Urban Watershed Forestry Manual

Part 1: Methods for Increasing Forest Cover in a Watershed

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Part 1: Methods for Increasing Forest Cover in a Watershed

Prepared by:

Karen Cappiella, Tom Schueler, and Tiffany Wright
Center for Watershed Protection
8390 Main Street, Second Floor
Ellicott City, MD 21043
www.cwp.org
www.stormwatercenter.net

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Forest Service
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11 Campus Boulevard, Suite 200
Newtown Square, PA 19073
www.na.fs.fed.us

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ABOUT THIS MANUAL SERIES

This manual is one in a three-part series on using trees to protect and restore urban watersheds. A brief description of each part follows.

Part 1: Methods for Increasing Forest Cover in a Watershed introduces the emerging topic of urban watershed forestry. This part also presents new methods for the watershed planner or forester to systematically measure watershed forest cover and select the best methods for maintaining or increasing this cover by protecting, enhancing, and reforesting large parcels of primarily public land across the watershed. These methods are based on extensive review of the latest research and input from experts in a wide range of related ýelds.

Part 2: Conserving and Planting Trees at Development Sites presents speciýc ways to enable developers, engineers, or landscape architects to incorporate more trees into a development site.

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Participants of the two design workshops are listed below:

- Matt Arnn, USDA Forest Service
- Miles Barnard, Southfork Studios
- Ken Belt, USDA Forest Service
- Ted Brown, Center for Watershed Protection
- Rick Brush, Montgomery County, MD, Department of Permitting Services
- Karen Cappiella, Center for Watershed Protection
- Sally Claggett, USDA Forest Service
- Steve Cohen, KCI Technologies, Inc.
- Stewart Comstock, Maryland Department of the Environment
- Martha Corrozi, Chesapeake Bay Program
- Martin Covington, Carroll County, MD, Bureau of Resource Management
- Jennifer Curkendall, USDA Forest Service
- Doug Curtis, National Park Service, U.S. Department of the Interior
- Allen Davis, University of Maryland
- Barbara Deutsch, Casey Tree Endowment
- Mike Galvin, Maryland Department of Natural Resources
- Steve Genua, Potomac Electric Power Company (PEPCO)
- Jason Grabosky, Rutgers University
- Mark Green, City of Topeka, KS
- Guy Hager, Parks and People Foundation
- Michael Helfrich, Gamma Engineering
- Lili Herrera, Cornell University
- Brian Le Couteur, Metropolitan Washington Council of Governments
- Vicki Luther, Carroll County, MD, Bureau of Resource Management
- Reggie Parrish, U.S. Environmental Protection Agency
- Rich Pouyat, USDA Forest Service
- Graham Ray, Deep Root Partners, L. P.
- Julian Ray, Deep Root Partners, L. P.
- Phillip Rodbell, USDA Forest Service
- Frank Rodgers, Parks and People Foundation
- Tom Schueler, Center for Watershed Protection
- Richard Straight, USDA Forest Service
- Anne Strang, Maryland Department of Natural Resources Forest Service
- Chris Swann, Center for Watershed Protection
- Al Todd, USDA Forest Service
- Jim Urban, James Urban and Associates
- Charles Wallis, Maryland Department of the Environment
- Tom Whitlow, Cornell Urban Horticulture Institute
- Tiffany Wright, Center for Watershed Protection
- Kaveh Zomorodi, Dewberry and Davis
- Roberta Zwier, AMEC Earth and Environmental

List of Text Boxes

Chapter 1: Introduction to Urban Watershed Forestry

This chapter introduces urban watershed forestry concepts, and makes the case as to why communities should integrate trees and forests into their planning practice in both developed and developing watersheds. Included are a discussion of terminology, principles, goals, objectives, and techniques related to urban watershed forestry; a review of the impacts of urbanization on forests and watershed health; a review of the watershed beneýts of forest cover; and unique considerations for reforesting urban areas.

What Is Urban Watershed Forestry?

Since the 1980ôs, urban forest research and new technical analysis tools have deýned a wider role and value for urban trees. There is greater recognition of how urban trees and forests improve air and water quality, reduce storm water runoff, conserve energy, and protect public health. Increasingly, these beneýts are being better deýned and quantiýed through scientiýc research. At the same time, the loss of trees and forests in developing watersheds continues, and urban tree canopy in inner cities deteriorates through removal or lack of replacement. The rate of conversion of forests to urban uses increased twofold from 1982 to 2001 in the United States, reinforcing the need for greater integration of forest and land use planning (NRCS, 2001).

The magnitude of impacts due to the loss of green space in urban watersheds, such as increased runoff and impervious cover, demonstrates the vital role of forestry in urban watershed management. Past approaches to restoring urban watersheds that have relied on structural solutions have failed to protect and restore urban streams. Many practitioners in the engineering community are now turning to vegetation and natural systems as a critical part of the solution; however, bringing these approaches together has not always been easy.

is an integration of the ýelds of urban and community forestry and watershed planning. is the management of the urban forest for environmental, community, and economic beneýts, while promotes sound land use and resource management to improve water resources within a watershed. Therefore, urban watershed forestry sets watershed-based goals for managing the urban forest as a whole rather than managing forest resources on a site-by-site or jurisdictional basis, and provides strategies for incorporating forests into urban watershed management.

This integration of urban forestry techniques into urban watershed management acknowledges the importance of trees and forests in protecting water resources. This approach encourages watershed managers and urban foresters to systematically assess existing urban forests to determine how best to manage them to meet watershed protection and restoration goals. Several important terms related to the concept of urban watershed forestry are deýned in the next section.

Te i, l g , f U ba Wa e hed F, e

It is important to distinguish the terms “forest,” “forest cover,” “urban forest cover,” and “urban tree canopy.ò The terms are similar, yet each is deýned, measured, and classiýed in a different manner by different authorities. These terms have confounding deýnitions and may even be used interchangeably. Box 1 gives examples.

BOX 1. SEEING THE FOREST FOR THE TREES

[illegible] **forest** [illegible] ([illegible] , 2004). [illegible]

Forest cover [illegible] 100% [illegible]

1. [illegible] **more than 70% canopy cover,** [illegible] 40% [illegible] 70% [illegible] *The Tropical Ecosystem Environment Observations by Satellite (TREES) project (Center for International Forestry Research, 2004).*
2. [illegible] **canopy cover of 61% or more,** [illegible] *National GAP Analysis (USGS, 2000).*
3. *“*[illegible] **60% to 100% cover** ([illegible] 25% [illegible] 60% [illegible]). *The U.S. National Vegetation Classification System (TNC, 1998).*
4. [illegible] **more than 40% canopy cover,** [illegible] 10% [illegible] 40% [illegible] *he United Nations Environment Programme (Center for International Forestry Research, 2004).*

[illegible] 40% [illegible] 70%, [illegible]

Since the methods in this manual apply to urban watersheds, what we are really concerned with measuring is **urban forest cover**. This manual deals primarily with forests, trees and shrubs, and does not address planting herbaceous vegetation. ñUrban forestò is deýned as trees growing individually, in small groups or under forest conditions, on public and private lands, in cities and towns and their suburbs (CBP, 2004). Therefore, our working deýnition of urban forest cover includes individual trees and groups of trees, as well as forests. The best measure of urban forest cover is attained by mapping the urban tree canopy.

Urban tree canopy is deýned as the layer of tree leaves, branches, and stems that cover the ground when viewed from above (CBP, 2004). Measuring tree canopy is also important because it is the tree canopy that provides such beneýts as rainfall interception, pollutant removal, and shading of streams and impervious surfaces (Box 2).

The term “forest cover” will be used throughout this manual when describing the recommended methodology (e.g., measure forest cover in the watershed, set numerical goals for forest cover in the watershed). **For the purposes of this manual, our operational def nition of forest cover is the total area of land that is classif ed as forest by the land cover data source you are using.** The ideal land cover data recommended for this analysis is urban tree canopy, which includes individual trees and groups of trees, as well as forest. We recognize, however, that this level of detail may not be attainable for all communities. Therefore, communities conducting an assessment of their urban forests should use the best available data.

BOX 2. MEASURING URBAN TREE CANOPY

[illegible] 1 [illegible] 3 [illegible] (, 2004). [illegible]

at a larger scale. For this reason, and for simplicity, this manual presents each step at the
scale. Many of the techniques related to urban watershed forestry are actually implemented at the parcel scale. A is a contiguous plot of land that is owned by a single entity.

are deýned for the purposes of this manual, as having more

1. [illegible]		
[illegible]	[illegible]	[illegible]
1. [illegible]	A. [illegible]	[illegible]
	[illegible]	[illegible]
	[illegible]	[illegible]
2. [illegible]	[illegible]	[illegible]
3. [illegible]	[illegible]	[illegible]
	[illegible]	[illegible]
	[illegible]	[illegible]

Techniques of Urban Watershed Forestry

Chapter 3 provides detailed information on 29 speciýc techniques that can be implemented to meet the goals and objectives of urban watershed forestry. Considerations for planting trees during development and redevelopment are covered in more detail in Part 2 of this manual series, Conserving and Planting Trees at Development Sites.

Why Is Urban Watershed Forestry Important?

Over 75% of the U.S. population lives in cities (Nowak and others, 2000). As a result, more and more people are disconnected from natural resources such as forests that support them and the watersheds in which they live. As a result, urban residents may take for granted the important beneýts provided by urban trees. Urban watershed forestry represents an important management approach, given the many beneýts provided by urban forests and impact of development on forest structure and function and watershed health. Managing urban forests in ways that explicitly address watershed health can mitigate some of the negative impacts of forest fragmentation, soil compaction, and increased impervious cover in urban watersheds.

An overview of the watershed beneýts of urban forests, the impacts of impervious cover on watershed health, the impacts of urbanization on forests, and the unique properties of the urban planting environment is provided below.

Wa e hed Be e [illegible] f F[illegible] e C[illegible] e

Forests provide numerous beneýts that can be divided into those that affect watershed health and those that are more apparent at the individual parcel scale. These beneýts can be further categorized into economic, environmental, and community beneýts. These beneýts are summarized in Table 2.

2. [illegible]		
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	– [illegible] – [illegible] – [illegible] – [illegible] – [illegible] – [illegible]
[illegible]	[illegible]	– [illegible] – [illegible] ([illegible] 34 [illegible] 445 [illegible] 187 [illegible]) [illegible] – [illegible] [illegible] 515 [illegible] 2 1 [illegible] 1 [illegible] 000 [illegible] 2 [illegible] ([illegible]) / 1 2 1
	[illegible]	[illegible]
	[illegible]	[illegible]

Table 3. Watershed Benefits of Forest Cover

Benefit	Description
[illegible]	– [illegible] – [illegible] – [illegible] – [illegible]
[illegible]	– [illegible] – [illegible] – [illegible]
[illegible]	– [illegible] – [illegible]
[illegible]	– [illegible] – [illegible] – [illegible] – [illegible]
[illegible]	– [illegible] – [illegible] – [illegible]
[illegible]	– [illegible] – [illegible]

BOX 4. MAXIMIZING WATERSHED BENEFITS

[illegible]

[illegible]

RAINFALL INTERCEPTION (CONT'D)

[illegible] ([illegible], 2002). A [illegible]

BOX 7. INFILTRATION

12.42

4.41 (, 1 80).

(, 1 80).

Improve regional air quality

Trees improve air quality by directly removing pollutants, including nitrogen dioxide, carbon monoxide, sulfur dioxide, ozone, and particulate matter such as dust, ash, pollen, and smoke (MD DNW mmhr2Tf10 0 a

Improve soil and water quality

Trees improve soil and water quality through uptake of soil nutrients (primarily nitrogen), filtering of sediment and associated pollutants from runoff, and removal of pollutants commonly found in runoff and urban soils (see Box 8 on phytoremediation). Over time, trees also increase the amount of organic matter in the soil, which binds many pollutants. Appendix A summarizes the effect of land cover on water quality in terms of nutrient loads. Sediment loads from forests are estimated at 50 tons of soil per square mile per year, compared with developing areas, which can lose 25,000 to 50,000 tons per square mile per year (Urban Forestry South Expo, no date).

BOX 8. PHYTOREMEDIATION

Phytoremediation [illegible]

[illegible]

Provide habitat for terrestrial and aquatic wildlife

Forests serve as wildlife habitat that supplies food, water, and cover for a variety of birds, mammals, amphibians, reptiles, and invertebrates. Large areas of contiguous forest are important habitat for interior dwelling species, while narrow strips of forest may connect larger forest tracts. Large forest areas and narrow strips both can serve as migratory corridors for wildlife.

Riparian forests provide multiple benefits for aquatic life. Trees provide leaf litter and large woody lack of forest cover in urban watersheds can increase summer stream temperatures by 2 to 10 degrees Fahrenheit (Galli, 1991). In some regions, summer stream warming can even shift a cold-water stream to a cool-water or a warm-water stream, and this change can be irreversible (FISRWG, 1998). Trees and forests that shade impervious surfaces can reduce the temperature of storm water runoff. Therefore, urban forests can mitigate the thermal shocks that would otherwise be transmitted to urban streams during storms.

Impacts of Impervious Cover on Watershed Health

Most watersheds in the eastern United States were once primarily forested. Today, many of these forests have been cleared to make way for farmland or urban development. As forests are cleared for development in urbanizing watersheds, they are replaced with paved surfaces such as roads, driveways, parking lots, and sidewalks. These paved surfaces combined with rooftops make up impervious cover. All surfaces in a watershed that are not considered impervious cover are generally lumped under the category “pervious cover,” and constitute most of the green space in the watershed (Box 9).

