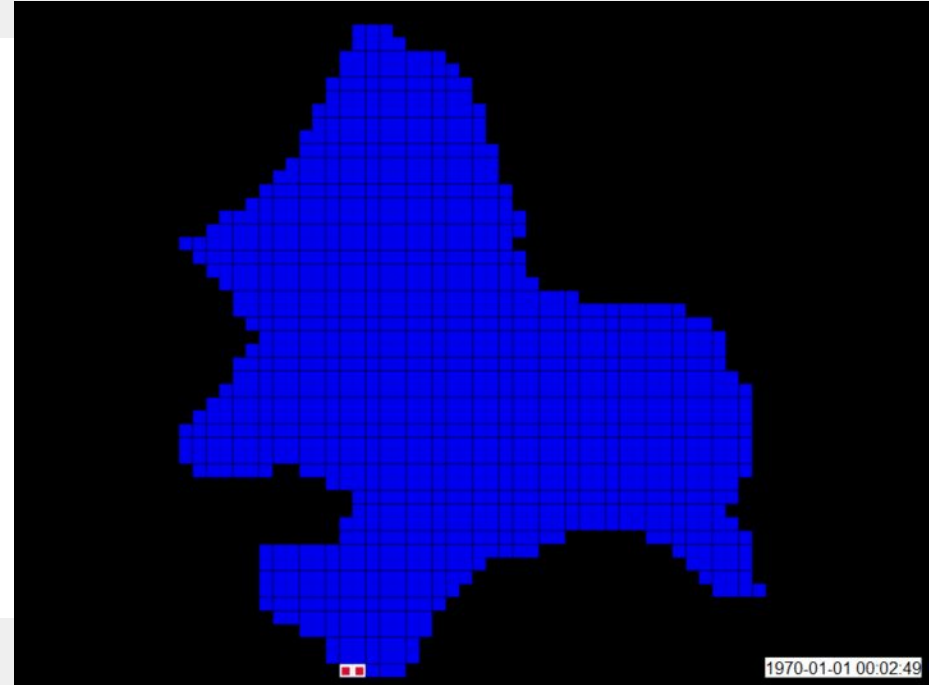
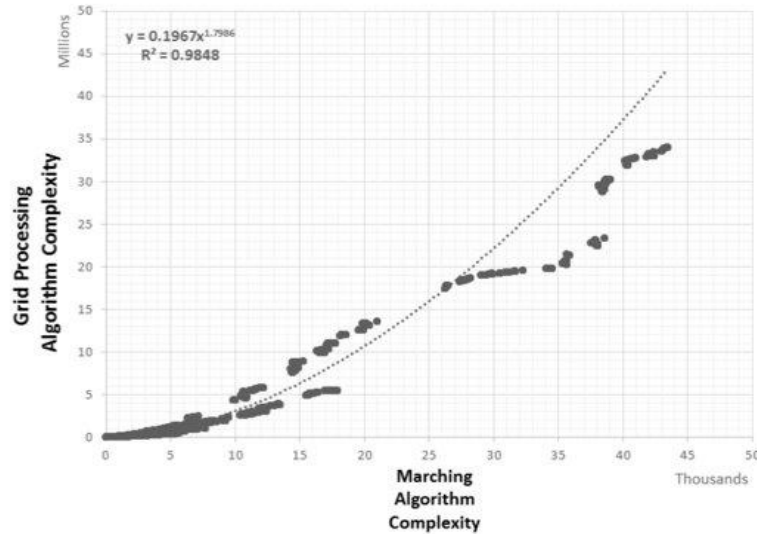
Use the approach that combines reductions from both buffers (based on area drained) and reduced streambank erosion. (i.e. needs a LineString geometry submitted and watershed boundary computed)

Drexel Microservice APIs

- Watershed delineation
 - Uses marching algorithm that scales with perimeter
 - Works for points, lines and polygons
 - Working on D-inf watershed delineation using internal watershed skeleton
- Fast Zonal Statistics
 - Based on Green's Theorem
 - Also scales with perimeter



