Prioritizing Riparian Buffer Placement in the Chesapeake Bay Watershed

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Abstract

The Chesapeake Bay watershed stretches across six states and the District of Columbia and includes areas which are highly urbanized, agricultural, and forested. The scale and ecological diversity of the watershed present a challenge for conservation managers charged with improving the health of the Bay. Best management practices (BMPs) could be targeted spatially to make the most positive impact. We demonstrate the utility of Geographic Information Systems (GIS) and Remote Sensing to locate hotspots of sediment and nutrient pollution by investigating two separate sub-watersheds of the James River: one centered around the City of Lynchburg and the other in a more agricultural and nutrient pollution by investigating two

Precision Conservation

Local municipalities seek ways to reduce their input into waterways in response to the Environmental Protection Agency’s total maximum daily load (TMDL) requirements for sediment and nutrient pollution. Conservation efforts face limits from time and financial resources and benefit from efficient and cost-effective pollution-reduction strategies such as strategic riparian buffer placement (precision conservation). Identifying hotspots for sediment and nutrient pollution reduction through precision conservation offers municipalities an efficient way to choose the right places and scales for conservation efforts. Ultimately, such methods help localities target efforts in places where they will have the most positive impact on water quality with the least cost.

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Keywords: precision conservation, sediment and nutrient pollution, riparian buffer placement, GIS, Remote Sensing, Chesapeake Bay Watershed

Methods

1) Land Cover Classification

We used both example-based (Figure 4) and rule-based (Figure 5) classification methods for feature extraction of the NAIP imagery. These object-based methods analyze groups of pixels with similar spatial, spectral, and textural characteristics rather than classifying by individual pixels. We classified the 1 m, 4-band NAIP imagery into seven distinct land-cover classes that have differing influences on water quality: rural open, tilled agriculture, water, impervious, coniferous forest, deciduous forest, and barren.

2) Accuracy Assessment

Using 260 random samples stratified on the seven different land-cover classes, we calculated overall accuracy, user accuracy, producer accuracy, and the kappa coefficient of each classified image.

3) Concentrated Flow Path Mapping

We assigned weights to each land cover type based on whether it generally increases or diminishes nutrients or sediments in runoff. Then using digital elevation models paired with the D-Infinity flow direction model from TauDEM, we calculated and mapped flow direction for all pixels in the watersheds (Figure 6). We weighted these flow paths by land-cover type to produce our final flow accumulation maps. The method targeted stream reaches that accumulated large amounts of flow from urban and agriculture sources for potential riparian buffer BMPs.

Results

1) Land Cover Classification Accuracy

Final land cover classifications had overall accuracies around 84% (Table 1). The greatest difficulties involved discriminating between Agricultural and Rural Open and between Barren and Impervious Surface classes (Table 2).

2) Proposed Hotspots for Riparian Buffer Placement

We weighted the hydrologic flow paths using the classified land cover maps to identify areas of potentially high flow accumulation of sediments and nutrients (red in Figure 7).

Discussion and Conclusion

The combination of high resolution land cover classification and concentrated flow path mapping presents an efficient way to pinpoint areas that would most benefit from conservation efforts. The object-based approach to classification would allow examples of the analysis results overlaid back on the NAIP imagery for the site.