Planting Trees for Water Quality: Guidance for Chesapeake Bay Communities

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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, 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.

Tree planting and forest buffers are key practices toward the needed pollution reduction. They are very cost effective strategies for achieving TMDL goals and can also help to meet other environmental mandates including MS4 permit requirements and air quality goals. Trees and forests improve water and air quality, provide recreational opportunities and wildlife habitat, and strengthen local economies, thereby improving the quality of life for everyone.

Tree planting and forest buffers have been included in each state's Phase II WIP. For example, Maryland has committed to reforesting rural residential land at a rate of 100 acres/year, the District of Columbia will increase urban tree canopy from 35% to 40% over 25 years, and Virginia will plant 99,437 acres of agricultural forest buffers and 4,115 acres of urban forest buffers. Local governments will ultimately need to determine their role in contributing to implementation of these strategies.

This guide provides information for Chesapeake Bay communities to identify where tree planting and forest buffers are needed and can provide the most benefit, and to quantify the potential pollutant reductions associated with implementation.

2.0 Trees and the Chesapeake Bay Watershed Model

The currently accepted best management practices (BMPs) involving tree planting that are included in the Chesapeake Bay Program (CBP)'s Watershed Model are forest buffers and tree planting. These BMPs can be applied on urban land or agricultural land. Definitions for each BMP are provided in Table 1 and are based on the CBP's DRAFT May 2011 documentation for the Scenario Builder model.

Table 1. Tree Planting BMPs in the Watershed Model		
BMP	**Type**	**Definition**
Forest Buffers	Agricultural	Agricultural riparian forest buffers are linear wooded areas along rivers, stream and shorelines. Forest buffers help filter nutrients, sediments and other pollutants from runoff as well as remove nutrients from groundwater. The recommended buffer width for riparian forest buffers (agriculture) is 100 feet, with a 35 feet minimum width required for most government cost share programs.
	Urban	An area of trees at least 35 feet wide on one side of a stream, usually accompanied by trees, shrubs and other vegetation that is adjacent to a body of water. The riparian area is managed to maintain the integrity of stream channels and shorelines, to reduce the impacts of upland sources of pollution by trapping, filtering, and converting sediments, nutrients, and other chemicals.
Tree Planting	Agricultural	Tree planting includes any tree planting, except those used to establish riparian forest buffers, targeting lands that are highly erodible or identified as critical resource areas.
	Urban	Urban tree planting is planting trees in an urban or residential environment. The intent of the planting is to have a living tree in that site or nearby in perpetuity and to expand the tree canopy. Tree replacement does not count. Planting 100 trees is equivalent to converting one acre of urban land to forest.

Pollution reduction for tree planting practices is calculated based on land use change and/or a pollutant removal efficiency. Land use change BMPs simply change one land use to another (e.g., agricultural land to forest land). The resulting pollutant load reduction is the difference in annual pollutant loading rate for the two land use types. Forest buffers work as both land use change and effectiveness value BMPs. In this case, the land use change is calculated first, and then an effectiveness value is applied to the pollutant loading rate for an additional number of acres of the original land use. It is assumed that the presence of these BMPs reduces the amount of nutrients delivered from upland acres as water and nutrients move through the soil matrix. Table 2 summarizes the method for calculating pollutant reduction for each of the tree planting BMPs, based on CBP (2011).

Table 2. Pollutant Reduction for Tree Planting BMPs		
BMP	**How Credited**	**Efficiency**
Forest Buffers (agricultural)	Land use change to forest in acres, plus efficiency for treating adjacent acreage	TN: 19-65% (4x acres); TP: 30-45% (2x acres); TSS: 40-60% (2x acres) (varies geographically)
Forest Buffers (urban)		TN: 25%; TP: 50%; TSS: 50% (1x acres)
Tree Planting (urban and agricultural)	Land use change to forest in acres	N/A

Communities can use the values in Table 2 to estimate pollutant reductions associated with reforestation of buffers and urban lands identified using the methods described in this guide.

3.0 Strategic Targeting of Riparian Buffer Sites

Riparian forest buffers are one of the key best management practices used in the Chesapeake Bay watershed to affect water quality and, given the scope of the effort required to meet the Bay TMDL, it is important that efforts to improve water quality be strategic and effective. Research by the USGS and USDA has shown that nutrient removal effectiveness of riparian buffers is dependent upon site-specific factors such as the depth to water table, soil properties and topography. A riparian forest buffer targeting matrix (Okay and Feldt 2010) was developed by the CBP to determine the best placement of riparian forest buffers for the most effective nutrient reduction. This geospatial targeting matrix is based on landscape attributes and the GIS data layers used are readily available and accepted by experts in the water quality community.

This method involves overlaying several map grids and assigning a rank and weight to each. The ranking and weights are used to determine a total score for each grid cell, which indicates its relative importance to nutrient reduction (Figure 1). The attributes considered in this method are: depth to water table, slope, land use, and nutrient loading. Readily available sources of data include USDA soils data, National Elevation Database, CBP land use/land cover data, and the USGS SPARROW model, although these sources should be replaced with locally available data if available at a higher resolution than these national and regional layers.

