Developing a Web-Based Prioritization Tool
for the Lower Susquehanna River

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Abstract

Chesapeake Conservancy has developed a tool that can display data layers and perform a custom analysis based on user input to determine the highest value conservation opportunities along the lower Susquehanna River corridor. By providing a way for users to balance the importance of ecological, historical, and cultural resources, this tool will encourage conservation groups to align their priorities in these high value areas and help regional efforts to create a landscape-scale conservation effort that is both effective and efficient. Throughout the process, Chesapeake Conservancy encountered a number of difficulties to implementing this type of tool as well as potential solutions that should facilitate a larger, regional adoption of this technology.

About the Authors

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Introduction

The Chesapeake Conservancy was founded when two organizations, Friends of the John Smith Chesapeake Trail and Friends of the Chesapeake Bay Gateways, merged to form an organization that could advocate for conservation of the region's most treasured landscapes and waterways, promote stewardship and enjoyment of the watershed's natural, cultural, and historic resources, and marshal new resources and forge new partnerships to increase public access to the Chesapeake and its great rivers. Combining the objectives of a program dedicated to promoting public access with one promoting a National Historic Trail has allowed Chesapeake Conservancy to support conservation efforts around the Chesapeake Bay using the nearly 3,000 mile trail as a planning framework. Having such a wide area of interest, both topically and geographically, provides us with the opportunity to engage a wide variety of partners in our conservation efforts; however, it has also created the challenge of balancing the interests of each group while identifying priorities that protect the greatest combination of the Chesapeake's most valuable resources.

Since its formation, Chesapeake Conservancy has been using innovative platforms to communicate with and engage the public in the conservation of the Chesapeake Bay's natural, cultural and historical landscapes. Embracing tools such as mobile apps, web- mapping, and advanced spatial analysis, the Conservancy has been successful at employing technology to improve the effectiveness and efficiency of its work. In 2012, the Conservancy formalized "Conservation Innovation" as a core principle in our strategic direction, emphasizing the need to identify and develop tools that allow the Conservancy to do more with the organization's resources and engage a wider audience than previously possible. Embracing this philosophy, Chesapeake Conservancy, working with the National Park Service and United States Fish and Wildlife Service, has begun organizing regional planning initiatives along the Chesapeake's major tributaries that facilitate the formation of a community-based vision for the river to benefit present and future generations. These efforts have seen a tremendous amount of participation in the planning process from local conservation groups and community members and have developed a considerable amount of "crowd-sourced" data identifying potential priorities for conservation along the river corridors using web-based geo-polling tools developed by National Geographic Maps.

One of the challenges the Conservancy faces in our corridor-wide approach to land conservation is balancing the interests of disparate constituencies: some groups are interested in preserving the region's history and culture, while others are interested in the ecologic value a parcel may provide. When possible, the Conservancy is working to protect landscapes that provide access to a variety of benefits, however identifying these areas can be a challenge without making appropriate datasets and tools available to the public. The Trust for Public Land and Lincoln Institute of Land Policy's Conservation Opportunity Analysis website, originally created for the Roundtable on the Crown of the Continent, provides an example of how innovative web-mapping

technologies can be used to display and analyze regional datasets using a readily accessible interface (Faber et al 2012). This tool puts data and advanced analysis techniques in the hands of the public and helps educate and engage local participants in regional conservation efforts. As Chesapeake Conservancy continues to expand the use of landscape-scale, "community-based", conservation efforts, the use of innovative tools to assimilate, analyze, and communicate regional datasets will be critical to the success of our work.

The Need for a Lower Susquehanna Prioritization Tool

In early 2013, Conservancy staff created a tool, based on the existing Conservation Opportunity Analysis site, to help communities and local partners identify priority landscapes in order to increase the effectiveness of its Envision the Susquehanna river corridor planning effort. The Lower Susquehanna River Conservation Opportunities Analyst displays data layers and allows users to identify landscapes that have a high conservation value based on their level of interest in five categories:

1. Historical and Cultural Resources,
2. Priority Habitats,
3. Ecological Connectivity,
4. Relationship to Existing Protected Lands, and
5. Proximity to Existing Public Access Points.

