Chesapeake Bay Program
Science. Restoration. Partnership.

Drexel University

The Commons

Chesapeake Conservancy

BMP Planning and Reporting: Scaling Precision Conservation in the Chesapeake Bay watershed

EPA Geospatial Support Cooperative Agreement
FAIN: 96363001

What is Objective 3?

BMP Planning and Reporting: Scaling Precision Conservation in the Chesapeake Bay Watershed

Challenge 1

Restoration investments are often made opportunistically and disparately. Partners are looking for better ways to identify and prioritize opportunities for restoration projects to maximize impact of dollars to meet WIP goals.

Challenge 2

Not all restoration progress is being recorded through current reporting structures. Additionally, reported data is only given back to planners in aggregated summaries, which doesn't help at the parcel-scale.

Proposed Solution

Creation of a data-driven blueprint and spatial planning, tracking, and reporting system that will better support project implementers, while also better relating local actions and regional goals. Enabling this system through high-performance analysis and routine data to keep planning efforts informed by tracked progress.

This pilot platform will help organize action around priority gaps in restoration progress by tracking proposed projects, in addition to funded, completed ones, to direct investment activities to priority landscapes where “shovel ready” opportunities are clearly defined and can best reduce nutrient and sediment loads.

What is being produced through this effort?

BMP Planning and Reporting: Scaling Precision Conservation in the Chesapeake Bay Watershed

1 Connecting BMP planning, tracking, and reporting

Development of a concept platform which connects sandbox environments for BMP planning, metric-based BMP tracking workflows, and project reporting. This platform supports BMP planning at site and regional scales and allows data transfer between project implementers and program administrators.

2 Understanding BMP impacts at the site scale

Utilizing novel methods from researchers at Drexel University, software has been developed to estimate nutrient and sediment reduction impacts of specific BMP polygons on-the-fly. These estimates can also be compared to regional averages to gauge confidence for effective impacts.

3 BMP Opportunity Layers

Utilizing research from USDA and insights from on-the-ground restoration practitioners, geospatial data representing footprints of potential opportunities for implementation of BMP practices are being generated to support watershed planning.

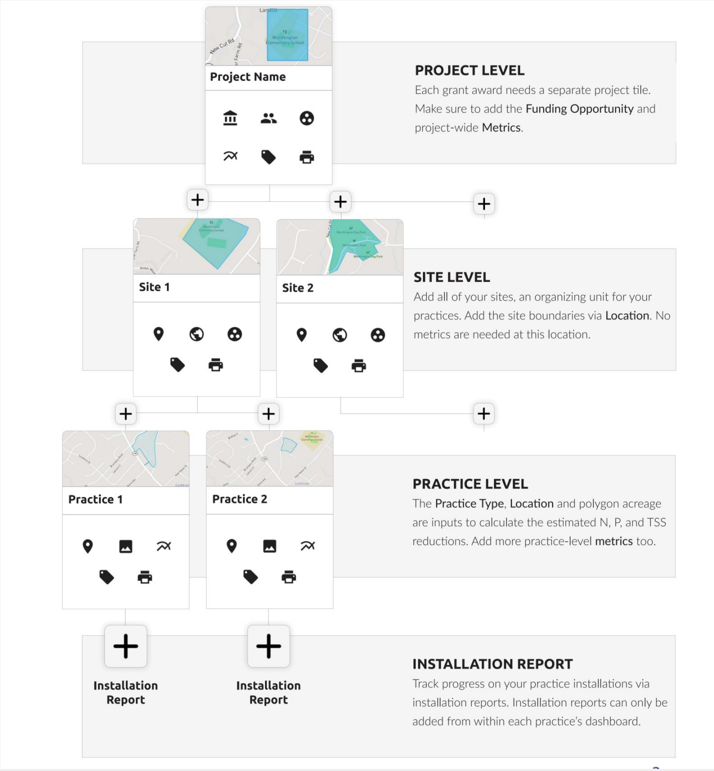
Who is on the Objective 3 project team?

