Urban Tree Canopy Goal Setting

A Guide for Chesapeake Bay Communities

Prepared By

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About this Manual

This guidebook is based on the Urban Tree Canopy Goal Setting Workshop, held in Annapolis, MD on March 7 – 8, 2006. The workshop was designed to give practical instruction on tools and methods for enhancing urban tree canopy cover. The topics covered in this guide include administrative considerations, canopy assessment techniques, goal setting criteria and implementation strategies. It also introduces the Forest Opportunity Spectrum (FOS), a new framework for attaining diverse social and ecological goals through urban forestry. This guide, based largely upon the material of the workshop, is meant to be a resource to Chesapeake Bay communities interested in reaping the environmental, social, economic, and aesthetic benefits of an enhanced urban tree canopy.

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- Maryland Department of Natural Resources
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CHAPTER 1: INTRODUCTION

The Chesapeake Bay Program Partnership

The Chesapeake Bay Program (CBP) is a partnership between federal and state agencies, non-profit organizations, and academic institutions whose aim is to protect and restore the Chesapeake Bay. The goal of these restoration efforts is to improve water quality, restore critical habitat, and ensure sustainable populations of fish and shellfish by balancing environmental protection with the needs of the Bay watershed's 15 million residents.

Restoring the Chesapeake Bay

The Chesapeake Bay is North America's (and possibly the world's) largest and most productive estuary. The Bay's 64,000 square-mile **watershed** spans portions of six states and all of the District of Columbia. It is home to more than 3,600 species of plants and animals. Unfortunately human activities have degraded the Bay's waters. **Nutrient pollution** from urban, suburban, and agricultural areas causes harmful algal blooms which block sunlight from reaching aquatic vegetation and leads to low oxygen conditions that are toxic to fish, shellfish, and other aquatic life. Sediment from urban development and agriculture also contribute to pollution. This sediment chokes oyster beds and further reduces water clarity. Fortunately, there are things we can do to reduce our impact on the Bay.

What is the Urban Forest? Urban Tree Canopy? Urparian?

Urban Forests include the trees in our yards, parks, public spaces, and along our streets. Though we don't often think of them as forests, they provide many forest benefits, such as cleaner air and water. In addition to environmental benefits, urban forests increase property values, reduce home energy costs, block UV radiation, buffer wind and noise, provide shade and beautify our neighborhoods.

Urban tree canopy (UTC) is defined as the layer of leaves, branches and stems that cover the ground when viewed from above.

Urparian describes the vegetated areas around roads and sidewalks. The term comes from combining urban and riparian to form a single word. In less urbanized systems, the corridor around streams (the riparian zone) is extremely important for water quality. This area of vegetation captures and processes pollutants before they can make it into surface waters.

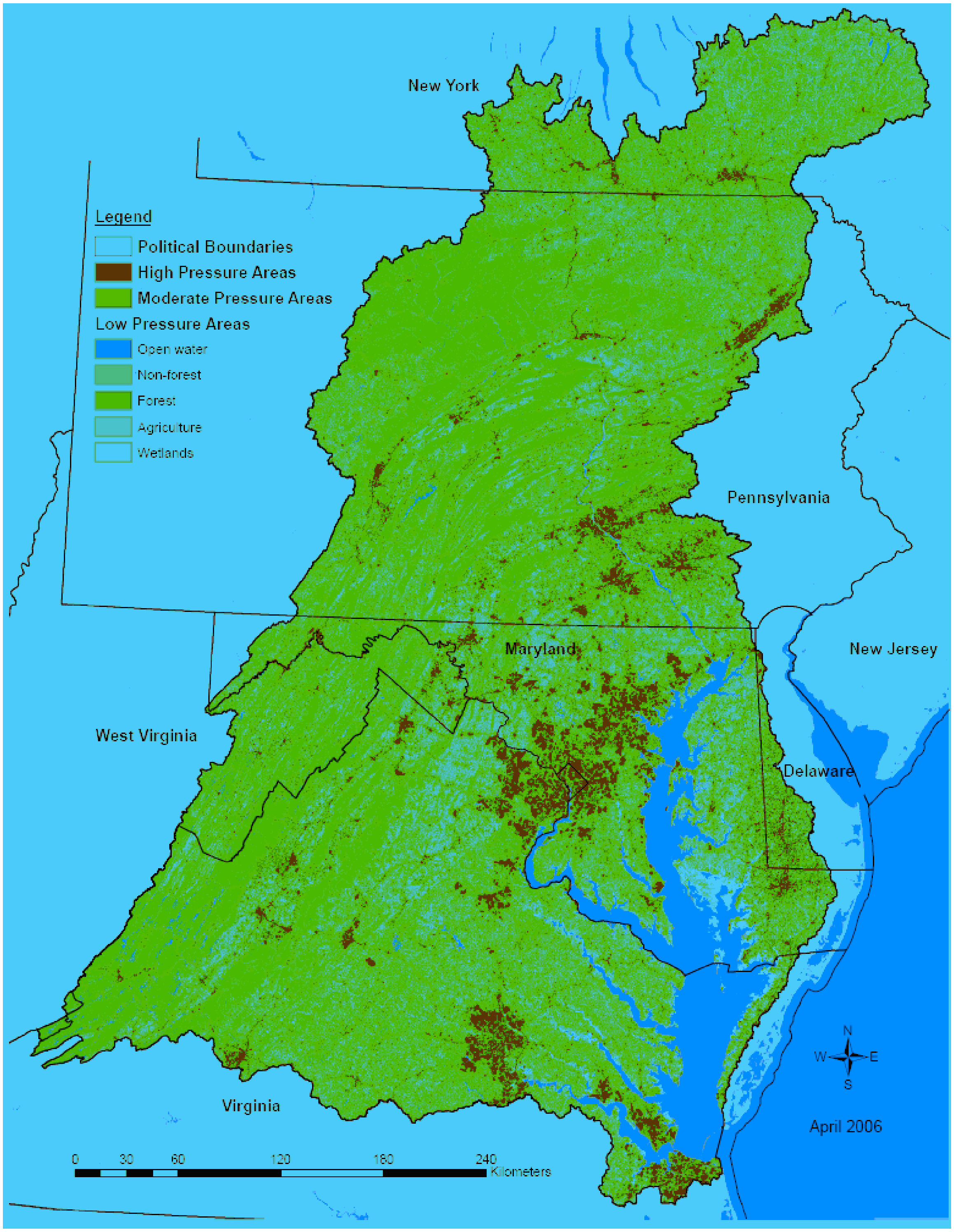
In urban areas, however, riparian zones are often less effective at removing pollutants. One reason is that urban streams tend to be deeply incised, causing the riparian zone to be disconnected from the stream below. Secondly, the streams in many urban areas have been functionally replaced with storm sewers. In this context, the soil and vegetation around roads and sidewalks is the new riparian zone. By increasing tree canopy in the urparian zone, we can return some of the environmental benefits of riparian areas to urban systems.

Urban Development and Water Quality

Urban areas cover just 20% of the land area of the Chesapeake Bay Watershed, yet account for much of the nutrient and sediment pollution to the Bay. When point sources are included, urban and suburban areas deliver more pollution on a per-area basis than other major land use types. Forests, on the other hand, cover 58% of the land area yet only contribute a small fraction of the nutrients entering the Bay. This makes forests the most beneficial land use for preserving water quality. As urban areas continue to expand, it is important that we expand urban tree canopy (UTC) in our cities. By slowing and intercepting rainfall, increasing groundwater infiltration, taking up nutrients, and transpiring water to the atmosphere, trees can reduce the amount of pollution-carrying stormwater runoff that enters the Bay.

Figure 1-1. Future Threats to Water Quality: The map (opposite page) shows areas of the Chesapeake Bay watershed that are under high development pressure. As more land in the Bay watershed is converted from forest to urban, water quality will likely decline. Urban Tree Canopy can help mitigate some of the impacts of urbanization.

Development Pressure in the Chesapeake Bay Watershed 2000 – 2010



Claggett, P.R., and C. Bisland, 2004. Assessing the Vulnerability of Forests and Farmlands to Development in the Chesapeake Bay Watershed. In Proceedings of the IASTED International Conference on Environmental Modeling and Simulation, November 22-24, St. Thomas, U.S. Virgin Islands.