Figure 1: Screenshot of the Lower Susquehanna River Conservation Opportunities Analyst showing an analysis that balances multiple interests.
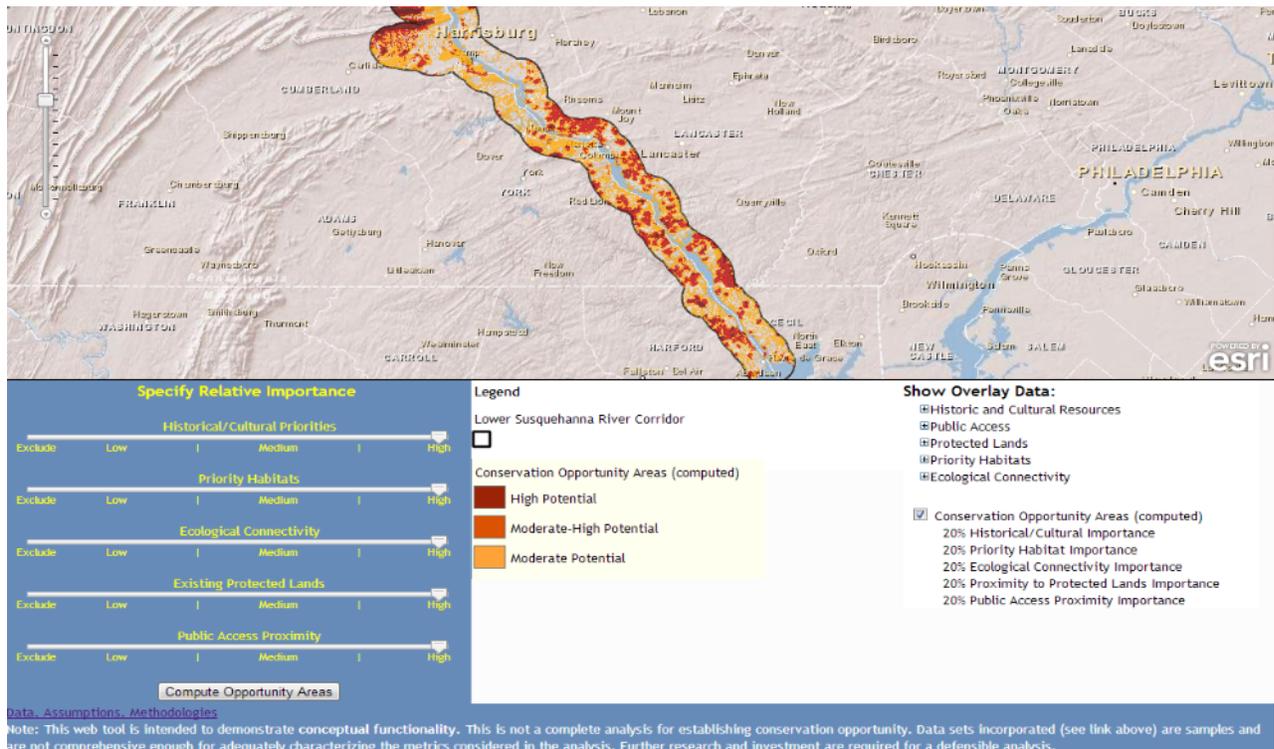
These categories encompass the majority of topics in which the groups that have been participating in the Envision the Susquehanna planning process have expressed interest. Using this tool, participants can identify landscapes that are indicative of their priorities and also gain a better understanding of how regional priorities change based on the importance placed on any given category. Identifying areas that are persistently significant as the relative weighting of each topic is changed will help community-based planning efforts, such as Envision the Susquehanna, identify priorities that will satisfy the needs of a number of user groups and protect the region's most valuable landscapes.

In addition to performing a custom analysis to identify priorities, users can view the background datasets on which the analysis is based. This information was collected by the Conservancy and our Partners and, in most cases, provides access to datasets that may not be publically accessible without expensive and complicated software.

