



# Simulation of Natural Landscape Features in the Watershed Model:

## A background document for attendees of STAC's workshop titled "Beneficial Effects of Healthy Watersheds on Pollutant Fate and Transport"

The Chesapeake Bay Program's Watershed Model provides decision makers with valuable estimates of nitrogen, phosphorus, and sediment loads coming off the land and travelling into tributaries of the Chesapeake Bay. However, the model is completely dependent upon the quality of data which the Bay Program can collect. Thus the model is sometimes limited due to a lack of real or literature-derived data. An example of one such limitation could be viewed on a Sunday drive from Washington D.C. up to Frederick, Maryland. While on your drive you encounter multiple wooded areas. You might pass by Washington D.C.'s Rock Creek Park and see a wooded park surrounded by an endless array of urban streets. On your way to Frederick, you might pass by the secluded, wooded slopes of Sugarloaf Mountain. These two "forests" certainly look different to the eye, and, in reality, almost certainly filter nutrients differently. Yet, due to limited data about the differences between forests, the Watershed Model assumes that the forests in Rock Creek Park and those on Sugarloaf Mountain filter nutrients in the exact same way. It is the goal of this workshop to help provide clarity about this and other differences so that the model can be improved, and decision makers can more easily understand the value of protecting existing natural landscapes.

While the data and calculations that are used to estimate the runoff of these pollutants can be quite complicated, this factsheet attempts to break down how the beneficial effects of forests, riparian buffers, wetlands and streams are currently modeled. Much more detailed information about the model can be found at: <http://ches.communitymodeling.org/models/CBPhase5/documentation.php>.

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### DIVIDING THE LAND

Before assigning a nutrient load (the amount of a nutrient that runs off a given piece of land and into a stream) to a given area of land, the model must first divide the landscape into land uses. The Chesapeake Bay Program uses data from the National Land Cover Dataset (NLCD), the agricultural census, and a number of other sources to divide the watershed into different land uses. Here, it is important to note that not all land covers listed in the NLCD are included within the Watershed Model. In fact, while the NLCD has land cover categories for deciduous forest, evergreen forest, mixed forest, woody wetlands and emergent herbaceous wetlands, the Watershed Model lumps all of these into one land use category: "forest, woodlots, and wooded." This means that the model assumes a wetland has the same nutrient load as a forest.

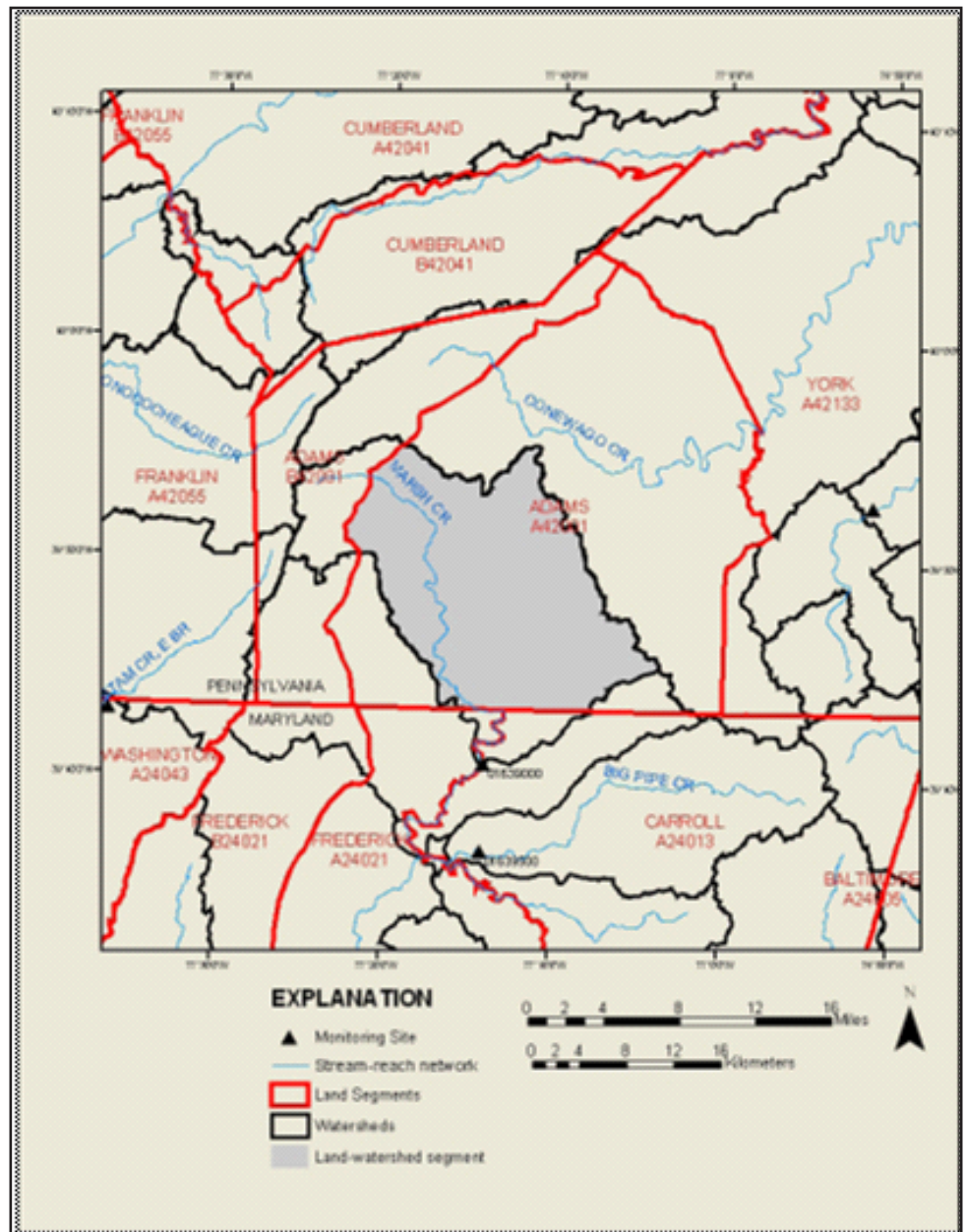
Land uses are then aggregated by county to produce county-wide acreage totals for forest, pasture, cropland, etc. These totals are further divided into what