- Chesapeake Conservancy's Conservation Innovation Center
    - BMP Opportunity Mapping
    - Programmatic administration
- The Commons
    - Software and web development of FieldDoc platform
- Drexel Environmental Data Science (EDS) Group
    - *Collaboration between Academy of Natural Sciences (ANS) scientists with the College of Computing and Informatics (CCI) scientists and PhD students*
    - Computational and environmental modeling
    - Software development for underlying APIs
- EPA Chesapeake Bay Program
    - Programmatic input

What is FieldDoc?

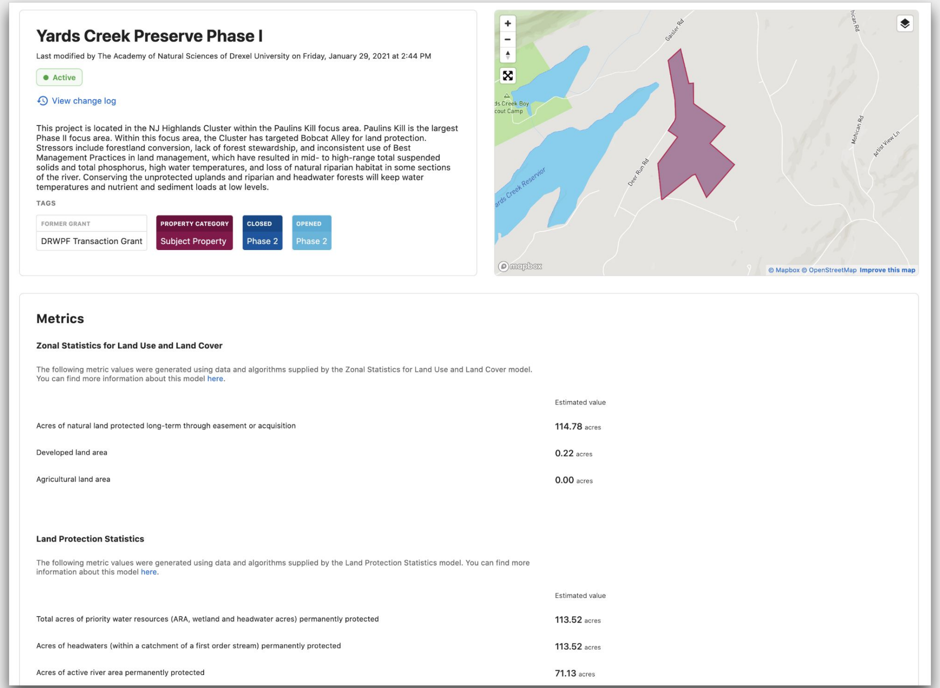
https://www.ourcommoncode.org/fielddoc

- An online platform developed by The Commons for metric based restoration planning and tracking that can also help practitioners set goals and track progress towards goals.
    - Standardized metrics, reporting processes, and project implementation reports
    - Supports grant program managers with metric-specific dashboards that rollup insight across their grant portfolio
    - Functionality to aide planning from individual practices on site to regional grant programs
- Current users
    - Grant administrators/managers
    - Regional WIP planners
    - Grant recipients/project implementers



How FieldDoc is used

1. Supports users in sub-parcel scale management practice tracking and reporting
   - Currently used by private and public foundations and restoration programs
   - Growing to support other restoration efforts outside The Bay jurisdictions
2. Users Establish an organization within FieldDoc
   - Practices are imported or drawn within a project
   - Metrics are completed related to the tracking requirements of the program