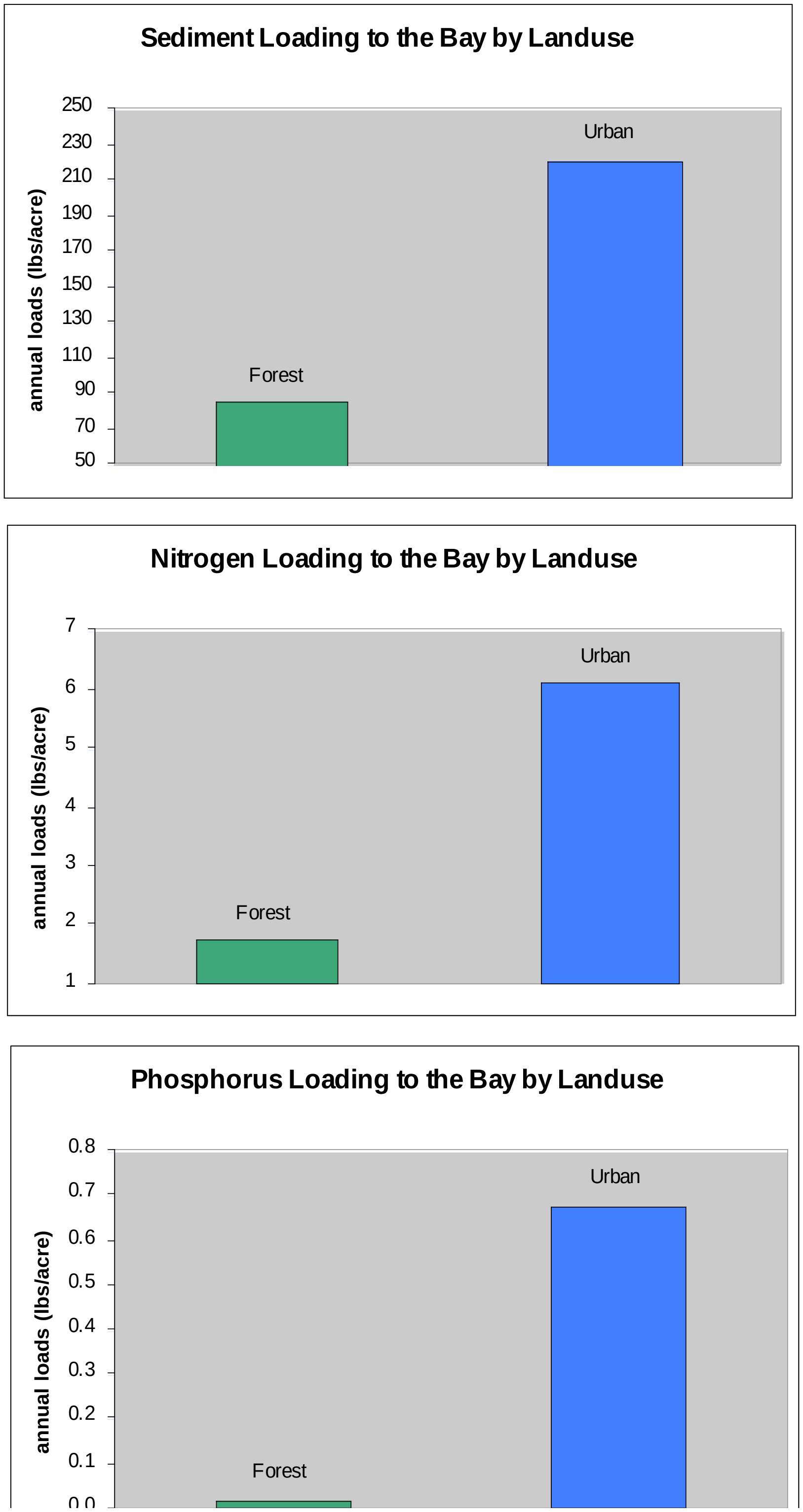


Figure 1-2. Urban areas contribute many times more nitrogen, phosphorus, and sediment to the Chesapeake Bay than forested areas. These elevated levels of nutrients and sediment contribute to the environmental problems facing the Bay. (Based on data from the 2004 Chesapeake Bay Model)

The Need for Urban Forestry

While we may not think of city trees as a typical forest, these trees provide valued services to our daily lives. By increasing tree cover in urban areas we can decrease the volume of pollution-carrying **stormwater runoff** flowing into the Chesapeake Bay, while simultaneously reducing air pollution, lowering city temperatures, enhancing property values, providing wildlife habitat, and adding to the beauty, livability, and desirability of our communities.

It is important to understand that urban development is increasing rapidly, and as urban areas grow, so will their contribution to water quality problems in the Chesapeake Bay. Urban tree canopy (UTC) enhancement can help mitigate some of the harmful effects of an increasingly developed landscape by providing many of the **ecosystem services** that forests would have provided. While a few communities have instituted **smart growth** strategies, which help mitigate **urban sprawl**, fewer still have developed land cover strategies like UTC to help mitigate the environmental effects of newly urbanized areas. UTC can play an important part in decreasing our impact on the environment.

Urban Forestry and Ecosystem Services

Urban forests provide numerous **ecosystem services** that become apparent at different scales. At the larger watershed scale we look to forests to reduce stormwater runoff, improve regional air quality, reduce stream channel erosion, reduce summer air and water temperatures, and provide habitat for terrestrial and aquatic wildlife. At the community and parcel scale we look to trees to improve public health, decrease home and office energy usage, provide recreation, buffer wind and noise, provide shade, and increase community desirability. Figure 1-3 shows the benefits that urban forests provide at the watershed and parcel scale. Figure 1-4 provides greater detail about the environmental benefits of urban forests.

Watershed Benefits of Forest Cover

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

Table 2. Economic, Environmental, and Community Benefits of Trees

Scale	Category	Benefit
Watershed	Environmental	• Reduce storm water runoff • Improve regional air quality • Reduce stream channel erosion • Improve soil and water quality • Provide habitat for terrestrial and aquatic wildlife • Reduce summer air and water temperatures
Parcel	Economic	• Decrease heating and cooling costs • Reduce construction and maintenance costs (by decreasing costs related to clearing, grading, paving, mowing, and storm water management) • Increase property values • Positively influence consumer behavior
Parcel	Environmental	• Reduce urban heat island effect • Enhance function of storm water treatment practices
Parcel	Community	• Increase livability • Improve health and well-being • Block UV radiation • Provide shade • Buffer wind and noise • Increase recreational opportunities • Provide esthetic value

Figure 1-3. From the Urban Watershed Forestry Manual, Part 1: Methods for Increasing Canopy Cover in a Watershed. The complete manual is available for download at http://www.na.fs.fed.us/watershed/publications.shtm

Table 3. Watershed Benefits of Forest Cover	
Benefit	**Description**
Reduce storm water runoff and flooding	• Trees intercept rainfall in their canopy, reducing the amount of rain that reaches the ground. A portion of this intercepted rainwater evaporates from tree surfaces. This effect is greater in low rainfall events. • Trees take up water from the soil through their roots during transpiration, which increases soil water storage potential and lengthens the amount of time before rainfall becomes runoff • Trees promote infiltration by attenuating runoff and by increasing soil drainage due to the creation of macropores by tree roots. The addition of organic matter (e.g., leaf litter) also increases storage of water in the soil, further reducing runoff. • Reduced runoff from forested land reduces the frequency and volume of downstream flood events.
Improve regional air quality	• Trees absorb nitrogen dioxide, carbon monoxide, ozone, and particulate matter from the atmosphere. • Trees reduce air temperature which reduces formation of pollutants that are temperature dependent, such as ozone • Trees indirectly improve air quality by cooling the air, storing carbon, and reducing energy use, which reduces power plant emissions
Reduce stream channel erosion	• Trees growing along a stream bank prevent erosion by stabilizing the soil with root systems and the addition of organic matter, and by substantially dispersing raindrop energy • Reduced runoff volume due to forests upstream can reduce downstream flood flows that erode the stream channel
Improve soil and water quality	• Trees prevent erosion of sediment by stabilizing soil with root systems and the addition of organic matter, and by substantially dispersing raindrop energy • Trees take up nutrients such as nitrogen from soil and groundwater • Forested areas can filter sediment and associated pollutants from runoff • Certain tree species break down pollutants commonly found in urban soils, groundwater, and runoff, such as metals, pesticides and solvents
Provide habitat for terrestrial and aquatic wildlife	• Forests (and even single trees) provide habitat for wildlife in the form of food supply, interior breeding areas, and migratory corridors • Streamside forests provide habitat in the form of leaf litter and large woody debris, for fish and other aquatic species • Forest litter, such as branches, leaves, fruits, and flowers, form the basis of the food web for stream organisms
Reduce summer air and water temperatures	• Riparian forests shade the stream and regulate summer air and water temperatures, which is critical for many aquatic species • Trees and forests shade impervious surfaces, reducing temperature of storm water runoff, which can ameliorate the thermal shocks

Figure 1-4. From the Urban Watershed Forestry Manual, Part 1: Methods for Increasing Canopy Cover in a Watershed. The complete manual is available for download at http://www.cwp.org/forestry/index.htm

The Value of Trees: Getting More than We Pay For

One issue that municipalities may contend with during the goal setting process is the cost associated with planting and maintaining a healthy urban tree canopy. Fortunately, research has shown that trees can be a positive economic investment. Below are the results of street tree analyses done in cities around the country using the **STRATUM** (Street Tree Resource Analysis Tool for Urban Forest Managers) tools developed by the US Forest Service Center for Urban Forest Research. These figures show the annual economic benefits achieved for each dollar spent on city street trees. Measured benefits include lower costs for stormwater treatment, energy savings for heating and cooling, carbon sequestration, air quality improvement and increased property values. The calculated costs of street trees include pruning, tree and stump removal, pest and disease control, irrigation, repair of infrastructure damage, litter cleanup, litigation and settlements for tree-related claims and program administration. The lowest benefit-to-cost ratio to date was in Berkeley, CA with $1.37 returned for each dollar spent. Other locations, such as Charlotte, NC, showed more than a $3.00 return in value for each dollar spent on street trees. In addition to these measurable benefits, trees provide numerous social, community, health and aesthetic benefits that are difficult to measure in dollars and cents.