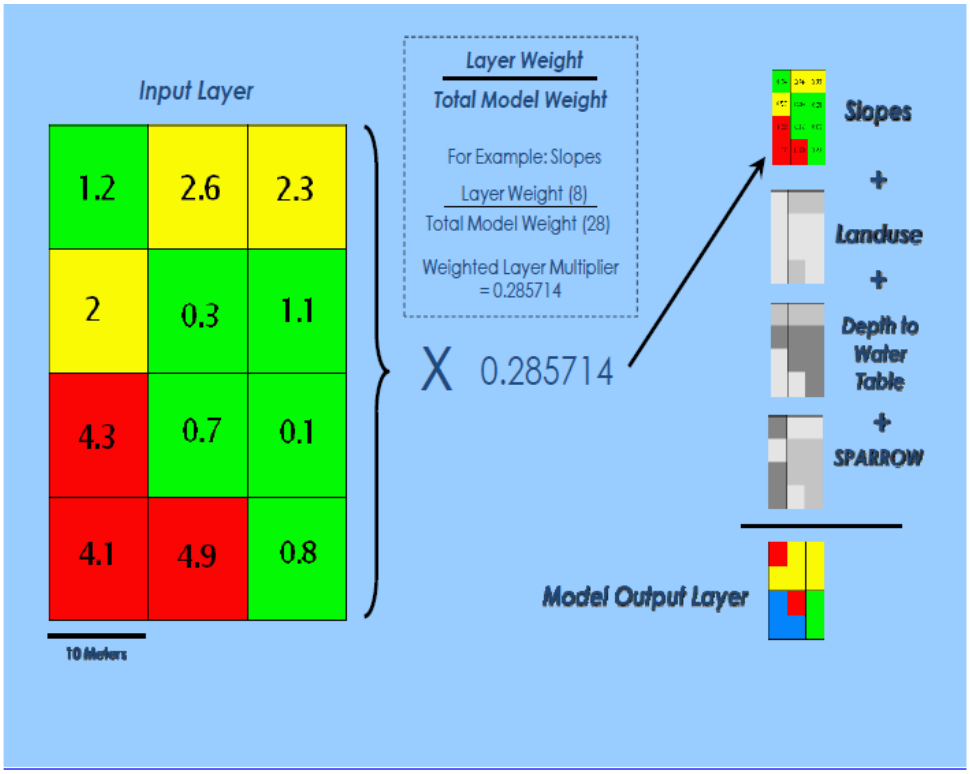

Figure 1. Graphical representation of model processing for the targeted riparian forest buffer analysis (Okay and Feldt 2010)

Details are provided below on obtaining data layers, implementing the steps of the targeting analysis and use of the results. The process developed by Okay and Feldt (2010) is the basis for this guidance, with some modifications to reflect different data sources. It is assumed that

ArcGIS (Version 10) will be used for this analysis and that Spatial Analyst is installed.

Note that the particular focus of this method is on nutrients and a broader water quality focus might not target the same areas. Regardless of where they are planted, riparian forest buffers will contribute to water quality, stream stability and habitat benefits, as well as carbon sequestration/storage and other non-water quality benefits. These are important for the Bay as well. For more on the science of riparian forest buffers and effects on water quality, see Klapproth and Johnson (2009).

3.1 Obtaining Data Layers

The USDA Natural Resources Conservation Service soil survey geographic (SSURGO) data layer is available online at: http://soildatamart.nrcs.usda.gov/. The NRCS Soil Data Viewer Tool is recommended to create the needed layers. The link to install Soil Data Viewer is: http://soils.usda.gov/sdv/. After installing the tool, the Access database that comes with the Soil Data Viewer 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 and used to create a layer based on the depth to water table. 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 (in this case, depth to water table, located under the "Water Features" category) and click on the "map" button to create a map layer based on the selected attribute.

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.

For this analysis, the land use data for the Phase 5.3.2 Watershed Model (circa 2006) can be used, unless more detailed/recent land use data is available locally. The CBP data is based on the National Land Cover Database but includes additional detail on the urban land use classes and can be downloaded from: ftp://ftp.chesapeakebay.net/Gis/. Land use categories and codes for the CBP data are as follows:

Barren = 31
Crop = 82
Deciduous forest = 41
Emergent wetlands = 95
Evergreen forest = 42
Grasslands = 71
High intensity developed (81-100% impervious) = 24
Medium intensity developed (51-80% impervious) = 23
Low intensity developed (21-50% impervious) = 22
Developed Open Space (0-20% impervious) = 21
Mixed forest = 43
Open water = 11

Pasture/hay = 81
Scrub/shrub = 52
Suburban lawns = 221
Suburban woods = 222
Unconsolidated shore = 32
Woody wetlands = 90

Water quality data, specifically the total amount of nitrogen delivered to the Chesapeake Bay, or "total delivered yield," has been estimated by the USGS using the Spatially Referenced Regressions on Watersheds (SPARROW) model. Water quality contributions from multiple sources were compiled from data collected in the 1990s and statistics calculated for each stream reach in a watershed. This produced a subwatershed-wide score for each nitrogen source, and the total amount of the combined sources. This total delivered yield value of nitrogen ("TOTTOT" in the attribute table) can be used to assign a score to this layer in the riparian buffer targeting model. SPARROW Version 3 geospatial data can be downloaded here: http://md.water.usgs.gov/gis/chesbay/sparrow3/doc/retv3.htm#section12

3.2 Creating the Model

Once the data layers are obtained, the basic steps of the riparian buffer targeting analysis are to:

1. Convert all data layers to a raster (grid) format, using the attribute of interest as the grid cell value (e.g., land use code for the land use layer).
2. For each layer, assign a rank to each grid cell based on the cell values and the rank shown in Table 3.
3. For each layer, multiply the cell ranks by the weighted layer multiplier shown in Table 4.
4. Add up cell values for all the layers to create a final grid with values representing nutrient reduction potential.

Table 3. Landscape Attributes, Ranking and Weighting for Riparian Forest Buffer Targeting Matrix

Attribute	**Rank**					**Weight**
	4 (high)	**3 (med-high)**	**2 (med-low)**	**1 (low)**	**0 (low)**	
Depth to Water Table (inches)	0 - 39.37	39.38 – 78.74	N/A	N/A	> 78.74	10
Slope (%)	0-5	5.1-10	10.1-15	N/A	>15	8
Land Use (CBP)	Barren, crop, grassland, pasture/hay, suburban lawns, developed open space	Low and medium intensity developed	Emergent wetlands, shrub/ scrub	Deciduous, evergreen, and mixed forest, suburban woods, woody wetlands	High intensity developed, open water, unconsolidated shore	6
Nutrient loading (kg/ha/yr)	>15	10.1-15	5.1-10	1.1-5	0-1	4
					Total weight	28

Once the final grid is created, parcel boundaries and other data can be overlain to identify priority planting parcels. The steps to create the model are described below.

Table 4. Weighted Layer Multiplier Used in Riparian Forest Buffer Targeting Matrix		
Layer	**Weight**	**Multiplier**
Depth to water table	10	0.357142
Slope	8	0.285714
Land use	6	0.214285
Nutrient loading	4	0.142857
Total	28	

All data layers not currently in raster format must be converted to raster files (using the Polygon to Raster function under Conversion Tools). The Cell Assignment type recommended for raster conversions is Maximum Combined Area. This means that features with common attributes are combined to produce a single area within the cell in question and the attribute of the largest area located within the cell is used to assign a value to the cell. Layers should also be put into the same projection and clipped to the boundary of interest using the Clip tool (found under Data Management/ Raster/ Processing).

