Precision Conservation Mapping on Turtle Creek Watershed in Union County, PA

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Watershed managers with limited resources need methods to prioritize possible restoration or remediation sites. The Chesapeake Conservancy developed a Geographical Information System (GIS) – based method to assist in this prioritization. Their method involved use of land-use / land_cover (LULC) maps and high-resolution digital elevation models (DEMs), and resulted in maps of concentrated flow paths, color-coded according to the value of an index called NDFI, representing the likelihood of a path carrying high concentrations of pollutants. Work in this area at Bucknell started in the 2014-15 academic year with a series of consultations with staff from Chesapeake Conservancy to better understand their methodology. The work continued in the 2015-16 academic year when maps of NDFI for Buffalo Creek were developed. Over the course of academic years 2016-17 and 2017-18 work was focused on the development of an Overland Flow Sediment Index (OFSI), tailored for sediment as the pollutant of interest.

During the summer of 2019, Bucknell researchers worked with an alternative, physically-based index for sediment transport in watersheds. Developed by Moore and Wilson (1992) and refined by Wilson and Gallant (1996), this methodology is also based entirely on DEM and LULC data. It differs from *NDFI* by accounting for the impact of topography on the development of saturation-excess runoff (the concept that runoff occurs when the water table rises to the surface), and it differs from the OFSI by accounting for the greater sediment-carrying capacity of steeper slopes. This index is called the sediment transport capacity T_c. It is a function of runoff-contributing area upstream of a point in the watershed, and the local slope of the watershed at that point. Runoff-contributing area is defined as the land area having a topographic wetness index (*TWI*) exceeding a threshold value. A large *TWI* corresponds to a large upstream watershed area and a shallow slope, leading to high subsurface flows which rise to the land surface and produce runoff. Prior to calculating *TWI* and T_c in ArcGIS, the DEM was smoothed multiple times to reduce the chaotic character of the *TWI* and T_c maps when smoothing was not performed.

Figure 1 shows the Turtle Creek watershed, just south and west of Lewisburg, PA and Bucknell. Figure 2 zooms in on a portion of the watershed and shows the concentrated flow paths color-coded for *NDFI*, from green (low pollution potential) to red (high pollution potential). Figure 3 shows a map of T_c for the same region of the watershed on a grey-scale.

Comparison of Figures 2 and 3 shows that NDFI identifies and prioritizes runoff coming from impervious surfaces and farms. Sediment transport capacity T_c, on the other hand, prioritizes steep slopes, where gravity and high runoff flow velocities contribute to erosion and high sediment transport. Ironically, these two indices target different parts of the watershed. Namely, *NDFI* targets the flat parts of the watershed in the valley bottom, where the fertile farmland is located. The T_c targets the steepest hills of the watershed, which occur in the forested areas in the southern third of the watershed. (see Figure 1).

A stream sampling program has been developed with about 10 sampling sites distributed through the watershed. Each site is on a second- or third-order tributary to Turtle Creek, and is located where a concentrated flow path crosses a road through a culvert, allowing easy access to the flow path. Successful sampling requires relatively steady rain over several hours during the daytime. Unfortunately, the storms in summer 2019 fitting that description occurred prior to the identification of appropriate sampling sites. The student and faculty researcher have agreed to collect and analyze water samples during the fall semester of 2019. This analysis will hopefully indicate whether the flatter, farming parts or the hilly, forested parts of the watershed result in more sediment in the flow paths. This will shed light on whether *NDFI* or T_c is more appropriate for predicting high sediment loads.

Figure 1. Map of Turtle Creek Watershed. Lewisburg is Comparison of Figures 2 and 3 shows that NDFI identifies and prioritizes runoff coming from impervious surfaces as farms. Sediment transport capacity Tc, on the other hand, prioritizes steep slopes, where gravity and high runoff flow velocities contribute to erosion and high sediment transport (visible in the upper right).

