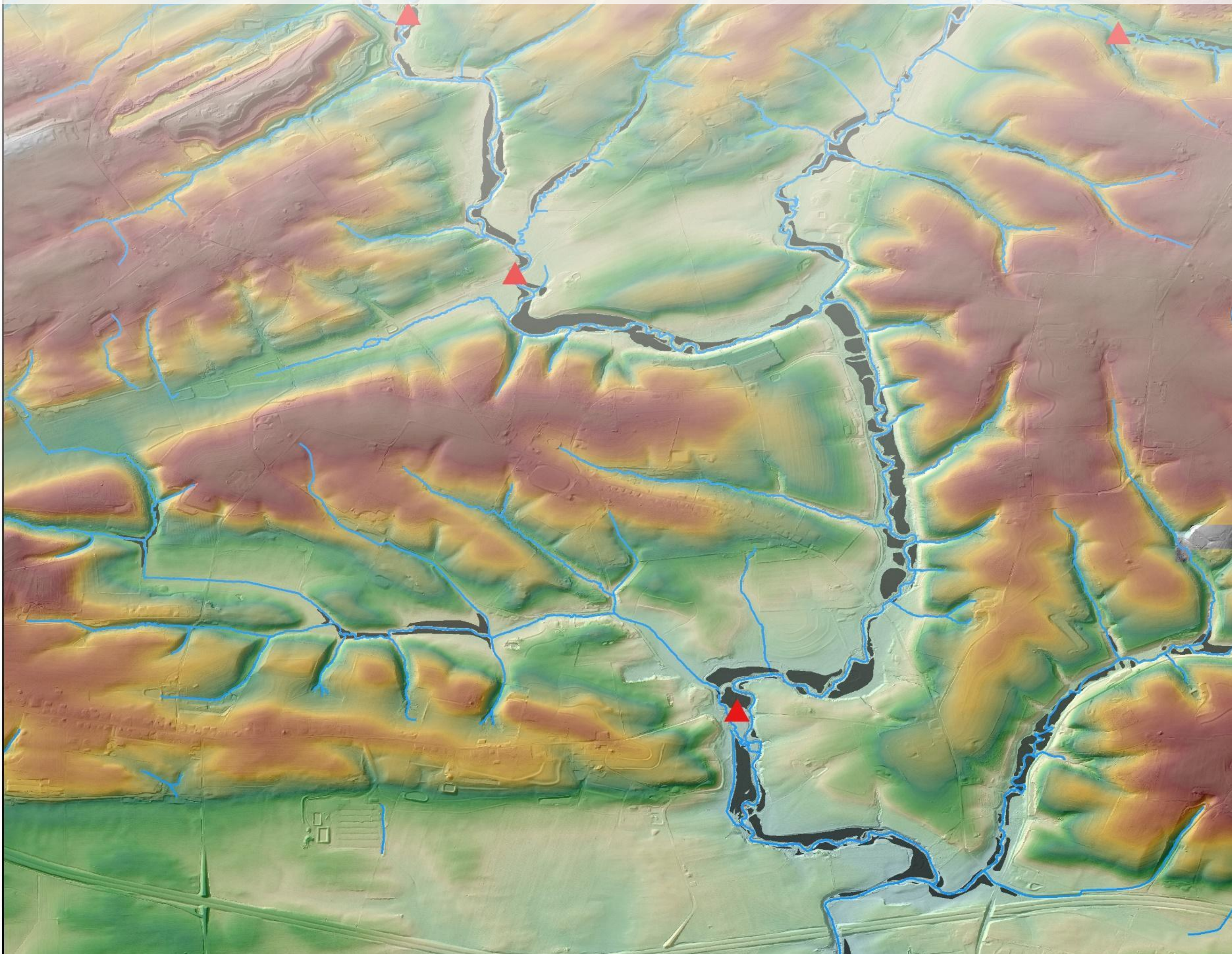
Legacy Sediment 2.0: Enhanced Mapping and Decision Support Tool

FINAL REPORT

NRCS CONSERVATION INNOVATION GRANT



NRCS CONSERVATION INNOVATION GRANT

Final Report

Grantee Entity Name: Water Science Institute

Project Title: Legacy Sediment 2.0: Enhanced Mapping and Decision Support Tool

Agreement Number: 69-2D37-18-002

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Final Report

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Project Summary

Legacy sediment (LS), an environmental consequence of post European settlement farming, milling and forestry practices has become a commonly recognized source of water quality impairments throughout the coastal plain, ridge and valley and piedmont regions of the mid Atlantic United States. Our inquiry built on the results of a long-term scientific experiment that removed LS from a marginal pasture section of the Big Spring Run (BSR) watershed in Lancaster County, Pennsylvania with the goal of restoring a buried Holocene era valley bottom to a functioning wetland/stream complex.