Understanding BMP impacts at the site scale

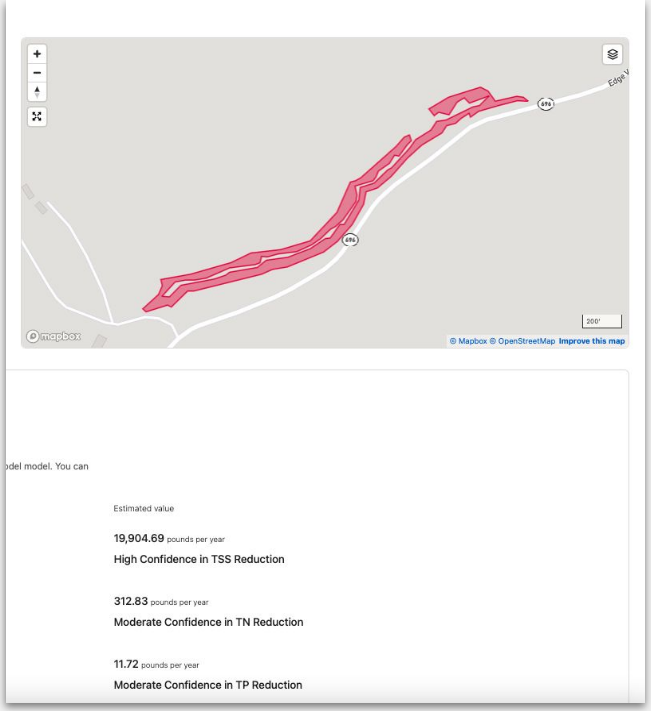
Relative Confidence Index (RCI) pilot

- **Goal**: to provide site-specific information about the impacts of BMP projects, and encourage BMP planning efforts to identify opportunities that could not only meet, but exceed expected water quality outcomes

- Evaluating implementation scenarios on their likelihood to achieve, exceed, or fall short of a CAST-ISO-based load reduction calculation based on site-specific metrics

- Incorporate high resolution data with current CAST ISO model estimates to provide a location and practice-specific confidence index to provide users a more locally relevant idea of reduction efficiency for a given best management practice (BMP) footprint

- Provided as an API through which user defined polygons and practice types can be returned as the RCI ratio of underperforming, performing, and overperforming. Currently available for forest and grass buffer practices, including narrow and exclusion fencing sub-types.

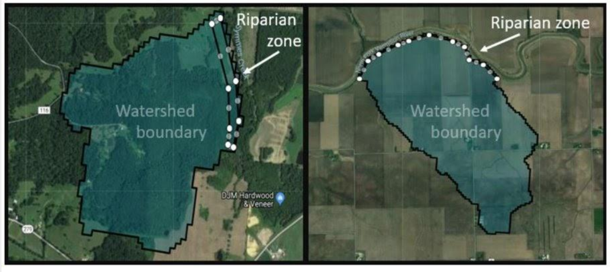


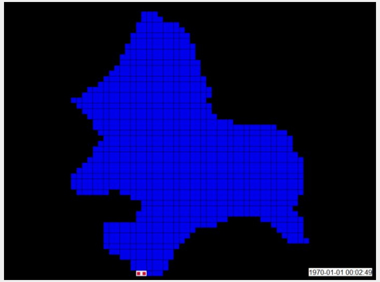
http://watersheds.cci.drexel.edu/docs

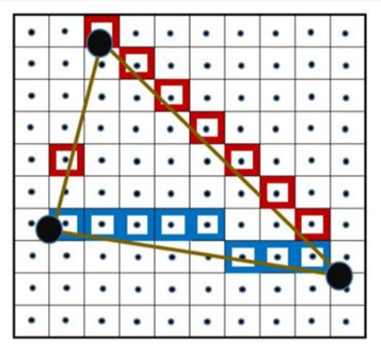
Powering on-the-fly modeling

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

- Watershed API
  - Drainage area delineation
  - Uses marching algorithm that scales with perimeter
  - Works for points, lines, and polygons
- Fast Zonal Statistics API
  - Based on Green's Theorem
  - Scales with perimeter
  - Requires pre-processing