Location	*Benefit-to-Cost Ratio (return on each dollar invested)*
**Charlotte, NC	$3.25
*Bismark, ND	$3.09
*Glendale, AZ	$2.41
*Fort Collins, CO	$2.18
*Cheyenne, WY	$2.09
**Modesto, CA	$1.85
**Santa Monica, CA	$1.52
*Berkeley, CA	$1.37

* McPherson, E.G.; Simpson, J.R.; Peper, P.J.; Maco, S.E.; Xiao, Q. 2005. Municipal forest benefits and costs in five U.S. cities. Journal of Forestry. 103(8): 411-416.

** Center for Urban Forest Research Newsletter, Fall 2005/Winter 2006; http://www.fs.fed.us/psw/programs/cufr/products/newsletters/UF632Fall2005Winter2006.pdf

Figure 1-5. Benefit-to-cost ratios for the planting and maintenance of street trees in eight US cities.

CHAPTER 2: THE CHESAPEAKE BAY PROGRAM'S URBAN AND COMMUNITY TREE CANOPY GOALS

In October of 1994, the Chesapeake Executive Council formally recognized the value of Urban Tree Canopy (UTC) for water quality:

> WE FURTHER RECOGNIZE THAT URBAN TREE CANOPY COVER offers stormwater control and water quality benefits for municipalities in the Chesapeake Bay watershed and can extend many riparian forest buffer functions to urban settings. (Directive #94-1)

In 2003, the Council signed an expanded directive that called for more specific actions to increase the benefits of urban tree canopy cover in the Bay watershed:

> • By 2010, work with at least 5 local jurisdictions and communities in each state to complete an assessment of urban forests, adopt a local goal to increase urban tree canopy cover and encourage measures to attain the established goals in order to enhance and extend forest buffer functions in urban areas.
>
> • Encourage increases in the amount of tree canopy in all urban and suburban areas by promoting the adoption of tree canopy goals as a tool for communities in watershed planning.

This represents a new approach to urban forestry. It asks communities to adopt specific goals for tree canopy cover to inspire policies and activities that will move communities toward those goals.

Definition of a Community

The unit of measure for setting a UTC goal is a **community**. The Executive Council has allowed for a broad definition of community to encourage goal setting among a wide range of entities. These entities may include counties, cities, towns, boroughs, school districts, military facilities, conservation groups, land trusts and others. The key requirement is that the community has an infrastructure that can support the goal setting and implementation process. If the community intends to receive grants to support the UTC goal, then they must also be a **legal entity** that can enter into contracts.

Canopy Assessment Criteria

Communities counting towards the five-per-state goal of the Executive Council will have to follow some basic guidelines for assessing existing tree cover. The types of information required for the assessment are: percent of land with tree canopy, percent of each land cover type, and percent impervious cover. This assessment must be done using up-to-date (less than 5 years old) remote sensing data with one-meter or better resolution. The area of the assessment should be clearly defined from the outset. Lastly, the assessment should be updated at regular intervals (every 5 to 10 years) so communities can evaluate progress towards their goal.

Goal Setting and Institutionalization

Communities must adopt a goal to *increase* tree canopy cover and a timeframe for achieving this goal. This goal must be endorsed by local officials or other authorities. However, it is important to realize that endorsement is not enough to ensure a successful program. To ensure that tree canopy goals survive transitions in leadership, these goals must be institutionalized in other processes. These processes include legislation, regulation, and modification of a community's comprehensive plan.

It is also important to realize that for communities where most of the land is in private ownership (e.g. towns and cities), this is unlikely to be a government-only process. In these cases, increasing tree canopy cover on public lands alone will not be enough to achieve UTC goals. Support from the public, non-governmental organizations (NGOs), the business community, and agencies involved with issues on private lands will be vital to ensuring the success of the program.

Outcome-based Goal Setting

Urban tree canopy goals are most meaningful when tied to specific desired outcomes. These outcomes may be environmental, social, or economic. Examples of environmental outcomes include the protection of streams, reduced stormwater runoff, reduced ozone concentrations, and increased carbon sequestration. Social outcomes may include improved human health, buffers for wind and noise, increased recreational opportunities, and neighborhood beautification. Economic outcomes can include reduced heating and cooling costs and increased property values.

Implementation Plan

Communities adopting a tree canopy goal should submit a one-time implementation plan to their States (or to the District of Columbia) that includes:

- The percent increase in canopy cover and specified time intervals for attainment;

• The relationship of the canopy goal to other local goals, ordinances or regulations;

• Identification of priority sites for implementation (e.g., tree planting) and rationale for selection;

• Any resolutions, motions or minutes from governing bodies or boards endorsing the participation in the program, the goals set by the community and plans for implementation.

• Listing of outreach, educational, and funding opportunities (optional).

Reporting, Evaluation and Monitoring

The States and the District of Columbia should report annually on UTC goal setting and implementation in their model communities. The report should identify canopy assessments that have been completed, canopy goals that have been established, and implementation plans that have been approved. The report should also include an annual evaluation of community progress. This evaluation should include information such as the number of trees planted, canopy area lost, forest acres protected by easements, or other measurable indicators.

Please see the document *Guidelines for Implementing the Chesapeake Bay Program's Urban and Community Tree Canopy Goals* for further information. This document can be found at www.chesapeakebay.net/pubs/Guidelines_for_Urban_Tree_Canopy_Goals_11_2004.pdf

CHAPTER 3: A BRIEF PRIMER ON REMOTELY SENSED DATA

Before delving into **top-down assessment** methods, we would like to bring readers up to speed on the basic principles of remote sensing and the types of remote sensing data that can be used for urban tree canopy assessment. Users with a strong background in remote sensing may want to skip ahead.

What is a remote sensor?

We all have some familiarity with remote sensors – for instance, our eyes are a type of remote sensor. They capture the light that bounces off objects, which is then processed by our brain to form an image. Most aerial and satellite based sensors work in a similar fashion.

Passive sensors record waves of electromagnetic (EM) energy that are either emitted or reflected from an object. These sensors may capture EM energy from the visible part of the EM spectrum (the light our eyes can see) or from other parts of the spectrum. **Active sensors**, on the other hand, send out their own EM signal and record properties of the waves that bounce back. Radar systems used to track airplanes are an example of an active sensor.

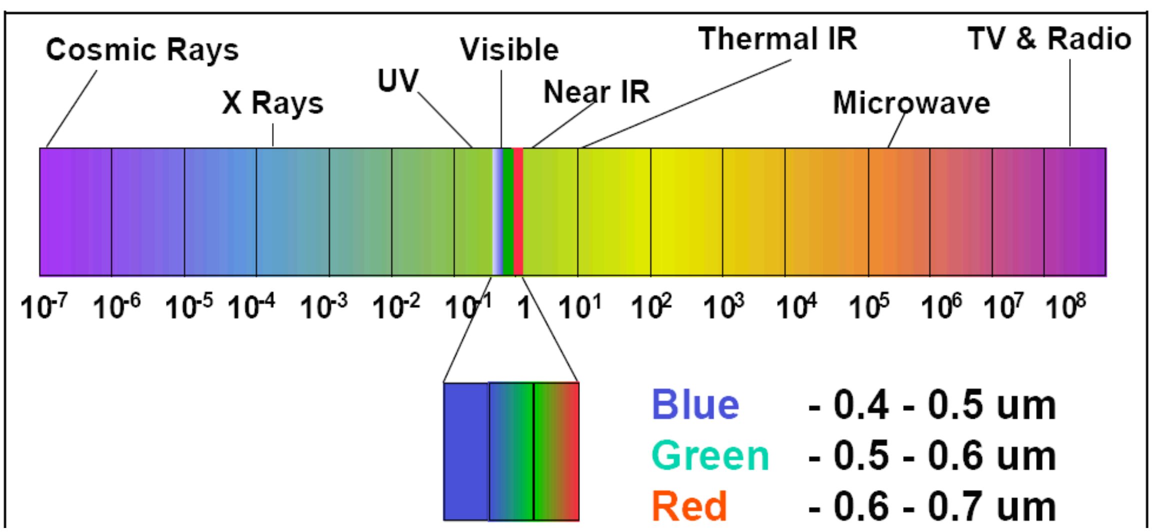


Figure 3-1. The Electromagnetic spectrum.   Overhead remote sensing devices such as aerial cameras and multispectral satellites typically operate in the visible and near infrared wavelengths, a relatively small portion of the electromagnetic spectrum.
Diagram Courtesy of the National Space Studies Center, Air University Space Primer, Maxwell AFB, AL; Chapter 12: Multispectral imagery. http://space.au.af.mil/primer/index.htm

Data Characteristics and Purchasing Decisions

It is crucial that when purchasing remotely sensed imagery the characteristics of the product deliverable are fully understood. Too often there is an over emphasis on the spatial resolution of the imagery, when this is only one of many factors that most be considered.