Using the Lancaster County mapping and BSR results as a baseline the CIG initiative focused on developing additional information for erosion identification and conservation targeting metrics for six additional counties in the lower Susquehanna River and Potomac River basins. The mapped Pennsylvania counties were Adams, Cumberland, Dauphin, Franklin, Lebanon and York. Watersheds mapped were:

Adams – Plum Creek Watershed

Cumberland – Mountain Creek Watershed

Dauphin – Paxton Creek Watershed

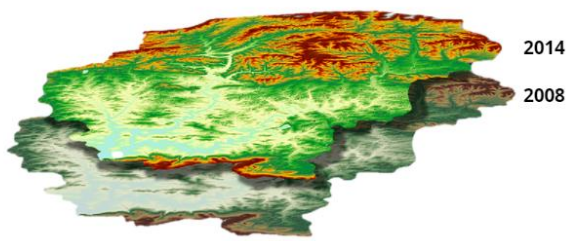
Franklin – Back Creek Watershed

Lebanon – Little Swatara Creek Watershed

York – Lower South Branch – Codorus Creek Watershed

The initial step in the process was to create Digital Elevation Models (DEM) using the most current lidar data sets available for individual counties. These were then differenced comparing the results from the initial set of data to the most current set. The landform change between the two sets is the difference that forms the baseline for the development of the erosion modeling process.

DEM differencing is the process of subtracting one digital elevation model from another on a cell-by-cell level. Applying this technique to detect change over time, WSI can visualize and quantify erosion across the landscape.