Impervious cover has recently been identified as an excellent indicator of stream quality in small watersheds. CWP (2003) summarized recent research findings and has integrated them into a watershed planning tool known as the Impervious Cover Model (ICM). The ICM predicts that most stream quality indicators decline when watershed impervious cover exceeds 10%, with severe degradation expected beyond 25% (CWP, 2003). The ICM predicts the behavior of a group of indicators over a of impervious cover and should not be used to predict the fate of individual species (e.g, trout, mussels).

The impacts of impervious cover on the health of small streams are reflected in four different indicators: hydrologic, physical, water quality, and biological. Impervious cover fundamentally alters the

[illegible] 2. [illegible] ([illegible], 1[illegible]8, [illegible]. 3-21)

BOX 9. ALL PERVIOUS COVER MATTERS

[illegible]

I ac f U ba i a i F e

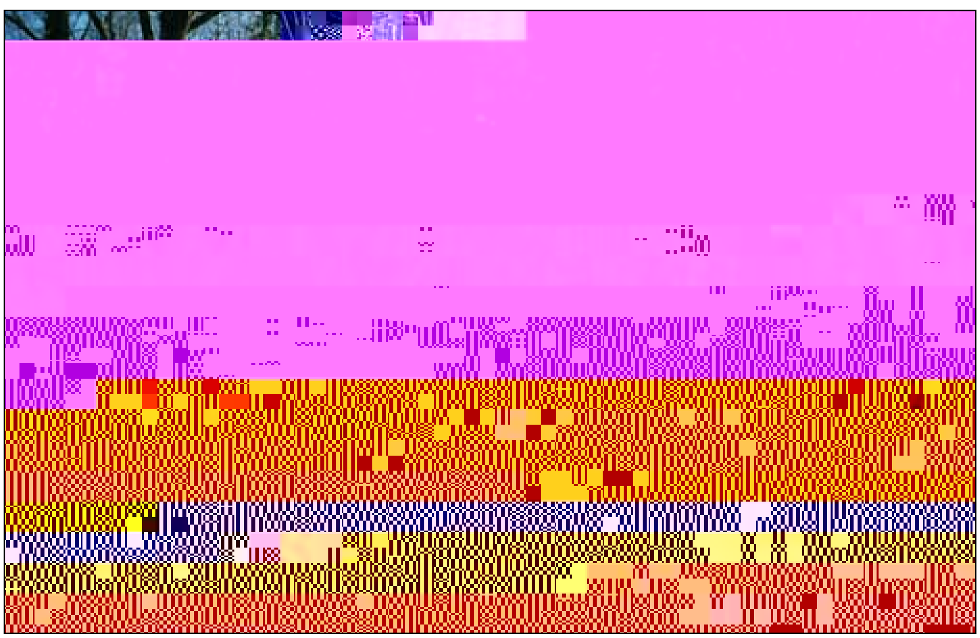
As land in a watershed is developed parcel by parcel, formerly continuous forests are divided into smaller patches. This process is referred to as . As forests are divided into smaller fragments, the proportion of edge to interior habitat increases, creating an " ." Edge habitat occurs at the boundaries between different types of land cover, while interior forest habitat is deýned as large tracts of continuous forest cover (Jones and others, 1997). Fragmentation diminishes habitat for forest interior dwelling species (e.g., interior-dwelling migratory birds), although the amount of interior forest habitat needed varies for different species (Jones and others, 1997; ELI, 2000). In general, habitat quality declines in relation to the size of the forest fragment.

American Forests estimates that tree cover in urban areas east of the Mississippi has declined by about 30% over the last 20 years, while the footprint of urban areas has increased by 20% (American Forests, no date). In fact, tree canopy cover across the United States averages only 27% in urban areas and 33% in metropolitan areas (Dwyer and Nowak, 2000). As forest cover within a watershed falls below 75%, fragmentation effects, such as changes in species composition and diversity, become more pronounced different soil characteristics. Wildlife in forest edges are also more vulnerable to external competition, predation, and nest parasitism because they are more accessible to predators (e.g., house cats) and parasites (e.g., cowbirds) (Hanssen, 2003).

4.

1 8, . 2-81)

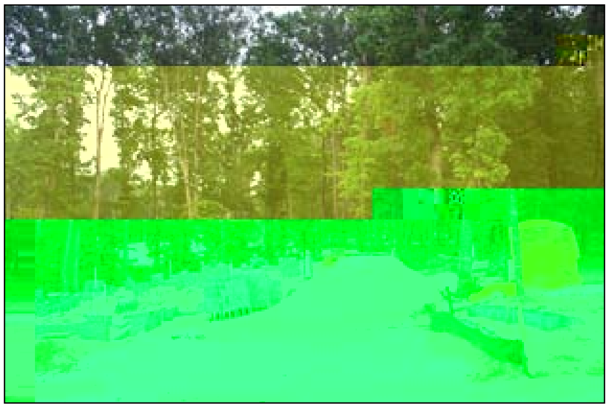
Due to the increased ratio of edge to interior forest habitat in urban watersheds, urban forest remnants are particularly susceptible to invasions of nonnative edge-loving plants such as ailanthus, kudzu, English ivy, and Japanese honeysuckle, and it is not uncommon for these invasive species to become dominant (Figure 5). Herbivory effects from whitetailed deer also tend to increase with increasing edge habitat. Deer browse primarily on woody plants and can thrive in transitional edge habitats that provide plenty of food and ample shelter (MD DNR, 1998). The lack of natural predators in urban areas combined with the effects of fragmentation can also concentrate large populations of deer in small forest fragments by restricting movement, which further magniýes the effects of browsing.



5.

Stresses from nearby development

Remaining urban forest fragments tend to be located in areas that are difýcult to develop, such as stream valleys and steep slopes, or in places where trees have been allowed to grow up over time, such as parks and vacant lands. Many stresses are placed on these remaining fragments from nearby development and land use activities. Construction activities can compact root zones and alter drainage patterns around remaining forest patches and groups of trees. Air pollutants such as ozone damage tree foliage and impair photosynthesis, making trees more susceptible to pest outbreaks, disease, and drought (MD DNR, 2002). Urban forests are exposed to higher temperatures than their rural counterparts because of ht (MD



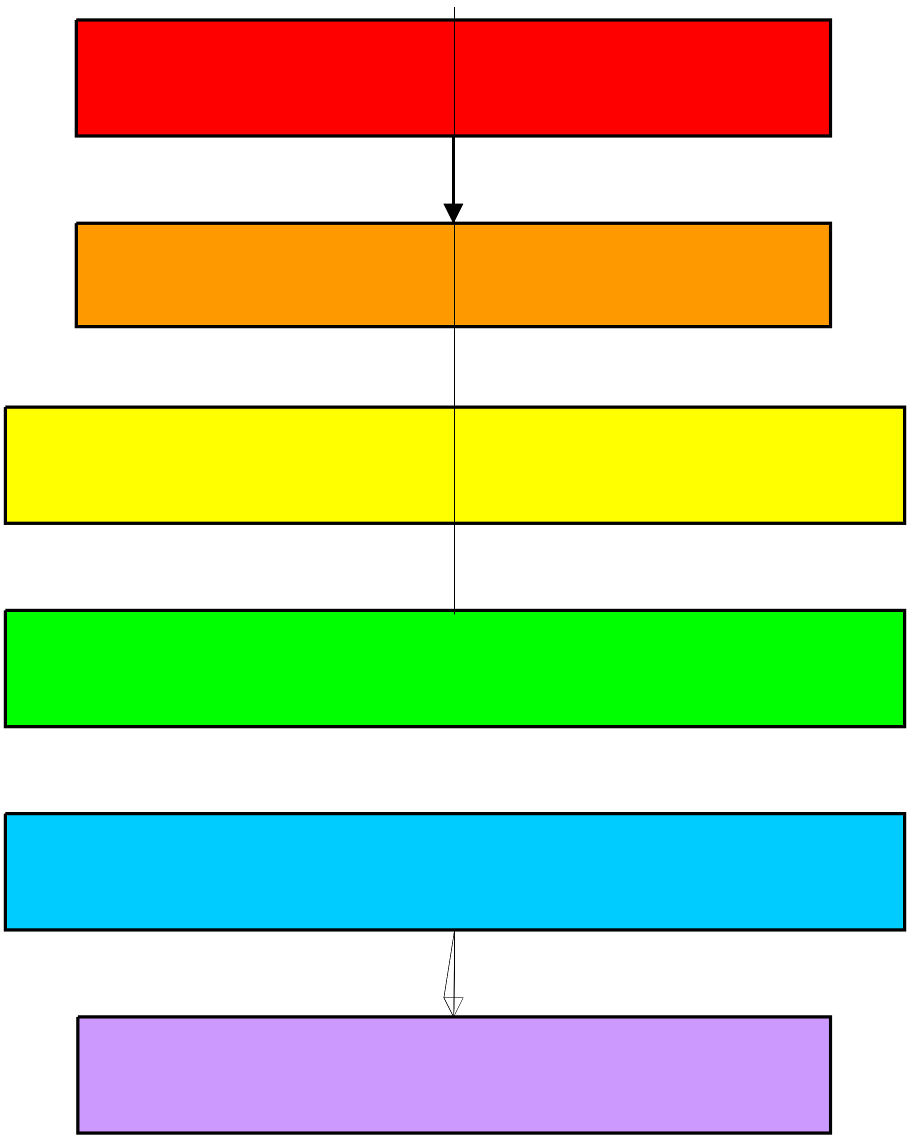
[illegible] 6. [illegible]

Urban or made soils are typically very compacted, which physically impedes root development and suffocates the tree by limiting available oxygen (VCE, 2002; Coder, 2002). Compacted soils typically become limiting to root growth at soil bulk densities around 1.4 to 1.6 grams/cm^2 or greater (Craul, no date; CWP, 2000a). Compacted soils also have poor drainage, which can cause the tree roots to drown. From a practical standpoint, the hydrology of many urban pervious areas is more similar to impervious areas than to natural ones.

The quality of most urban soils is poor and is usually not ideal for plant growth. Most of the soil organic matter is removed along with the topsoil during construction (Figure 7). Turf is often established after construction, which does not contribute much organic matter to the soil. In addition, the soil pH in urban areas is often elevated from excessive building rubble, which contains calcium.

Chapter 2: Planning Methods for Increasing Forest Cover in a Watershed

This chapter guides the watershed planner or forester through a six-step method for increasing forest cover in a watershed, deýning watershed-based forest cover goals, and identifying priority sites for protection, restoration, and reforestation. Figure 8 presents the six-step method for increasing watershed forest cover, which is explained in detail in this chapter. These methods are only one component of the larger urban watershed restoration process, and should be coordinated with other restoration practices such as those outlined in Schueler (2004). For example, the baseline and sentinel monitoring of watershed conditions recommended in Schueler (2004) are essential to evaluate the effect of increasing forest cover through urban watershed forestry techniques.



[illegible] 8. [illegible]

This method is based on the assumption that a municipal or community program has mapping and other resources and the ability to conduct the method. The method is typically conducted across an entire watershed or subwatershed, but could easily be applied to a different scale, such as a small urban catchment or an entire metropolitan area. In addition, the actual implementation of several of the steps occurs at the individual parcel scale (e.g., evaluating reforestation sites, implementing reforestation projects). The use of Geographic Information Systems (GIS) is required, and the resolution of data should be appropriate for the scale of analysis.

The six-step method described here focuses on   to increase forest cover in the watershed. Detailed guidance on   of techniques to increase forest cover is outside the scope of this manual; however, speciýc references direct the reader to the best implementation resources.

Step 1: Conduct a Watershed "Leaf-Out" Analysis

Watersheds are constantly gaining and losing forest cover at the same time due to the clearing of forests for land development, homeowner landscaping, abandonment of farm land or open space, reforestation, or other activities. The ýrst step in planning to increase forest cover entails an inventory of existing and future watershed land cover to systematically account for forest losses and gains. The inventory

BOX 11. USING GEOGRAPHIC INFORMATION SYSTEMS FOR THE LEAF-OUT ANALYSIS

[illegible] (2003) [illegible]

Step 1.1 Estimate the Distribution of Current Land Cover in the Watershed

The ﬁrst step is to create or acquire a GIS layer of current land cover in the watershed that distinguishes between three cover types: impervious cover, forest cover, and nonforest vegetative cover. Open water and non-forested wetlands are not included in the land cover analysis.

- is deﬁned as any surface that does not allow water to inﬁltrate and typically includes roads, buildings, parking lots, driveways, sidewalks, and decks.
- includes all land that is primarily covered by trees and shrubs, although the actual classiﬁcation of forest cover can vary greatly with the data source (see Box 1 on page 2). The ideal forest cover layer in this scenario is actually urban tree canopy, which includes the canopy of individual trees, groups of trees, and forests.
- can include turf, bare ground, landscaping, meadow, and crops. In urban watersheds, the majority of non-forest vegetation is usually turf. Since it is difﬁcult to distinguish between these cover types from aerial photos, and because all of these cover types are potential reforestation candidates, any land cover that is not forest or impervious is considered turf for the purposes of this analysis.