are called land-watershed segments, or geographic areas represent the intersection of a sub-watershed and a county (See Figure 1 for a representation of a land-watershed segment overlay). This is done by overlaying a map of sub-watersheds onto a map of a county, and calculating the percent of county area that exists in each watershed, and calibrating these land uses using land cover data to ensure that land uses are applied in a rational way across the landscape. For example, one county may contain 10,000 acres of land characterized as "forest, woodlots, and wooded." If the county's land area makes up 50 percent of a sub-watershed, then the land-watershed segment is assumed to contain 5,000 acres of "forest, woodlots, and wooded." However, if land cover data clearly shows that the land-watershed segment contains more than 5,000 acres of "forest, woodlots, and wooded," then this number can be adjusted. In this way, the Watershed Model does not directly model the spatial distribution of land uses, but does attempt to place land uses in their correct land-watershed segments.

## ASSIGNING NUTRIENT LOADS

All land uses receive nitrogen from atmospheric deposition, some land uses receive additional inputs of nitrogen and phosphorus from fertilizer and manure, and all land uses export a different amount of that nitrogen and phosphorus into streams. By using an atmospheric deposition model that is calibrated to real air quality data at various locations around the Watershed, the Bay Program is able to estimate nitrogen deposition in different geographic areas across the Watershed. Similarly, inputs of fertilizer and manure are assigned according to crops grown and livestock censuses. Literature values from case studies of land uses are then used to estimate the amount of nitrogen and phosphorus that is exported from a given piece of land considering input load and other factors. For example, the model estimates that an acre of “forest, woodlots, and wooded” land contributes 3.1 pounds/year of nitrogen to the watershed.

These deposition loads are assigned to the aggregated land uses within each land-watershed segment. Continuing with our previous example, if a land-watershed segment has 5,000 acres of “forest, woodlots, and wooded,” and the model assumes that the nitrogen load for this land use is 3.1 pounds/acre/year, then the model assumes that the land-watershed segment is contributing 15,500 pounds/year to its streams and rivers, less any reductions from management practices. It is important to note that because land uses are aggregated at the land-watershed segment level, there is no variability in loads from any particular acre of forest within each



**Figure 1: Relationship between Sub-watersheds and Land Segments in the Watershed Model**

*Note: The Marsh Creek sub-watershed (outlined in black) actually covers three counties in two states. So, the Watershed Model divides the sub-watershed into smaller entities called land-watershed segments. The gray area is one such intersection that lies completely within the Marsh Creek watershed and completely within Adams County,*

segment. A forest at one location in the segment has the exact same nitrogen load as a forest in another location regardless of that forest’s distance to a stream, the slope of the land, or a number of other essential factors that help determine the forest’s real nitrogen load.

Another factor that can affect a land-watershed segment’s nutrient load is a regional transport coef-

ficient. This coefficient represents the percentage of one pound of a deposited nutrient that reaches the Chesapeake Bay. This regional transport coefficient differs across the Chesapeake Bay Watershed, and is derived from calibrating the Watershed Model with in-stream monitoring data (See Figure 2 for a map of these factors). These coefficients allow the Chesapeake Bay Program to account for regional differences in groundwater flow, soil characteristics, slope, etc that are not due to factors already in the watershed model. For example, if our 5,000 acres of forest were located within a land-watershed segment in New York, our forest would contribute an estimated 110 percent of its initially estimated nitrogen load of 3.1 pounds/acre/year, or 17,050 pounds/year. In contrast, if our 5,000 acres of forest were located within a land-watershed segment in the Coastal Plain of Maryland, our forest would contribute an estimated 50 percent of its deposited nitrogen load of 3.1 pounds/acre/year, or 7,750 pounds/year.