Spatial Resolution is the “pixel size” associated with the data. For reference, it generally takes at least 4 pixels to identify a feature. So, while Landsat imagery, with its 30 square-meter resolution, may be adequate for measuring large areas of intact forest it will do a poor job of identifying street trees in urban areas. This is why the Chesapeake Bay Guidelines suggest a minimum resolution of one-meter or better. As spatial resolution increases so does the storage size of the data.

Radiometric Resolution is the number of brightness levels that the remote sensing technology can sense. The higher the radiometric resolution, the better the sensor will be able to distinguish objects with similar spectral properties. Most remote sensors, such as Landsat, yield 8-bit data (2^8) where each pixel has a possible value of 0-255. Newer sensors are capable of collecting data at a much higher resolution. For example, the IKONOS and QuickBird satellites gather 11-bit (2^{11}) data, allowing for improved feature recognition when compared to traditional 8-bit data. Compressing imagery results in a degradation of the radiometric quality. Automated feature extraction algorithms are particularly sensitive to the radiometric quality of the data. As radiometric resolution increases so does the size of the dataset.

Temporal Resolution represents the time frequency for the data. This component of data quality recognizes that it is not just the image quality that matters, but also when the information was acquired. The Chesapeake Bay Program Guidelines recommend that the data used in UTC assessment be less than five years old. In some communities, where rapid change or development is taking place, a much higher temporal resolution may be required (i.e. data that is less than one year old) to accurately reflect the extent of current tree canopy. The age of the data is not the only important temporal requirement that we must consider for tree canopy assessment. The time of year the data was collected will be equally important. For instance, remote imagery acquired in the winter would not be very useful for quantifying tree canopy cover in a system dominated by deciduous trees.

Spectral Coverage is another consideration for data acquisition. Certain features and properties of land cover may be more distinguishable in different bands of the electromagnetic spectrum. For instance, the inclusion of a NIR (near infrared) band is optimal for classifying vegetation data as the majority of EM energy reflected by vegetation is in the NIR portion of the spectrum. Data that spans several parts of the EM spectrum is referred to as **multispectral data**.

Other considerations

UTC assessment requires the integration of multiple data sources. This necessitates that any remotely sensed data being used in the UTC assessment have a high enough horizontal accuracy so that it overlays as precisely as possible with the other layers being used. Typically this requires that the remotely sensed data meet National Map Accuracy Standards of 1:12,000 or better.

When a community signs a contract to acquire remotely sensed data they agree to accept a certain percentage of cloud cover, haze, and other data irregularities. A small amount of cloud cover may be acceptable, but a large amount of cloud cover would make much of the data unusable. Similarly, shadows from tall buildings may interfere with UTC assessment, causing tree canopy to be underestimated. For these reasons, it is very important to read the fine print before purchasing imagery.

Lastly, communities should realize that remote sensing data can have many potential users and numerous applications. This opens up the possibility of cost-sharing partnerships with other agencies or neighboring communities. In some cases, the coverage area can be expanded at only a small extra cost. This allows neighboring communities to purchase data together at a lower cost than if they had purchased the same data separately. Communities should also consider their future data needs. They may, for instance, choose to acquire **multispectral data** instead of black-and-white or natural color data, so the data might be used for natural resource analyses outside the context of urban tree canopy.

[SIDE BAR] Natural Color Composite versus Color Infrared (CIR)

Figure 3-2. While natural color imagery is something that we are used to and generally comfortable working with, multispectral imagery, such as color infrared CIR, hold several advantages for users evaluating natural resources. With CIR imagery we can distinguish between tree types (broadleaf versus conifer), evaluate vegetation stress, and better identify surface feature types (asphalt versus concrete, forests versus forested wetlands, etc). The example above shows true color (left) and color infrared (right) versions of an IKONOS satellite image (© Space Imagine, 2004). The color infrared version allows for improved detection and discrimination of the vegetation, particularly in the forested areas where the lighter deciduous species can be distinguished from the darker coniferous species.

LIDAR

LIDAR (LIght Detection And Ranging) sensors are active sensors that collect extremely detailed elevation data by way of a laser. By emitting pulses from the laser, then sensing the time it takes for the pulse to return, the height of objects on the ground can be inferred. Processed LIDAR typically yields data for both the reflective surface and bare earth. Processing typically removes man made structures from the bare earth data. By subtracting the bare earth from the reflective surface a relative surface digital elevation model (DEM) can be created. A relative surface DEM generated from LIDAR data can greatly complement imagery when performing a UTC assessment as it allows for features that have similar spectral and textural properties, to be differentiated based on height. LIDAR can be particularly useful in separating trees from shrubs and buildings from parking lots.

Remotely Sensed Data Providers

While the availability of remote sensing data changes rapidly over time, these are a few of the current data sources that meet UTC assessment guidelines:

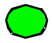
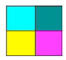
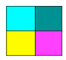
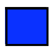
Company	Products	Web Site
GeoEye	High-resolution satellite imagery from the IKONOS and OrbView satellites	www.geoeye.com
DigitalGlobe	High-resolution satellite imagery from the Quickbird and WorldView (not yet operational) satellites	www.digitalglobe.com
EarthData	High-resolution digital aerial imagery and LIDAR	www.earthdata.com
Triathlon	High-resolution digital aerial imagery and LIDAR	www.triathloninc.com
Optimal Geomatics	High-resolution digital aerial imagery and LIDAR	www.optimalgeo.com

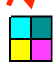
Data to Use

Data Type	Level	Format	Use	Specifications	Source
Building Footprints	■	Vector polygon	Helps to better define possible UTC by excluding areas occupied by an existing structure	High-resolution planimetric data.	Local
Hydrology	●	Vector polygon	Trees cannot be planted here, so these areas must be removed from the analysis when assessing potential planting locations	Open water (lakes, wide streams, coastal features)	Local or National Hydrography Dataset (NHD)
Imagery	■	Raster	Needed to derive land cover data.	1m or better spatial resolution, multispectral with near infrared band, digital acquisition	Local
Land Cover	◆	Raster	Derived from imagery to map existing conditions.	High-resolution; attributes must include grass, canopy, and impervious	Local
Parcels	■	Vector polygon	Required for computing possible UTC in parcel land versus the public rights of way.	High-resolution; attributes must include land use and PROW	Local
Roads	◆	Vector polygon	When combined with parcel data, can be used to define the urparian zone	Road polygons that depict the left and right boundaries. In combination with parcel data can be used to delineate the urparian zone.	Local
Target Geographies	■	Vector polygon	Polygons for performing additional statistical summaries	Wards, neighborhoods, boroughs, critical areas, census block groups, etc.	Local, regional, or national databases

● *Readily accessible exists for the entire country*
■ *Localized data, exists for most major cities*
◆ *Highly specialized data, limited availability*
Vector polygon data
Vector line data
Raster data

Data Not to Use

Data Type	Level	Format	Reason Not to Use	Source
Low Resolution Imagery			Because of the spatial heterogeneity found in urban systems (patchiness), high resolution data is needed to accurately measure tree canopy cover. A UTC project runs the risk of losing credibility if a projected canopy goal falls within the margin of error for measurement. For this reason, the Chesapeake Bay Program set the minimum standard at 1 meter resolution or better.	Landsat, AVHRR, MODIS, etc.
National Land Cover Data			See above.	NLCD
Outdated data			Measurements of progress will lose credibility if the initial tree canopy assessment is based upon outdated, inaccurate data. The Chesapeake Bay Guidelines suggest using data that is less than 5 years old.	Various
Data not properly aligned			The crux of the geoprocessing for a UTC assessment involves overlay analysis. Typically this requires that the remotely sensed data meet National Map Accuracy Standards of 1:12,000 or better. Datasets that do not line up due to differences in horizontal accuracy and/or spatial resolution will result in incomplete or inaccurate conclusions.	Various

 *Readily accessible exists for the entire country*
 *Localized data, exists for most major cities*
 *Highly specialized data, limited availability*
 *Vector polygon data*
 *Vector line data*
 *Raster data*

It is important to realize that data by itself does not equal information. While acquiring the data outlined above is an essential first step, a lot of processing is required to turn that data into information that can support decision-making. It requires time, expertise, computers and software to make it all work. While some communities have the necessary expertise on-hand, other communities may need to seek out partnerships with local and state universities, agencies, or consulting firms to assist with UTC analysis.