Next, the Reclassification tool (located on the Spatial Analyst Toolbar) should be used to create a new raster file for each data layer with values that represent a score that is based on the layer attributes, as shown in Table 3. Note that any floating point raster files must be converted to an integer raster before any reclassification can occur. The Raster Calculator (located on the Spatial Analyst toolbar) can be used to convert a floating point raster to an integer file by entering the expression: *INT (filename)*, where *filename* is the name of the floating point raster. Figure 2 shows an example of the four grids resulting from the reclassification process.

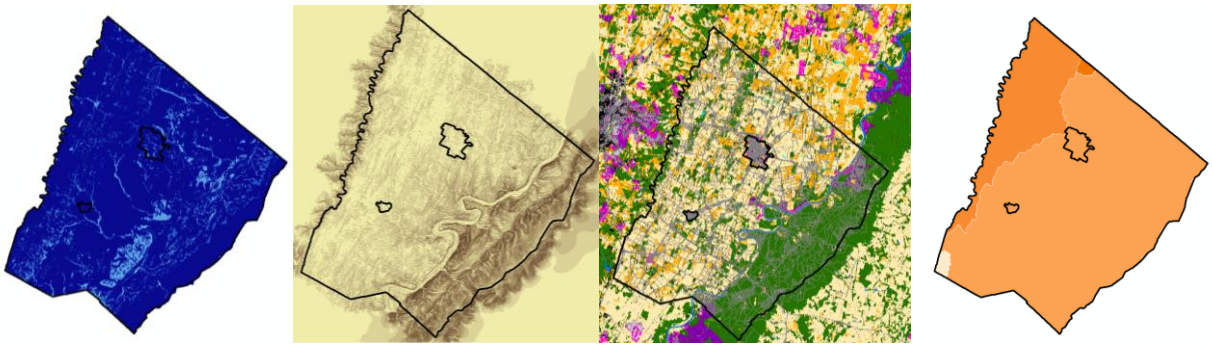

Figure 2. Input grids for the riparian forest buffer targeting analysis (from left to right): depth to water table, slope, land use, nutrient loading

The scores shown in Table 3 were based on Okay and Feldt (2010) but modified to reflect the different land use layer. If a local land use layer has different categories than what is shown here, the scoring can be adjusted. The basic premise is that a lower score is given to areas that are unable to be reforested (e.g., open water, impervious cover) and areas where changing the land use to forest would not result in significant nutrient reduction (e.g., existing forest, wooded wetlands). Conversely, a higher score is given to areas where changing the current land use to

forest would provide significant nutrient reduction and reforestation is more feasible (e.g., crop and pasture land, developed lands that have open areas such as turf and barren lands).

The weight given to the attribute in Table 3 considers the importance of that attribute in the context of the map layer being used. Although the features are all related and all important, some have more influence than others on forest buffer function. The age of the map layers and data, confidence in the accuracy also play a role in the weight value given to the particular attribute, and these can be adjusted as needed to reflect local data sources. The Weighted Sum tool (an Overlay function found in Spatial Analyst) can be used to create a new raster that sums the weighted values for all of the model layers. The weights entered in this tool are multipliers shown in Table 4 and reflect the layer weights used by Okay and Feldt (2010). The multiplier is determined by dividing the individual layer weight by the total model weight.

The final buffer targeting grid will need to be converted to an integer grid and reclassified in order to view the cell values. Because the INT function truncates values as opposed to rounding, this will result in a range of values from 0 to 3. It is recommended that the final grid be reclassified so that the values range from 1 to 4 to eliminate any zero values (e.g., reclassify 0 values to 1, 1 values to 2, 2 values to 3, and 3 values to 4). The final grid values represent the relative importance of each grid cell for nutrient reduction, with 1 representing low potential and 4 representing high nutrient reduction potential (Figure 3).

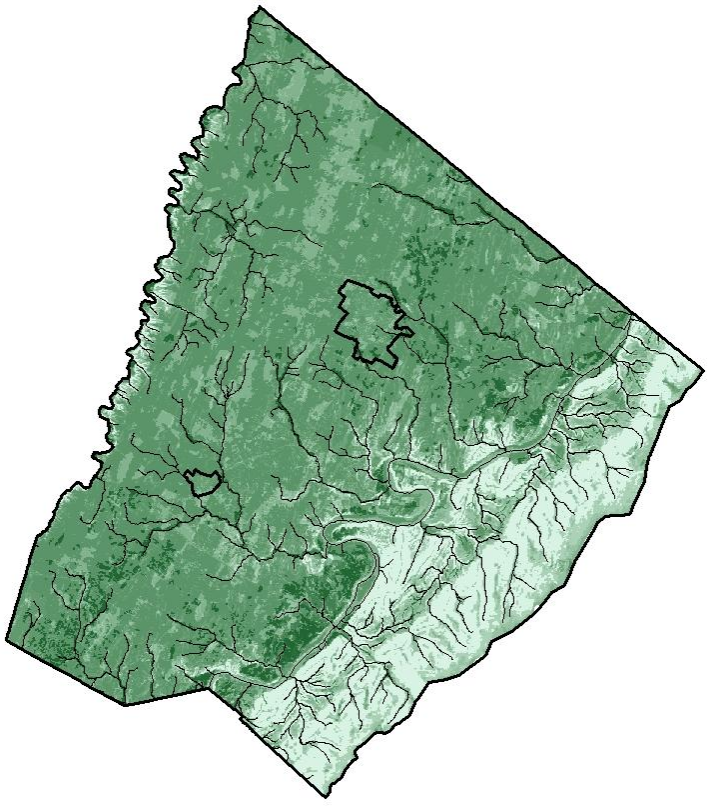

Figure 3. Final output grid where the darker green indicates a higher score for nutrient reduction with reforestation (streams shown in black)

3.3 Using the Results

The results can be overlain with data layers such as current land cover/land use, stream buffers and parcels to determine priorities for restoration. The layers of interest and process for identifying priority parcels will be different for each community based on available layers and local goals. As an example, the process used to identify priority parcels for buffer reforestation in Clarke County, VA is described below.