WMA vs Watershed Delineation Methods

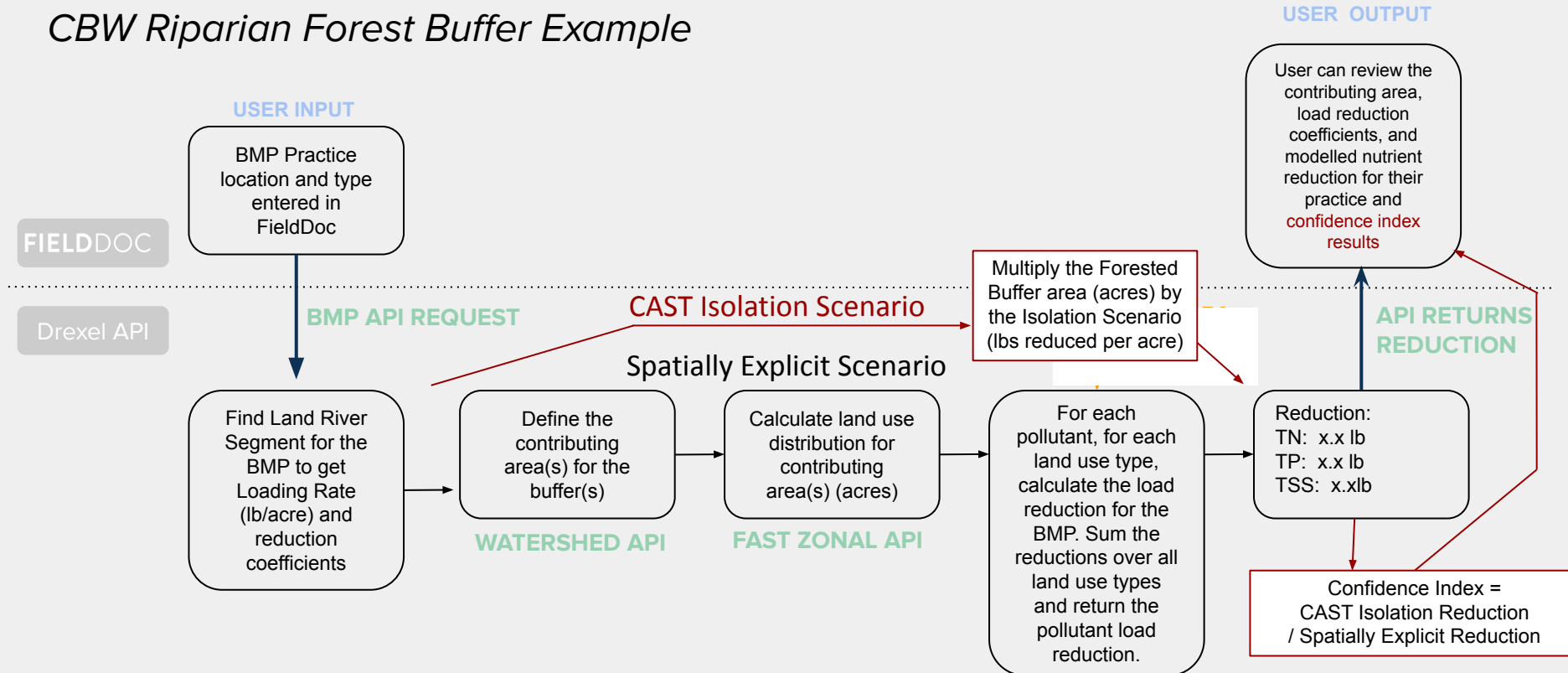


Progress to Date

- Eight BMPs have been implemented thus far:
 1. Forest Buffer
 2. Grass Buffers
 3. Forest Buffer-Streamside with Exclusion Fencing
 4. Forest Buffer – Narrow
 5. Forest Buffer-Narrow with Exclusion Fencing
 6. Grass Buffer - Narrow
 7. Grass Buffer-Streamside with Exclusion Fencing
 8. Grass Buffer-Narrow with Exclusion Fencing
- Tested high resolution watershed delineation and land cover (1m)
- Updated API architecture from Django to Flask
 - More lightweight, more easily containerized

API Workflow

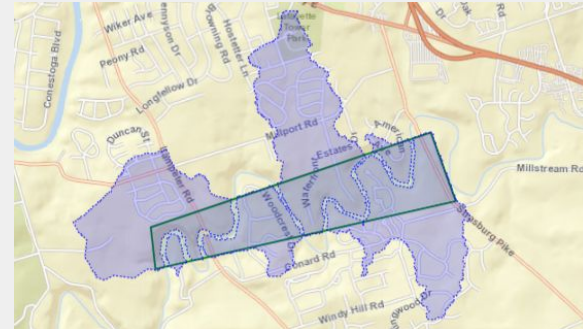
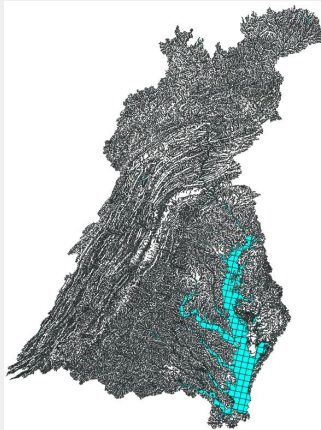
CBW Riparian Forest Buffer Example