2014 USGS post-Sandy LiDAR (above) and 2008 DCNR PAMAP LiDAR (below) of Chiques Creek Watershed, Lancaster County, PA.

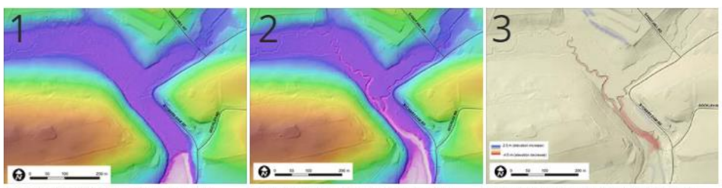


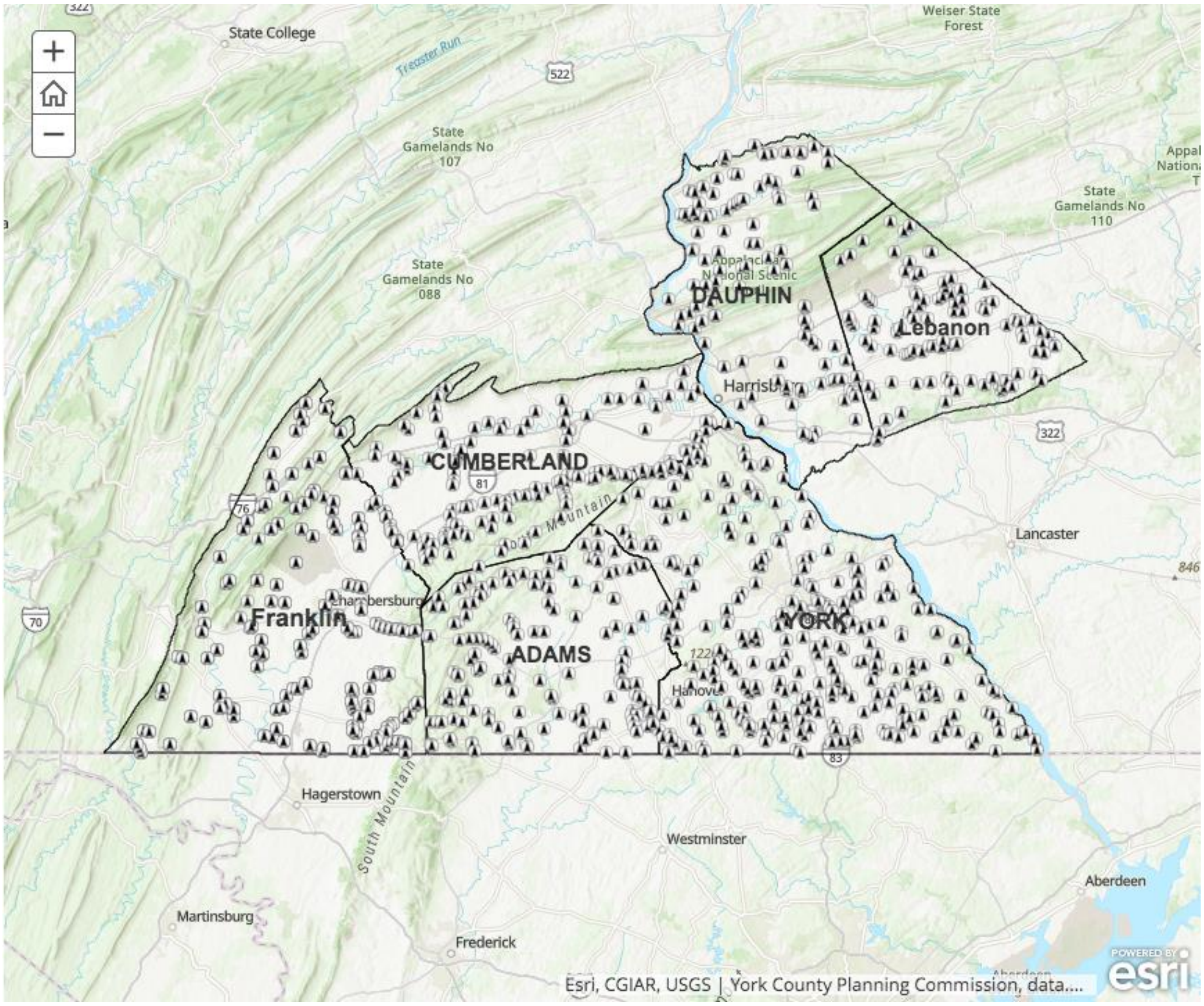
Figure 1. This digital elevation model shows a legacy sediment terrace surface (purple area) prior to the breach of Stobers' dam in Denver, PA. *2008 USGS PAMAP LiDAR*

Figure 2. This digital elevation model of the same area, created from LiDAR data collected after the dam breach, shows the stream incision that resulted from the drop in the water table. *2014 USGS post-Sandy LiDAR.*

Figure 3. This figure shows the result of the post-dam breach incision seen in Figure 2. Here, the red area represents erosion measured from "differencing" or "subtracting" the two digital elevation models (Figs. 1 & 2). *2014 USGS post-Sandy LiDAR.*

Our pilot program then developed selected HUC 12 watershed maps of potential legacy sediment sites, erosion rates and “hot spots” with high rates of sediment removal that can be determined on a parcel, stream length or watershed scale. Field verification has confirmed these results with an up to 90%~ certainty which allows the user with high confidence to prioritize potential restoration sites and other BMPs with desk top technology. The project used existing LIDAR data sets, historic 18th-20th century atlases for historic dam placement, custom and open-source code to produce 1 meter resolution stream center lines and applied block statistic heat methodology and canopy mapping to produce additional data points for enhanced conservation prioritization.

The project mapped approximately 1200 Mill dams with related data including date of Atlas identification, latitude and longitude, mill use and current status-breeched or intact which has been incorporated into the Story Map product.