Using Riparian Buffer Targeting Results in Clarke County, Virginia

In Clarke County, discussions with staff identified impaired waters as an additional important layer to use in determining reforestation priorities. As a first step, the County stream layer was buffered (100 feet on either side of the stream) using GIS to create a stream buffer layer. The Select by Location function in ArcMap was used to select all County parcels that were crossed by the outline of the stream buffer layer. Several selection techniques were tested (including selecting parcels that contain or intersect the stream buffer) and the Select by Location function appeared to result in the best selection, i.e., it included all parcels that contained the buffer while minimizing the selection of parcels where only the parcel boundary intersected with the stream buffer. This process resulted in 1,943 parcels being selected from the County's 9,285 parcels and a new shapefile was created from this selection.

Next, Zonal Statistics were used to calculate the majority rank (1-4) from the riparian buffer targeting grid for each parcel in the selected parcels layer. This process created a new field within the attribute table of the selected parcels layer that identified whether the majority of cells within each parcel were ranked as 1, 2, 3, or 4. To save this data in the attribute table, the shapefile was converted to a new file with a new name. Of these parcels, a new Select by Location run selected only those parcels that were crossed by the outline of the VA DEQ impaired stream layer. This resulted in the selection of 1,103 parcels and creation of another new shapefile. A query of the data showed that 21 parcels had cells with a majority rank of 4 and 370 parcels had cells with a majority rank of 3. All 391 parcels with a majority rank of 3 or 4 were selected and used to create another new shapefile representing the priority planting parcels for the County.

Next, the acreage of each parcel was added to the attribute table of the priority planting parcels layer. All parcels with a majority rank of 4 and acreage > 2 were selected and used to create a new shapefile containing 14 parcels. Lots less than 3 acres were determined to be lower priority due to the lower likelihood of any significant acreage being available for planting on a given property of that size. The Top 14 parcels layer was recommended for use by the County as a starting point for identifying potential reforestation sites. The parcel ID in the GIS layer can be linked to the County's tax map data to determine the specific parcel owner and contact information. Once these top sites have been exhausted, the priority planting parcels shapefile can be re-queried to identify parcels with specific characteristics, such as a majority nutrient reduction rank of 3, acreage > 5, drainage to a specific impaired waterway, potential to connect to existing forest tracts, and/or existence of conservation easements, depending on the County's interest. The land use of all parcels should be verified against the most recent aerial photos before contacting landowners.

Field verification for a subset of parcels is recommended by Okay and Feldt (2010) as a final step in selecting sites for riparian restoration. In the field verification, hydrology indicators to evaluate include standing water, proximity to a body of water, or vegetation that requires or tolerates high moisture (hydrophytic) soils. Topographic features such as rolling hills, steep slopes, or lack of detectable gradient variability are also noted and land use is verified. Field verification can help to increase the accuracy of the model. Communities applying this method may wish to perform some field verification and update the model as needed.

Although priority riparian buffer sites identified through the process described here do not currently receive an increased credit for reforestation in the Watershed Model, the CBP has assembled a review panel to evaluate the possible addition of a targeted riparian forest buffer BMP and determine how to assign pollutant removal credit.

4.0 Urban Tree Canopy Assessments

Urban tree canopy (UTC) is the layer of leaves, branches, and stems of trees that cover the ground when viewed from above. In urban areas, the UTC provides an important stormwater management function by intercepting rainfall that would otherwise run off of paved surfaces and be transported into local waters though the storm drainage system, picking up various pollutants along the way. UTC also reduces the urban heat island effect, reduces heating/cooling costs, lowers air temperatures, reduces air pollution, increases property values, provides wildlife habitat, and provides aesthetic and community benefits such as improved quality of life.

The Chesapeake Bay Program (CBP) has included UTC in its strategies to improve water quality in the Bay and the Chesapeake Bay Executive Council has committed to having 120 communities develop urban tree canopy expansion goals by 2020. Figure 4 shows areas where work has begun to assess tree canopy and set goals. These localities are good targets for strategic investments to support tree canopy expansion. UTC assessments provide an idea of the potential UTC in a given community and help to identify specific planting locations for urban tree planting to achieve the UTC goal.

In order to set UTC goals,

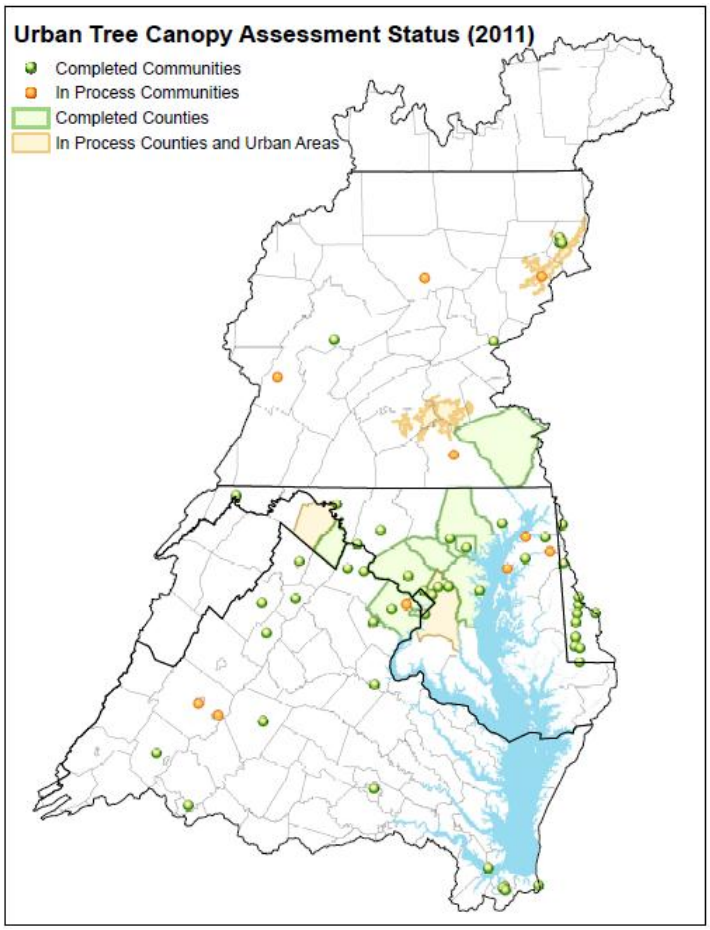

Figure 4. Municipalities with urban tree canopy assessments/goals in the Chesapeake Bay Watershed (Source: CBP)

communities must first have an idea of how much current canopy is present. The process for conducting UTC assessments and goal setting generally includes use of remote sensing imagery and GIS to quantify current tree canopy and identify locations with potential for urban tree planting. Various methods and tools are available for conducting UTC assessments. These are described briefly below.