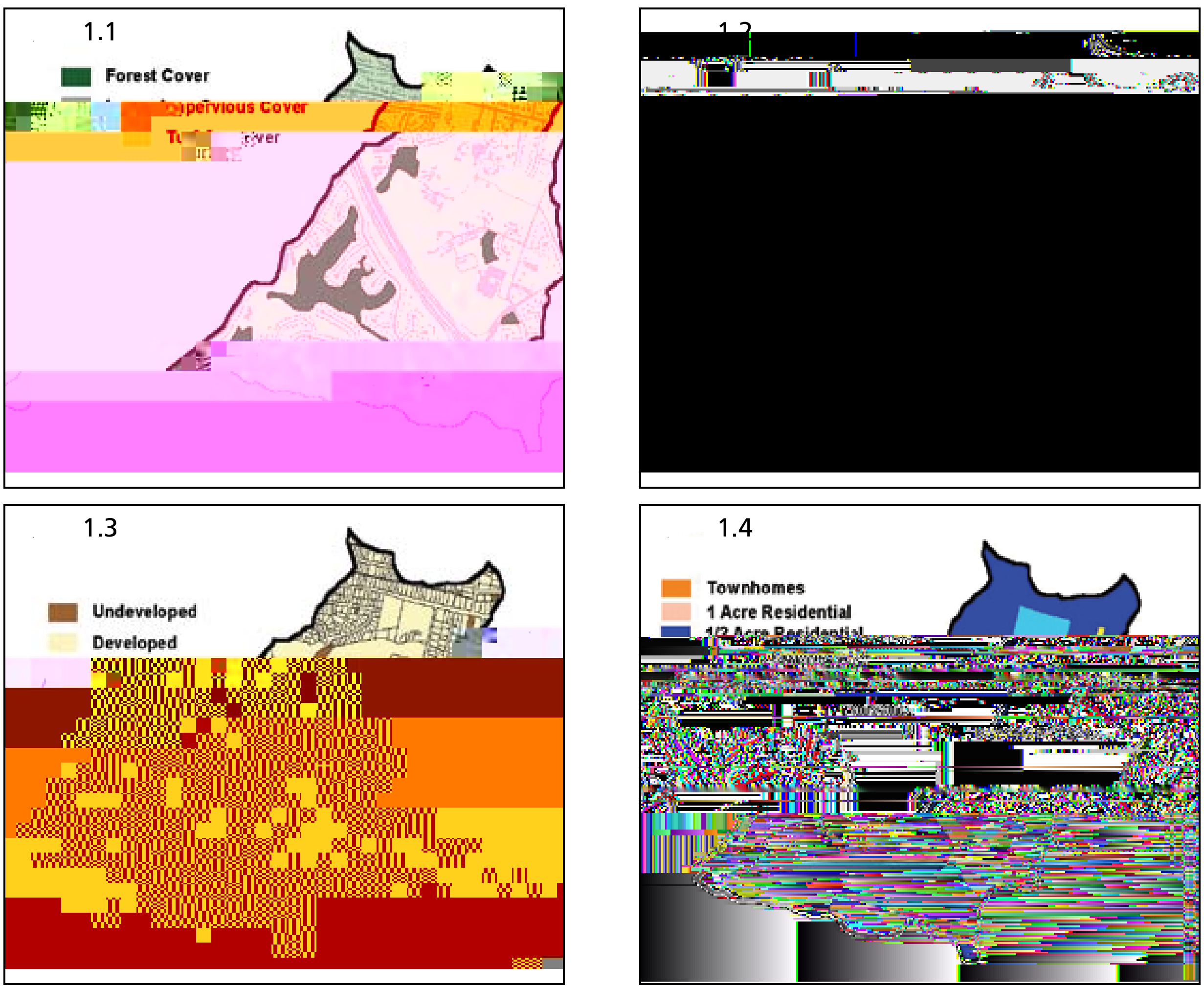
Depending on current GIS data, staff expertise, and resources available, there are three options for obtaining a current land cover layer:

1.

Step 1.3 Determine Whether Parcels Are Developed or Undeveloped

The next step is to create or acquire a GIS layer of developed and undeveloped parcels in the watershed to identify which parcels have already been developed, or “built-out” to the maximum extent allowed by zoning (Figure 9, Step 1.3). The development status (developed or undeveloped) of a parcel may be readily available in the associated data table of a good parcel boundary GIS layer. Ideally, this layer will contain ownership data to be used later to prioritize sites based on ownership and to contact landowners about potential projects. If this is not the case, the development status of each parcel can be estimated by initially classifying all parcels containing buildings as developed. Aerial photos and local knowledge of the area can be used to verify this classiýcation. Parcel boundaries can be digitized from paper maps if they do not currently exist in GIS format.

Alternatively, state planning agencies or the municipal department that handles land development permits may have a composite set of parcel maps in a digital format or a database of developed and undeveloped parcels (e.g., property tax maps) that can be linked to a GIS layer. One example is the Maryland PropertyView Database available from the State Planning Department: www.mdp.state.md.us/data/index.htm.



[illegible] 1.1 [illegible] ([illegible]), 1.2 [illegible] ([illegible]), 1.3 [illegible] ([illegible]), [illegible] 1.4 [illegible] ([illegible]).

Step 1.4 Determine Allowable Zoning for Undeveloped Land

Most local planning and zoning departments maintain a GIS or paper map of zoning categories, or both. A zoning map dictates the allowable land uses and development densities within the community and provides a snapshot of what land use will look like with future build-out. If a GIS layer of zoning does not exist, one can be digitized from the paper zoning map. If the watershed spans more than one community, zoning information from each community must be acquired and combined (Figure 9, Step 1.4).

Step 1.5 Summarize Watershed Data

In this step, the data collected in the four previous steps is used to develop a summary table that provides the necessary variables for estimating future forest cover (Table 4). This can be done using GIS by merging the four layers created in Steps 1.1 through 1.4 and querying the resulting data table. The variables highlighted in Table 4 are inserted into a worksheet designed to estimate future forest cover in Step 1.7.

Table 4. [illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	100	1,000	50	0	3,000	50
[illegible]	150	2,000	100	4,000	0	0
2 [illegible]	500	500	200	0	4,000	1,000
1 [illegible]	1,000	500	2,000	0	2,000	500
[illegible]	1,000	500	3,000	0	1,500	1,000
[illegible]	2,000	500	1,000	0	1,000	500
[illegible]	2,000	0	50	0	150	100
[illegible]	4,000	0	500	0	100	400
[illegible]	3,000	0	100	0	100	0
[illegible]	1,000	0	500	3,000	500	0
[illegible]	5,000	0	500	0	50	100
[illegible]	5,000	0	2,000	0	500	500
[illegible]	24,750	5,000	10,000	7,000	2, 50	4,150

Each of the variables quantiýed in this step serves some function in estimating future forest cover:

- The in the watershed will limit the potential for future forest cover (unless impervious cover is removed in order to reforest).
- is assumed to remain forested with future watershed development.
- is considered "buildable," and some proportion of that forest will be cleared during future development (Step 1.6 will estimate that proportion).
- probably provides the best opportunities for reforestation, especially public land; however, only some proportion of public turf will actually be available for reforestation. Privately owned developed turf is likely to be residential lawns or commercial or industrial land and has the potential to greatly increase forest cover by reforestation, but will require extensive education, outreach, and possibly incentives to be implemented.

- may also provide some opportunity for reforestation; however, land should always be reforested in conjunction with protection measures, to ensure long-term sustainability of the forest.

S e 1.6 Ac i e F e C e C ef cie

Forest cover coefýcients represent the fraction of developed land that is forest. These coefýcients are applied to speciýc zoning categories to estimate the amount of future forest cover on all buildable land in the watershed. Little data exist for forest cover or turf cover coefýcients; however, some data is available that represent the fraction of developed land that is impervious. The methods used to derive these impervious cover coefýcients may be used to estimate forest cover and turf cover coefýcients.

Impervious cover coefýcients for 12 urban and suburban land uses are available from Cappiella and Brown (2001) and are presented in Table 5. These coefýcients were derived from recently developed urban-suburban areas in the Chesapeake Bay region and are applicable to areas with similar types of development. Where possible, local or regional estimates of impervious cover should be used. If none are available, communities should derive their own from local data (see Cappiella and Brown, 2001, for methods). Communities should also derive their own forest and turf cover coefýcients by analyzing limits of disturbance on site plans or by analyzing turf cover or forest cover at the parcel scale as a sample of actual development sites. Appendix C and Cappiella and Brown (2001) provide detailed methods for deriving land cover coefýcients.

Impervious, forest, and turf cover percentages are also provided in Table 5 for three forest conservation scenarios. These percentages are examples only and are based on a number of assumptions and data sources described below. Conversion of these percentages to coefýcients for use in worksheets requires division by 100. Additional data sources that may be used to develop land cover coefýcients are provided in Appendix D.

5. [illegible] [1]

[illegible]	[illegible] (%)[2]	[illegible] (%)[3]			[illegible] (%)[3]		
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
A [illegible]	2	3	83	78	5	15	20
[illegible]		86	76	41	5	15	50
2 [illegible]	11	84	74	3	5	15	50
1 [illegible]	14	81	71	36	5	15	50
— [illegible]	21	74	64	54	5	15	25
[illegible]	28	67	57	47	5	15	25
[illegible]	33	62	52	47	5	15	20
[illegible]	41	54	44	3	5	15	20
[illegible]	44	51	41	36	5	15	20
[illegible]	34	61	51	46	5	15	20
[illegible]	53	42	32	32	5	15	15
[illegible]	72	23	13	13	5	15	15

The turf and forest cover percentages presented in Table 5 are representative of three tiers of local forest conservation regulations: no forest conservation, indirect forest conservation, and direct forest

Most communities fall into one of these three tiers of forest conservation. Communities should select

BOX 13. LEAF-

The worksheet result gives an estimate of future forest loss (%) in the watershed with no additional forest conservation or reforestation efforts. In the example shown, 48% of existing forest in the watershed is lost to development.

The USDA Forest Service's Northeastern Research Station is developing a new tool to project future forest canopy cover that may facilitate the Leaf-Out Analysis. The tool involves a GIS-integrated management decision program that is a component of the Urban Forest Effects (UFORE) Model. This tool is called UFORE Future Effects and is designed to project future canopy cover over a 30-year period based on estimated growth and mortality rates. More information about UFORE is available at www.fs.fed.us/ne/syracuse/Tools/UFORE.htm and www.ufore.org/.

Step 2: Develop Forest Cover Goals and Objectives for the Watershed

The second step is to develop overall goals for increasing forest cover in both the watershed and the community, and to identify speciýc objectives for attaining these goals. Forest cover goals should be speciýc, measurable, and realistic, and have an associated timeline for attainment.

S e 2.1 Se N e ical Ta ge f F e C e

A numerical target for forest cover should be deýned ýrst for the entire community, and then for each individual watershed within the community. American Forests recommends 40% cover for most metropolitan areas, and a number of communities have already adopted this as a goal (see Appendix F). [illegible]

Because most metropolitan areas contain multiple watersheds that often have varying land use and development patterns, a numerical target should be deýned for each watershed, based on community-wide targets but taking into account speciýc watershed protection or restoration goals and using the results of the Leaf-Out Analysis. It may not be realistic for some watersheds to meet the community-wide forest cover goal, while other watersheds may surpass them. To date, few communities have adopted numerical targets for forest cover at the watershed scale; however, some data indicate that watershed forest cover of at least 45% to 65% is most beneýcial in terms of stream health (Appendix F). These studies provide a starting point for setting watershed-wide forest cover goals. Table 6 provides some example forest cover goals for four watershed scenarios.

6. [illegible]

[illegible]	[illegible] %	[illegible]	[illegible]
[illegible]	[illegible] 25	60% [illegible] 70% [illegible]	[illegible]
[illegible]	[illegible] 25	40-50% [illegible]	[illegible]
[illegible]	26 [illegible] 60	25-40% [illegible]	[illegible]
[illegible]	[illegible] 60	15-25% [illegible]	[illegible]

The forest cover goals presented in Table 6 are examples only and should be reýned based on individual watershed characteristics, modeling, or literature review, to directly address storm water, air quality, or other outcomes. Current forest cover should be used as a starting point for goal setting. Current watershed impervious cover may also help determine the maximum limit of forest cover that it is possible to achieve without removal of impervious surfaces. Numerical forest cover targets should be revisited periodically and revised if necessary. Cost estimates for implementing forest conservation and reforestation objectives are necessary for communities to determine what is a realistic forest cover increase to achieve given a speciýc timeframe and budget. Two examples are presented in Box 15.

BOX 15. QUANTIFYING REALISTIC FOREST COVER GOALS

[illegible] 26.6% [illegible] 25.1 [illegible] 30%. [illegible] **increase of 3.4%** [illegible] **25 years** [illegible] 1,360 [illegible], 2001). [illegible] $272,000 ([illegible] $200 [illegible], 2004).

[illegible] ([illegible], 2002) [illegible] **10% increase in canopy cover** [illegible] 1, 50 [illegible] **30-year time period.** [illegible] 41%. [illegible] 1 [illegible] $212 [illegible]).

