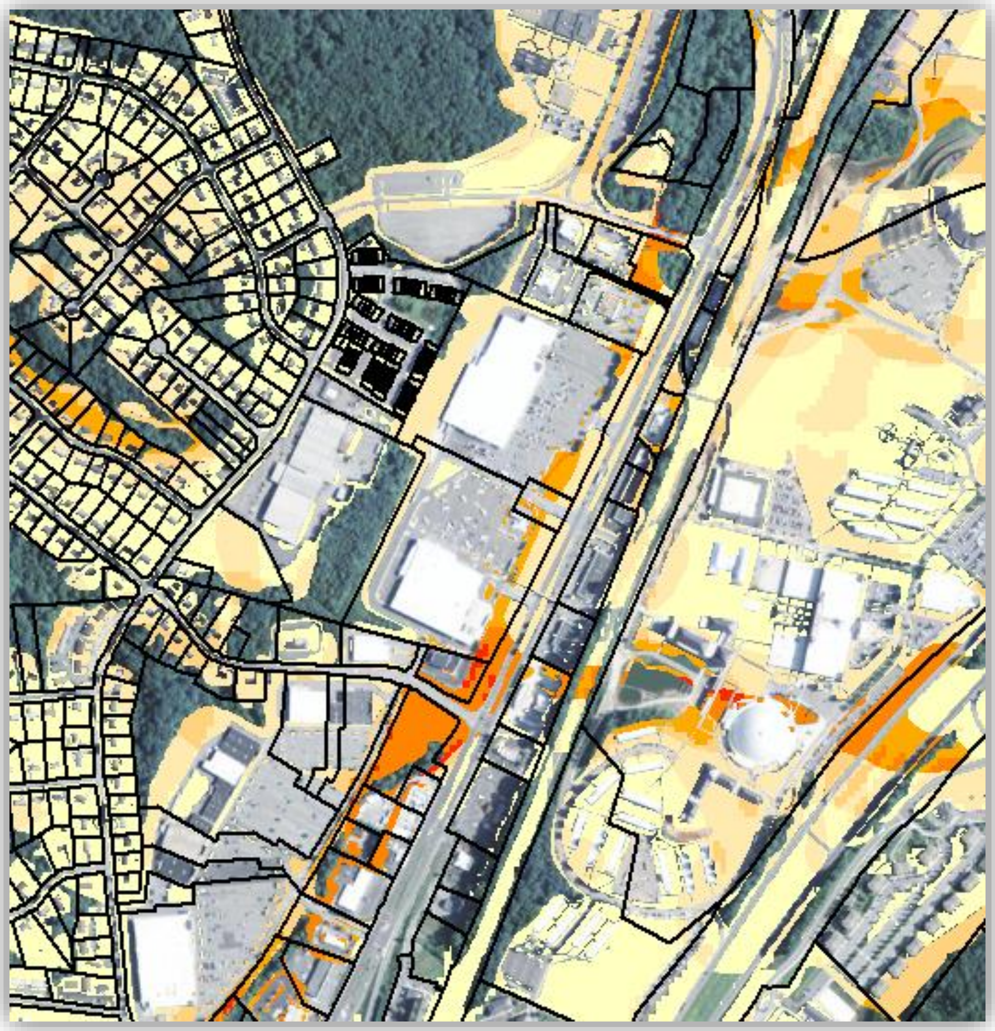
Identification of High Risk Lawns for Water Quality: Guidance for Chesapeake Bay Communities

Center for Watershed Protection

and

Chesapeake Stormwater Network



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1.0 Introduction

In 2010, the U.S. Environmental Protection Agency established the Chesapeake Bay Total Maximum Daily Load (TMDL). The TMDL limits the load of pollutants that can enter waterways, essentially establishing a comprehensive “pollution diet” with rigorous accountability measures to restore the Chesapeake Bay and all streams feeding it. The goal of the pollution diet is to reduce nitrogen (N) by 25%, phosphorus (P) by 24%, and suspended sediment by 20%. Each of the six Chesapeake Bay states (PA, NY, MD, VA, WV, and DE) and the District of Columbia developed a Watershed Implementation Plan, or WIP, which is a plan that identifies how the states and DC intend to meet their pollutant limits. The Watershed Implementation Plan has 3 Phases. Phase I entails large scale statewide efforts and strategies to meet overall basin pollutant load allocations. Phase II WIPs, are designed to more closely engage local governments, watershed organizations, conservation districts, citizens, and other key stakeholders in real on the ground strategies and programs aimed at reducing water pollution. Phase III will take place in 2017 and will seek to further refine and develop strategies based on programs and projects to meet load reduction requirements implemented after the Phase II WIP process.

Pervious urban lands comprise nearly 10% of the total watershed area of the Chesapeake Bay, and about 80% of pervious urban lands are specifically devoted to home lawns. These turf areas can be significant sources of nutrients to surface waters and the Bay; therefore, better management of fertilizer and turf biomass can help to reduce nutrient runoff from these areas. The Chesapeake Bay Program defines these management actions as a best management practice (BMP) called Urban Nutrient Management (UNM) and recently convened an expert panel to quantify the nutrient reductions associated with this BMP. The panel found that UNM has the greatest potential to reduce nutrient inputs from lawns categorized as “high risk,” i.e., having greater potential to contribute nutrients to surface waters or groundwater.