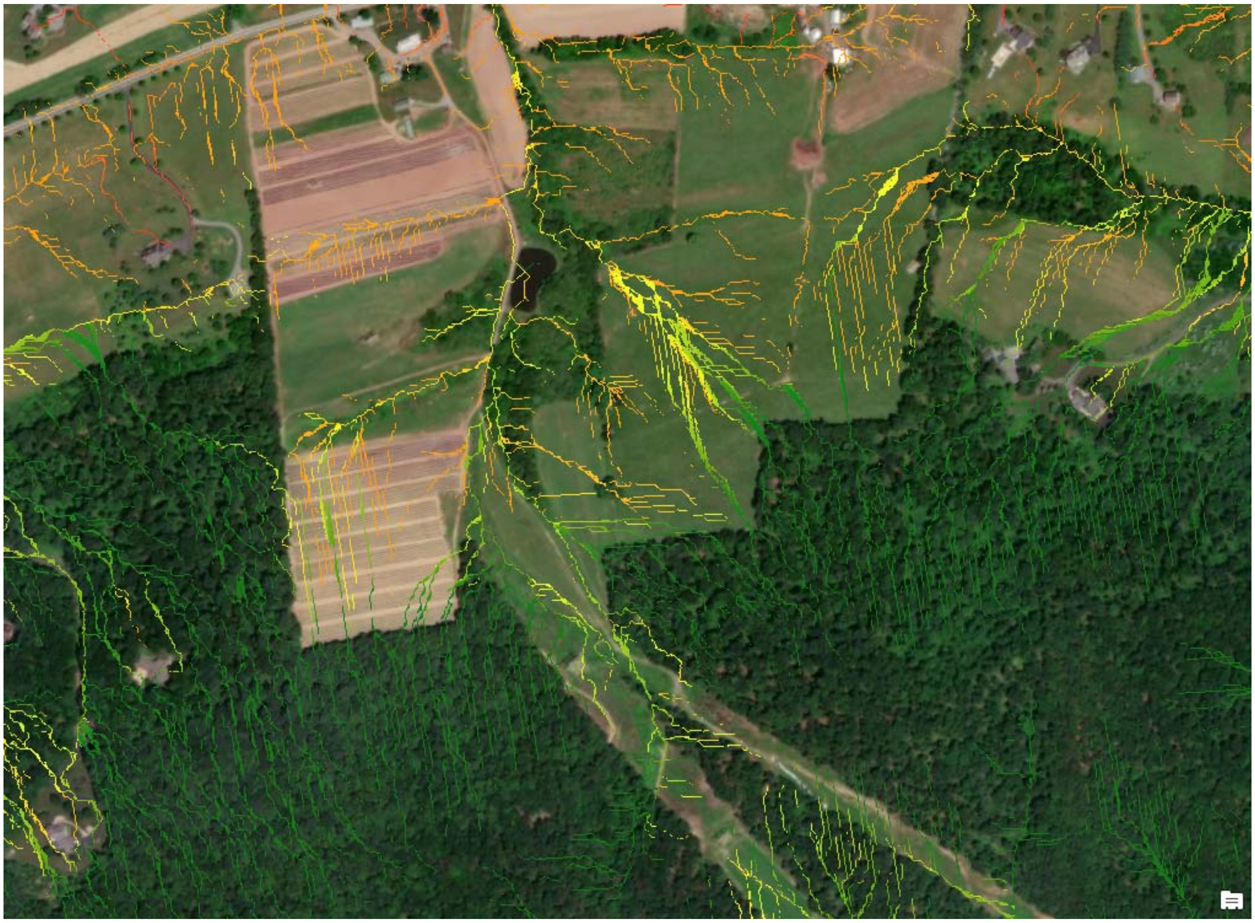

Figure 2. NDFI map showing green flow paths from forests, with a predicted low pollution potential, and yellow or orange paths from farmlands with higher potential.

Figure 3. Map of T_c, ranging from low sediment transport potential (clear) to high (dark). The land area is the same as that shown in Figure 2. Darkest areas are near the base of steep hillsides

References

Moore, I. D., and Wilson, J. P., Length-slope factors for the Revised Universal Soil Loss Equation: Simplified method of estimation, *J. Soil and Water Conserv.* 47(5), 423-428, 1992.

Wilson, J. P. and Gallant, J. C., EROS: A grid-based program for estimating spatially-distributed erosion indices, *Computers and Geosciences*, 22(7), 707-712, 1996.