- The Cultural and Historical dataset, created by the Susquehanna River Heartland Coalition for Environmental Studies, a coalition of six universities in Pennsylvania, identifies previously unrecorded areas that featured significantly into pre-colonial and early colonial history as well as sites identified by the National Park Service, the National Register of Historic places, and state historical trusts.

- The Priority Habitats dataset, created by Chesapeake Conservancy and Wildlife Management Institute staff and developed using an analysis of data collected by the North Atlantic Landscape Conservation Cooperative, identifies terrestrial habitats that are used by species of greatest conservation need, as recognized by state natural heritage programs.

- The Ecological Connectivity dataset uses information created by The Nature Conservancy to show habitats that have the greatest permeability, or the highest amount of regional connectivity between similar ecosystems.

- The Protected Lands dataset identifies land that has been acquired through local, state, federal, and private conservation programs as well as the location of conservation easements identified by the Land Trust Alliance and other partners.

- The Public Access dataset uses information collected by the National Park Service as part of their Chesapeake Bay Watershed Public Access Plan and identifies both existing and potential public access sites along the river.

Allowing the Conservancy's partners to easily view these datasets and identify regionally important landscapes based on the general categories will significantly improve our ability to balance the varying interests of the community.

Figure 2: Comparing the relative importance of the Lower Susquehanna River Corridor a) with all categories equal, b) weighted more heavily towards priority habitats and ecological connectivity, and c) weighted more heavily towards historical and cultural resources shows how conservation priorities change based on a user's preferences and how some landscapes maintain a persistently high-value.
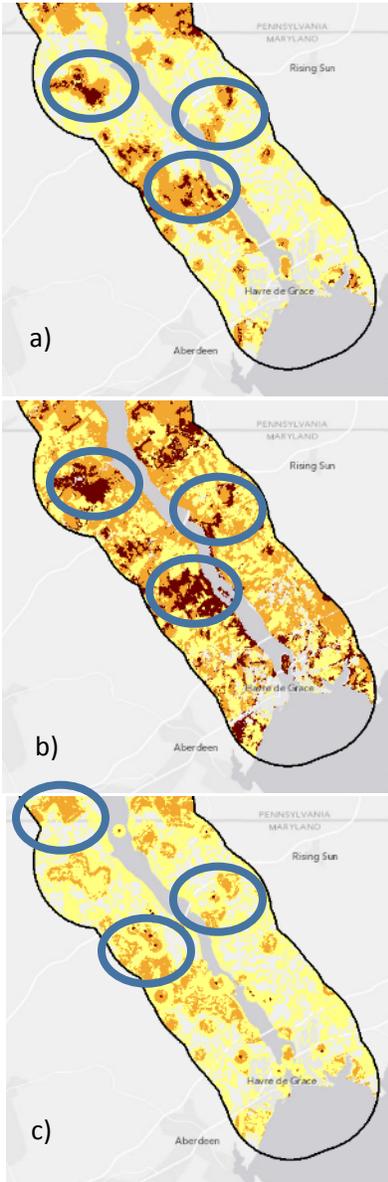
This tool will also fill a gap in both data access and user engagement that currently exists throughout the Chesapeake Bay watershed. While a number of regional or state web- mapping tools exist and have the ability to access a variety of useful information, many of these sites are extremely limited as to the scope of information they display. Sites often focus only on one topic, such as ecological resources, and ignore other resources the land may hold, such as culturally significant areas or public access opportunities, leading to a narrow definition of "importance" with no ability to incorporate other datasets. Two websites, Chesapeake Commons