4.1 University of Vermont Spatial Analysis Laboratory

The University of Vermont (UVM) Spatial Analysis Laboratory has developed a remote sensing approach to UTC measurement that has been applied in a number of Chesapeake Bay communities. Land cover data are analyzed to determine existing and possible UTC, while detailed parcel level information guides where to focus tree planting efforts. Figure 5 and Figure 6 show examples of the results from one of these assessments in Hyattsville, MD.

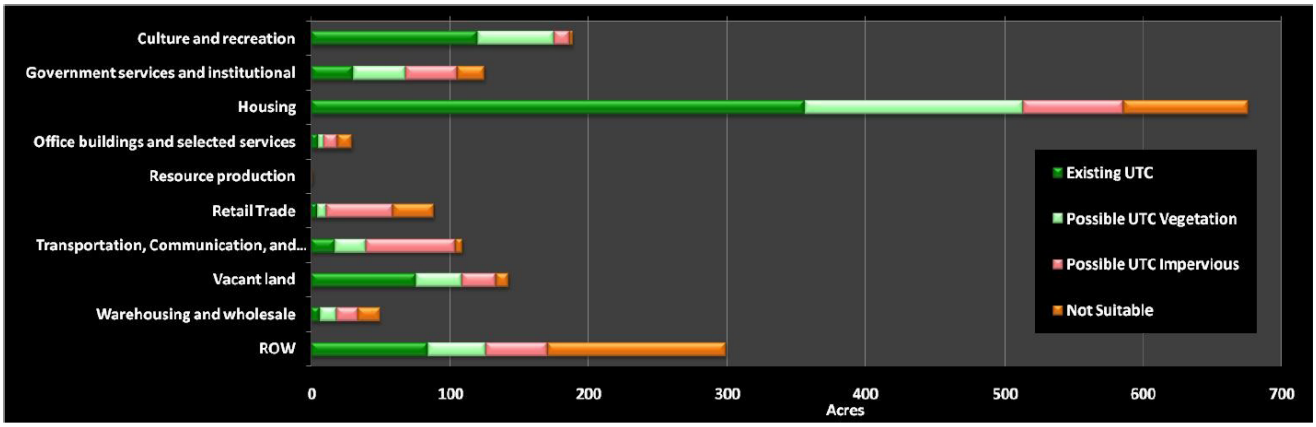

Figure 5. Existing and possible UTC by land use category in Hyattsville, MD (Source: O'Neil-Dunne, 2008)

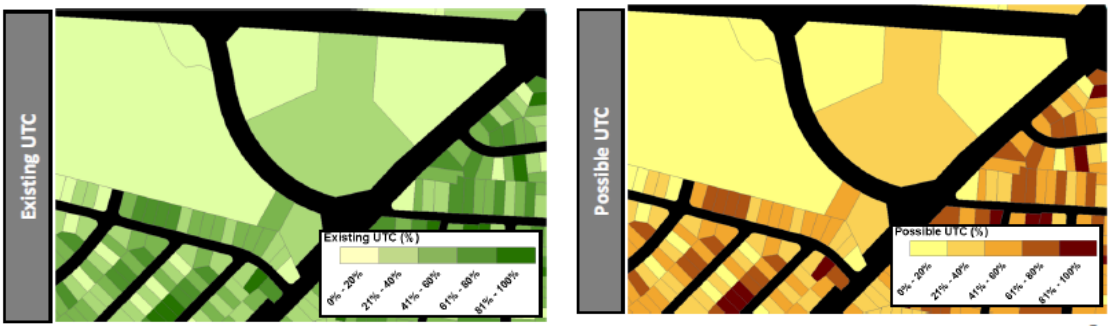

Figure 6. Parcel-based UTC metrics for Hyattsville, MD (Source: O'Neil-Dunne, 2008)

Chesapeake Bay localities who wish to have UVM perform a UTC analysis for their community can contact Jarlath O'Neil-Dunne at Jarlath.ONeil-Dunne@uvm.edu or 802.656.3324.

4.2 i-Tree VUE

The National Land Cover Database (NLCD) can be used to estimate UTC for your community. NLCD data consists of 3 types of imagery: derived from Landsat satellite data: 1) 29 Land Cover classifications; 2) Percent Impervious Cover; and 3) Percent Tree Canopy. This data is free and fairly easy to use but is relatively coarse (30 m) so it is not typically recommended for small areas. However, the Forest Service has developed correction factors for the data that account for the fact that NLCD underestimates UTC and impervious cover. The NLCD files by state, county,

and county subdivision can be downloaded here: http://nrs.fs.fed.us/data/urban, along with the reports that include the correction factors.

Using i-Tree VUE, NLCD data can be analyzed to summarize the acreage and percent tree cover and impervious cover for each land cover class in a particular community. A simple clipping tool allows users to refine basic area of interest boundaries from NLCD images within the Vue application. Interactivity with Google Maps allows for improved NLCD image interpretation. The user can select the state of interest which allows the software to apply the previously-mentioned correction factors when calculating results. Open areas with planting potential can be roughly estimated by subtracting the tree canopy and impervious cover acreage from the total acreage of the municipality of interest. I-Tree VUE also estimates some of the ecosystem services provided by the current urban forest and allows some modeling of the effects of planting scenarios on future benefits. The i-Tree software is available for free download from: http://www.itreetools.org/vue/index.php

4.3 i-Tree Canopy

With i-Tree Canopy, you review Google Maps aerial photography at random locations to conduct a canopy cover assessment within a defined project area. There are three steps to this analysis:

1. Import a file that delimits the boundary of your area of analysis (e.g., city boundary) or draw your project area boundary directly onto Google Maps.
2. Name the cover classes you want to classify (e.g., tree, grass, building). Tree and Non-Tree are the default classes given, but can be easily changed (Figure 7).
3. Start classifying each point: points will be located randomly within your boundary file. For each point, the user selects from a dropdown list the class from Step 2 that the point falls upon. It is suggested to survey 500-1000 points; the more points that are interpreted, the more accurate the estimate.