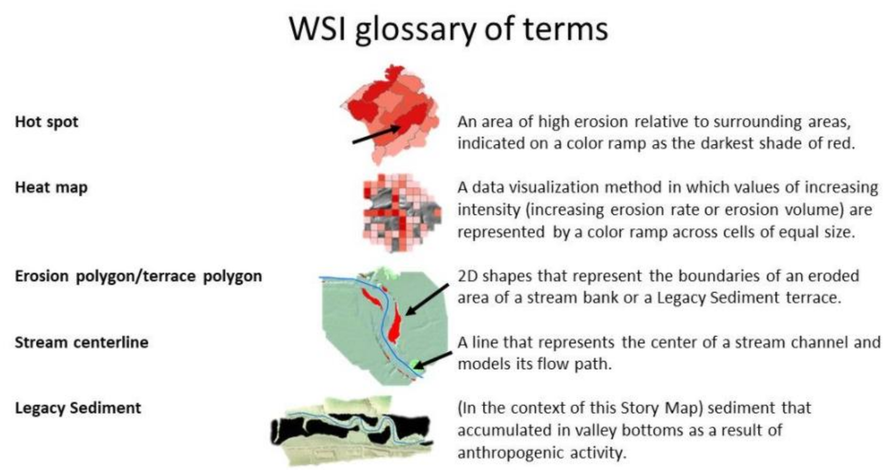


The user may click on individual data points to determine the erosion rate or load of individual polygons, the status and location of a mapped dam or the volume of a potential legacy sediment restoration site. Conservation professionals can use the data sets to identify and prioritize potential sites to develop and monitor preferred BMP strategies.

In our selected watersheds for each county, we manually reviewed and edited erosion polygons produced by the differencing process that were determined to be unlikely sources of erosion based on field investigation, prior experience and current geomorphological science.

Two publications previously produced support and demonstrate our conclusions and recommendations. The first, "Cost Effectiveness of Legacy Sediment Mitigation at Big Spring Run in Comparison to Other Best Management Practices in the Chesapeake Bay Watershed", formed the basis for an article which appears in the Journal of Soil and Water Conservation. *See*: Fleming, P.M., D.J. Merritts and R.C. Walter, 2019. Legacy Sediment Erosion Hotspots: A Cost-Effective Approach for Targeting Water Quality Improvements. Journal of Soil and Water Conservation, 74(4): 67A-73A, doi: 10.2489/jswc.74.4.67A. The full report is available on the WSI website. www.waterscienceinstitute.org

The primary product of our current project is the Legacy Sediment 2.0 story map which incorporates all of the data acquired and produced by the project in a user-friendly format. The map has been provided to participating counties and permits the user to click on a selected county watershed and use the various attribute tables to create a profile of conservation data sets at the parcel, stream or watershed scale. The map can be customized to import multiple data layers including topography, soil profiles, wetlands and ortho images from both ArcGIS and other public data platforms. A glossary of terms and prompts are incorporated throughout the map to further enhance the products ease of use.



Legacy sediment restoration at both headwater and impaired valley bottom sites needs to be recognized as a unique opportunity to deliver a range of scalable, cost-effective results to local watersheds and larger public environmental goals such as the Chesapeake Bay total maximum daily load (TMDL). Public funders should begin to accept that nutrient loads are often the result of legacy impairments within the stream and not solely the result of inadequate farming practices. In many instances the purchase of a farm with a stream is not just the acquisition of an unrecognized pollution source but an important conservation opportunity.