(http://www.chesapeakecommons.org/) and LandScope Chesapeake (http://www.landscope.org/chesapeake) successfully bridge these topic areas and provide access to a variety of data including information about the region's cultural, historical, and ecological landscapes. These sites can be extremely useful to users attempting to identify the resources an area may contain, however, they are limited to only being able to display data and provide no way to analyze it. The prioritization tool the Conservancy developed for the Lower Susquehanna represents one of the only tools, if not the first, in the region that allows users to conduct an analysis of the conservation potential of the land based on its cultural, historical, and ecological significance. While it is extremely important for the public to be able to visualize and interact with regional datasets, the Lower Susquehanna River Conservation Opportunities Analyst elevates the capabilities of users allowing them to not only look at the data but also interact with it and understand how regional priorities change based on their input. As a result of this innovative tool, the Conservancy hopes that our partners along the lower Susquehanna River will see a greater amount of engagement by the community in public meetings and find that participants are better informed when discussing their priorities and the justifications behind them. The entire Envision the Susquehanna process relies on the input of the communities along the river and as the public uses the Conservation Opportunities Analyst to understand the region's conservation potential, the Conservancy hopes that they will participate more in the public meetings and remain engaged in the process. Furthermore, as disparate user groups identify high-value landscapes based on their own priorities, the Conservancy hopes that it leads to increased collaboration and partnership forming where overlaps exist. Leveraging resources, funding, and engagement from multiple user groups will help realize landscape-scale conservation opportunities that protect a wide variety of the region's most important cultural, historical, and ecological resources.

Creating the Tool

The Lower Susquehanna River Conservation Opportunities Analyst was created using ArcGIS Server 10.1 and runs a geoprocessing service that leverages the power of ArcGIS Online web-mapping tools with the ability to run a custom script written in the Python programming language. The tool takes the relative weightings of the input layers, as determined by the user in the web-tool interface, and performs a weighted overlay of the source data to determine the value of each pixel on the map. This data is then normalized and reclassified to determine the high, medium-high, and medium potential landscapes, which are then displayed on the web-map.

Since this tool operates using a Python script it is able to process the datasets more quickly than a similar tool that runs strictly in ArcGIS Server meaning users are able to visualize the resulting data with a shorter delay between submitting the request and receiving the result. During testing of the tool on an internal server the average time for an analysis was about fifteen to twenty seconds. With such a quick turnaround, users are able to experiment with different prioritizations more readily and can identify areas that have a consistently high value across weighting schemes. This structure also decreases the amount of time that the service takes, which should speed up the response time with multiple users attempting to access the system simultaneously.

Community Uses

The Lower Susquehanna River Conservation Opportunities Analyst will assist a number of initiatives with which Chesapeake Conservancy is engaged along the lower Susquehanna River and will provide a replicable template that can be used for regional planning efforts throughout the Chesapeake Bay watershed. In addition to the Envision the Susquehanna community meetings, this tool has two other immediate uses: to support the comprehensive negotiations currently underway surrounding the Federal Energy Regulatory Commission's relicensing of Conowingo Dam and Muddy Run Pumped Storage Facility and to identify priorities for the Lower Susquehanna Heritage Greenway.

As part of the relicensing negotiations, a number of regional land conservation organizations have the opportunity to identify priority parcels as they relate to lands currently owned by the power company. As with Envision the Susquehanna, each organization has its own priorities and areas of interest, which, if not rectified prior to the negotiations, could hinder the ability to reach a beneficial agreement with the power company. Chesapeake Conservancy will be coordinating the effort to prioritize the parcels that the groups have expressed interest in by identifying the parcels' relative conservation value for each of the five categories used by the Conservation Opportunities Analyst. To properly weight the importance of each category for the final analysis, the Conservancy will use the tool to conduct on-the-fly calculations in an effort to inform an internal discussion and rank the parcels, developing a portfolio that the majority of the groups can agree on. The Conservancy hopes that by identifying and discussing priorities prior to the negotiations the conservation organizations can present a unified stance and negotiate a more substantial agreement from the power company that protects the most comprehensive variety of ecological, cultural and historical resources as possible. In the coming years, the Conservancy intends to expand the coverage of this project to the entire Susquehanna River basin.