The purpose of this document is to provide guidance for Chesapeake Bay communities to identify high risk lawns in order to target their Urban Nutrient Management practices and outreach to those sites where the greatest benefit can be achieved. With this information, every community in the Chesapeake Bay can maximize the use of Urban Nutrient Management practices on public and private turf as a major strategy to help meet the Bay pollution diet.

2.0 Urban Nutrient Management and the Chesapeake Bay Watershed Model

UNM is defined as the proper management of major nutrients for turf and landscape plants on a property to best protect water quality. Core practices that involve the use of appropriate fertilizer and application, proper lawn mowing, maintenance of dense grass or conservation landscaping, and increasing lawn porosity and infiltration capability can make lawns more Bay-friendly and reduce the risk that fertilizers or plant biomass will be exported to the Bay. When combined with much lower phosphorus content in lawn fertilizer due to recent state laws, these practices can greatly reduce the risk that nitrogen and phosphorus will get into stormwater or move through groundwater.

The 2013 Chesapeake Bay Program Expert Panel Report (Schueler and Lane, 2013) identifies two different credits that are available to Bay communities:

- The first is a state-specific phosphorus reduction credit that reflects the adoption of state-wide legislation to limit or eliminate phosphorus in fertilizer products sold to the consumer. These recent laws prompted the fertilizer industry to phase phosphorus out of its products, so even states that have not yet passed laws are eligible for phosphorus reduction credit. Local governments do not have to do anything to receive the credit.

- The second is a site-specific credit for properties that employ ten core urban nutrient management practices, as confirmed by a written plan or pledge. Both a nitrogen and phosphorus reduction credit are given, the actual size of which is based on the risk that the lawn will export nutrients to the Bay. Local governments simply report the aggregate acres of urban land that are subject to UNM plans on an annual basis to get the credit.

This guidance document focuses on the second credit for individual properties that employ the core urban nutrient management practices. There are three levels of risk: high, low and blended. High risk lawns exhibit one or more of the 'risk factors' listed below in Section 3.0, while low risk lawns do not. A blended risk level may be considered a 'default' if a locality does not have data to characterize the acreages of pervious land as either high or low risk. Table 1 presents the nutrient load reduction credit for properties with urban nutrient management plans.

Table 1. Credit for urban nutrient management plans

Management Action	Nitrogen Reduction	Phosphorus Reduction
Low Risk	6%	3%
High Risk	20%	10%
Blended	9%	4.5%

3.0 Identification of High Risk Lawns

The Urban Nutrient Management Expert Panel Report (Schueler and Lane, 2013) defined high risk lawns as those with the factors listed below. Not all of these factors can be incorporated into the geospatial targeting matrix due to limitations in available GIS data layers. For example, few, if any, communities collect data on which landowners are currently over-fertilizing or over-irrigating their lawns. This guidance document relies on data that is generally available for the Chesapeake Bay watershed. However, localities are encouraged to use their own local data and incorporate additional data layers if available to improve accuracy. Section 4.0 provides a local example.

High risk lawn factors with available GIS data layers:

- Steep slopes (more than 15%)
- High water table (within three feet of surface)

- Soils that are shallow, compacted or low water holding capacity
- High use areas (e.g., athletic fields, golf courses)
- Sandy soils (infiltration rate more than 2 inches per hour)
- Adjacent to stream, river or Bay (within 300 feet)
- Karst terrain
- Newly established turf

High risk lawn factors not typically gathered in GIS data layers:

- Owners are currently over-fertilizing beyond state or extension recommendations
- P-saturated soils as determined by a soil analysis
- Exposed soil (more than 5% for managed turf and 15% for unmanaged turf)
- Over-irrigated lawns

Additional Virginia UNM High Risk Factors Stipulated by Regulation:

- Soils with high potential for leaching based on soil texture or excessive drainage
- Shallow soils less than 41 inches deep likely to be located over fractured or limestone bedrock
- Subsurface tile drains
- Soils with high potential for subsurface later flow based on soil texture and poor drainage
- Floodplains as identified by soils prone to frequent flooding in county soil surveys
- Lands with slopes greater than 15%

Localities should also consult their state TMDL implementation guidance documents for further any additional restrictions on where credit can be taken for UNM. For example, in Virginia, credit for nutrient management plans is only provided for lands outside the MS4 service area, public lands within the MS4 service area that are one contiguous acre or less, or privately owned lands where nutrients are applied that are not golf courses (Commonwealth of VA DEQ, 2015).

An overlay analysis can be used to identify high risk lawns. This method involves overlaying GIS data layers that correlate to the high risk factors listed above. All of the layers are assigned a score and intersected using GIS. The result is a new layer that contains all of the attribute information from the intersected layers so that a score can be summed for each individual polygon, which indicates its relative importance to nutrient reduction.