S e 2.2 De e P i i Objec i e Mee G al

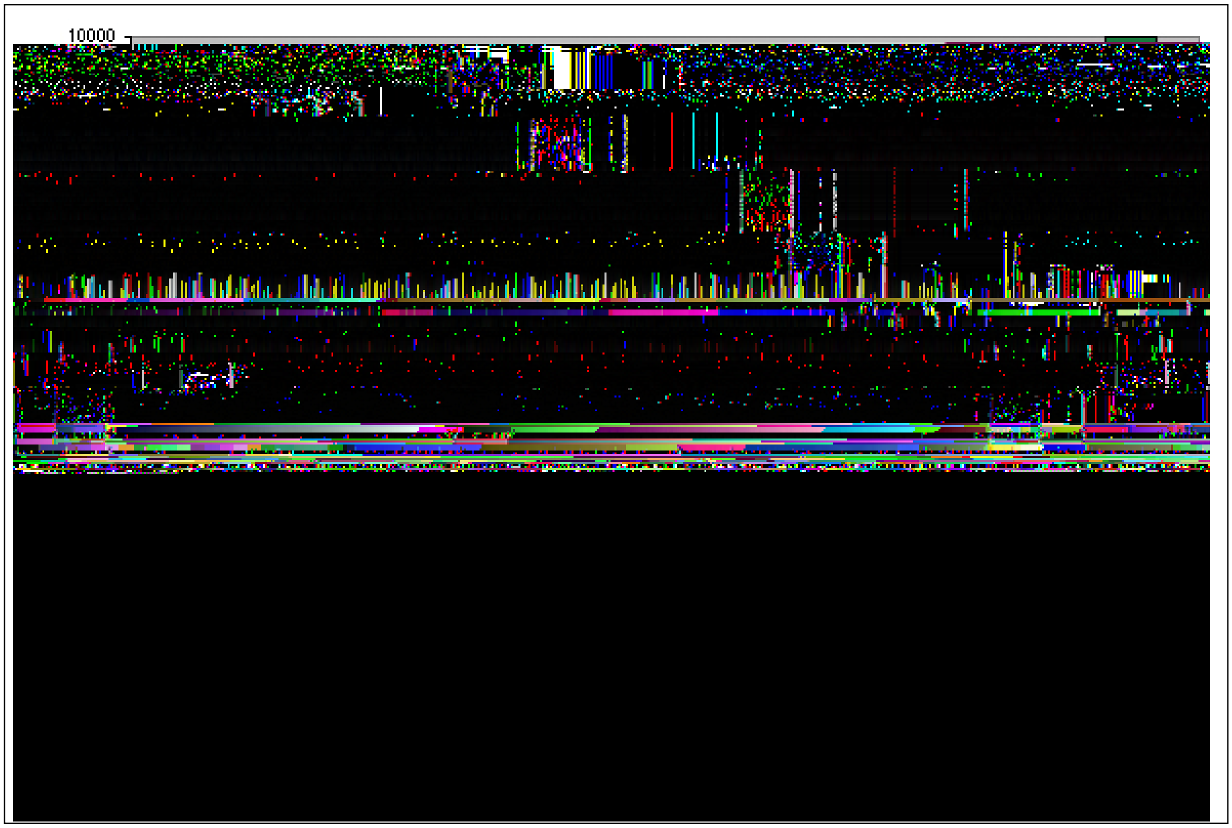
Forest cover goals for a watershed should represent an increase in the existing percentage of forest cover. The specific objectives utilized to meet forest cover goals may vary with each watershed and should be based on the data derived from the Leaf-Out Analysis (e.g., current impervious cover, area of protected forest, area of buildable forest, proportion of public and private developed turf).

Table 7 provides guidance on identifying priority objectives to meet forest cover goals in specific types of watersheds.

BOX 16. LEAF-OUT ANALYSIS WORKSHEET FOR ESTIMATING FUTURE FOREST COVER IN A WATERSHED (FOREST CONSERVATION AND REFORESTATION SCENARIO)

Section 1. Future Forest Cover

Section 3. Results Summary				
Total Current Forest Cover	*15,000*	[illegible]		
From Table 4.				
Total Future Forest Cover	*16,000*	[illegible]		
From Section 2.				
Future Forest Increase	*1,000*	[illegible]	7	%



11.

Figure 11 illustrates the effect of priority forest cover objectives on future forest cover compared with future forest cover with no protection or reforestation efforts.

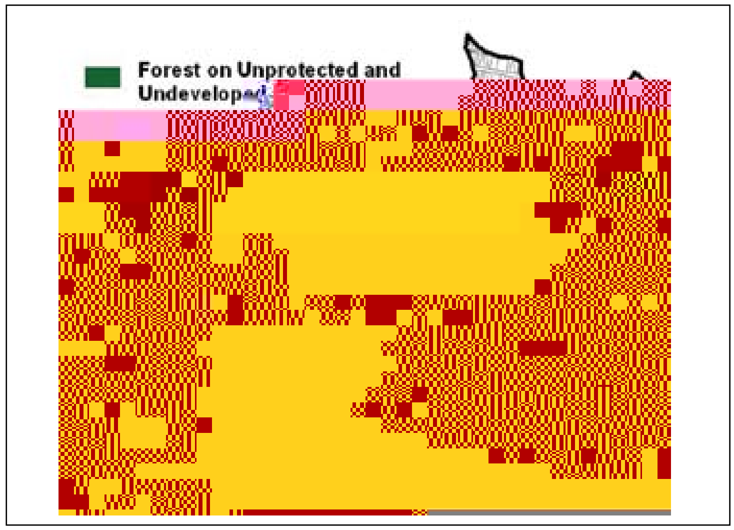
Step 3: Identify Existing Forest and Reforestation Opportunities

Once numerical targets for protection of existing forest and reforestation are identified, the next step involves locating the best sites in the watershed for these activities. In this step, priority forest and reforestation sites are selected for further evaluation in the field based on the inventory of current land cover in the watershed. Due to factors such as budget and land ownership, however, it is not desirable or feasible to pursue each and every forested site for protection, or each and every open area for reforestation. Using the information generated through the inventory of current and future land

prior site use (e.g., potential for soil or groundwater contamination), and natural, cultural, and historical resources.

Forests selected for further evaluation are assessed in the field to determine whether they are good candidates for protection or restoration and to select appropriate protection or restoration techniques. In highly urban watersheds where few remaining forests exist, it may not be necessary to whittle down the forested sites to a more manageable number. Criteria for selecting forested parcels for further evaluation include the following:

- Currently unprotected
- Publicly owned or willing land owner
- Contiguous forest greater than a specified acreage (set by municipality, dependent on average size of forest fragments)
- Strategic location in watershed (e.g, is adjacent to existing forest parcel, reforestation site, or protected land; connects or has the potential to connect two existing contiguous forest parcels; has significant natural, historic, cultural or recreational value).



12.

Each community should tailor these criteria for selecting forest parcels to take into account the specific characteristics of their watersheds. The possibility of expanding forested areas or linking them to the stream corridor or other remnants should always be considered when selecting priority forest sites. Owners of large forested tracts may be contacted at this stage to gauge their interest in forest conservation efforts, and to get permission to evaluate their land further.

S e 3.2 Ide if Ref e a i O i ie f F he A e e

To select reforestation sites for further assessment, a map that displays the existing non-forest vegetative cover in the watershed should be analyzed along with property boundaries, vacant lands, public lands, storm water treatment practices, and natural cultural and historical resource information.

Sites with turf cover typically present the best reforestation opportunities because they do not involve extensive removal of vegetation or impervious cover. If the GIS layer of land cover does not distinguish between turf and other types of non-forest vegetation, aerial photos may be used to verify which parcels contain turf. Turf cover typically represents the largest portion of non-forest vegetative cover and can comprise up to 80% of urban pervious cover (CWP, 2000b). Figure 13 shows the distribution of turf cover at the state level across various land uses (composite of MTC, 1996; VASS, 1998; and PTC, 1989).

Public lands are attractive from the standpoint of reforestation because of their large size and ownership. These include highway cloverleafs and buffers, parks, schools, storm water dry ponds, and utility corridors. Vacant lands and stream corridors provide additional opportunities to reforest the watershed. Criteria for selecting reforestation opportunities for further evaluation include the following:

- Turf cover
- Developed or vacant land
- Publicly owned (e.g., highway cloverleafs, highway buffers, parks, schools, storm water dry ponds, utility corridors)
- Strategic location in watershed (e.g, stream corridor, adjacent to existing forest parcel, reforestation site, or protected land; connects or has the potential to connect two contiguous forest parcels; has signiýcant natural, historic, cultural or recreational value).

Each community should tailor these criteria to select reforestation opportunities that take into account the speciýc characteristics of their watersheds. For example, a community with a very large number of sites that meet the above criteria may elect to evaluate only turf parcels larger than 2 acres. The possibility of expanding existing forested areas or linking two forest fragments should always be considered when selecting priority reforestation sites.

Step 4: Conduct a Field Assessment of Existing Forest and Reforestation Opportunities

The next step is to select existing individual forest and/or potential reforestation sites for further evaluation in the ýeld to verify their existence and use, determine if they are good candidates for

Table 9. Summary of Forest Assessment Methods

Forest Assessment Method	Applicability	Description	Source
Unified Subwatershed and Site Reconnaissance (USSR)	Urban upland forests	The Pervious Area Assessment form of the USSR is used to collect basic information about existing forest remnants	Wright [illegible], (2004)
Woodland Buffer Habitat Assessment	Riparian forest	Evaluates the value of riparian forest for wildlife habitat	Hanssen (2003)
Upland Contiguous Forest Assessment	Upland forests	Designed to evaluate large parcels of contiguous forest to determine which are priorities for conservation	CWP (unpublished)
Maryland's Green Infrastructure Assessment	Regional application	Evaluates hubs and corridors in terms of ecological significance for the purpose of land acquisition	Weber (2003)
Maryland Forest land ac 0 9 7on 0 9 27fd1e2 iguous [illegible]			

Step 4.2 Conduct a Field Assessment of Potential Reforestation Sites

Most potential reforestation sites are public or private turf. Turf areas should be assessed in the field to verify their condition, evaluate the feasibility of reforestation, and collect information to prioritize candidate sites. If desired, additional information may be collected at this time to use in developing a reforestation plan for the sites (e.g, detailed soil characteristics). Table 11 summarizes three assessment methods for evaluating urban reforestation sites. Additional information on evaluating planting sites is provided in Part 3 of this manual series, and in Reynolds and Ossenbruggen (1991) and WFC and Morgan (1993).

Table 11. Summary of Reforestation Site Assessment Methods			
Reforestation Site Assessment Method	**Applicability**	**Description**	**Source**
[illegible] ( )	[illegible]	[illegible]	[illegible]

Separate prioritization methods may be developed to rank forested sites and reforestation sites. Several examples of detailed prioritization methods for protection, enhancement, and reforestation projects are summarized in Table 14.

Table 14. Summary of Prioritization Methods for Protection, Enhancement, and Reforestation

Prioritization Method	Applicability	Description	Source
Maryland's Green Infrastructure Assessment	Regional application	Prioritizes hubs and corridors for land acquisition based on ecological significance	Weber (2003)
Urban Riparian Restoration Project	Urban riparian areas	Three-tiered ranking system for prioritizing riparian sites for reforestation	Virginia Department of Forestry (1993)
Watershed Analysis Extension for ArcView	Watershed scale	Provides tools for quantitatively ranking land in a watershed by estimated surface water quality impact	de la Cretaz and others, (2003)
Chesapeake Bay Resource Lands Assessment	May be applicable at a variety of scales	GIS-based methods for identifying forests in the Chesapeake Bay watershed that are important for protecting water quality and watershed integrity	Painton-Orndorff and others, (2004)
Forest Areas of Local Importance	County or regional application	GIS-based decision tool to identify critical forest areas for protection	NEGRDC (2004)
Urban Forest Effect (UFORE) Model	Site level	GIS-based tool for selecting the best locations to plant trees to improve air quality and building energy conservation	USDA Forest Service (2004)

Step 6. Develop Recommendations for Meeting Forest Cover Goals

The last step in planning to increase forest cover is to integrate forest cover goals for the watershed in

A watershed plan should incorporate the forest cover goals developed in Step 2 as well as the priority objectives identified and any related numerical targets. The watershed plan should also include priority sites identified for protection, restoration, and reforestation. Detailed information should be provided for the top priority sites, including the following:

- Specific techniques recommended for protection, enhancement, or reforestation
- Cost estimates for implementation and maintenance
- Potential funders, partners, and other entities who will be involved in project implementation and long-term maintenance (e.g., watershed organizations, homeowners associations or HOAs)
- Implementation schedule.

Step 6 will involve some decisionmaking as to what types of protection, enhancement, or reforestation techniques to use at each priority site. Protection, enhancement, and reforestation techniques are described in detail in Chapter 3.

Chapter 3: Techniques for Maintaining and Increasing Forest Cover in a Watershed

This chapter provides a summary of techniques and further resources for the protection and enhancement of forests and the reforestation of open lands in a watershed. Table 15 lists the techniques according to the corresponding goals and objectives.

Table 15. Summary of Protection, Enhancement, and Reforestation Techniques

Goals	Objectives	Techniques
[illegible]	A. [illegible]	1. [illegible] 2. [illegible] 3. [illegible]
	[illegible]	4. [illegible] 5. [illegible] 6. [illegible] 7. [illegible] 8. [illegible] . [illegible] 10. [illegible] 11. [illegible]
	[illegible]	12. [illegible] 13. [illegible]
[illegible]	[illegible]	14. [illegible] 15. [illegible] 16. [illegible] 17. [illegible] 18. [illegible] 1 . [illegible] 20. [illegible]
[illegible]	[illegible]	21. [illegible] 22. [illegible] 23. [illegible] 24. [illegible]
	[illegible]	25. A [illegible] 26. A [illegible]
	[illegible]	27. [illegible] 28. [illegible] 2 . [illegible]

Techniques for Protecting Forests

Different techniques are used to protect existing forests. Generally, these fall into three categories depending on the stage of development. Techniques related to Objective A, Protect Priority Forests, focus on techniques to protect large tracts of forest that are currently undeveloped. Techniques related to Objective B, Prevent Forest Loss During Development and Redevelopment, focus on limiting the clearing of forests during the actual construction process. Techniques related to Objective C, Maintain Existing Forest Canopy, include techniques that prevent landowners from clearing forests on land that has already been developed. Most techniques are regulatory tools that local governments can adopt to protect forests during each stage of development. One exception is the urban forestry management plan, which is described in Box 17.

This section brieþy describes each technique and includes relevant links to model regulations, example ordinances (see Box 18), and comprehensive references. Additional information about many of these techniques can be found in ELI (2000), Palone and Todd (1998), Georgia Forestry Commission (2001), and Wenger and Fowler (2000).

BOX 17. URBAN FORESTRY MANAGEMENT PLANS

61 254 053

BOX 18. A NOTE ABOUT ORDINANCES

1 0. *Municipal Tree Manual. Urbana, IL*

2004.