## APPLYING BEST MANAGEMENT PRACTICES

While we are primarily concerned with existing natural landscape features in this workshop, riparian forest buffers are an example of an existing, man-made landscape feature that filters nutrients from farmlands. The implementation of this best management practice (BMP) is “credited” with reducing pollutant loads in the Watershed Model in two ways. First, riparian forest buffers are removed from a crop or pasture land use and placed into the “forest, woodlots, and wooded”, reducing loads from the converted acreage by approximately an order of magnitude. Secondly, a coefficient is applied to reduce pollutant loads from upland land sources (See Table 1 for a listing of riparian buffer coefficients). While BMPs can be credited for reducing nutrients from upland sources, there are no credits within the model for sources upland from existing natural landscape features such as wetlands or forests.

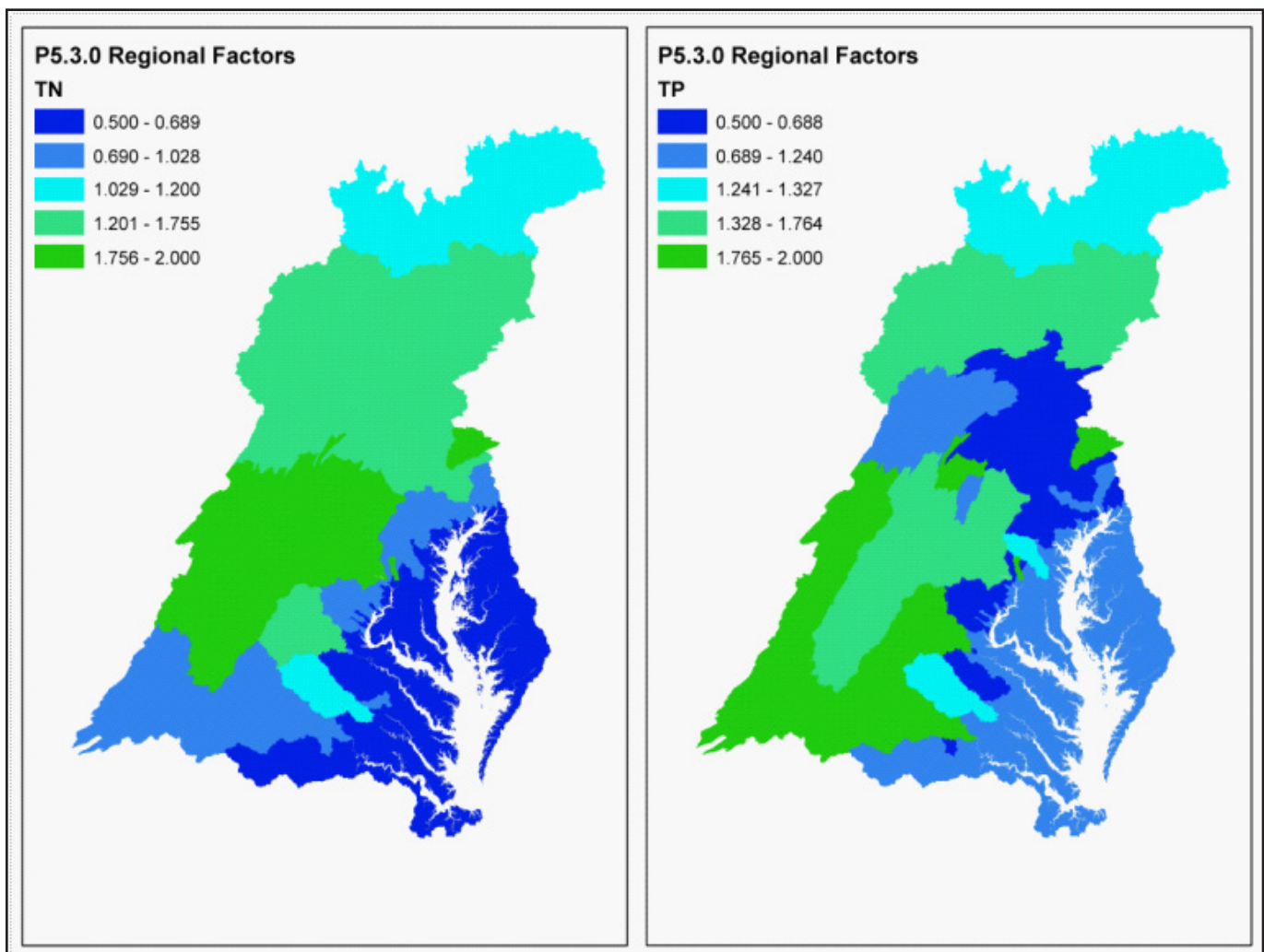


Figure 2: Regional Transport Factors for Nitrogen and Phosphorus