3.1 Obtaining Data Layers

GIS data related to this analysis that can be obtained for the entire Bay watershed is described below, including data sources and how to extract the high risk factors from the data. The USDA Geospatial Data Gateway can be used to obtain the SSURGO, NHD, and DEM data listed below all in one place - https://gdg.sc.egov.usda.gov/GDGHome.aspx. Note that individual jurisdictions may have more detailed/accurate data layers that would be more useful and should be used if available.

- USDA NRCS SSURGO Data – The USDA Natural Resources Conservation Service soil survey geographic (SSURGO) data layer is available online at: http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/survey/. The NRCS Soil Data Viewer Tool is recommended to create the needed layers. The link to install Soil Data Viewer is: http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/soils/home/?cid=nrcs142p2_053620.

After installing the tool, the Access database that comes with the SSURGO data download can be opened and the soil tabular data files for the county of interest can be imported. In ArcMap, the Soil Data Viewer tool (found under Toolbars) should be turned on. This requires loading the appropriate spatial file for the soil data, as well as loading the newly created soil database. The Soil Data Viewer allows you to select the attribute of interest and click on the "map" button to create a map layer based on the selected attribute. High risk lawn factors can be obtained using the Soil Data Viewer are included in Table 2 below.

Table 2. High risk lawn factors that can be obtained from the NRCS Soil Data Viewer.

High Risk Lawn Factor	**Attribute and (Folder) in Soil Data Viewer**	**Description**
High Water Table	Depth to Water Table (Water Features)	Select all soils that have a depth to water table of 3 feet or less. Note that the units in the soils data are in centimeters and will need to be converted.
Shallow Soils	Depth to Any Soil Restrictive Layer (Soil Qualities and Features)	Select all soils that have a depth to a restrictive layer less than 41 inches. Note that the units in the soils data are in centimeters and will need to be converted.
Sandy Soils	Saturated Hydraulic Conductivity (Ksat), Standard Classes (Soil Physical Properties)	Select all soils with a Ksat of high and very high.[1]
Floodplains	Flooding Frequency Class (Water Features)	Select all soils where flooding is classified as Frequent or Very Frequent.

[1]Permeability (percolation) was historically included in the soils data where anything greater than 2 in/hr for permeability was classified as moderately rapid, rapid, or very rapid. NRCS has declared Ksat as the scientific standard and is now using it in place of permeability. Percolation rates typically exceed Ksat by a minimum of 15% and there is no simple transformation to convert percolation rates to Ksat. The standard Ksat classifications of high and very high correlate to 1.4 in/hr and greater and are used here as a conservative estimate of the 2.0 in/hr or greater infiltration rates for permeability notes as a high risk factor in the Urban Nutrient Management Panel Expert Report (Schueler and Lane, 2013).

- Slope – Slope data can be derived from a Digital Elevation Model (DEM), such as the USGS National Elevation Dataset (NED) data. This seamless data is available in 1 Arc Second (30 meter) and 1/3 Arc Second (10 meter) data at: http://seamless.usgs.gov/. However, for many communities, locally-derived contour layers are available that provide more detail than the NED. The Topo to Raster Tool (an Interpolation tool found in Spatial Analyst) can be used to create a DEM from a contour layer where the cell values represent elevation in feet. The chosen grid cell size should be determined by the resolution of the data. Whether the NED is used or a DEM is derived from local contours, the ArcMap Surface Slope tool (part of Spatial Analyst) can be used to create a slope raster from the DEM. The raster can then be converted to a polygon using the ArcMap Raster to Polygon tool (under Conversion Tools). Select all polygons with a slope greater than 15%.

- High Use Areas (athletic fields and golf courses) – These areas can be identified by querying the locality's parcel data for schools, recreational areas, and golf courses. A visual analysis of aerial photography can also identify these areas to either verify the parcel data or to identify the high use areas when they can't be easily extracted from the parcel data.

- Streams, Rivers, or Waterbodies – The National Hydrography Dataset (NHD), unless more detailed data is available locally. NHD is a comprehensive set of digital spatial data that represents the surface water of the United States using common features such as lakes, ponds, streams, rivers, and canals. Polygons are used to represent area features such as lakes, ponds, and rivers; lines are used to represent linear features such as streams and smaller rivers. Use the ArcMap Buffer tool (under Proximity) to create a 300 foot buffer around all streams, rivers, and waterbodies. The buffers should all be merged and dissolved into one single GIS layer.

- Karst Terrain – USGS National Karst Map - These data were compiled by the U.S. Geological Survey to delineate the distribution of karst and potential karst and pseudokarst areas of the United States. Most of the spatial data originated as lithologic map units on geologic maps produced by various State geological surveys. The resolution of the geologic data ranges from 1:24,000 to 1:500,000. http://pubs.usgs.gov/of/2014/1156/.

3.2 Data Analysis

Once all the data layers are obtained, the basic steps of the high risk lawns overlay analysis are to:

1. Save all of the data identified as a high risk lawn factors as separate GIS layers. For example, one layer that contains all the soils with a depth to water table greater than 3 feet, one layer for slopes greater than 15%, and so forth.
2. Add an attribute field called "Score" in each of the layers. The Score for all of the attributes in each of the layers will be 1.
3. Union all of the high risk lawns layers using the ArcMap Union tool (part of Analysis Tools).
4. Add an attribute field called "Tot_Score." Use this attribute field to sum up the total score of all the high risk lawns layers.
5. The total score represents the potential for high risk lawns. The higher the total score, the higher the potential.