Progress - Continued

Erase Surface Water Network from BMP

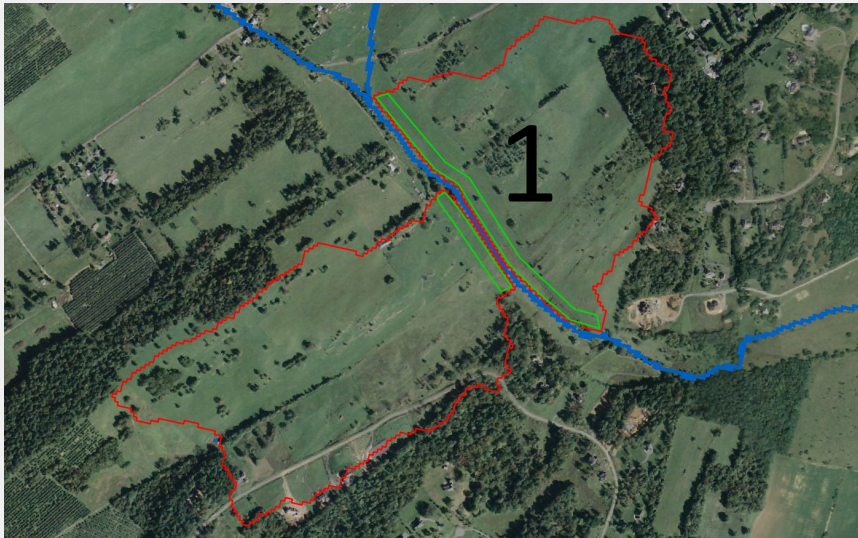
- Download NHDplus HR network for each HUC04 in the Chesapeake Bay
- Polygonalize the Network and Buffer by 10 meters
- Run through a fishnet to take advantage of spatial indices
- Create function that erases the SW network from the BMP before watershed delineation



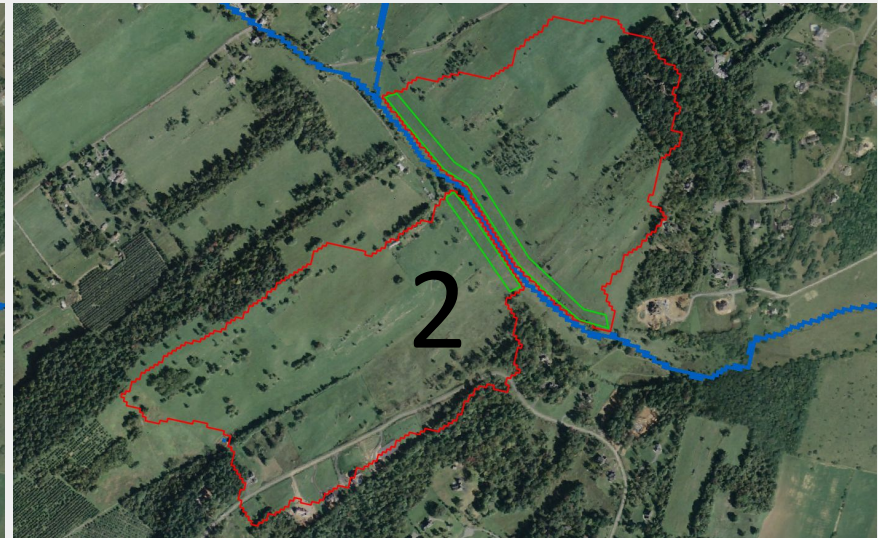
Example: Testing Two Riparian Buffers

- Two riparian buffers, 100 ft wide each
- Buffer 1 is roughly 0.5 miles long, while buffer 2 is roughly 0.2 miles long