Results from Jupyter Notebook

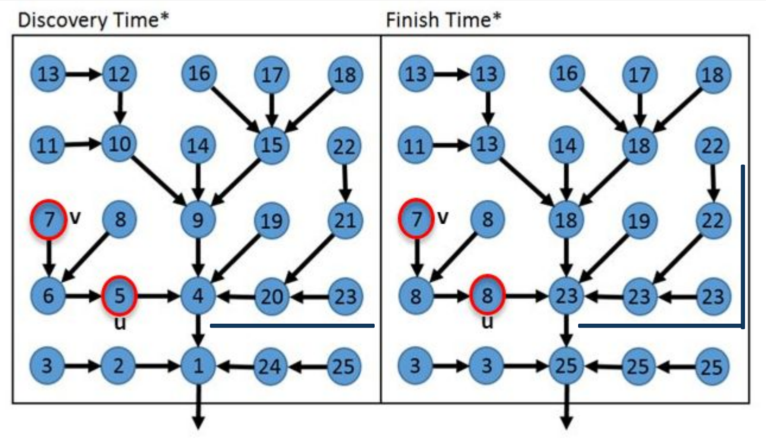
HUC Level	FZS imp	Raster Stats imp	FZS retrieval time	Raster Stats retrieval time	Polygon Area
	Σ	Σ	*seconds*	*seconds*	*(1,000s km)*
2L	464,936,066	464,936,066	3.468	76.262	178.02
4L	75,097,455	75,097,455	1.328	4.836	15.21
4L	138,308,609	138,308,609	1.875	10.656	38.02
4L	137,562,599	137,562,599	2.587	19.705	71.22
4L	113,967,403	113,967,403	1.878	13.421	53.57
6L	75,097,455	75,097,455	0.739	4.327	15.21
6L	15,682,206	15,682,206	1.451	4.738	18.07
6L	43,807,532	43,807,532	1.638	8.753	29.28

Watershed API

Watershed Marching Algorithm (WMA)

- Since a hydrologically conditioned D8 Flow Direction Grid (FDG) can be represented as a tree, a Modified Nested Set labeling algorithm can be applied

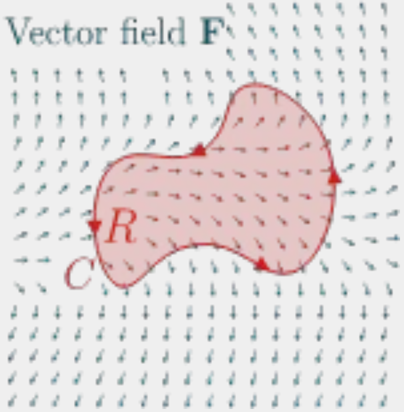
- We can determine connectivity of geometric objects if they are labeled such that Vertex *v* flows to vertex *u* if and only if the discovery value for *v* is between the discovery and finish value of *u*



Fast Zonal API

Green's Theorem

- **F** is a two-dimensional vector field
- **R** is some region within the xy-plane
- **C** is the boundary of the region, oriented **counterclockwise**



Green's theorem states that the line integral of **F** around the boundary **C** of **R** is the same as the double integral of the *curl* of **F** within **R**

https://www.khanacademy.org/math/multivariable-calculus/greens-theorem-and-stokes-theorem/greens-theorem-articles/a/greens-theorem

Riparian Forest Buffer Example

Polygon Drainage Archetype

FIELDDOC

USER INPUT

BMP Practice location and type entered in FieldDoc

BMP API REQUEST

Drexel API

Find LRS for the BMP to get Loading Rate (lb/acre) and reduction coefficients

Multiply the Forested Buffer area (acres) by the Isolation Scenario (lbs reduced per acre)

CAST ISO Scenario

N: 0.54
P: 0.41
TSS: 0.40

Define the contributing area(s) for the buffer(s)

WATERSHED API

Calculate land use distribution for contributing area(s) (acres)

FAST ZONAL API

For each pollutant and for each land use type, calculate the load reduction for the BMP. Sum the reductions over all land use types and return the pollutant load reduction.

Reduction:
TN: x.x lb
TP: x.x lb
TSS: x.xlb

API RETURNS REDUCTION ESTIMATES

API request can review the contributing area, load reduction coefficients, and modelled reduction scenario estimates