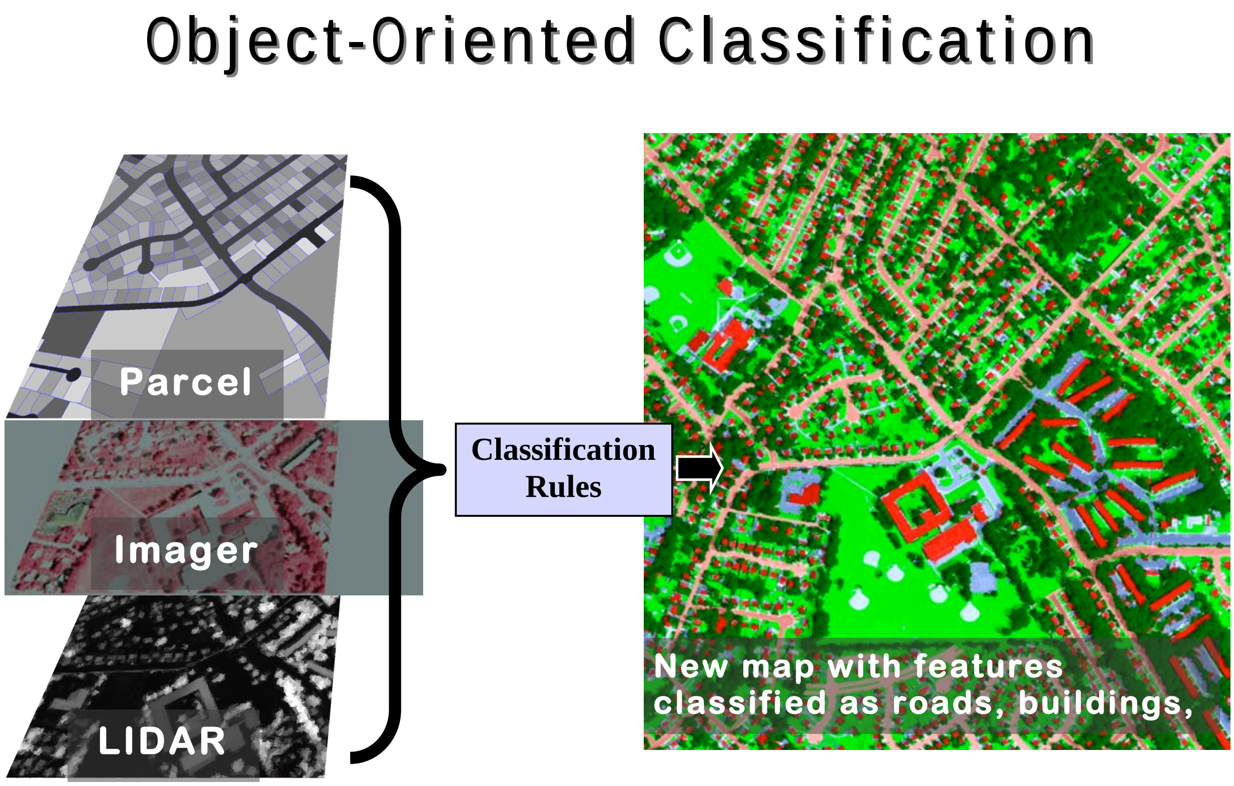
Advances in automated feature extraction

As humans we are very adept at interpreting high resolution imagery because we can incorporate the spectral, spatial, and contextual properties of the image into the classification process. While **manual interpretation** is the most accurate method of extracting features from imagery it is also extremely time consuming. In addition, manual interpretation allows for little flexibility since all protocols and classification rules have to be set at the outset.

Fortunately, advances in object-oriented classification systems have made **automated feature extraction** a much more viable solution. Object-oriented classifiers segment a remotely sensed image into objects based on the spatial and spectral properties of the image. Objects contain substantially more information (such as texture and shape) than individual pixels. Objects can also have relationships with adjacent objects, thereby bringing some context into the classification process. Finally, object oriented classifiers allow multiple data types to be used in classifying an object. Taken together, these abilities make object-oriented classification a powerful method of interpreting remotely sensed data.

An example of automated feature extraction

Figure 3-3. In this example, **LIDAR** and parcel data are integrated into a single classification. The classification depicts buildings (red), roads (tan), other paved surfaces (blue), grass (light green), and tree canopy (dark green). The fine scale classification influences the parcel scale classification by evaluating which parcels are most suitable for tree planting efforts. Because the classification is based on rules, different scenarios can be examined by changing the rules.



CHAPTER 4: URBAN TREE CANOPY ASSESSMENT & GOAL SETTING

This chapter takes a more detailed look at the canopy assessment process. It will look at the three Ps of natural resource management (Possible, Potential, and Preferable), GIS methodology, the Forest Opportunity Spectrum (FOS), and application of the FOS to goal setting. Taken together, these tools provide the theoretical and practical framework for planning and implementing a successful urban tree canopy program. It should be noted that while the following approach has been used successfully, it should not be considered the only approach. Depending on the size of the community and the resources available, other approaches may be more appropriate. The key is making sure that the community can answer three basic questions:

- How much tree canopy do we have?
- How much is possible?
- How much do we want to achieve?

HOW DO COMMUNITIES SET UTC GOALS?

1) Assess present condition - How much UTC do I have?

- Use remote sensing to measure existing urban tree canopy
- Identify forestry opportunity types (FOS types) in the community, including:

  Public opportunities - street trees, parks, etc.

  Private opportunities - residential, commercial, and industrial areas

2) Assess potential UTC - How much UTC can I get?

- Assessment of potential UTC by FOS type.
- Assessment of possible, potential, and preferable UTC by FOS type.

3) Adoption of a Goal based on the findings of the assessments

- It is preferable for a community to institutionalize UTC goals in legislation, regulation, or the community's comprehensive plan to ensure that these long term goals come to fruition.

4) Development of an Implementation Plan

- Requirements for new tree planting, protection and maintenance of existing trees, and predicted canopy loss from tree mortality and land conversion
- Relationship of canopy goals to local ordinances, regulations, and the community's comprehensive plan
- Strategies for including a range of stakeholders in the implementation process.

What are the Three Ps?

> "In order for us to be together, we must find some space between us"
> (Mark Twain in a letter to his wife)

When moving from a canopy assessment to an implementation plan, it is useful to separate the process into a sequence of steps. This allows the task to be broken into manageable components and prevents each step from being bogged-down by details that belong in later stages of the process. The Three Ps, Possible, Potential, and Preferable, provide a useful sequence for structuring the goal setting and implementation process. The three Ps are defined as follows:

1. **Possible:** Where is it biophysically *feasible* to plant trees?
    - This is the first step in the assessment process. It is not concerned with costs or the fact that tree planting may not be appropriate or desirable in some locations.
    - For the Baltimore UTC assessment, all land that was not covered by water, a road, or a building was considered a "possible" planting location.
2. **Potential:** Where is it economically *likely* to plant trees?
    - Which areas have regulatory constraints that conserve tree cover or have incentive supports for adding tree cover? (example: Riparian buffer ordinances near streams or tax incentives for conservation easements)
    - Which areas are most cost-effective for achieving water quality or other goals?

3. **Preferable:** Where is it socially *desirable* to plant trees?
    For example,
    - Where will tree cover make neighborhoods more attractive?
    - Where will tree cover address other issues such as cooling and cleaning the air?

In this report, we focus mainly on the first step of developing a UTC goal, "What is Possible?" Once the Possible is known, communities will have to work with various stakeholders to identify Potential and Preferable planting locations.

Approaches to Canopy Assessment: Top-down or Bottom-up?

There are two primary types of canopy assessment: top-down and bottom-up. **Bottom-up** approaches use a plot-based, field sampling scheme to measure tree canopy cover. In this approach, the amount of tree canopy cover that falls within study plots is extrapolated and taken to represent the urban tree canopy cover as a whole. This on-the-ground method may be most appropriate for very small communities, such as a homeowner's association or a school district's properties. Plot data can be collected using the US Forest Service's i-Tree tools and methods at www.itreetools.org.

Top-down approaches use remote sensing data, such as satellite imagery, to quantify the extent of tree cover. For most communities, a top down approach is recommended. This guide will focus on a top-down approach for several reasons. First, the Chesapeake Bay Program guidelines are based on tree cover and extent which are readily assessed using top-down methodologies. Second, percent cover is easy to conceptualize and communicate. Third, remote sensing makes it easy to track progress over time. Lastly, these methods are well documented and have been used successfully here and elsewhere.