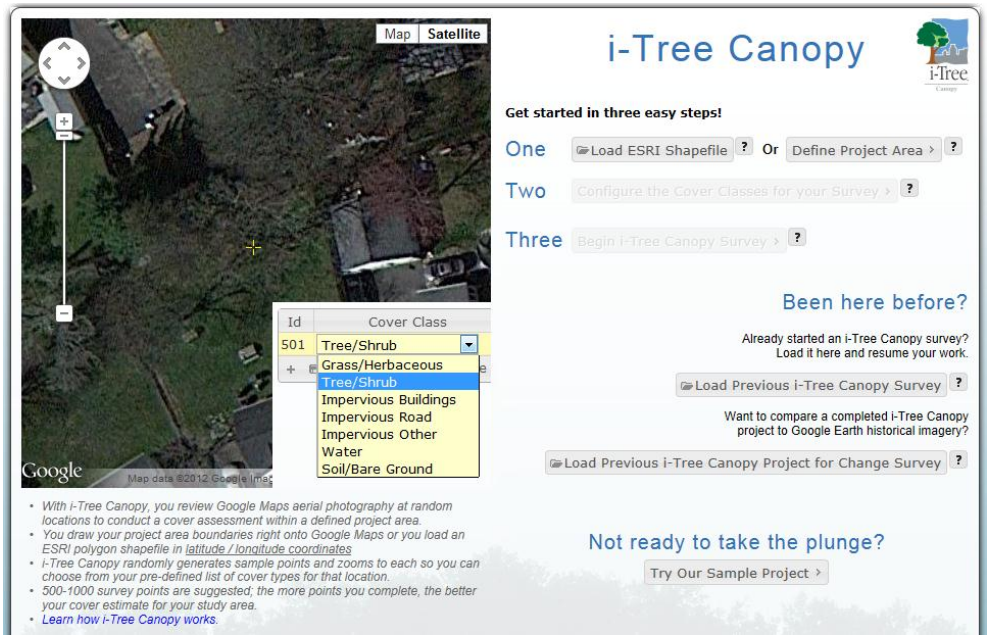

Figure 7. i-Tree Canopy land cover classification

The result of the i-Tree Canopy analysis is a statistical estimate of the amount or percent cover in each land cover class along with an estimate of uncertainty of the estimate (standard error). The i-Tree software can be downloaded at: http://www.itreetools.org/canopy/index.php.

Whichever method is used to estimate current UTC, the results provide a baseline for goal-setting. If using the NLCD data or i-Tree methods, some additional analysis of land use/cover and parcel data will be necessary to estimate potential UTC and begin to identify likely places for urban tree planting. This can be as general as quantifying the extent of non-forest pervious cover and assuming that some percentage could reasonably be reforested, or as detailed as evaluating planting potential for specific land use types, public lands or parcels. The end result is a UTC goal that is based on an assessment of how much UTC can reasonably be increased, and is translated into the number of acres and trees that must be planted to achieve the goal.

Communities using urban tree planting to achieve UTC and water quality goals must consider that sustaining healthy trees in our cities is challenging because the urban landscape does not usually reflect a tree's natural growing conditions. It is important to evaluate potential planting sites to determine if you need to apply soil amendments to improve the soils or remove invasive species to reduce competition, and to ensure the right species are selected for this site conditions. The Center for Watershed Protection's Urban Reforestation Site Assessment (provided in Attachment A) can be used for this purpose.

5.0 Turf-to-Trees Programs

Schueler (2010) estimates that turf cover in the Chesapeake Bay Watershed ranges from 2.1 to 3.8 million acres, or 5.3% to 9.5% of total Bay watershed area. This same study finds that approximately 75% of current turf cover is potentially devoted to home lawns. Most of this turf is found in the suburban counties that ring the major cities such as D.C., Baltimore, Harrisburg, Richmond and Norfolk (Schueler, 2010). Given the extent of turf cover and the water quality benefits of forests, reforestation of "extra" turf found on rural residential properties has been identified as an important strategy for some Chesapeake Bay communities to achieve their TMDL water quality goals.

5.1 Baltimore County's Rural Residential Stewardship Initiative

Baltimore County, which ranked as the #2 "turfiest" county in the Schueler (2010) study, has pioneered a "turf-to-trees" program called the Rural Residential Stewardship Initiative (RRSI). To identify potential areas to target for this program, Baltimore County Department of Environmental Protection and Sustainability (EPS) first identified riparian buffers and areas adjacent to existing forest patches in the Loch Raven and Prettyboy Reservoir watersheds as priorities. Next, a GIS analysis was conducted to evaluate parcel-scale reforestation potential based on current land cover (forested versus unforested), land ownership and conservation status, and location relative to streams. One specific threshold was to target properties having at least one acre of "excess" lawn, i.e., lawn that was not being used by the landowners for a specific purpose. Once priority neighborhoods were identified, input from landowners was used to identify specific planting areas within the neighborhoods (Figure 8).

The RRSI required extensive outreach to landowners, and resulted in a total of 38.7 acres of reforestation on lands owned by 19 different landowners. EPS worked to reduce rural landowners' perceived barriers to beneficial stewardship practices, including costs, technical knowledge of reforestation, and legal consequences of required easements for reforestation areas. EPS's experience with these projects supports the conclusion that using education, reducing barriers, and providing technical and financial incentives is just as necessary to achieve successful stewardship for rural residential landowners as it is for farmers. For more on the RRSI, see http://www.baltimorecountymd.gov/Agencies/environment/forestsandtrees/workgroup/programimplementation.html or http://www.conservationfund.org/sustainable-chesapeake/

Figure 8. Bernoudy Farms Stewardship Plan shows the actual locations of reforestation in one large-lot subdivision in Baltimore County

5.2 Identifying Potential Sites for a Turf-to-Trees Program

Chesapeake Bay communities wishing to replicate the Baltimore County program can begin by assessing the acreage potentially available for converting "turf to trees." A first step may be to consult Schueler (2010) for an initial estimate of the percent turf cover in your community. If turf is significant, a GIS analysis can help to target specific neighborhoods. Although this process will be unique to each community based on available layers and local goals, a basic approach is outlined below. This approach requires land use and parcel data at a minimum and assumes the use of ArcGIS Version 10.