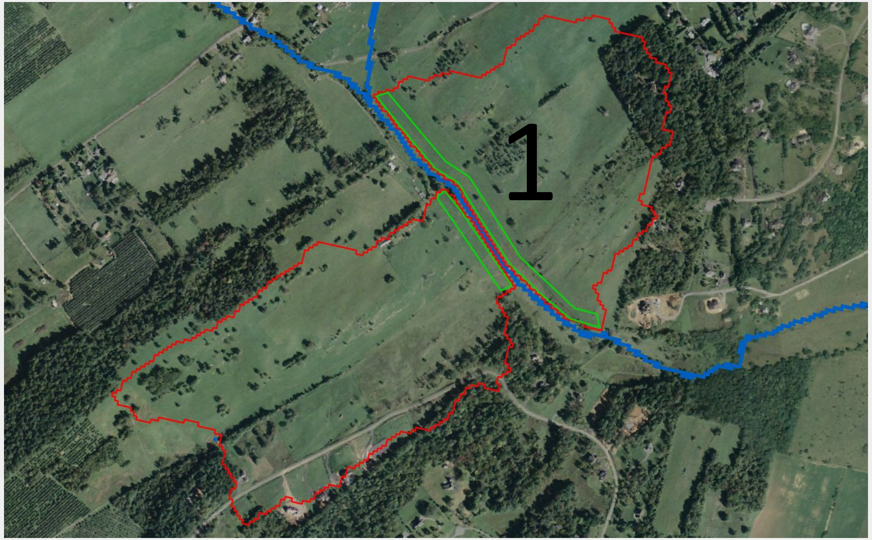
USER OUTPUT

User can review the RCI results, as shown as a ratio for performance confidence (X<1, x=1, x>1 not meeting, meeting, or exceeding assumed averages, respectively)