Protecting Priority Forests

Large tracts of high quality forest or those potentially valuable to watershed functions can be protected from future development through conservation easements, land acquisition, or transfer of development rights.

1. Conservation easements

Conservation easements are conveyances of development rights from a property's landowner to a

construction, such as mechanical injury to roots, trunks, or branches; compaction of soil; or changes to existing grade that may expose or suffocate roots.

To ensure long-term protection of trees, forest conservation and protection regulations may require permits for removal, encroachment, or pruning of trees. They may also require posting of signs to inform residents of the tree protection areas and should include enforceable penalties for encroachment on tree protection areas.

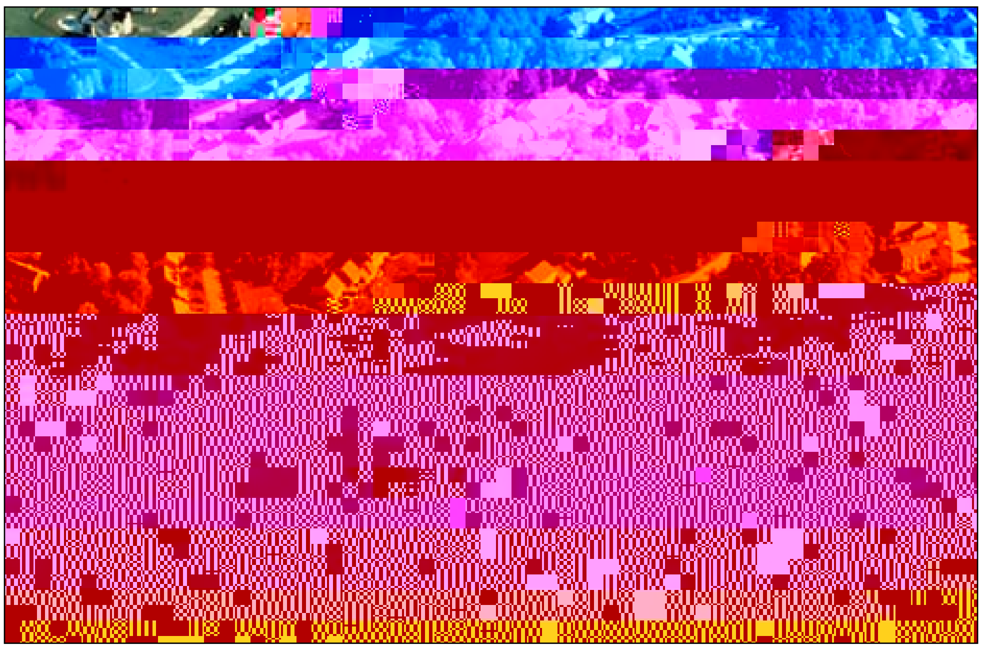
> American National Standards Institute Tree Protection Standards:
> http://webstore.ansi.org/ansidocstore/dept.asp?dept_id=30
>
> Frederick County, MD, Forest Conservation Ordinance:
> www.stormwatercenter.net/Model%20Ordinances/buffer_model_ordinance.htm
>
> Maryland Forest Conservation Act: www.dnr.state.md.us/forests/programs/urban/explained.html
>
> City of Pasadena, CA, Tree Protection Guidelines:
> www.ci.pasadena.ca.us/publicworks/PNR/TreeOrdinance/protectionGuidelines.asp
>
> International Society of Arboriculture. Avoiding Tree Damage During Construction:
> www.isa-arbor.com/consumer/avoiding.html
>
> Minnesota Department of Natural Resources. Conserving Wooded Areas in Developing Communities: Best Management Practices in Minnesota:
> http://ýles.dnr.state.mn.us/forestry/urban/bmps.pdf
>
> Tree Protection Ordinance for Chapel Hill, NC:
> http://ourworld.compuserve.com/homepages/DoanePerry/ChapelHillNC.htm.

[illegible] 15. [illegible]

7. Open space design

Open space design is a compact form of development that concentrates density on one portion of the site in exchange for reduced density elsewhere. Open space design allows for the preservation of forests, using less space for streets, sidewalks, parking lots, and driveways (Figure 16). Requirements in an open space design ordinance generally set aside a percentage of the site for active or passive open space area (e.g., ballýelds or trails). Minimum lot sizes, setbacks, and frontage distances are relaxed to provide this common open space. Open space regulations can protect existing forests, provided the regulations identify allowable types of vegetation, minimum area, native species, allowable uses, and maintenance responsibilities. An open space design ordinance should also specify that the open space be maintained in a natural condition.

> Stormwater Manager's Resource Center. Open Space Design Model Ordinance: www.stormwatercenter.net/Model%20Ordinances/open_space_model_ordinance.htm.



[illegible] 16. [illegible]

8. Overlay zoning

Overlay zoning superimposes additional regulatory standards or development criteria onto existing zoning provisions. Overlay zones can be created to protect particular resources, such as forests, wetlands, or historic sites. The provisions of the overlay zone incorporate mandatory requirements that restrict development in some way to reach the desired level of forest conservation or other goal. This land use management technique gives a community legal control without having to purchase land (CWP, 1998b; Palone and Todd, 1998; McElýsh, 2004).

9. Performance-based zoning

Performance-based zoning is designed to ensure an acceptable level of performance within a given zoning district, such as providing a certain open space/development ratio, an impervious area target, or a desirable density. Performance factors include storm water runoff quality and quantity criteria, protection of wildlife and vegetation, or trafýc and noise generation limits. The developer is given þexibility and control over development as long as these criteria are met (CWP, 1998a; Palone and

Todd, 1998). Performance-based zoning can be used to protect a speciýed percentage of forested land. For more information on performance-based zoning, see McElýsh (2004).

10. Storm water credits

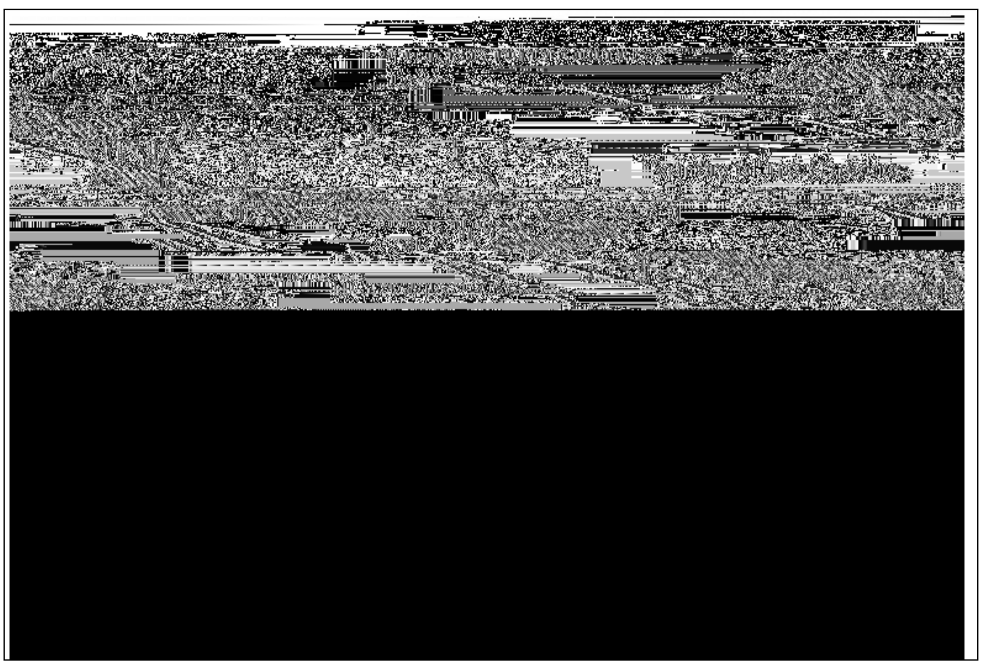
Recognizing that trees reduce runoff and provide other watershed beneýts, the Council of the City of Takoma Park, MD, has instituted tree removal regulations. The Takoma Park ordinance requires a permit to remove "urban forest trees," and requires residents to replace any urban forest tree removed or excessively damaged. This ordinance also requires the replacement of trees that were initially recorded as trees to protect during construction but were subsequently damaged or cut down. All replacement trees must be equal or superior to the original tree with respect to species quality, shade potential, and other characteristics, and it must be from nursery stock with a 1-year guarantee. Enforcement is an important factor to consider when implementing tree removal restrictions.

City of Takoma Park, MD, Tree Ordinance: www.207.176.67.2/pw/treeordinance.html.

Techniques for Enhancing Remaining Forest Fragments

While regulatory tools can prevent a forest from being cleared, enhancement may still be needed to improve its value for wildlife (provide food, water, cover, and nesting sites), improve tree growth and canopy condition, and guarantee the long-term perpetuation of forest vegetation. Urban forest fragments present many opportunities to restore the condition and function of an urban forest. Enhancement techniques increase and improve wildlife habitat and improve conditions for tree growth to ensure long-term sustainability of the forest. This section summarizes techniques for restoring and enhancing forest fragments and includes links to relevant resources. Much of the information in this section was adapted from Hanssen (2003) and Adams (1994).

Existing urban forest fragments on protected lands in the watershed can be enhanced by expanding the forest area, increasing habitat diversity, managing deer, providing food, cover and nesting sites for wildlife, reducing or eliminating invasive species, protecting soils from erosion and compaction, and by removing trash and preventing dumping.



18.
(A
, 2001,
. 41)

14. Increase forest area where possible

Forest area can be increased incrementally over time by strategically reforesting areas around remnants

Woody debris and leaf litter also provide unique habitat features within a natural forest, but may be eliminated in urban forest fragments because landowners wish to “clean up” the debris. A simple

Deer browse primarily on woody plants, so a large deer population can essentially deplete the forest of native understory or midstory vegetation. An overbrowsed forest may have a characteristic browse line about 4 to 5 feet high, under which no green leaves are present (evident only during the growing season) or may have all unprotected understory vegetation removed. (Figure 21). Several methods exist to control deer populations and manage their impacts on forests, including hunting, sterilization, fencing, and other barriers and repellents

Deer in Maryland: www.dnr.state.md.us/wildlife/deerhunting.asp

Montgomery County Deer Management Work Group 2004. Comprehensive Management Plan for White-Tailed Deer in Montgomery County, Maryland: Goals, Objectives, Implementation. Silver Spring, MD. www.mc-mncppc.org/Environment/deer/DEERPLAN%20update%208-2004.pdf.

17. Protect soils from erosion and compaction

Forest soils can be protected from erosion and compaction by restricting access and use. One example is to limit access to designated trails only and to restrict ATV use entirely. Trails should be designed properly to prevent erosion, and special care must be taken in areas with steep terrain. For more information on trail design, see TCF (1993). Another way to improve forest soils is to ensure that the leaf litter layer is not disturbed. Leaf litter contains organic matter that improves water retention and inýltration. Finally, signiýcant inputs of storm water to the forest fragment should be managed to prevent erosion from high þows.

18. Provide food, cover, and nesting sites for wildlife

To encourage desirable wildlife in the urban forest, such as woodpeckers, wood ducks, owls, bluebirds, chipmunks, and foxes, adequate food, cover, and nesting sites must be present. Plant species that provide food, cover, or habitat for speciýc wildlife species can be planted, or artiýcial structures that provide cover or nesting sites can be created. These include mast species, brush piles, evergreens, snags and cavity trees, and nesting structures.

Mast species are tree species that produce fruits, nuts, seeds, and other sources of food for wildlife. A healthy forest should have a continuous supply of 40- to 80-year-old healthy mast-producing species (Hanssen, 2003). Examples of mast species are oak, cherry, hickory, beech, and walnut. Many other native plants provide food or habitat for speciýc wildlife species, and these should ildl

Brush piles (Figure 22) are made of brush, tree branches, and cut shrubs and serve as cover for wildlife such as rabbits, squirrels, chipmunks, foxes, and songbirds (Hanssen, 2003). Brush piles are particularly important in a forest that lacks understory because they may provide the only shelter for these animals. Brush piles should be built close to a water or food source. Evergreens also serve as cover for wildlife in winter.

> Maryland DNR Wild Acres Program. Brush Piles: www.dnr.state.md.us/wildlife/wabrush.asp
>
> National Wildlife Federation. Backyard Habitat: www.nwf.org/backyardwildlifehabitat/logpile.cfm.

Snags and cavity trees are dead or partially dead trees that are still standing. Unless they pose a safety hazard, snags should be left standing because they provide habitat for certain species, such as woodpeckers, wood ducks, bluebirds, hawks, and owls. These animals typically feed on insects and can help control insect infestation in the forest.

> How is a Dead Tree Good? www.fs.fed.us/r6/nr/wildlife/animalinn/goodtree.htm
>
> Maryland DNR Wild Acres Program. Snags and Logs: www.dnr.state.md.us/wildlife/wasnags.asp.

Nesting structures can be built and installed in the forest for species of birds that nest in cavities such as bluebirds. There are various types of nesting structures speciýcally designed for particular bird species.

> Maryland DNR Wild Acres Program. Eastern Bluebirds: www.dnr.state.md.us/wildlife/wabluebird.asp
>
> Ducks Unlimited: www.ducks.org/conservation/duck_box_plans.pdf
>
> Bat Conservation International: www.batcon.org.

19. Reduce or eliminate invasive species

20. Remove trash and prevent dumping

be reforested, provided some measures are taken to ensure long-term protection of the land from development. Public parks also afford a measure of long-term protection to the newly planted forest.