"confidence_index": {"tn": 1.74, "tp": 1.56, "tss": 0.062}

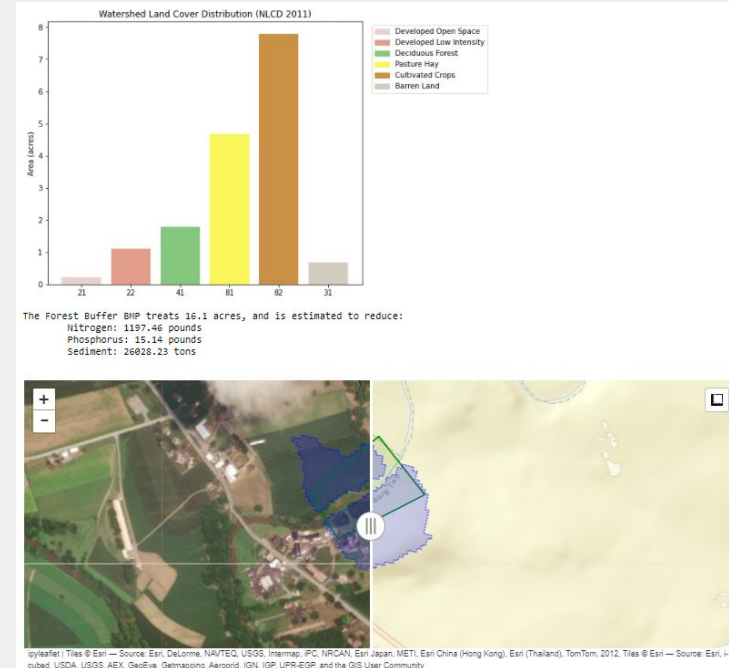


"confidence_index": {"tn": 2.0, "tp": 2.0, "tss": 1.76}



Jupyter Notebook Demonstration

- We use Jupyter Notebooks for testing and documentation for our APIs as well as Swagger
- Useful for testing projects against one another
 - Twice as big does not always mean twice as effective



Next Step Objectives

- Urban Stormwater Management
 - Prioritization / placement of low-impact development control (LID) BMPs
 - We have tested and implemented on high resolution raster datasets (1m)
 - Would need R&D and outreach, current method would need data for engineered environments, i.e. subsurface infrastructure that is not widely available
- Potential Investigations
 - Wetlands BMPs methodology
 - Remove Concentrated Flow Paths from Contributing Area for Buffers
 - Was of interest to Bay modelers, need more feedback before implementation
 - Pilot scale test using dataset available for the lower Susquehanna River

Technical Documentation




API Documentation:

<http://watersheds.cci.drexel.edu/docs>

API Demo Jupyter Notebooks:

https://github.com/TheAcademyofNaturalSciences/Jupyter_Notebooks

 Swagger
powered by SMARTBEAR

/swagger.yml

Explore

Drexel Environmental Data Science (EDS) ^{3.0.1} OAS3

/swagger.yml

The Drexel University College of Computing and Informatics (CCI) and the Academy of Natural Sciences (ANS) of Drexel University have developed Application Programming Interfaces (APIs) which incorporate novel algorithms to apply efficient solutions to complex environmental queries. The APIs are built in Python using a Django Web framework, Nginx, Docker, PostgreSQL, and Swagger.

The Watersheds API utilizes a rapid watershed delineation algorithm for 2D flow direction grids. This API quickly delineates a watershed boundary for any simple geometric object (point, line, or polygon). This algorithm provides geometric speed increases in watershed boundary retrieval while keeping storage constraints linear in comparison to existing techniques. Existing techniques also scale proportionally to the area of the underlying region; however, the complexity of this algorithm is proportional to the boundary length as is relies on a Watershed Marching Algorithm (WMA). (Haag et al. 2018, <https://www.sciencedirect.com/science/article/abs/pii/S1364815218303530>)

The Fast-Zonal Statistics (FZS) API can return numerical attributes (mean, sum, and count) for a submitted polygon query region over any regular grid or raster dataset. Common applications of this technology include determining the amount of precipitation or impervious surfaces in a watershed. This algorithm is labeled "fast" because to determine the zonal sum for a polygon over a raster surface, only the cells which intersect the boundary of the polygon must be traversed rather than all the interior cells. This means that computationally the approach scales much better with increased data resolution as the FZS algorithm is constant in relation to the length (meters) of the polygon perimeter rather than its area (meters square). (Haag et al. 2020, <https://www.sciencedirect.com/science/article/pii/S0098300419306697>)

The Best Management Practice (BMP) API returns BMP specific nutrient and sediment reduction estimates for a user-supplied area of interest. The API supports BMPs within the Delaware and Chesapeake Bay basins. In the Delaware, the API uses the Generalized Watershed Loading (GWLFE) model outputs at the HUC12 scale. In the Chesapeake, the API relies on the Chesapeake Bay Model scenarios within the Chesapeake Assessment Scenario Tool (CAST), also at the HUC12 scale. The API calculates the watershed boundary and land cover distribution for the BMP area of interest, then re-allocates the loads using BMP-specific modeling approaches and efficiencies. BMP efficiencies used vary spatially depending on the watershed. This API is being extended to incorporate local factors that affect pollutant transport and BMP efficiency, such as ecoregion or soils.

Servers

http://watersheds.cci.drexel.edu/

Authorize

Watersheds

POST /api/watershedboundary/ Retrieve a watershed boundary for any simple geometric object (point, line or polygon).

OSI Spatial Analysis

POST /api/osigeo/ OSI Summary Statistics for Polygon

Fast Zonal Statistics

POST /api/fzs/ NLCD 2011 Fast Zonal Statistics

POST /api/fzs_cb10m/ Chesapeake Bay High Resolution Land Cover Fast Zonal Statistics

CBP-CC Cooperative Agreement Objective 3
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