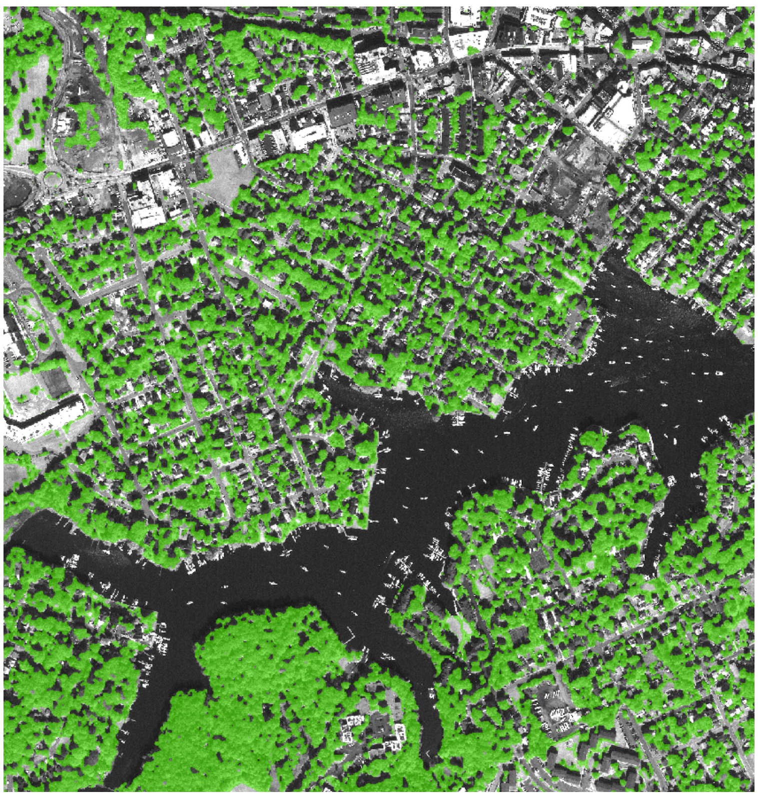


Figure 4-1. Top-Down Approach: Existing UTC mapped from IKONOS satellite imagery.

GIS Methodology

In the following sections we will detail the GIS methodology that was used in the Baltimore urban tree canopy assessment. This is not the only possible approach to UTC assessment, but it does provide a useful framework for other communities to follow. These techniques should be adapted to fit the unique resources, data availability, and desired goals of each community.

Measuring Existing Tree Cover

Existing UTC can be measured from remotely sensed data by manual interpretation, pixel-based classification, or object-oriented classification. Each method has its pros and cons. The land cover data used in the Baltimore UTC assessment came from the MD DNR ***Strategic Urban Forests Assessment*** **(SUFA)** land cover layer that was created from high-resolution leaf-on *IKONOS* satellite imagery in 2001 (Irani and Galvin 2003). IKONOS imagery of two different types was purchased: (1) 1 m panchromatic (black and white) imagery and (2) 4 m multispectral (visible + NIR) imagery. These two images were combined, through a process known as pan-sharpening, to create a 1 m resolution image that retained the spatial qualities of the 1m panchromatic while incorporating the spectral properties of 4 m imagery.

To separate vegetation from non-vegetation features a NIR/Red ratio image was created by dividing the NIR band by the red band. Vegetation reflects high amounts of NIR energy and low amounts of red light, causing pixels containing vegetation to have relatively high NIR/Red ratio values compared to other features (impervious and water). Following this, a texture image of the resulting ratio image was produced to separate UTC vegetation from non-UTC vegetation pixels (separate trees from other vegetation). Shadowing in tree canopy results in pixels containing tree canopy having higher texture values compared to those containing grass and herbaceous vegetation. The resulting image provides for quantification of existing UTC and non-UTC vegetation.

Measuring the Possible

The first step in computing possible UTC for Baltimore was to determine what UTC metrics would be computed. These metrics were based on both the desirability of the information and the feasibility of obtaining the metric based on the available geospatial data. It was decided that the Baltimore UTC analysis would focus on measuring the possible UTC, that is, the land that is available for canopy, but that is not currently canopy. For parcel land, possible UTC was defined as land not occupied by existing canopy, buildings, or water. For the PROW (Public Right Of Way), possible UTC was defined as land not occupied by existing canopy or roads (buildings and water were not present in the PROW). The parcel was selected as the base unit of analysis for summarizing information, with census block groups as the geographical boundaries for aggregating the parcel level data for additional analysis.

It is important to remember that we are restricting this part of our analysis to the Possible. We acknowledge that places like baseball diamonds, while considered Possible planting locations, may not be Preferable. By restricting ourselves to the Possible, we prevent ourselves from getting bogged down by decision-making that should be done later in the goal-setting process. At the end of the day, it is up to the community to decide where, amongst the Possible planting locations, increased tree canopy cover will be desirable.

The relevant geospatial data was assembled in a GIS: building footprints (polygons), property parcels - including PROW (polygons), surface water (polygons), streets (polygons), land cover (raster) and census block groups (polygon). Building footprints, property parcels, and street polygons were obtained from the City of Baltimore. Surface water polygons were extracted from the National Hydrography Dataset (NHD) and edited using the 2001 IKONOS satellite imagery. Land cover data came from the MD DNR SUFA dataset. Census block group boundaries, produced by the Tele Atlas Corporation, were available on the data media that ships with ArcGIS.

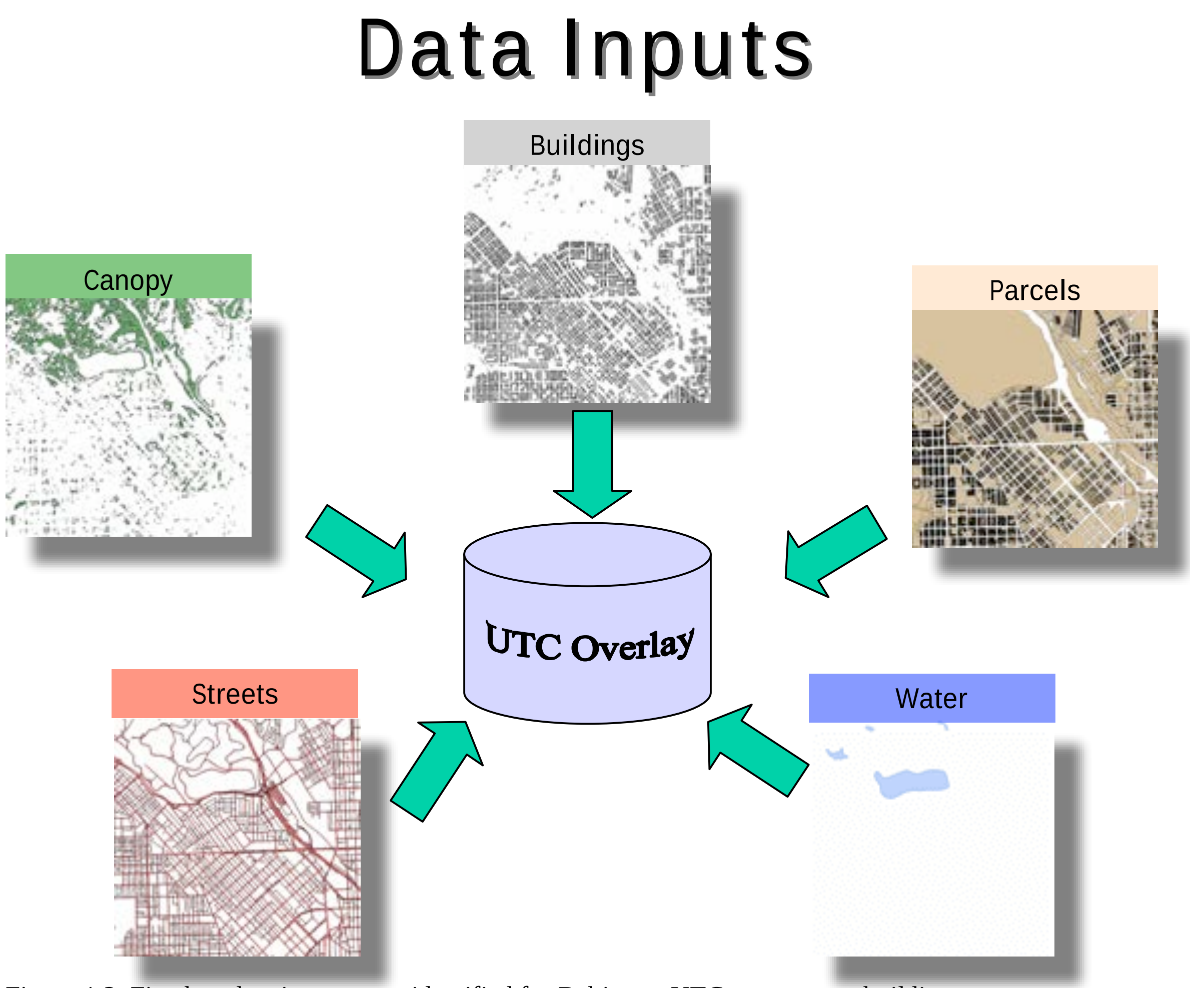


Figure 4-2. Five key data inputs were identified for Baltimore UTC assessment: building footprints (polygons), property parcels (polygons), surface water (polygons), streets (polygons) and land cover (raster)

Possible UTC metrics were computed through geoprocessing overlays and database queries. The methods for computing possible UTC are consolidated in the *Possible UTC* model in the **FOS toolbox**, however they are explained here so that the process can be replicated if one chooses not to use the model. The principal challenge in computing possible UTC is the numerous polygons that are created by overlaying the various input datasets. The limitation of current GIS software packages to deal with extremely large datasets my necessitate tiling the data by smaller geographical boundaries during the overlay process.