Note that a simple scoring approach is used as part of this guidance document where all identified high risk lawn factors are assigned a score of 1. In comparison, a weighted scoring approach could be used to assign a weight and rank to the individual high risk factors based on their importance or priority. The simple scoring approach was selected because high risk lawns are defined as those that exhibit one or more of the 'risk factors' listed in the UNM Expert Panel Report, without a distinction as to which factor(s) are a higher priority or variations in ranking within the individual factors. In addition, a feature overlay (intersecting polygons) approach was used. If you are conducting this analysis for a large area or want to do weighted scoring, a raster overlay may be a better option because it is computationally less demanding. For an example of a weighted scoring approach and a raster overlay analysis, see Okay and Feldt (2010).

The next step is to clip the high risk lawn ranking layer to the turf areas within your watershed or community boundary. The Chesapeake Bay Program is in the process of developing 1-meter land use data for Phase 6 of the Chesapeake Bay Watershed Model. This data will include turf areas and is estimated to be released in 2016. In the interim, turf areas can be approximated through the use of local planimetric data and land use/land cover data. By subtracting impervious cover, agricultural land, forest cover, tree canopy, and water bodies from your watershed or community boundary, the remaining areas provide a rough approximation of the turf cover. Local data will need to be used for impervious cover and agricultural land because national and Bay-wide data sources do not have a high enough resolution to be of value. Water bodies can be obtained from the National Hydrography Dataset, as described in Section 3.1. Sources of forest and tree canopy data are provided below if a local dataset is not available.

- Virginia Department of Forestry - http://www.dof.virginia.gov/gis/dwnload/index.htm
- EarthDefine Spatial Tree Canopy for Pennsylvania - http://www.earthdefine.com/spatialcover_treecanopy/pennsylvania_2013/
- Maryland iMap Forest and Canopy Cover - http://geodata.md.gov/imap/rest/services/Biota/

3.3 Using the Results

The results can be overlain with parcels in GIS to determine priority properties to target for urban nutrient management plans. The layers of interest and process for identifying priority parcels will be different for each community based on available layers and local goals. A good place to start is public lands, which can represent as much as 15% of all the pervious land in a community. These lands include parks, schools, road rights-of-ways, athletic fields, and municipal open space. The next step is to work with residents, businesses, and institutions to apply UNM practices on private lands, particularly in partnership with a local UNM plan provider.

4.0 Example from Lynchburg, VA

This section provides an example of identification of high risk lawns within the Blackwater Creek watershed in the City of Lynchburg, VA. Table 3 describes the high risk indicator layers used as part of the analysis and Figure 1 shows them each displayed individually.

Table 3. Indicator layers used to identify high risk lawns in the Blackwater Creek watershed.

Indicator Layer	Data Source	Steps to Prepare the Data
High Use Areas	City	The City's parcel data was overlain with additional layers from the City that included public schools, colleges and universities, and parks to locate athletic fields and recreational area. All parcels that contained athletic fields and recreational areas were selected.
Newly Established Turf	City	Parcels with a build date of 2013 or later were selected to identify areas that may have new turf cover.
Karst	USGS	The National Karst Map data was clipped to the watershed. Only one small area was noted as having carbonate rocks at or near the land surface.
High Water Table	SSURGO	The soil data viewer was used to select all soils with a depth to water table of 3 ft or less.

Shallow Soils	SSURGO	The soil data viewer was used to select all soils that have a depth to restrictive layer of 41 inches or less.
Floodplains	SSURGO	The soil data viewer was used to select all soils where flooding is classified as frequent. No soils were classified as very frequent within the watershed.
Adjacent to Stream, River, or Water Body	City	The City's hydrology data contains streams, rivers, lakes, ponds, river areas, and stream areas. A 300 ft buffer was created around all of these layers.
Sandy Soils	SSURGO	The soil data viewer was used to select all soils with a Ksat standard classification of high or very high.
Steep Slopes	City	A DEM was created from the City's contour data and then converted to a polygon layer. All polygons with a slope greater than 15% were selected.