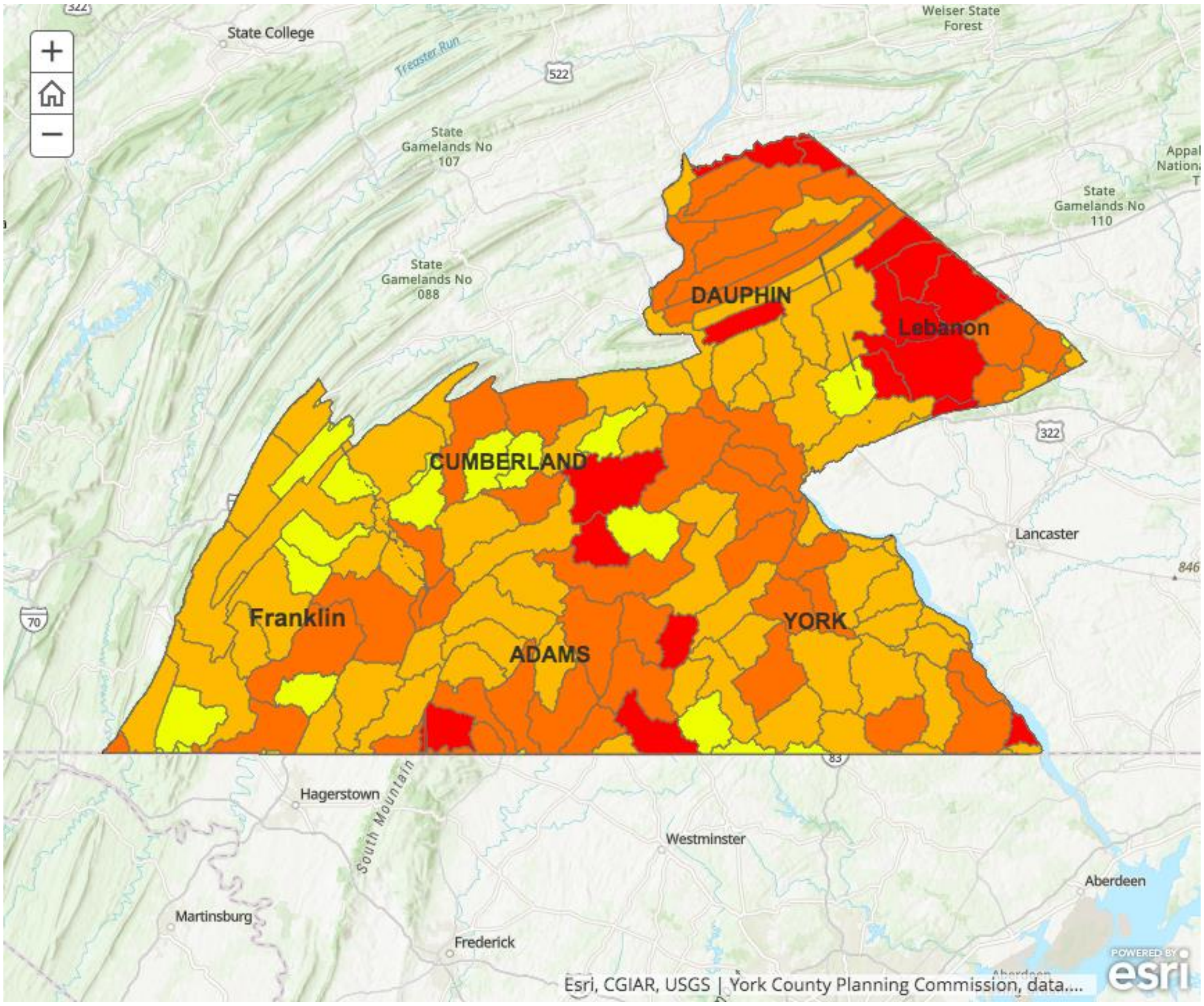
This Story Map is another product to recognize and support that approach.

Introduction

The final product for this project is the Story Map Legacy Sediment 2.0: Enhanced Mapping and Decision Support Tool.

Click here for access Legacy Sediment 2.0: Enhanced Mapping and Decision Support Tool (arcgis.com)

It was the result of 4 years of intensive research and data organization to provide a more user-friendly approach to conservation planning that recognized and incorporated the effects of mill dams and other impairments on local watersheds in the lower Susquehanna and Potomac watersheds. It complements and expands the users understanding of the links between human alterations and the upstream effect these alterations have on local and Chesapeake Bay water quality. Incorporated into the individual demonstration watersheds are data layers that permit the identification of mill dams, legacy sediment terraces, erosion rate and volume metrics, custom code to create enhanced stream centerlines that capture higher resolution hydrologic networks, block statistic “hotspot” identification, parcel data and canopy layers to provide context for developing precision restoration planning strategies. Additional layers may be imported into the map to identify soil profiles, wetlands, topography and ortho images from other publicly available data sets.



Summary of Methods

The project first created digital elevation models (DEM) of each county using publicly available Lidar data sets while simultaneously mapping historic milldams from existing historic atlases

The models were then differenced – the earlier data set was compared to a later data set to quantify the rate of change in the landscape – and erosion rate and volume could be quantified and assigned a rate of uncertainty. County GIS officials were contacted to request parcel data layers to permit site specific targeting of erosion potential. All six counties provided their parcel data as a courtesy to the project.