With the datasets coming from differing sources numerous hours were spent editing the datasets to ensure that all inputs adhered to a common geographical boundary. For Baltimore City the base unit of analysis was the parcel data, and thus all data were clipped or adjusted to adhere to the parcel data. Unfortunately it was not feasible to correct all alignment errors that existed between the datasets. For example, building footprints occasionally overlapped parcel boundaries and grass and low lying shrubs were sometimes misclassified as canopy. Tests for topological and geometry errors were run for each layer, and any errors were corrected.

Prior to carrying out the overlays each layer had a field added to binary code the layer according to its source. For example, the roads layer had a *Roads* field added to it, where each road was coded as '1.' Having each layer with a binary coded field facilitated running the queries used to compute the metrics later in the analysis. With all layers adhering to the parcel boundaries the overlay process involved a step wise application of the IDENTITY tool. In ArcGIS the IDENTITY tool overlays two layers, creating new polygons at the intersection, while retaining all polygons from the input layer along with the attributes from both layers. The result of the step wise application of this tool was a single layer, called *UTC Overlay*, containing the polygons and attributes of the parcels, buildings, roads, water, and land cover layers.

Using the attributes of the *UTC Overlay* layer, queries were run to compute the UTC metrics. Land area, existing UTC, and possible UTC were summarized at the city level, by parcel and urparian, and within the parcel by land use type (Figure 4-3).

Existing UTC		
Land Type	Acres	Percent of Total Area
City	**10323**	**20%**
Urparian	1192	2%
Parcel	9122	18%
Parcel Breakout by Land Use Code		
Unknown	130	0%
Commercial	729	1%
Commercial Condo	0	0%
Commercial Residential	0	0%
Exempt	512	1%
Exempt Commercial	3187	6%
Industrial	551	1%
Apartments	382	1%
Residential	3628	7%
Residential Commercial	0	0%
Residential Condo	4	0%

Possible UTC		
Land Type	Acres	Percent of Total Area
City	**27605**	**53%**
Urparian	3936	8%
Parcel	23897	46%
Parcel Breakout by Land Use Code		
Unknown	344	1%
Commercial	3587	7%
Commercial Condo	2	0%
Commercial Residential	0	0%
Exempt	453	1%
Exempt Commercial	7203	14%
Industrial	4301	8%
Apartments	1048	2%
Residential	6950	13%
Residential Commercial	0	0%
Residential Condo	9	0%

Figure 4-3. UTC metrics for Baltimore City. A summary of the existing UTC and possible UTC at the city level. UTC metrics are presented for the urparian and parcel areas, and within parcels by land use. Such metrics can be generated at various geographies (city, census block, neighborhood, etc.).

Metrics for describing the Possible

To assist communities in decision-making, a variety of metrics can be used to summarize existing and Possible canopy distribution. This is where the data overlays we discussed earlier come into play. For example, if parcel data were available for a community, they might rank parcels by their relative possibility for increased canopy cover. Figure 4-4 shows an example of this approach from Baltimore.

Possible UTC by Parcel

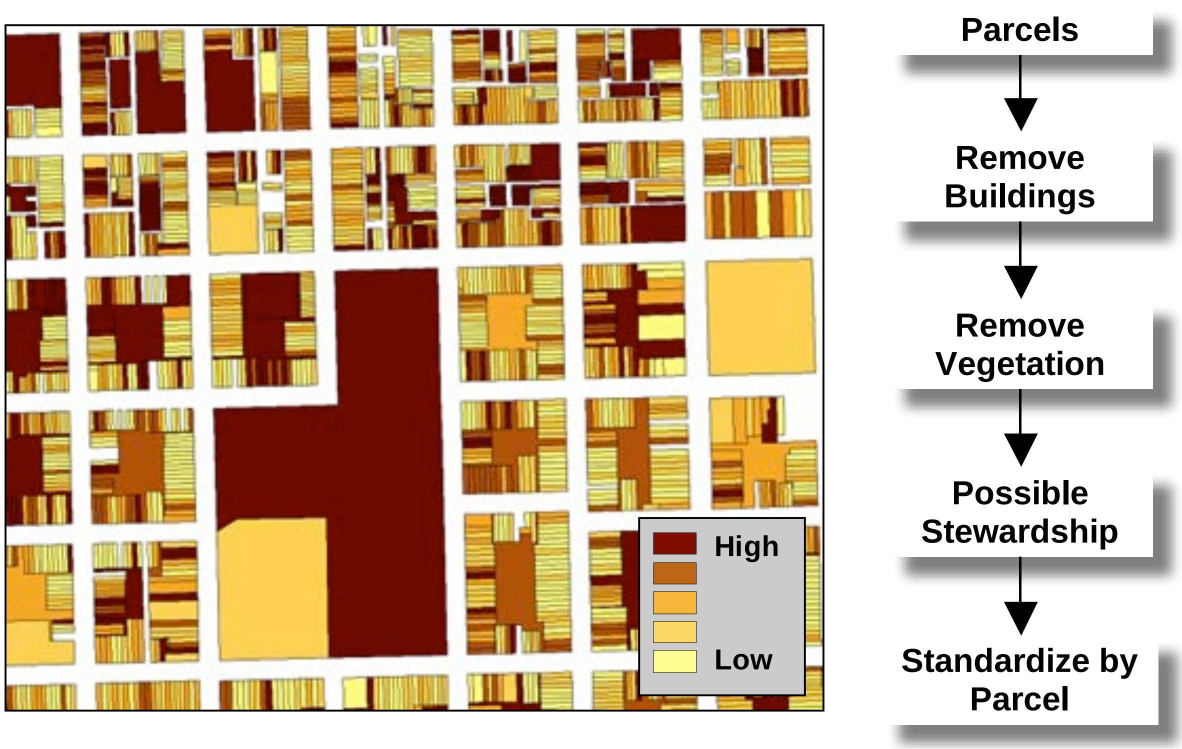


Figure 4-4. In this analysis, individual land parcels are ranked by the relative possibility for forest stewardship. Darker areas represent parcels where a larger percentage of the land is available for planting (i.e. the Possible planting area is high).

Alternatively, tree canopy can be delineated by neighborhood, ward, district, or land use type (residential, commercial, industrial) to see where the greatest opportunities for greening may lie. Figure 4-5 shows the breakdown of Possible and existing tree canopy in Baltimore by land use type. It is important to note that the area available for planting on public land in Baltimore (the entire urparian and part of the exempt classes) is only a fraction of the Possible planting area. It is clear that in Baltimore, and in many other communities, that setting a UTC goal will not be a government-only effort. In most towns and cities, it will be crucial to bring community groups, businesses, and other entities into the process.

"We will organize an inter-departmental cabinet and a citizen's panel to help write our Urban Forestry Management Plan. But Government can not reach this goal alone. If every household and every business in Baltimore planted a tree in their yard, we might just be there in 30 years."
- Otis Rolley III, Director, Baltimore City Dept of Planning, March 28, 2006

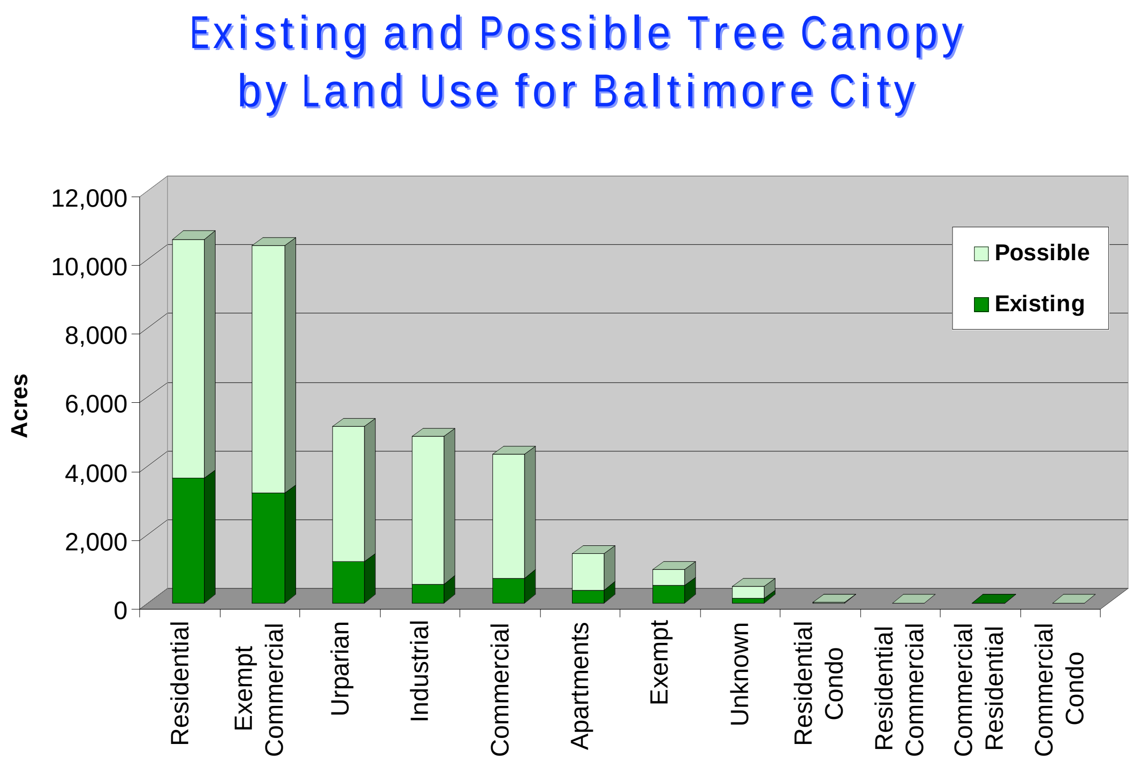


Figure 4-5. This chart shows existing and possible forest cover in Baltimore by land use type. Analyses like this can help communities in targeting areas for tree planting.