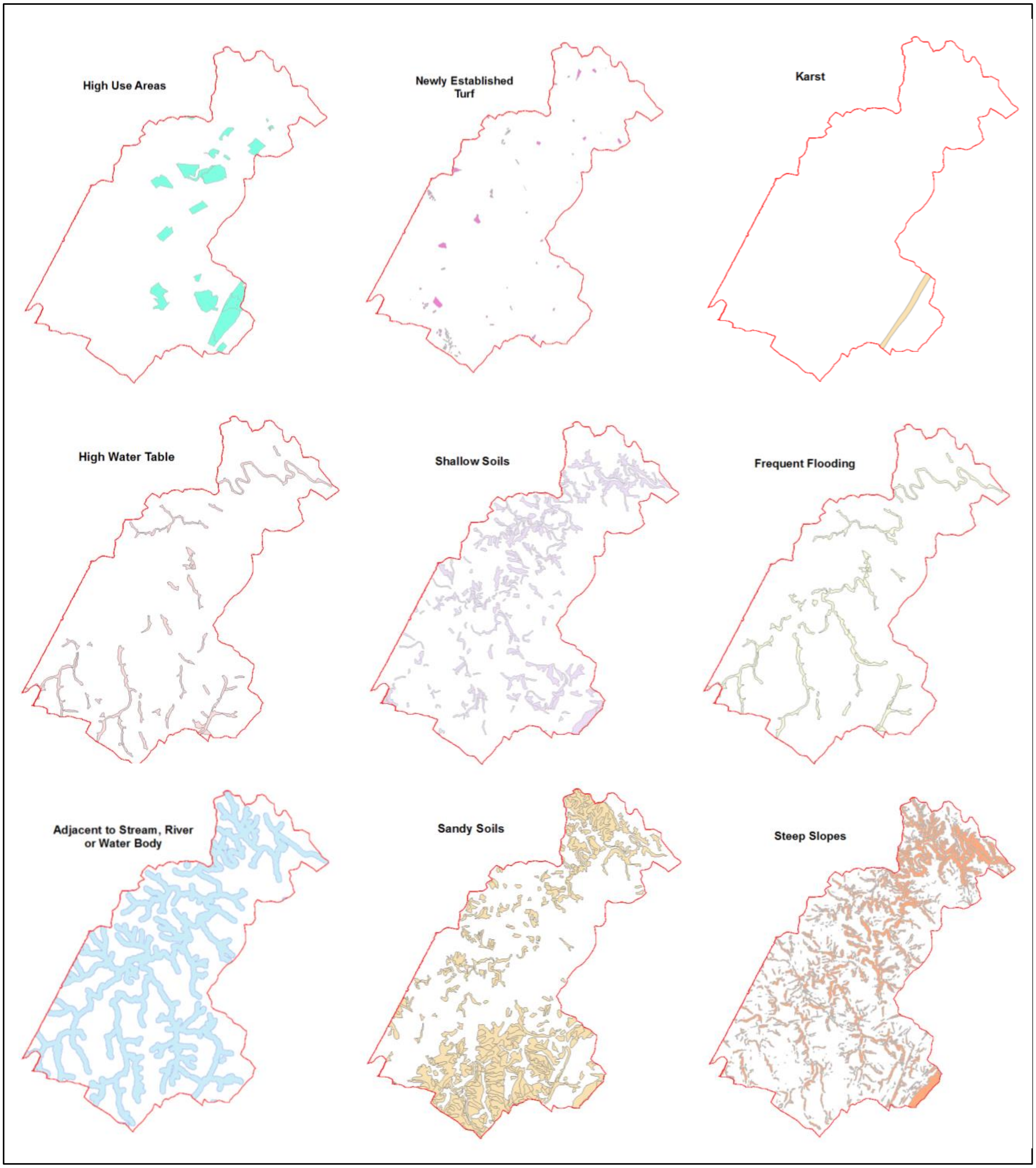

Figure 1. Blackwater Creek indicator layers

A field was added to the attribute table of each data layer to note the score. All of the features in each data layer were assigned a score of 1. A union was then done to combine all of the layers and attributes into one data layer, as shown in Figure 2. A field was added to the combined data layer to denote the total score and the scores from each of the individual data layers were summed. There were a total of 9 indicator layers, and therefore, the highest possible score was 9. After the layers were combined, the scores ranged from 1 to 6, with the higher scores indicating areas with a greater potential for high risk lawns.