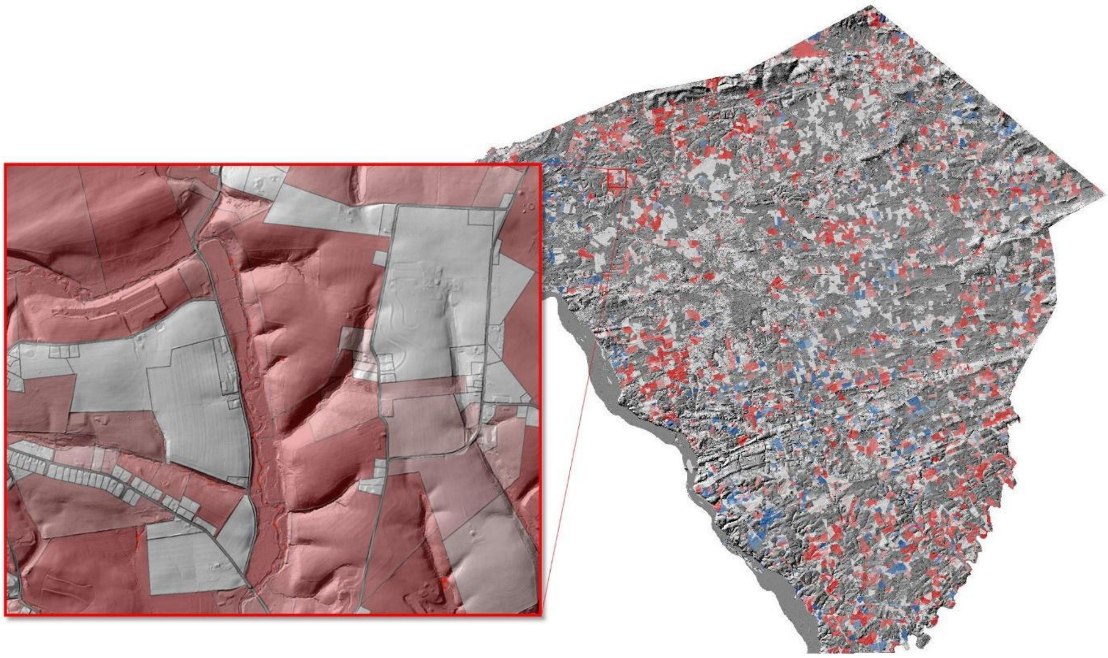
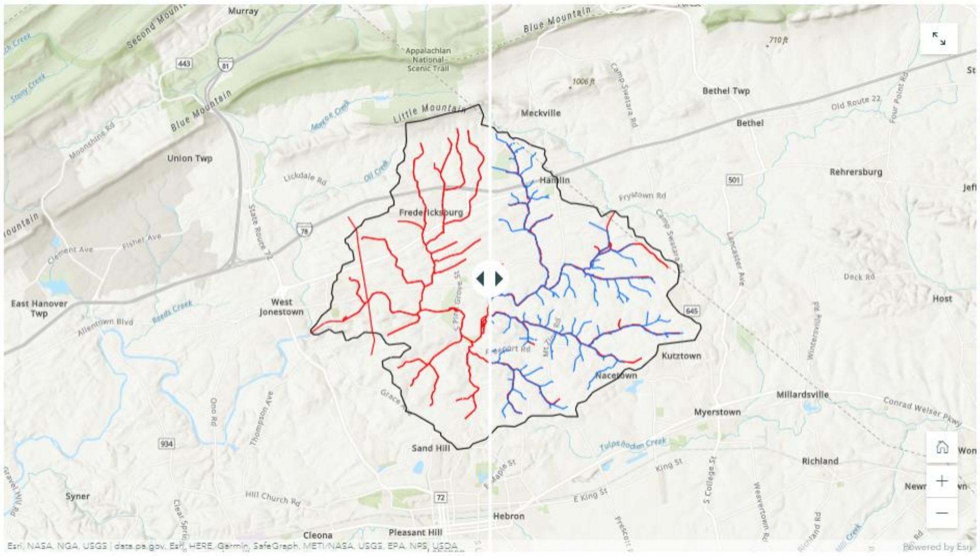


Figure 1. Parcel mapping assigns the appropriate erosion and stream length to individual parcels and allows for the identification of "hotspot" parcels where elevated rates of erosion occur. Figure by E. Lewis.

As the erosion data was identified by individual polygons a manual editing process was implemented. The editing was based on experience, stream centerline parameters and current geomorphological science.