Unless a community has a local turf layer available in GIS, the CBP land use data for the Phase 5.3.2 Watershed Model can be used for this analysis. The data can be downloaded here: ftp://ftp.chesapeakebay.net/Gis/. The land use category 221 (Suburban Lawns) represents the best available watershed-wide turf coverage, and was developed using the following methods: High-Intensity Developed, Medium-Intensity Developed, Low-Intensity Developed, and Developed Open Space land uses were multiplied by estimates of mean percent impervious cover for each developed class derived from the National Land Cover Dataset. The remaining 'non-impervious' portion of each developed class was considered to be pervious and consist of mostly turf grass (Claggett et al. in press).

The land use data should be re-projected if needed to overlay with local data and clipped to the boundary of interest using the Clip tool (Data Management/Raster/Processing/Clip). This clipped raster layer must be converted to a polygon using the Raster to Polygon function (under Conversion Tools). The resulting shapefile can then be intersected with the parcel polygon, resulting in a new shapefile that contains the parcel boundaries and the land use categories for each parcel. Next, parcels that are greater than one acre in size (or whatever size threshold is desired) and categorized as land use category 221 should be selected.

After an initial set of parcels has been identified, closer examination of the selected parcels can be used to determine if any changes to the selection methodology are needed. For example, if road segments or other areas that are not suitable for planting are included in the selection results, these may need to be hand selected and deleted or deleted in an automated fashion if possible. Depending on how many parcels are selected during the first cut, the acreage threshold may need to be revised if there are too few or too many parcels. Or, additional selection factors (e.g., land ownership, proximity to a stream) can be added to help with prioritization. Once priority parcels are identified, specific neighborhoods or subdivisions having significant acreage available for planting may be identified as possible sites for a turf-to-trees program.

The results can be used to focus discussions with residents in these neighborhoods to evaluate interest in a turf-to-trees program, identify specific planting areas, target land protection efforts, and address any landowner concerns. Since sites planted under these programs are privately owned, it will be especially important to have a maintenance agreement in place to maximize tree survival. A sample maintenance agreement is provided in Attachment B. Turf-to-trees programs can maximize forest restoration on residential land currently managed as lawn, which provides the largest opportunity for reforestation in many suburban watersheds.

6.0 Resources for Reforestation Planning and Forest Management

Identification of high priority reforestation sites and the development of tree planting programs are only the first steps to achieving water quality benefits. Developing and adopting policies and guidelines for community tree planting projects can ensure that projects that are appropriately designed and installed. This includes providing guidelines for species selection, size, arrangement, spacing, and maintenance with a focus on long-term project success and forest health.

Species selection should be guided by the documented historical ranges of native trees in the specific hardiness zone and physiographic province where the project is occurring. Additionally species selection should, to the extent possible, favor tree species that provide greater ecosystem benefits and generally favor larger canopy native species over smaller ornamental species. Choosing the best tree stock size (i.e., seedlings, containerized, ball and burlap, caliper) is often a function of project budget; however, site access, anticipated maintenance level, aesthetic concerns, and the overall site characteristics can play a significant role in dictating the size of plant material desired. Generally, larger tree stock requires more maintenance (i.e., watering) over a longer period of time; however, survival is anticipated to be higher. The arrangement of trees within the project site is critical to ensure that trees are planted where they match the site characteristics. While tree spacing is often tied to species, stock, and anticipated maintenance activities, it is critical that trees are adequately spaced to ensure that desirable canopy species compete favorably, and yet have adequate stocking density to be creditable. Reforestation is an act of stewardship and the ultimate success of the forest is linked to continued forest stewardship throughout the establishment period and into the long-term management of the established forest.

Some additional resources for reforestation planning and reforestation management are listed below.

- Baltimore County Department of Environmental Protection & Sustainability. 2012. *Policy and Guidelines for Community Tree Planting Projects.* Towson, MD.

- Cappiella, K., Schueler, T., Tomlinson, J., and T. Wright. 2006. *Urban Watershed Forestry Manual. Part 3: Urban Tree Planting Guide.* NA-TP-01-06. USDA Forest Service, Northeastern Area State and Private Forestry. Newtown Square, PA. http://na.fs.fed.us/watershed/pdf/Urban%20Watershed%20Forestry%20Manual%20Part%203.pdf

- Maryland Department of Natural Resources Forest Service. 2005. *Riparian Forest Buffer Design and Maintenance*. Annapolis, MD. http://www.dnr.state.md.us/forests/download/rfb_design&maintenance.pdf

- Watershed Forestry Resource Guide, *Planting and Maintaining Trees*: http://www.forestsforwatersheds.org/planting-and-maintaining-trees/

References

Chesapeake Bay Program (CBP). 2011. *ESTIMATES OF COUNTY-LEVEL NITROGEN AND PHOSPHORUS DATA FOR USE IN MODELING POLLUTANT REDUCTION DOCUMENTATION FOR SCENARIO BUILDER VERSION 2.4.* Completed for the U.S. EPA. May 2011 DRAFT.

Claggett, P., Irani, F., and R. Thompson. In press. *Estimating the Extent of Impervious Surfaces and Turf Grass Across Large Regions.* Journal of the American Water Resources Association.

Klapproth, J. C. and J. Johnson. 2009. *Understanding the Science Behind Riparian Forest Buffers*. Virginia Cooperative Extension, Blacksburg.

Okay, J. and R. Feldt 2010. *Guidance for Use of Landscape Targeting Matrix for Riparian Forest Buffer Effectiveness.* *http://archive.chesapeakebay.net/pubs/calendar/FWG_09-01-10_Handout_4_10993.pdf*

O'Neil-Dunne, J. 2008. *A Report on the City of Hyattsville's Existing and Possible Urban Tree Canopy.* Prepared by the University of Vermont for the City of Hyattsville, MD.

Schueler, T. 2010. *The Clipping Point: Turf Cover Estimates for the Chesapeake Bay Watershed and Management Implications*. CSN Technical Bulletin No. 8. Chesapeake Stormwater Network. Ellicott City, MD.