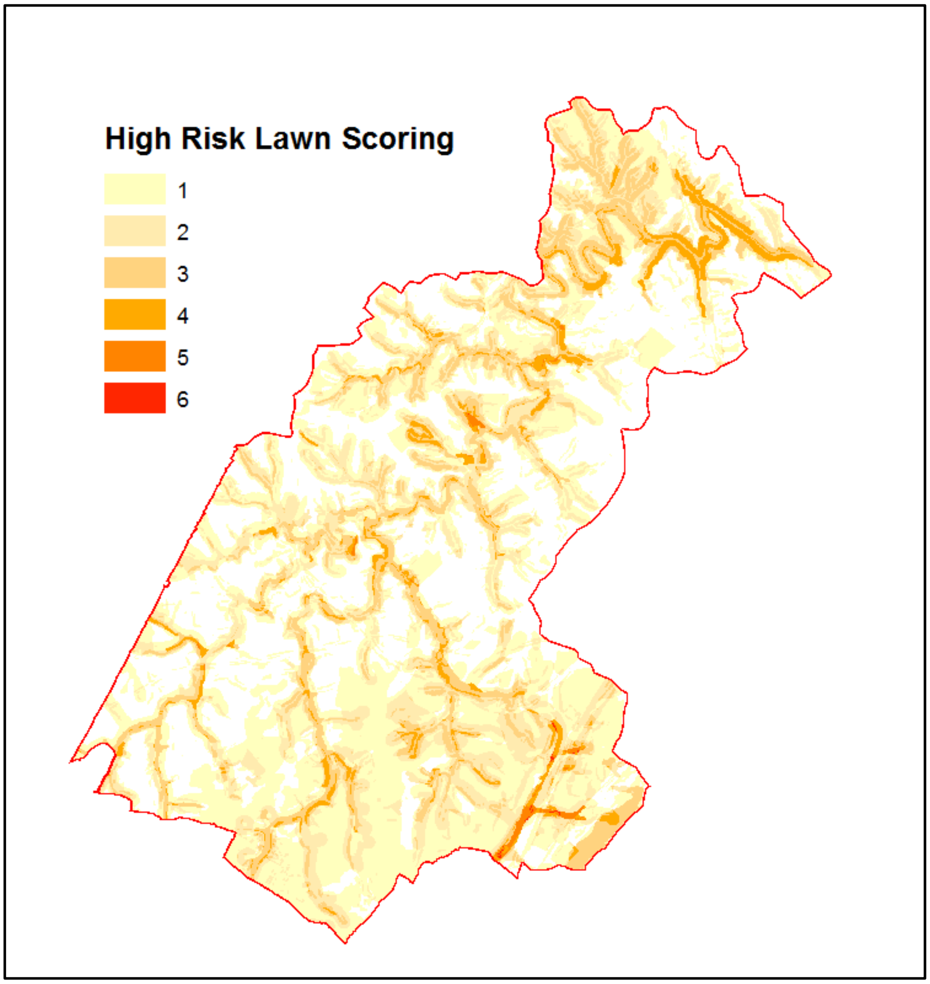

Figure 2. Combined high risk lawn indicator layers.

The next step was to identify the turf areas within the watershed. Local planimetric data obtained from the City that was used includes: bridge areas, driveways, roadway areas, parking areas, sidewalk areas, and structures (buildings). In addition to this planimetric data, a tree line layer was also obtained from the City. This layer was last edited in 2006/2007 and is not currently maintained. However, it has a higher resolution than the Virginia forest cover/tree canopy layers provided in Section 3.2 and was the best data currently available for use. Lastly, the City's lake, pond, river area, and stream area data layers were also used. A union was done to combine all of these layers into one layer that represents areas within the watershed that are not turf. The ArcMap Erase tool (under Analysis Tools) was used to subtract the areas that were not turf from the watershed boundary. The areas that remain as a result were assumed to approximate the turf cover within the watershed. The results from these analyses are shown in Figure 3 below as the areas within the watershed that are not turf and the approximated turf areas.

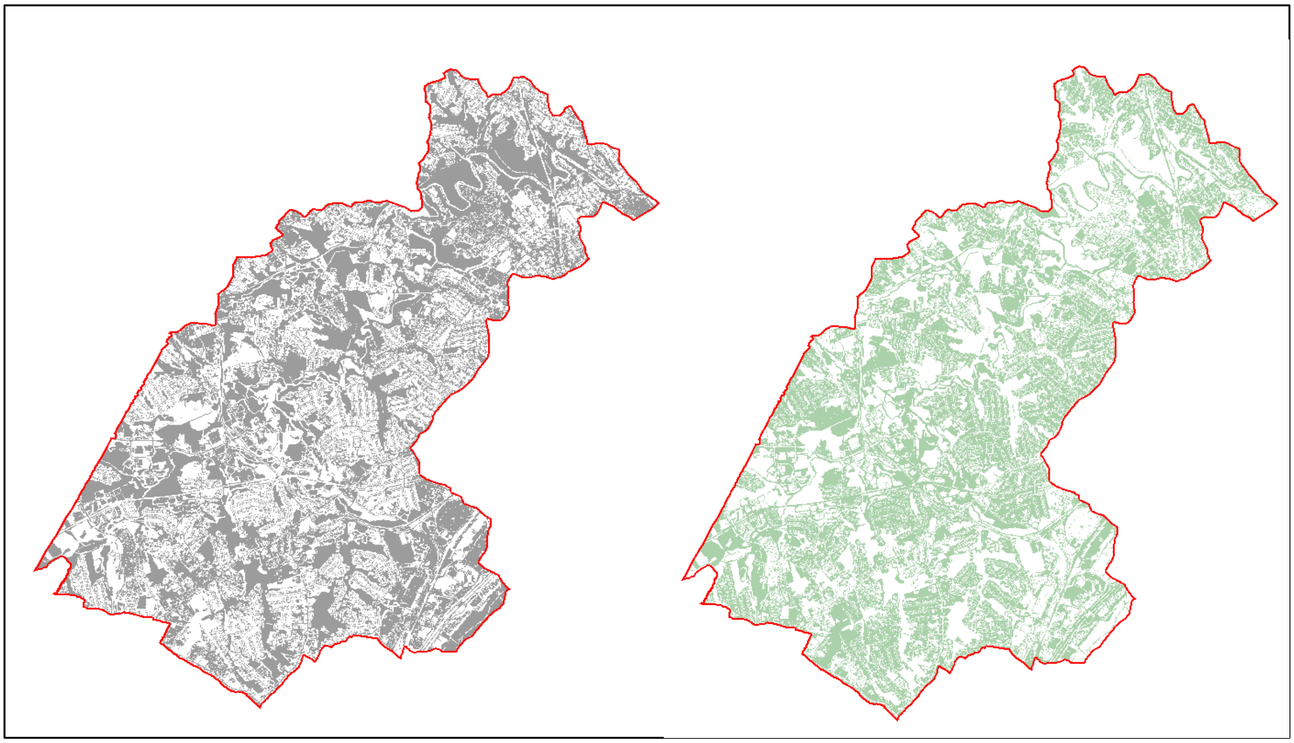

Figure 3. Areas within the watershed that are not turf (left) and approximated turf areas within the watershed (right).