25. Allowing natural regeneration

Natural regeneration is a passive method of reforesting a site that entails restricting mowing by posting signs or installing fencing to restrict access and allowing trees to regenerate naturally. This method

28. Incentives for tree planting

Financial incentives can encourage private landowners to plant trees on their property. These incentives

Chapter 4: Planting Guidelines for Priority Reforestation Sites

This chapter provides detailed guidelines for planting trees on these priority reforestation sites in a watershed:

1. Highway rights-of-way
2. Residential lawns
3. Parks
4. School grounds
5. Storm water dry ponds
6. Streams and shorelines
7. Utility corridors
8. Vacant lots.

The guidance is presented in a series of fact sheets that describe the basic reforestation concept and address the following topics:

Pla i g T ee i High a Righ -of-Wa

Description

Larger highways often have fairly large parcels of unused land in the form of cloverleafs and diamonds near interchanges, median strips, and buffers. These rights-of-way can be ideal locations for reforestation because they generally serve no other purpose.

Planting trees along highways can reduce air pollution and stormwater runoff, provide habitat for wildlife such as birds, reduce air temperatures, stabilize the soil, provide a visual screen and buffer from noise and highway fumes, and create a visually pleasing environment for the highway driver.

Pre-Planting Considerations

Do highway planting guidelines prohibit or restrict trees?

How do I address potential conþicts between trees and utilities?

Do I need to use different methods for planting trees on steep slopes?

How do I address potential damage to trees from deer?

How do I provide unobstructed vehicle recovery areas, clear lines of sight, safe travel surfaces, and access to maintenance structures?

Can I make the area more attractive with plantings?

How do I address soil conditions such as severe compaction or ýll soils?

How do I manage invasive plants?

How do I address illegal dumping?

How do I address exposure of trees to auto emissions, polluted runoff, wind, and drought?

Species Selection

Selecting appropriate tree species is key because it can address most site conditions and is often more efýcient than trying to change the site characteristics. Select a diverse mix of hardy, native species that are adapted to soils and site conditions.

Other desirable species characteristics include the following:

- Tolerates urban stormwater pollutants (oil and grease, metals, chloride)
- Tolerates air pollution
- Tolerates poor, highly compacted soils
- Tolerates drought (rainfall may be the only source of water)
- Tolerates inundation (if used for stormwater treatment)
- Provides food, cover, or nesting sites for wildlife

Specific Planting Guidance

Highway Cloverleaves

Provide a setback of 30 to 50 feet between tree planting areas and the edge of pavement, and plant trees or allow natural regeneration in the center of the cloverleaf. The setback ensures adequate sight lines, allows for vehicle recovery and prevents tree branches in roadways (NC DOT, no date).

Highway Buffers

Provide a setback between tree planting areas and the edge of pavement of 20-50 feet for þat areas (or slopes of 3:1 or less) and 17 feet for slopes of 3:1 or steeper (MD SHA, 2000). This setback generally restricts trees in the area between the edge of the pavement and the toe of the slope (swale) to allow adequate sight lines and vehicle recovery and to prevent tree branches in roadways. Create a gradual transition from grasses to trees on cut slopes.

Highway Medians

Medians greater than 25 feet wide can support two rows of trees spaced 20-40 feet apart (GFC, 2002). Provide adequate setbacks to keep utilities clear (if present) and to prevent downed trees or limbs in the roadway. Consider planting large shrubs in median strips if utilities are an issue or if space is limited.

Maintenance

Plan for minimal maintenance of trees (watering may not be feasible)

Use mulch to retain moisture. Do not mulch deeper than 3 inches or build up mulch around trunks.

Mow setback zones and remove any fallen trees or limbs

Manage height of volunteer trees to prevent falling during storms

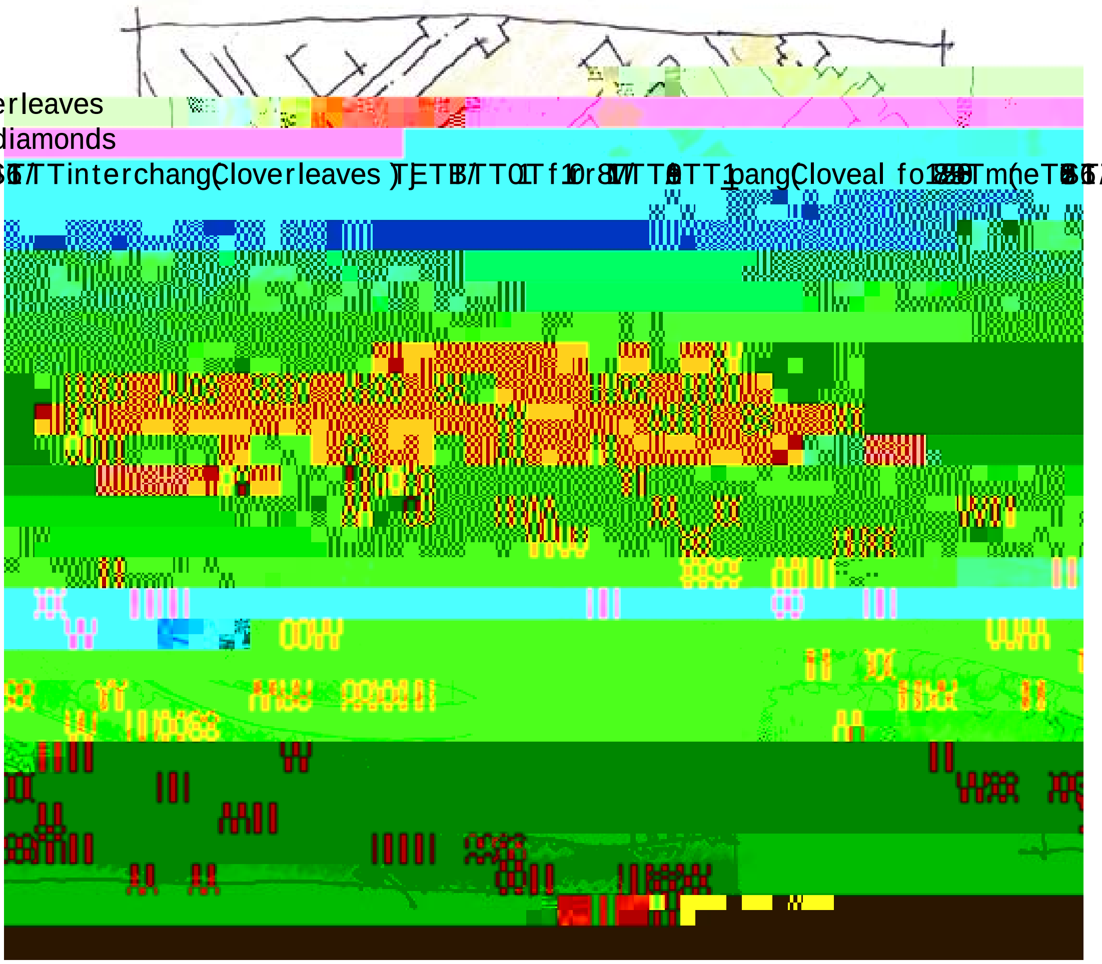
Monitor and control invasive species

Use integrated pest management to control insects.

Potential for Stormwater Treatment

Trees planted in highway cloverleaves, medians, and buffers can be used to provide treatment of stormwater runoff, since these areas typically already receive polluted runoff from the highway. Cloverleaves are generally large enough to locate most stormwater treatment practices, while median strips and buffers lend

Cloverleaves
and diamonds



26.

Pla i g T ee , Re ide ial La

Description

Residential lawns are ideal tree planting locations, particularly in former agricultural areas where few trees exist. Planting trees on home lawns can signiýcantly increase the overall tree cover in the watershed since residential lawns typically constitute a large portion of the plantable area. The key is to educate homeowners about the beneýts of trees and provide incentives and assistance with tree planting and care so that the number of trees planted is signiýcant.

Trees on residential lawns provide many beneýts, including energy cost savings, shade, habitat for wildlife, esthetic value, privacy, and reduction of stormwater runoff. Trees planted next to buildings can reduce summer air conditioning costs by 40% (Akbari and others, 1992).

Pre-Planting Considerations

How can I improve the energy efýciency of my home with tree plantings?

How can I integrate trees with open turf areas?

Site Preparation	Remove invasive plants such as multiþora rose (may include mowing,

Further Resources

Akbari, H., Davis, S., Dorsano, S., Huang, J. and S. Winnett. 1992.

Evergreens block winter winds

Air conditioning unit is shaded by trees

Deciduous trees provide shade from the summer sun

[illegible] 28. [illegible]

Pla i g T ee i Pa k

Description

Parks provide ideal locations for reforestation since they often have large underutilized open areas for planting trees and are publicly owned. Beneýts of planting trees in parks include wildlife habitat, shading, soil stabilization, reduced storm water runoff, and improved recreational opportunities, quality of life, and air quality.

Pre-Planting Considerations

How do I address concerns about vandalism, safety, liability, and visibility?

How do I integrate trees with recreational uses, such as ballýelds and trails?

How do I prevent soils in the planting area from being compacted by foot trafýc?

Can I make the area more attractive with plantings?

Is there an opportunity to create habitat for wildlife?

How do I address illegal dumping?

How do I manage invasive plants?

How do I address potential damage to trees from deer?

How do I address potential conþicts between trees and street lights, utilities, and pavement?

How do I prevent damage to trees from lawnmowers?

Species Selection

Selecting appropriate tree species is key because it can address most

Maintenance	Plan for low maintenance of trees (frequent watering may not be feasible) Use mulch to retain moisture and protect trees from mowers and foot

[illegible] 2. [illegible]

Planting Trees on School Grounds

Description

Schools provide ideal locations for reforestation since they are publicly owned and often have large underutilized open areas for planting trees. Benefits of planting trees on school grounds include wildlife habitat, shading, soil stabilization, improved recreational opportunities and quality of life, educational opportunities, improved air quality, and reduced stormwater runoff.

Pre-Planting Considerations

How do I address concerns about vandalism, safety, liability and

Site Preparation

Clean up trash or other illegally dumped material

Remove invasive plants such as multiþora rose (may include mowing, cutting, or stump treatment)

Improve soil drainage if needed (e.g., amend with compost, mix soils to a depth of 6 to 18 inches).

General Planting Guidance

Trees can be incorporated when developing landscaping plans for new schools. Select planting areas that are adjacent to existing forest or other natural areas or protect natural features such as streams.

Plant to provide shade around bleachers and ballýelds (Figure 30). Use trees to create screen and boundaries between different areas.

Plant street trees or specimen trees around the perimeter of the site at spacing of 30 to 45 feet on center to allow mowing in between for invasive control.

Cluster trees to provide shared rooting space and an even canopy, using species that grow at about the same rate so they don't shade each other out. Do not include turf in tree clusters. Instead, use mulch rings and mow around the clusters.

Post signs to identify intentional plantings

Use small plant materials (e.g., seedlings, whips) where foot trafýc is not an issue and larger stock elsewhere. Mix stock where both understory and canopy trees will be planted (e.g., use small understory stock and large canopy stock), or in tree clusters to protect seedlings (e.g., plant large stock around perimeter and seedlings in center).

Where potential liability from tree climbing is a concern, prune mature trees to the shoulder height of an adult and plant low shrubs or ground cover at tree base.

Plant only low growing herbaceous vegetation in areas where visibility is important for safety reasons or limb trees up to 8 feet in these areas to maintain visibility.

Plant trees where trafýc is minimal, such as along fencelines. Protect trees and their critical root zone (generally a 25-foot radius) from foot trafýc (soil compaction) by using recycled rubber or by directing foot trafýc to certain areas using low metal fences, curbs, posts and chains, or porous pavers (Patterson, 1995)

Maintenance

Plan for low maintenance of trees (frequent watering may not be feasible)

Use mulch to retain moisture and protect trees from mowers and foot trafýc. Do not mulch deeper than 3 inches or build up mulch around tree trunks.

Mow around tree clusters, in setback areas, and other areas to maintain access, safety, and visibility

Monitor and control invasive plants

Prune trees where necessary to maintain visibility and safety.

Potential for Stormwater Treatment

Trees planted at schools may be used to provide treatment of stormwater runoff since school grounds often have large open areas available for stormwater treatment practices. Depending on available space, site conditions, and runoff volume, the following types of practices may be used: stormwater wetlands, bioretention and bioinýltration, swales, and ýlter strips. Trees can be incorporated into all of these treatment practices, and design guidance for each is provided in Part 2 of this manual series. Safety concerns may limit the use of stormwater wetlands or other practices with standing or deep water.

Further Resources

Martin, D., D. Lucas, S. Titman and S. Hayward. 1996. Green Brick Road. 800-471-3638. $27 Cdn.

Maryland State Department of Education. 1999. . Baltimore, MD.

National Wildlife Federation (NWF). 2001. . www./nwf.org/bookstore

Northeastern Illinois Planning Commission (NIPC). 1997. *for Public Offcials*. Chicago, IL.

U.S. Fish and Wildlife Service (USFWS). Schoolyard Habitat Program. Online: www.fws.gov/r5cbfo/schoolyd.htm

[illegible] 30. [illegible]

Pla i g T ee i S, a e T ea e D P, d

Description

In urban areas, lands devoted to treating urban stormwater runoff and septic efþuent can comprise up to 3% of the total land area in the watershed (CWP, 2000b). Stormwater dry ponds are one such type of land and are typically maintained as turf. Planting trees in existing dry ponds increases their esthetic value in the community (particularly if they are highly visible) and may increase pollutant removal. Few engineering constraints exist with planting trees in dry ponds as they may be planted anywhere within the practice.

Pre-Planting Considerations

Can I make the pond more attractive with plantings?

How do I prevent damage to trees from lawnmowers?

How do I manage invasive plants?

How do I address potential damage to trees from deer?

How do I address soil conditions such as severe compaction and þuctuations in soil moisture?