Attachment A: Urban Reforestation Site Assessment

Urban Reforestation Site Assessment (URSA)

1. General Site Information

Location:

Property owner:

Current landuse:

2. Climate

USDA plant hardiness zone:

Sunlight exposure:

- ☐ Full sun (6 hours or more of direct sun per day)
- ☐ Part sun or filtered light (< 6 hours per day)
- ☐ Shade (< 3 hours of direct sun per day)

Micro-climate features (check if present):

- ☐ High wind exposure
- ☐ Re-reflected heat load
- ☐ Other:

3. Topography

Steep slopes

Are any slopes > 15% present in the proposed planting area? Y/N

If Yes, estimate slope:

Low-lying areas

Are any low-lying areas present in the proposed planting area? Y/N

Notes:

4. Vegetation

Regional forest association (or dominant species from reference site):

Current vegetative cover (check all that apply and note percent of planting area):

- ☐ Mowed turf: _____%
- ☐ Other herbaceous: _____%
- ☐ None: _____%
- ☐ Trees or shrubs: _____%

Note species to be preserved:

Are invasive plants/noxious weeds present? Y/N

If Yes, note species and % coverage at site

Adjacent vegetative cover:

Is forest present? Y/N

If Yes, note dominant species:

Are invasive plants/noxious weeds present? Y/N

If Yes, note species and % coverage at site

5. Soils

Texture:

- ☐ Clay
- ☐ Loam
- ☐ Sand

Drainage:

- ☐ Poor (< 1” per hour)
- ☐ Moderate (1” - 6” per hour)
- ☐ Excessive (> 6” per hour)

Compaction:

- ☐ None
- ☐ Moderate
- ☐ Severe

pH:

- ☐ Acid (5.0 – 6.8)
- ☐ Neutral (6.8 – 7.2)
- ☐ Alkaline (7.2 – 8.0)

Other soil features (check if present and describe:

- ☐ Active or severe soil erosion
- ☐ Potential soil contamination
- ☐ Debris and rubble in soil
- ☐ Recent construction or other soil disturbance
- ☐ Other:

Soil Chemistry

List results of soil tests if applicable (e.g., levels of phosphorus, salt, or organic matter in the soil). Describe any visual indicators of soil quality.

6. Hydrology

Site hydrology:

- ☐ Upland
- ☐ Riparian

Note: For riparian planting sites where planting is proposed on both stream banks, fill this section out for each bank individually

Stormwater runoff to planting site (check all that apply):

- ☐ Bypasses site in pipe
- ☐ Upslope drainage area outfalls to site

Note diameter of pipe outfall:

- ☐ Open channel directs flow across or around the site
- ☐ Shallow concentrated flow (e.g., evidence includes rills, gullies, sediment deposits)
- ☐ Sheetflow
- ☐ Unknown

Contributing flow length:

Slope: _____%

Length: _____ft

Dominant cover type:

- ☐ Impervious
- ☐ Pervious

Floodplain connection (riparian areas only):

Are levees present? Y/N

Bank height: _____ft

Depth to water table (optional): _____ft

Stream order: _____

Contributing Flow Length Sketch:

7. Potential Planting Conflicts

Space limitations (check if present, and note height of overhead wires, signs and lighting):

- ☐ Overhead wires: _____ft
- ☐ Pavement
- ☐ Structures
- ☐ Signs: _____ft
- ☐ Lighting: _____ft
- ☐ Underground utilities

Note type:

- ☐ Other:

Other limiting factors (check if present and describe below):

- ☐ Trash dumping/debris
  Note type of trash, volume (estimated pickup truck loads), and source if known:
- ☐ Deer, beaver or other animal impacts
- ☐ Mowing conflict (e.g., site is mowed regularly)
- ☐ Wetland present
- ☐ Insect infestation or disease
- ☐ Heavy pedestrian traffic
- ☐ Other:

Notes:

Local Ordinance Setbacks

Check local ordinances or utility requirements and note any required setbacks from these features.

8. Planting and Maintenance Logistics

Site access (check if present):

- ☐ Delivery access for planting materials
- ☐ Temporary storage areas for soils, mulch, etc.
- ☐ Heavy equipment access
- ☐ Volunteer parking
- ☐ Nearby facilities for volunteers

Party responsible for maintenance (if known):

Water source (check all that apply):

- ☐ Rainfall only
- ☐ Storm water runoff
- ☐ Hose hook-up nearby
  Note distance from hook-up to planting area (ft):
- ☐ Irrigation system in place
- ☐ Overbank flow from river or stream
- ☐ Fire hydrant nearby
- ☐ Other:

9. Site Sketch

Sketch the site below and include the following features at a minimum:

- ☐ Property boundary, landmark features (e.g., roads, streams) and adjacent land use/cover
- ☐ Boundary and approximate dimensions of proposed planting area
- ☐ Variations in sun exposure, microclimate and topography within planting area
- ☐ Current vegetative cover, location of trees to be preserved and invasive species
- ☐ Location and results of soil samples (if variable)
- ☐ Flow paths to planting area and contributing flow length
- ☐ Above or below ground space limitations (e.g., utilities, structures)
- ☐ Other limiting factors (e.g., trash dumping, pedestrian paths)
- ☐ Water source and access points
- ☐ Scale and north arrow

Attachment B: Sample Maintenance Agreement

SAMPLE TREE MAINTENANCE AGREEMENT

This Agreement constitutes the long term protective agreement for _____ acres of reforestation/afforestation in _____(jurisdiction). This Tree Maintenance Agreement between _____ (entity) and _____ (landowner) certifies that customary and reasonable tree care and maintenance will be performed for three (3) years for trees planted under the terms of the _____ (tree planting program) and that the landowner will maintain the area identified for tree planting with the objective of creating forest conditions.

The Landowner agrees to maintain the area designated for tree planting to the minimum standards for care contained in the Forest Stewardship Plan. Typical tree maintenance activities include, but are not limited to, watering (optional but encouraged), pruning, mulching (if applicable), maintaining deer protection (if applicable), maintaining weed mat (if applicable) and control of undesirable vegetation. Additionally, when conducting maintenance operations the Landowner agrees to implement reasonable measures to prevent damage to the bark by mowers, string trimmers, tractors or other maintenance equipment.

I have read and understand the above requirements and responsibilities.

Signature: _____Date_____
Printed Name: _____
Address: _____
Phone: _____