The final step was to intersect the approximated turf areas from Figure 3 above with the high risk lawn scoring in Figure 2. The result is shown in Figure 4 below and represents the turf areas within the watershed that are ranked by their potential to be high risk.

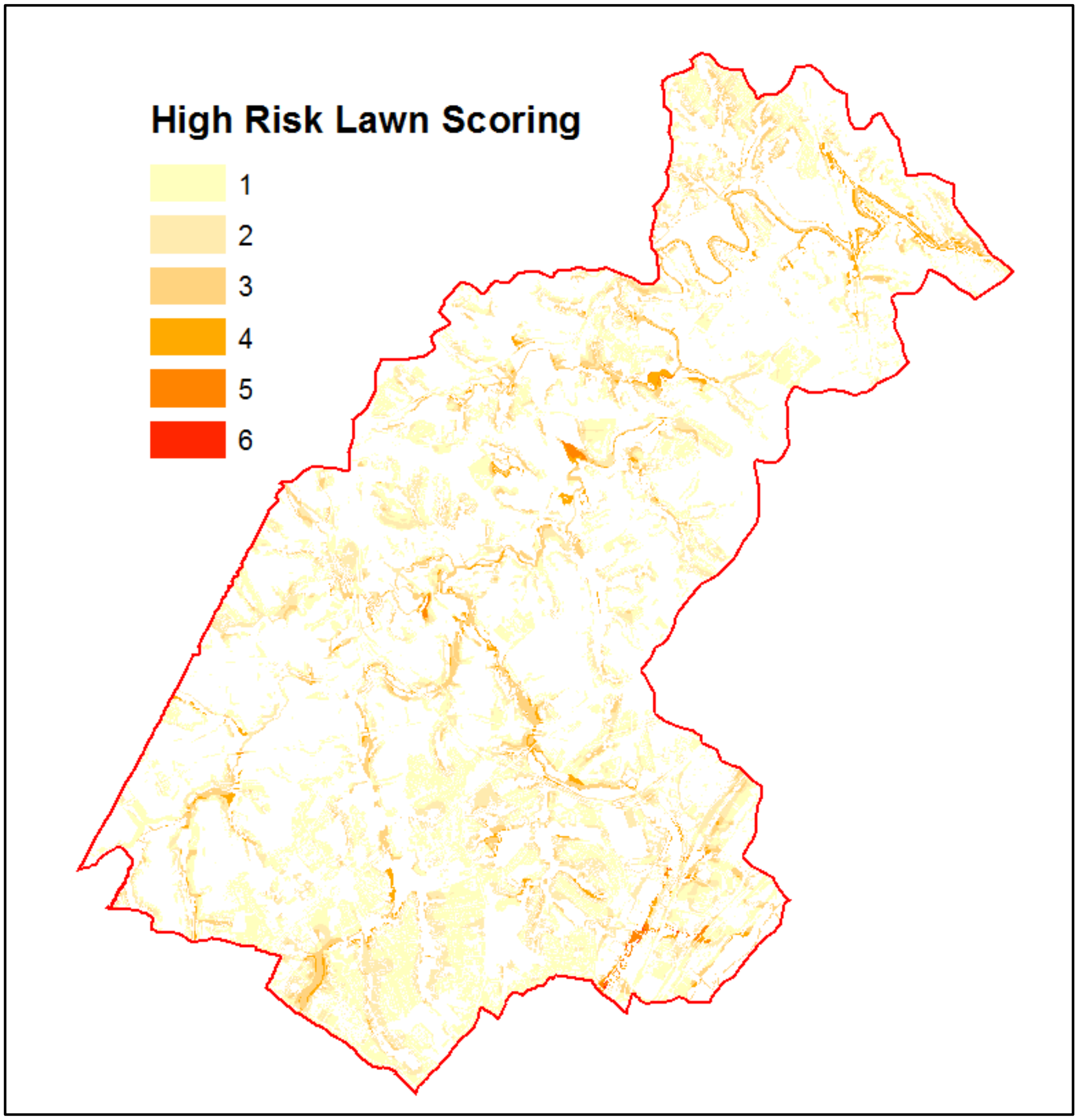

Figure 4. Turf areas within the Blackwater Creek watershed ranked according to their potential to be high risk.