Species Selection

Selecting appropriate tree species is key because it can address most site conditions and is often more efýcient than trying to change the site characteristics. Select a diverse mix of hardy, native species that are adapted to soils and site conditions.

Other desirable species characteristics include the following:

- Tolerates drought
- Tolerates inundation
- Tolerates urban pollutants (sediment, nutrients, metals, bacteria, pesticides)
- Tolerates poor or compacted soils
- Has fall color, spring þowers, or other esthetic beneýt.

Site Preparation

Remove invasive plants such as multiþora rose (may include mowing or cutting)

Improve soil drainage if needed (e.g., amend with compost, mix soils to a depth of 6 to 18 inches).

General Planting Guidance

Plant trees in groups to provide shared rooting space and allow mowing around trees to control invasive species

Use groupings of species that provide fall color, þowers, evergreen leaves, and varying heights to create an esthetically pleasing landscape (Figure 31)

When planting on pond side slopes, create small earthen berms around trees to help retain moisture.

Where soils are compacted and amendments are not possible, provide adequate soil volume in planting hole.

Maintenance

Plan for little maintenance of trees (regular watering may not be feasible)

Mow around tree clusters to control invasive plants. Do not mulch deeper than 3 inches or build up mulch around trunks.

Use mulch to retain moisture

Potential for Stormwater Treatment

A dry extended detention pond provides treatment of stormwater primarily through settling. After storms, stored runoff is gradually released over a period of 1 to 3 days, allowing an opportunity for pollutants to settle out to the þoor of the pond. Trees may increase the pollutant removal ability of a dry pond through nutrient uptake.

Further Resources

Shaw, D. and R. Schmidt. 2003. . Minnesota Pollution Control Agency. Saint Paul, MN.

[illegible] 31. [illegible]

Pla i g T ee Al g S ea a d Sh eli e

Description

Trees planted along streams and shorelines provide many beneýts, including regulation of stream temperature, stabilization of streambanks, enhancement of habitat for both aquatic and terrestrial species, and pollutant removal. The urban stream corridor is an ideal place for reforestation because of these many beneýts, and because it often includes land that cannot otherwise be developed due to its location within the þoodplain or inclusion of steep ravines. Three typical urban stream corridor scenarios and related reforestation goals are described below.

Natural forested stream buffer	Provides habitat for wildlife, stream shading, pollutant removal, large woody debris, leaf litter, bank stabilization
Landscaped buffer (residential backyards, parks, and other managed spaces)	Provides access to stream, passive recreation and water views for residents and park users, stream shading and bank stabilization, some pollutant removal
Highly modiýed buffer (ultra-urban channelized stream)	Provides beautiýcation opportunities even though the forestable area may be limited. Daylighting or removal of impervious cover may increase tree planting opportunities.

Pre-Planting Considerations

Do þoodway regulations prohibit trees?

How do I manage invasive plants?

How do I address potential damage to trees from deer?

How do I address potential conþicts between trees and utilities?

Do I need to use different methods for planting trees on steep slopes?

How do I address illegal dumping?

Is there an opportunity to create habitat for wildlife?

How do I address concerns about safety, nuisance rodents, weeds, esthetics, and wildlife?

How do I address urban stream impacts, such as lowered baseþow?

Species Selection

Selecting appropriate tree species is key because it can address most site conditions and is often more efýcient than trying to change the site characteristics. Select a diverse mix of hardy, native species that are adapted to soils and site conditions.

Use large trees for small streams with shallow banks, and shrubs or small trees to provide stability for steep banks or larger streams with high þows. Mix canopy and understory species to create vertical structure. Other desirable species characteristics include the following:

- Tolerates inundation (although upland species may do well where the riparian zone is drying out)
- Wide, spreading canopy
- Provides food, cover, or nesting sites for wildlife.

Site Preparation

- Remove any trash or other illegally dumped material
- Remove invasive plants such as multiþora rose (may include mowing, cutting, or spraying with aquatic-use herbicide)
- Improve soil drainage if needed (e.g., amend with compost, mix soils to a depth of 6 to 18 inches).

General Planting Guidance

- Use three-zone buffer design (Welsch, 1991) with the following zones: streamside, middle, and outer. Each zone should have different vegetative targets, widths, and allowable uses that are progressively more restrictive as you move towards the stream (Figure 32).
- Focus on providing a forested strip immediately adjacent to the stream if land use limits reforestation of the entire site (Figure 33)
- Select a mix of stock so trees do not all die at the same time. Use larger trees next to the stream and seedlings elsewhere. Bare root stock may be easier for volunteers to plant and require less water.
- Random spacing is preferred but can make survival counts difýcult
- If mowing between trees is necessary, provide enough space for mowers to avoid damaging trees.

Maintenance

- Design for little or no maintenance (watering may not be feasible)
- Use mulch to retain moisture. Do not mulch deeper than 3 inches or build up mulch around trunks.
- Use tree shelters to protect seedlings from deer
- Continually monitor for and remove invasive species (mowing in between trees may be necessary).

Potential for Stormwater Treatment

If stormwater runoff crosses the stream buffer in a pipe, potential for stormwater treatment is low. Runoff from adjacent land uses may be directed to the buffer as sheetflow for stormwater treatment. Linear stormwater treatment practices such as filter strips and bioretention may work best here, although depending on space available, stormwater wetlands could also be used. Guidance for incorporating trees into these practices is provided in Part 2 of this manual series.

Further Resources

Alliance for the Chesapeake Bay (ACB). 2002. . Pennsylvania Department of Environmental Protection, Bureau of Watershed Conservation.
www.dep.state.pa.us/dep/deputate/watermgt/wc/subjects/StreamReLeaf

Native Plants by Region for Riparian Forest Buffers:
www.rce.rutgers.edu/njriparianforestbuffers/nativeALL.htm

Palone, R. and A. Todd. 1998. . USDA Forest Service, Northeastern Area State and Private Forestry.
www.chesapeakebay.net/pubs/subcommittee/nsc/forest/handbook.htm

Schueler, T. 1995. . Center for Watershed Protection and the Metropolitan Washington Council of Governments.

Standard for Riparian Forest Buffer from the New Jersey BMP Manual:
www.state.nj.us/dep/watershedmgt/DOCS/BMP_DOCS/chapter5_reparian_buffer.PDF

Welsch, D. 1991. . 28 pp. USDA Forest Service NA-PR-07-91. Radnor, PA. www.na.fs.fed.us/spfo/pubs/n_resources/buffer/cover.htm

Planting Trees in Utility Corridors

Description

Utility corridors are linear features that contain power and gas transmission lines. These corridors can be up to 150 feet wide and contain above- and below-ground utility lines. Most utility corridors are privately owned; therefore, their reforestation potential will depend on the vegetation management policy of the utility company. Planting trees in utility corridors can create wildlife habitat corridors, and improves air quality, stabilizes soil, reduces runoff, and reduces air temperature.

Pre-Planting Considerations

Do I have permission of utility company to plant trees?

How do I address potential conflicts between trees and utilities?

How do I manage invasive plants?

Is there an opportunity to create habitat for wildlife?

How do I address potential damage to trees from deer?

How do I provide maintenance access to utility structures and visibility for fly-over inspections?

How do I address security concerns?

Species Selection

Selecting appropriate tree species is key because it can address most site conditions and is often more efficient than trying to change the site characteristics. Select a diverse mix of hardy, native species that are adapted to soils and site conditions.
Other desirable species characteristics include the following:

Is a shrub or small tree less than 10 feet high when mature

Provides food, cover, or nesting sites for desired wildlife

Tolerates drought (rainfall may be the only source of water)

Tolerates inundation (if used for stormwater treatment)

Tolerates urban pollutants and poor soils.

Site Preparation

Clean up trash and other illegally dumped material

Remove invasive or unwanted plants such as multiflora rose (may include mowing, cutting, or spraying with herbicide approved for aquatic use)

Improve soil drainage if needed (e.g., amend with compost, mix soils to a depth of 6 to 18 inches).

General Planting Guidance

Do not plant trees or shrubs along gas transmission lines since canopy limits ability to inspect lines for leaks. Establish meadow vegetation instead.

Promote the growth of low-growing, shrub or scrub plant communities within electric transmission corridors. Do not plant trees greater than 10 feet mature height within 75 feet of electric transmission lines (Head and others 2001). Instead, plant small trees, shrubs, or meadow vegetation (Figure 34).

Create soft edges between the utility corridor and adjacent vegetation by providing a gradual transition from herbaceous vegetation to shrubs to trees as you move away from the power lines. These edges provide a diversity of habitat for wildlife.

Provide setbacks from utility structures to provide maintenance access.

Maintenance

Plan for minimal maintenance of trees and shrubs (watering may not be feasible)

Use mulch to retain moisture. Do not mulch deeper than 3 inches or build up mulch around trunks.

Monitor and control invasive plants

Use Integrated Vegetation Management (IVM) to maintain low-growing vegetative community (less than 10 feet in height). This includes mowing, hand removal of vegetation, and selective spraying of individual trees in early growing stage (Genua, 2000).

Where utility corridor crosses the stream, do not mow within 50 feet and use only herbicides approved for aquatic use.

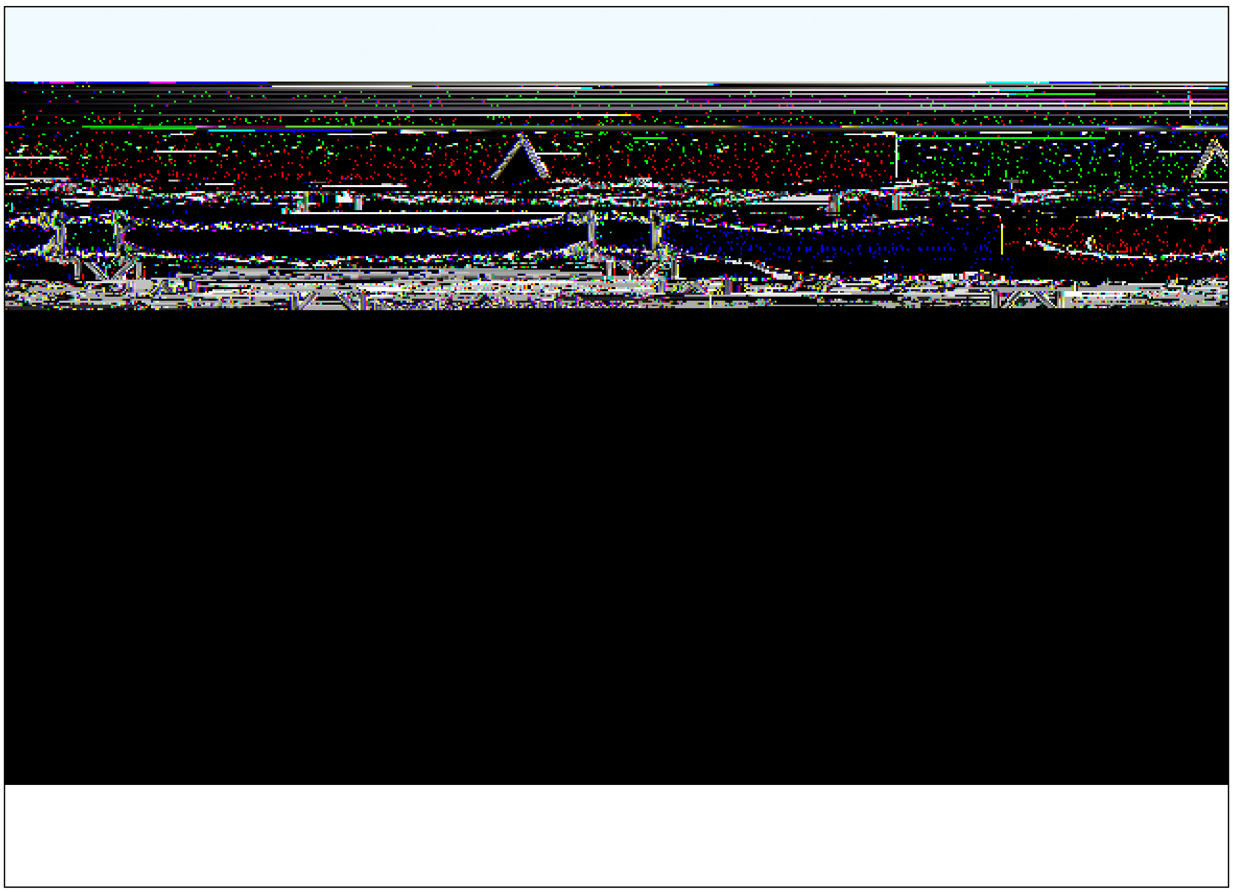
Potential for Stormwater Treatment

Trees and shrubs planted in utility corridors may be used to provide treatment of stormwater runoff from nearby impervious surfaces. Linear stormwater treatment practices such as swales, bioretention, and ýlter strips are most applicable in a utility corridor. Perhaps the most appropriate use of trees for stormwater treatment in a utility corridor is a ýlter strip incorporating multiple vegetative zones to provide a gradual transition from herbaceous vegetation to trees. Design guidance for these practices is provide in Part 2 of this manual series.

Further Resources

Genua, S. M. 2000. *Converting Power Easements into Butterfy Habitats*. Potomac Electric Power Company (PEPCO). Online: www.butterþybreeders.org/pages/powerease_sg.html

Wildlife Habitat Council. Online: www.wildlifehc.org/spotlight/index.cfm



[illegible] 34. [illegible]

Pla i g T ee i Vaca L

Description

Many older urban areas have numerous vacant lots that cumulatively can increase watershed forest cover through reforestation. Planting trees in vacant lots can also provide much needed community green space for local residents. Other beneýts of planting trees in vacant lots include wildlife habitat, shading, soil stabilization, improved air quality, and reduced stormwater runoff.

Pre-Planting Considerations

Do I have landowner permission to plant trees?