Figure 3: Screenshot of an analysis that is evenly balanced between the various layers that highlights certain landscapes as "high priority" within the boundary of the Lower Susquehanna Heritage Greenway Boundary (light blue line).
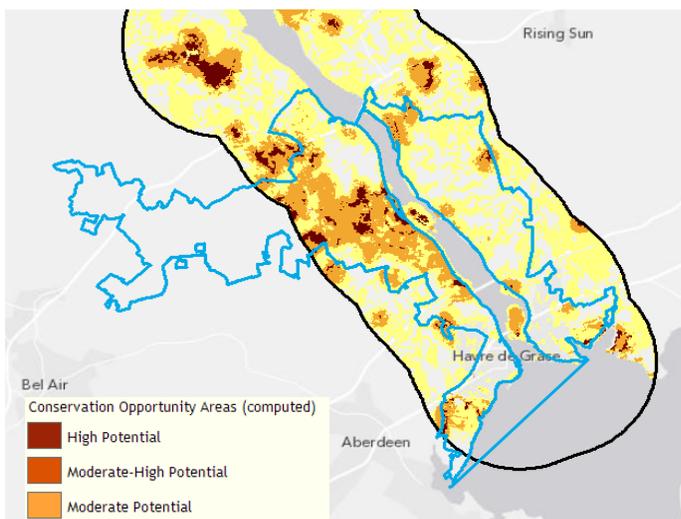
Planning efforts for the Lower Susquehanna Heritage Greenway represents another opportunity to use the Conservation Opportunities Analyst. This state recognized Heritage Area, located along the Maryland portion of the Susquehanna River, was developed to stimulate local economic activity by developing a linkage between the area's natural, historic and cultural resources. The Greenway's management plan provides recommendations for conservation priorities within the Heritage Area's boundary and is incorporated into two counties' and three municipal jurisdictions' comprehensive plans. The Lower Susquehanna Heritage Greenway is currently updating its management plan and Chesapeake Conservancy is providing mapping and planning support to identify landscapes along the river that contain key resources. To help identify these areas, the Greenway's staff and community members engaged in the plan's update can use the Conservation Opportunities Analyst to identify significant areas for each of the five categories as well as prioritize regions that contain a diverse collection of natural and cultural resources for resource protection and infrastructure development. While the Lower Susquehanna Heritage Greenway has had maps of these resources for quite some time, they have no internal mapping capabilities and have never had the ability to interact with their data or explore the implications of emphasizing some resources over others.

The Conservation Opportunities Analyst will allow them to delve deeper into the resources their region contains and tailor their management plan to more closely fit the conservation and economic development priorities the Greenway is intended to promote.

Fostering Additional Partnerships

As discussed in the previous sections, the Lower Susquehanna River Conservation Opportunities Analyst is already benefiting a number of Chesapeake Conservancy's conservation programs. In addition to supporting its existing programs, it hopes that the tool will help promote new programs and relationships with information and communications technology (ICT) companies. The Chesapeake Conservancy's Conservation Innovation Center currently receives support from a small number of technology companies. This type of regional analysis tool produces a large demand for many of these companies' technologies and the Conservancy believes that this tool represents an appealing program that could engage a much larger group of supporters and result in a larger analysis of the entire Susquehanna River. Any sort of large-landscape analysis generates a tremendous amount of data that must be housed on either hard drives and servers or using "cloud" storage, both areas of growth for the ICT industry. If these data and analysis tools are going to be made publically available, additional web servers and geo-processing servers will need to be installed to handle the data requests. As other organizations see the capabilities of the Conservancy's tool, the demand for similar applications to address other conservation or geographic prioritization needs will increase. Ultimately, supporting data gathering and analysis initiatives such as the Conservation Opportunities Analyst drives demand for the companies' products.