Enhanced stream centerlines were created using a blend of custom and open-source coding processes developed by project partner Mike Rahnis of Topomatrix, LLC. These one-meter resolutions substantially improved the ten-meter resolution of the current NHD data set, allowing the project to capture a greater volume of potential polygons with enhanced accuracy.

Move the slider below to compare WSI's Hydrography Dataset (light blue) to USGS' NHDPlus HR Hydrography Dataset (red).

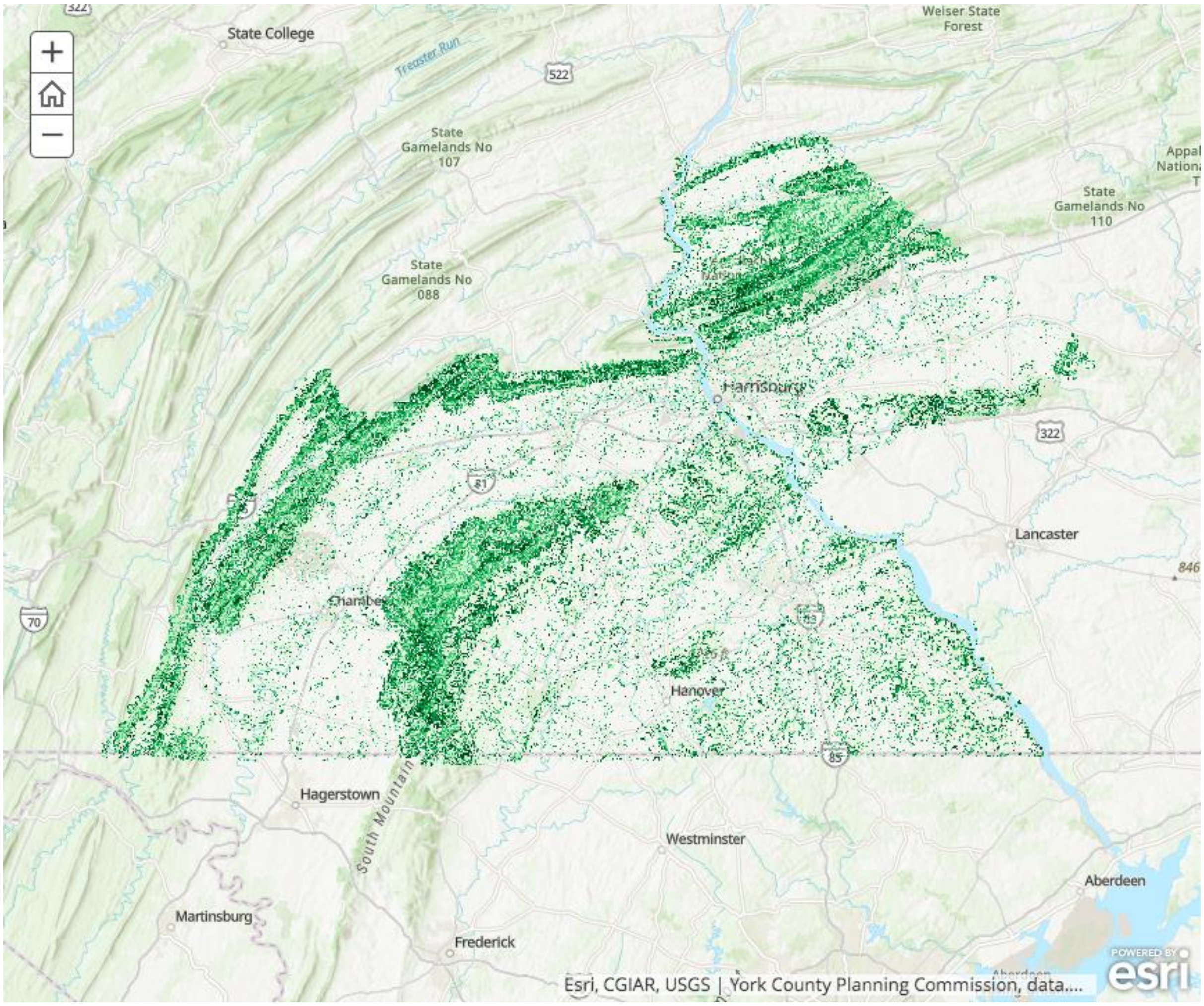


Take a closer look...