The next steps that the City could take is to select the parcels that overlap the higher risk areas, verify them in the field, and evaluate them for the possibility to implement UNM plans. Figures 5 and 6 below show examples of parcels that contain high risk lawns that could be targeted for UNM.

Figure 5. Parcels within a commercial area that contain high risk lawns.

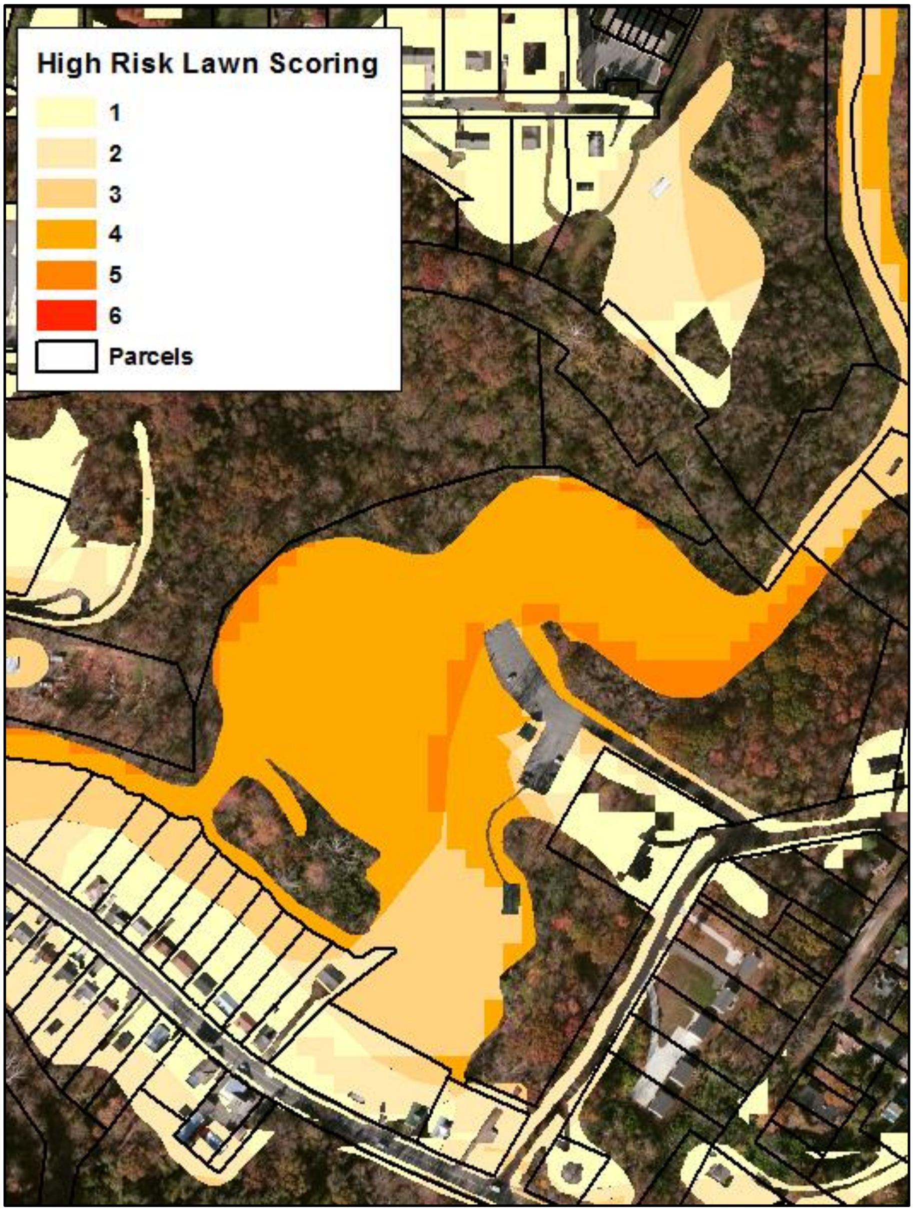

Figure 6. High risk turf identified in the Blackwater Creek recreational area.

In the example shown in Figure 5, municipal staff might select all properties where greater than 20% of the parcel has a High Risk Lawn score of 5 or 6. The parcel data could then be used to contact landowners to target an outreach program on UNM. Similarly, a community could select all single family residential properties or recreational areas (as shown in Figure 6) with greater than 1 acre of turf categorized as High Risk (a score of 4 or greater) to target for an UNM outreach or incentive program.

The exact parameters used to select the parcels of interest will depend upon the results of the ranking as well as the interest of the local program. This example analysis for the City of Lynchburg resulted in 176 acres categorized as High Risk with a score of 4 or greater. A total of 684 of the City's 31,515 parcels were found to contain high risk lawns.

5.0 Conclusion

This guidance document focused on the site-specific credit identified in the 2013 Chesapeake Bay Program Expert Panel Report (Schueler and Lane, 2013) for properties that employ ten core UNM practices. Through the identification of high risk lawns, communities can target their UNM practices and provide outreach to those sites where the greatest benefit can be achieved. The information provided in this guidance document was developed to help communities in the Chesapeake Bay maximize the use of UNM practices on public and private turf as a major strategy to help meet the Bay pollution diet.

6.0 References

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