Additionally, there is currently a large amount of private philanthropy from these companies supporting Science, Technology, Engineering and Math (STEM) education. The Conservancy believes that the Conservation Opportunities Analyst represents an ideal program that will engage universities throughout the region in the collection and interpretation of scientific and cultural

data and will provide students with the opportunity to be involved in cutting-edge research. With the current tool, Chesapeake Conservancy relied heavily on universities to provide the base data upon which the tool was built and it would not have been able to complete the ecological assessments without a generous grant from the Richard King Mellon Foundation to support this research. If the tool is going to be replicated elsewhere the Conservancy will need to employ other universities throughout the watershed to assist in data collection and raise more support from regional partners. The Conservancy is hopeful that it can engage some of its technology partners in supporting this work to expand its knowledge of the region's resources, teach students advanced techniques, and provide local conservation organizations with the tools and data they need to make informed decisions.

Conclusions

The Lower Susquehanna River Conservation Opportunities Analyst represents a significant step forward in providing the public with the tools and information they need to make informed decisions about protecting their region's cultural, historical, and ecological resources. Not only does this tool fill a gap in data access in the Chesapeake Bay, it has helped drive the collection of historical and cultural information that will help present an entirely new view of a stretch of river that is often overlooked. While the Conservancy believes that the Conservation Opportunities Analyst will ultimately help many of its programs, there were three significant difficulties it experienced during the tool's development and implementation.

First, this tool relies entirely on having accurate and detailed datasets upon which the analysis is based. Many of the datasets the Conservancy initially considered including in the tool were not of the quality it deemed necessary for the analysis; resulting in the need to collect or obtain datasets from other partners. While the Conservancy ultimately created a tool that incorporates some of the most up-to-date and scientifically defensible information relating to the region's cultural, historical, and ecological resources; it took considerably longer than initially expected to gather the datasets needed to run the analysis.

Second, the geo-processing service used to run the custom analysis requires a substantial knowledge of geospatial analysis and the development of tools and models within ESRI's ArcGIS application. While Chesapeake Conservancy staff had experience with developing both web-maps and advanced geo-processing models, there was still a fairly steep learning curve required to translate this knowledge into a new geo-processing tool that worked with the web-map.

Third, the web-mapping side of the tool, which employs the geo-processing service, must be run in an ArcGIS Server environment. As Chesapeake Conservancy did not currently have this program, both a physical server and the ArcGIS Server software had to be purchased, at a total cost of about $3,500. ESRI, the makers of ArcGIS Server, has a strong non-profit program that makes the software more accessible to conservation organizations, however, the price of ArcGIS Server was still $2,000. Chesapeake Conservancy also did not anticipate needing to purchase a server, which led to the need for additional fundraising. Along with this delay, additional time

had to be spent for Chesapeake Conservancy staff and pro-bono volunteer technology experts to setup and learn how to use both the program and server.

Many of these issues, especially the cost of a server and the need to run ArcGIS Server software, will prevent other conservation organizations from developing a tool like the Conservation Opportunities Analyst by themselves. While this initially seems like it will discourage these tools' use throughout the region, the Conservancy believe that it actually presents an opportunity for developing additional partnerships throughout the Chesapeake Bay watershed. Currently, Chesapeake Conservancy and Chesapeake Commons have the capability of maintaining such a tool and both have expressed the willingness to partner with other organizations to develop and implement additional tools. By consolidating the geo-processing services on these two organizations' servers, there is the possibility that additional tools similar to the Conservation Opportunities Analyst could be developed as other organizations supply funding and local datasets and help with the tool's design.

Overall, the Conservancy believes there is a tremendous amount of potential for custom web-analysis tools such as the Conservation Opportunities Analyst to thrive throughout the Chesapeake Bay watershed. While there are still obstacles that will have to be overcome before these tools see widespread use, the Conservancy feel that their development will foster innovative partnerships, promote landscape-scale conservation efforts, ensure efficient use of limited conservation resources, and educate the public about the cultural, historical, and ecological resources of a region. Over time, the Conservancy hopes that they encourage increased dialogue between the public, conservation organizations and user groups that balances the interests of each group while identifying areas that protect the greatest combination of the Chesapeake's most valuable resources.

Bibliography

Faber, Brenda, Breece Robertson, and Ellie Knecht (2012) "Large Landscape Conservation: Recommendations for Online Data and Tools." Lincoln Institute of Land Policy Working Paper.