How do I address concerns about vandalism, crime, vagrants, visibility, and safety?

Is there an opportunity to create wildlife habitat?

Si

Potential for Stormwater Treatment	Trees planted in vacant lots may be used to provide treatment of stormwater runoff if soils and the water table allow. Vacant lots may have signiýcant area available for stormwater treatment practices, but if soils are highly disturbed and poorly drained, or water table is close to surface, treatment may be limited (or underdrain may be needed) to prevent soggy basements next door or standing water. Depending on available space, site conditions and runoff volume, the following types of practices may be used: stormwater wetlands, bioretention and

Lighting discourages
illegal dumping

and prevents vehicle access for
dumping

[illegible] 36. [illegible]

Appendix A. Effect of Land Cover on Runoff and Nutrient Loads in a Watershed

Most urban watersheds are a mosaic of forest, turf, and impervious cover. Traditional monitoring efforts have been unable to distinguish the relative contribution of each type of cover to nutrient loading. With the advent of source area monitoring, however, it is now possible to estimate how much each cover type contributes to nutrient loading in urban watersheds.

As noted earlier, forest cover is the highest and best use of land in a watershed, in terms of reducing excess nutrient runoff. Forests act as a sink for nutrients and lock them up in live and dead biomass, as well as soils. As a result, measured nutrient concentrations in forest runoff are quite low (Table A-1). Turf, on the other hand, generates much higher nutrient levels, according to source area monitoring of both fertilized and unfertilized lawns. Impervious cover produces intermediate nutrient concentrations that reþect the washoff of nutrients deposited from the atmosphere, car exhaust, or household pets.

difference is even more signiýcant when forest cover is compared with impervious cover ð over 25 times more nitrogen and phosphorus are lost from impervious cover. The nutrient beneýts of maintaining forest cover (or increasing it by converting turf to forest) can be impressive at the watershed scale.

NRCS State Soil Geographic Database (STATSGO)
www.ftw.nrcs.usda.gov/stat_data.html
Download soil layers for U.S. states. This layer is most useful for counties with no SSURGO data available.

NRCS Soil Survey Geographic Database (SSURGO)
www.ftw.nrcs.usda.gov/ssur_data.html
Download soils layers for counties. Not available for all counties.

Space Imaging
www.spaceimaging.com
Purchase high-resolution Ikonos satellite imagery. Can be very expensive.

U.S. Bureau of the Census Topologically Integrated Geographic Encoding and Referencing System (TIGER)
www.census.gov/geo/www/tiger/index.html
Download TIGER/Line ýles from the year 2000 and earlier by state. These ýles include roads, railroads, rivers, lakes, legal boundaries, and census statistical boundaries. Requires special conversion tools to use in GIS.

USGS Geographic Data Download
http://edc.usgs.gov/geodata
Download the National Hydrography Dataset, 1:24,000 Digital Line Graphs and national scale Land Use/Land Cover, Digital Elevation Models, and Digital Line Graphs. Contains information on obtaining other USGS map products.

USGS Seamless Data Distribution
http://seamless.usgs.gov/website/Seamless/
Download high-resolution orthophotos, National Elevation Dataset, National Land Cover Database, and various other layers using interactive map.

USGS Earth Explorer
http://edcsns17.cr.usgs.gov/EarthExplorer/
Purchase reasonably priced satellite imagery, aerial photos, Digital Line Graphs, elevation data, and Digital Raster Graphics.

Chesapeake Bay Regional and Local Data

Canaan Valley Institute
http://canaanvi.org/gis/gis_links.asp
Contains links to downloadable GIS layers for Maryland, Pennsylvania, West Virginia, and Virginia.

Chesapeake Bay Program FTP Site
ftp://ftp.chesapeakebay.net/pub/Geographic/
Download Arc/Info export ýles for the Mid-Atlantic, Chesapeake Bay, or individual states, including hydrography, land cover, political boundaries, transportation and watershed boundaries (HUC 8, HUC 11).

Chesapeake Bay Program (CBP) Resource Lands Assessment

www.chesapeakebay.net/rla.htm

Download Bay-wide GIS data results of CBP model scenarios. Data includes ranking of lands by importance to: Prime Farmland, Ecological Network, Water Quality Protection, Forest Economics, Cultural Assessment and Vulnerability to Development.

Maryland Department of Natural Resources Geospatial Data

http://dnrweb.dnr.state.md.us/gis/data/data.asp

Download 4-meter Digital Orthophoto Quadrangle Quarters (DOQQs), þoodplains, wetlands,

Appendix C. Methods for Deriving Land Cover Coefficients

This Appendix describes the general methods to derive land cover coefýcients for use in the Leafout Analysis. Table C-1 presents impervious cover coefýcients for various land uses, for four urban and suburban counties in the Chesapeake Bay Watershed: James City County, VA, Baltimore County, MD, Howard County, MD, and Lancaster County, PA (Cappiella and Brown, 2001). These coefýcients can be generalized beyond the individual counties in which they were derived, and they are broadly transferable to other Chesapeake Bay communities with similar development patterns.

-1 [illegible]		
[illegible]	[illegible]	[illegible] (%)
A [illegible]	8	2
[illegible]	11	
2-A [illegible]		

within the Chesapeake Bay Region, as well as the variety of land uses within the study areas. In addition, there was a direct attempt to target and derive impervious cover coefýcients for land uses that had little or no previous research associated with it (e.g., open urban land, institutional land).

-2. [illegible]		
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	10
[illegible]	[illegible]	10
[illegible]		
2-[illegible]	[illegible] 1.70 [illegible] 2.30 [illegible]	10
1-[illegible]	[illegible] 0.75 [illegible] 1.25 [illegible]	20
[illegible]-[illegible]	[illegible] 0.40 [illegible] 0.60 [illegible]	20
[illegible]-[illegible]	[illegible] 0.20 [illegible] 0.30 [illegible]	20
-[illegible]	[illegible] 0.10 [illegible] 0.16 [illegible]	10
[illegible]	5-10 [illegible] / [illegible]	20
[illegible]	10-20 [illegible] / [illegible]	10
[illegible]	[illegible]	20
[illegible]	[illegible]	20
[illegible]		
[illegible]	[illegible]	10
[illegible]	[illegible]	10
[illegible]	[illegible]	10
[illegible]		200

The number of polygons sampled for each land use were chosen based on the frequency and variability of land uses or zoning categories. For example, over 120 sample polygons were needed to characterize the range of housing densities within residential zoning. Given the limited resources available for the study, sample targets were kept to 10 or 20 for each land use. Rigorous statistical analysis was conducted to demonstrate that the sample size would still yield information, particularly across certain land use types. Standard statistics of the results, such as the standard error, were used as measures of the reliability of the results. Based on this study design, between two and ýve polygons were sampled for each land use within each jurisdiction.

Step 2. Delineate Land Use Polygons

The criteria used when selecting land use polygons in the GIS are listed below.

For single family residential polygons:

> For residential land uses, the parcel boundary information was used to ýrst classify parcels based on acreage (shown in the description in Table C-2). Development patterns that most closely matched the land use category (e.g., ¼-acre lots) were selected for sampling. Because most subdivisions do not have uniform lot sizes, subdivisions were selected if the majority of lots or average lot size met the general criteria for the land use category.
>
> Because of difýculty in ýnding subdivisions that met the above criteria for polygon delineation, no minimum area was set for the polygon size for residential areas. Instead, it was decided that each residential polygon must include a minimum of ýve lots.
>
> Polygons were drawn by following the lot lines of contiguous parcels and excluding areas of "unbuildable" land located in the interior of the polygon. Stream valleys that did not originate within the subdivision were excluded from the land use polygons, as were other "unbuildable" lands, such as þoodplains, wetlands, and conservation areas. The basis behind this rule is that not all development sites include these types of characteristics. When predicting future impervious cover, a planner could estimate the areas based on existing mapping and based on local codes and ordinances that determine "unbuildable" acreage. This acreage could then be removed from the total acreage of the planning area.

For other land use polygons:

> Stormwater ponds and open water were not considered to be impervious cover because they generally occupy a small area and are not always associated with a single land use. While water surfaces do act as impervious surfaces in a hydrologic sense, they generally do not have similar consequences on stream quality, watershed health, or pollutant loading, as do more conventional types of impervious cover, such as roads, parking lots, and rooftops.
>
> Minimum lot sizes were set for agriculture (50 acres), commercial (1 acre), industrial (5 acres), and multifamily (5 acres) categories.

Once a development area was selected, generally the following criteria were used to delineate the polygons:

> Parcel lines were used as guides for drawing the polygon boundaries.
> ñUnbuildableò land, such as þoodplains, steep slopes, and conservation areas, were not included in the polygons.
> Subdivision lots that were not built out were not included in the polygons.
> Large forested areas located outside parcel boundaries were not included in the polygons.
> Local and arterial roads were included in the polygons if the parcels bordering each side of the road had the same land use.
> If a local or arterial road bordering a parcel had a different land use bordering the other side of the road, only half the road was included in the polygon.

Orthophotos were used to digitize an impervious cover layer that included tennis courts, garages, and other impervious surfaces not included in the buildings, parking lots, roads, driveways, or sidewalks layers. This impervious cover layer was included in the processing and calculation of total impervious cover.

Appendix D. Sources of Data for Forest Cover Coefficients

The Leaf-Out Analysis method described in Chapter 2 requires the input of forest cover coefýcients that represent the fraction of land that is forest for a given land use. Data is currently lacking for forest cover coefýcients; however, it can be assumed that the amount of forest cover for a given land use will vary with development intensity, age of development, prior land use, and local forest conservation or natural resource protection regulations. In Table 5 in Chapter 2, the forest cover coefýcients presented for the Direct Forest Conservation Scenario were loosely based on the Maryland Forest Conservation Act Forest Cover Requirements shown in Table D-1.

[illegible]	
[illegible]	[illegible]
[illegible]	20-50
[illegible]	20-25
[illegible]	15-20
[illegible]	15-20
[illegible]	

[illegible]-3. [illegible] (A[illegible], 2003)	
[illegible]	% [illegible]
[illegible]	20
[illegible]	2
[illegible]	25
[illegible]	6
[illegible]	8

[illegible]-4. [illegible] (A[illegible], 2000)	
[illegible]	% [illegible]
[illegible]	26
[illegible]	13
[illegible]	7
[illegible]	1
[illegible]	4

Appendix E. Blank Worksheet for Leaf-Out Analysis

Leaf-Out Analysis Worksheet For Estimating Future Forest Cover in a Watershed

Section 1. Future Forest Cover

Current Protected or Developed Forest Cover:			
All protected or developed forest will remain forested.		+	
Priority Forest Area Protected			
See section 2 of this worksheet. Default value is zero.		+	
Area of Forest Conserved During Development			
See section 2 of this worksheet./ActualText<FEFF0032>BDC (2)TjEMC (of th)Tj/Spa.ealText/Text<FEFtrhtualText<FEFF0			

Section 3. Results Summary

Total Current Forest Cover		[illegible]		
	-			
Total Future Forest Cover		[illegible]		
From Section 1 above.	–			
Future Forest Loss		[illegible]		%

Appendix F. Resources for Setting Urban Canopy Goals

In this manual, numerical goals are recommended for forest cover (or, ideally, canopy cover) in urban watersheds. Chapter 2 provides some general guidelines as to what these numerical goals should be for different types of watersheds. These recommendations are based on the data summarized below and should be tailored to the needs of each community.

The ýrst recommendation made in Chapter 2 was to set a numerical target for forest cover for the entire community. Table E-1 lists various canopy goals for metropolitan areas. The 40% goal set by American Forests (2003) is used by a number of communities. This recommendation comes from extensive analysis of urban tree coverage. American Forests measured tree cover in 440 communities and found that most communities in the southeastern United States have more than 60% canopy cover. The

The most extensive data found on canopy goals included recommendations for canopy cover for individual land uses. This is important because although goals may be deýned for a larger area such as a watershed or city, the implementation of these goals will often occur at the site level. Table F-3 summarizes recommended or adopted canopy goals for various zoning categories.

[illegible] -3. [illegible]				
[illegible]	[illegible] (% [illegible])			
	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] (2003)	25-50	15	[illegible]	[illegible]
[illegible] (2002)	15	10	[illegible]	[illegible]
[illegible] (2002)	15-20	10	[illegible]	[illegible]
[illegible] (2002)	[illegible]	10-25	[illegible]	[illegible]
[illegible] (2002)	15-20	10	[illegible]	[illegible]
[illegible] (2002)	10-20	10	[illegible]	[illegible]
[illegible] (2002)	15	10	[illegible]	[illegible]
[illegible] (2002)	20	15	[illegible]	[illegible]
[illegible] (2003)	[illegible]	[illegible]	[illegible]	65
[illegible] (1[illegible]1)	15-25	15-20	[illegible]	20-50
[illegible] (2001)	40-60	0-40	[illegible]	70
[illegible] (2002)	10-20	0-15	[illegible]	[illegible]
[illegible] (2003)	35-40	15	35	30
[illegible] (2002)	10-20	10	[illegible]	[illegible]
[illegible] (1[illegible]8)	10-20	10	[illegible]	[illegible]
[illegible] (1[illegible]3)	[illegible]	[illegible]	50	[illegible]

Meteorological models have also been used in determining realistic goals for canopy cover (Luley and Bond, 2002). Table F-4 summarizes the results of one such model (MM5) in estimating current forest cover, proposed (realistic) forest cover, and the maximum possible forest cover for three urban land uses in the New York City area.

[illegible]-4. [illegible] ([illegible], 2000)			
[illegible]	[illegible] %		
	[illegible]	[illegible]	[illegible]
[illegible]	14	24	48
[illegible]	33	43	68
[illegible]	25	35	41

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