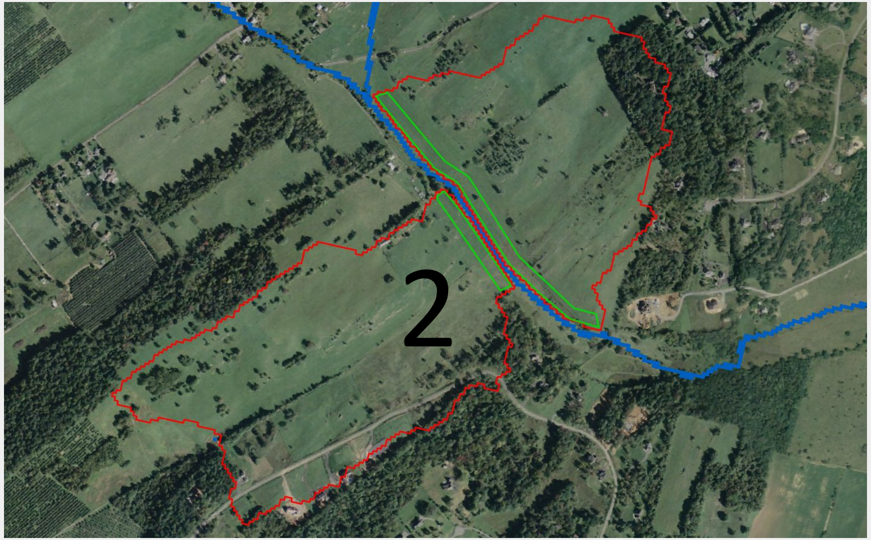
Example: Testing Two Riparian Buffers

- 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}



BMP Load Reduction API - Data Sources & Models

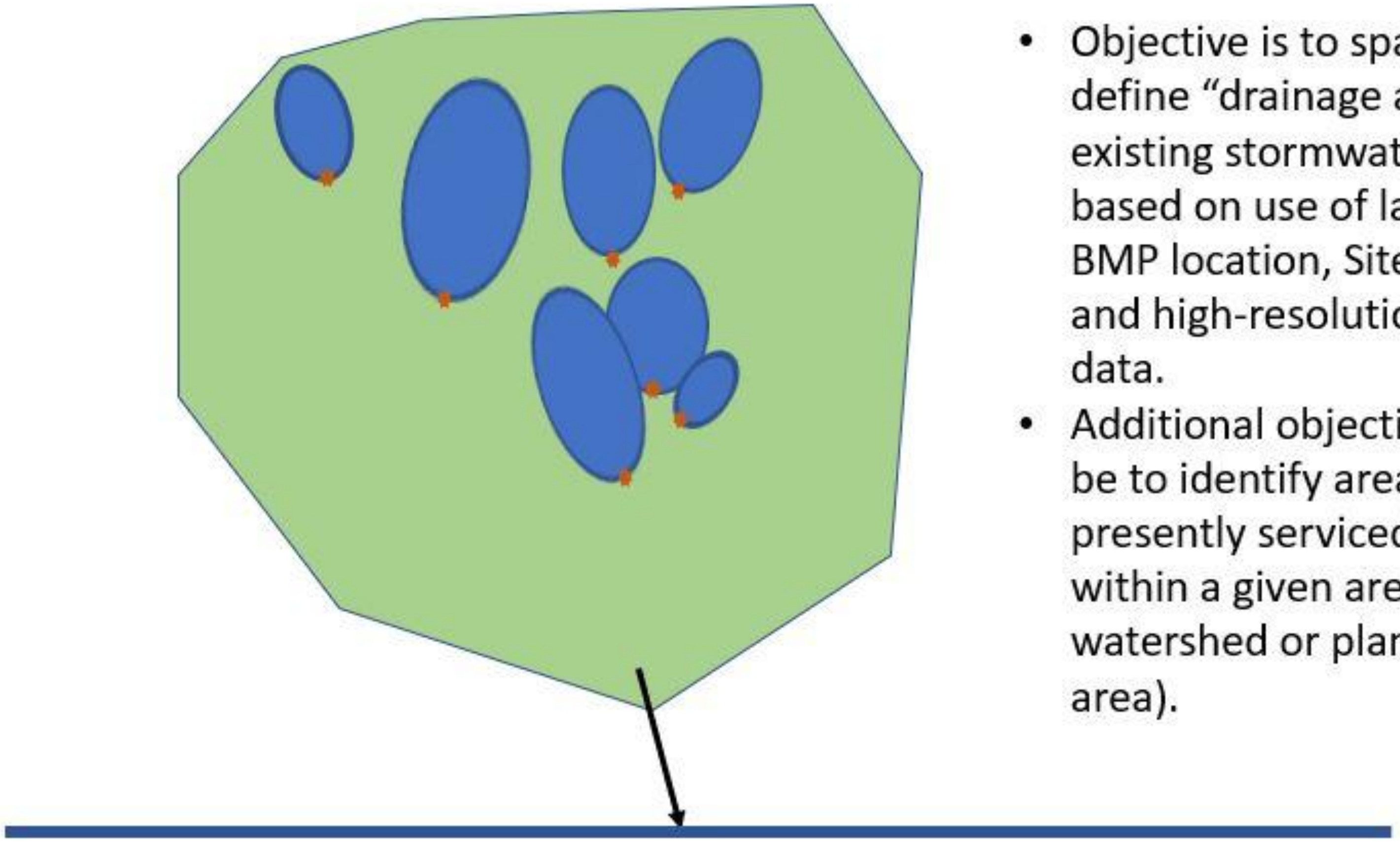
Chesapeake Bay Watershed (CBW)

- 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

- Investigating the capacity to better identify opportunities for stormwater BMP implementation through hydro-conditioning of DEMs with available infrastructure data and existing BMPs
- Pilot performed in the City of Lancaster, where extensive data on sewersheds and stormwater networks is available

Stormwater BMP Pilot

Report available on request
Contact Katie Walker
kwalker@chesapeakeconservancy.org



- Objective is to spatially define “drainage areas” for existing stormwater BMPs based on use of lat/lon of BMP location, Site Area and high-resolution DEM data.
- Additional objective would be to identify areas not presently serviced by BMPs within a given area (e.g., watershed or planning area).

Contact Information & Next Steps

- Chesapeake Conservancy / Project Lead
    - Katie Walker, kwalker@chesapeakeconservancy.org
- Drexel
    - Ali Shokoufandeh, as79@drexel.edu
    - Scott Haag, smh362@drexel.edu
    - Barry Evans, bme39@drexel.edu
- The Commons
    - John Dawes, Dawes@chesapeakecommons.org
- CBPO
    - Ruth Cassilly, rcassilly@chesapeakebay.net

1. *Discussion on how to utilize any of the outcomes from this project to progress BMP planning efforts*
2. *Discussion on how aspects of this project could be used for CBP modeling efforts*
3. *Discussion on what more could be done to continue this research*
    a. *Developing the workflows for additional BMP archetypes*
    b. *Additional research or metrics for the existing workflows to better estimate site-scale reductions*