Use the buttons to zoom in and out and scroll around the map to view and compare WSI's stream centerlines (blue) with the USGS National Hydrography Dataset (red). Note: stream bank erosion (2008-2017) is shown in red.

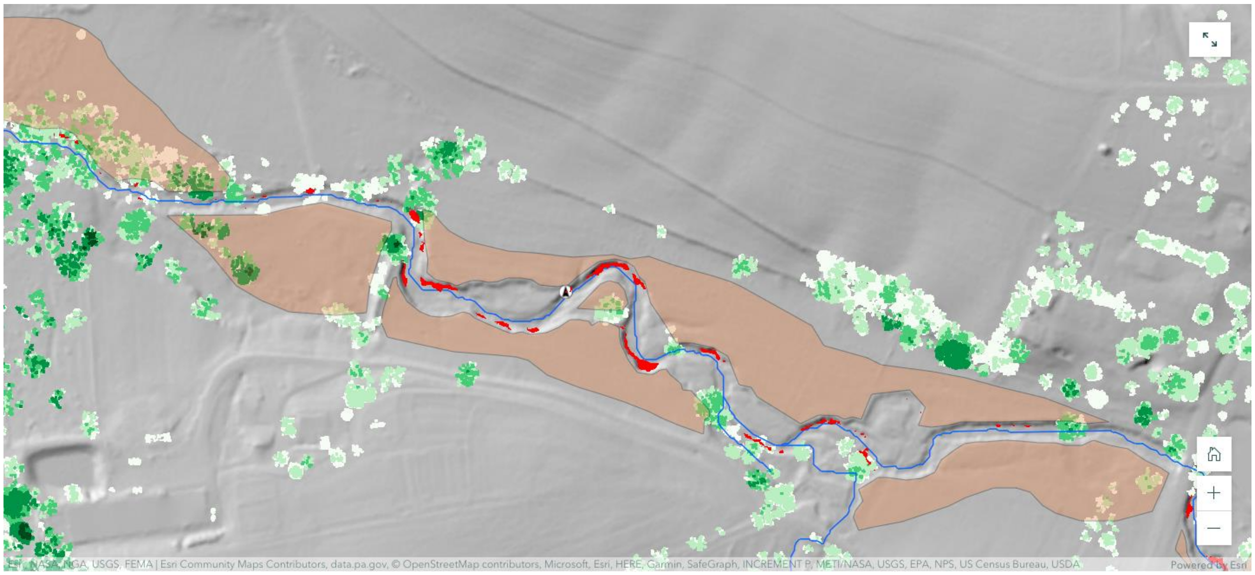
Legacy terraces, often identified as flood plain features, were measured by height and surface area to allow soil volume estimates of potential restoration sites or inform the installation of other BMPs

Canopy layers were created to further allow the identification of potential restoration and bmp installation opportunities**.**



Additional data layers were added to these attribute tables to permit soil identification, wetland sites, topography or ortho imagery available from other public data sets.

All of the above data was then used to create the form and features of the Storymap narrative which when completed was presented in private and public forums for review, comment and modification.



Results

The story map and reaction to it have led to additional requests for demonstrations from both the targeted counties and other jurisdictions, including the PA NRCS technical committee.

Challenges

Acquiring and organizing the data was a much greater task than originally contemplated and that was exacerbated by the pandemic which restricted some field investigation, communication with potential third-party users, and forced some team members to limit their original participation in the project.

Conclusions and Recommendations

This initiative is an important development in how investments in data acquisition (like lidar) when combined with increasingly powerful platforms, can develop useful and accessible tools for precision conservation planning and implementation. Sediment, and particularly legacy sediment, are a significant local impairment that is a primary factor in 303D stream listings. In many legacy sites, located in agricultural areas, stream bank sediment is a much greater source of impairment than from adjacent agricultural uplands and how it is recognized and addressed can be a significant contribution to conservation strategies.

Our primary recommendation is that NRCS and Pennsylvania partners should continue to invest in high quality lidar and fund additional projects that can apply that data to other watersheds and counties in the Commonwealth facing both MS4 and Chesapeake Bay WIP requirements. Further support of communication strategies regarding legacy sediment's effects and greater funding of legacy sediment removal and restoration sites is encouraged.