The Forest Opportunity Spectrum: Moving Beyond the Possible (to the Potential and the Preferable)

What is the Forest Opportunity Spectrum?

The Forest Opportunity Spectrum provides a framework for organizing data, as well as for asking and answering urban forestry related questions. This framework may assist decision-makers as they decide what their tree canopy goal will be and what actions they can take to achieve that goal. In other words, the FOS framework and data types can help communities move beyond the Possible and into the realm of the Potential (economically likely) and the Preferable (socially desirable).

Why was the Forest Opportunity Spectrum developed?

The Forest Opportunity Spectrum was developed to deal with the challenges of forest management in the urban environment. Urban forestry includes all of the trees in the community, not just the fraction that exists in parks and public rights of way. Dealing with this spatially heterogeneous landscape requires a foundation of biophysical and social data that can inform policymaking, planning, and management. The FOS provides the data to support these activities.

How can we use the Forest Opportunity Spectrum?

We can use the FOS to:

- Inventory existing forestry opportunities.
- Analyze opportunities to enhance ecosystem services such as air or water quality.
- Link stakeholders' desires with urban forestry opportunities.
- Identify and assess the effects of different forest opportunities on other community initiatives.
- Develop inter-organizational partnerships within and among public, NGO, and private interests.
- Monitor and evaluate urban forestry outcomes.
- Enhance the FOS approach with new capabilities as needs are identified.
- Modify FOS using an Open Source approach to reduce costs, increase the rate at which tools are developed, and the diversity of those tools.

FOS Data Hierarchy

FOS classifies data needs in terms of "green circles, blue squares, and black diamonds" using the metaphor from skiing trails to denote difficulty in creating, obtaining, and processing data. Coding data with these symbols helps to better match the questions we are asking and the level of data needed to answer them.

Green Circle data are easy to work with, readily available, and have already been collected for other purposes. For the Possible stage of analysis, these data include topography, streams, roads, land use types, parks, public rights-of-way, and vegetation cover based on 30 meter satellite data.

The next difficulty level, Blue Square data, has also been acquired for other uses or can be acquired relatively easily. These data are usually more detailed than Green Square data and consequently, more difficult to work with. Blue Square data include high resolution vegetation cover (1m), impervious surface data (from LIDAR), parcel boundaries, and land use codes by parcel.

Black Diamond data are often local data that must be collected specifically for the purpose at hand. Because we must collect these data ourselves, it is usually the most costly data to obtain. An example of black diamond data would be up-to-date information regarding the health and condition of community trees and vegetation.

The type of data needed for a UTC assessment will depend largely on the questions being asked. Many questions can be answered in a meaningful way using only Green Circle and Blue Square data. Other questions may require Black Diamond data. In cases where we must collect the data ourselves, we must decide whether the information being collected is worth the time and cost required to collect it. We might also seek creative ways to answer the question at hand using existing data sources.

Data Hierarchy (in order of increasing difficulty)	Planning Phases		
	Possible: Ecologically Feasible	**Potential:** Economically Likely	**Preferable:** Socially Desirable
●	Topography, streams, roads, vegetation cover (30m), land use, parks, public rights-of-way	Regulatory and incentive programs for environmental quality and natural resources, particularly trees	Population and household characteristics, Community stability, Market classifications of neighborhoods, lawncare expenditure data
■	Vegetation cover (<1m), Impervious surfaces (areas not road or building from LIDAR), Parcel boundaries, Land use codes by parcel, Rare and endangered species	Slope, soils, Planting and maintenance requests, water and air quality,	Terrestrial and aquatic habitat, Crime, Health
◆		Vegetation condition, Perceptions of environmental problems, Recreation behaviors,	Vegetation diversity, Neighborhood desirability, Neighborhood quality of life, Environmental and social capital

Figure 4-6. A summary of data to be used in a FOS analysis, sorted by the level of difficulty (green circle, blue square, black diamond) and planning phase (possible, potential, and preferable). As the analysis moves from the possible to the preferable phase, the need for social science increases.

Types of Forest Opportunities

FOS allows forest opportunity types to be user-defined. For example, Baltimore City identified six major forest opportunity types:

- *Regional Forestry* – large, contiguous forests
- *Riparian Forests* – stream valleys and coastal areas
- *Large Protected Areas* – parks greater than 35 acres
- *Abandoned Industrial Areas*
- *Neighborhood Areas* – including small, local parks, abandoned lots, and community gardens
- *Roads* – including street trees

A critical feature of forest opportunity types is that they are not mutually exclusive – they can overlap in geography (figure 4-7), goals (figure 4-8), and ownership (figure 4-9). In the case of overlapping geography, for instance, stream valleys may overlap with other FOS types such as regional forest patches, large parks, industrial areas, residential areas, and PROW (Public Rights of Way). The goals of each forest opportunity type can overlap (Figure 4-8). Several FOS can be used to achieve a specific goal. Or, several goals can be met with a FOS type. For example, UTC along roads and around residential areas are particularly important for reducing home energy use (cooling and heating). Or trees planted along roads can improve stormwater quality, trap particulates from the air, decrease ground-level ozone formation, add aesthetic appeal, and increase property values. Because different stakeholder groups are motivated by different sets of goals, we can use this overlap in goals to bring together diverse stakeholders by examining the full range of benefits offered by different forest opportunity types. Finally, FOS types often overlap in ownership. For instance, stream valleys may have public, institutional, residential, industrial, and commercial owners. Each of these types of owners might have different motivations and capacities for increasing urban tree canopy in stream valleys. By combining geography, owners, and goals (figure 4-10), we can:

- link places to owners,
- link owners to goals, and
- link goals to places

Finally, each of the forest opportunity types can be modified or an opportunity can be added or deleted, depending upon the analyst's needs. For instance, the buffer width for riparian areas can be changed from 100' to 300' or, in the case of Annapolis; a Critical Areas Forest Opportunities can be added and defined as the 1,000' along the shoreline of the Chesapeake Bay. Or, in the case of New York City, possible and existing UTC areas along highways and parkways can be identified as a sub-type of all Roads.

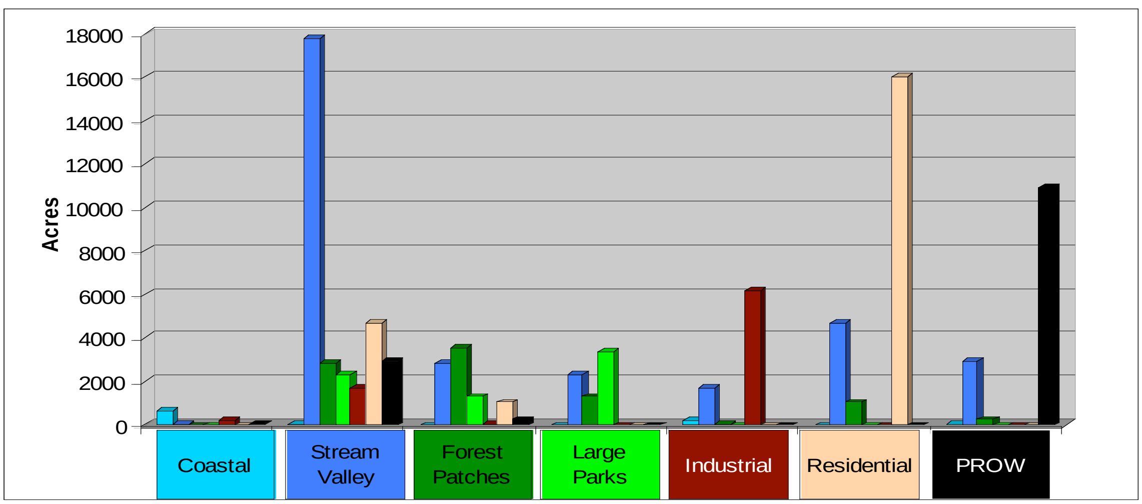


Figure 4-7. This figure demonstrates the possibility for overlap among FOS types. Looking at this chart we can see, for instance, that stream valleys in Baltimore occupy nearly 18,000 acres and contained within these stream valleys are forest patches (2800 acres), large parks (2300 acres), industrial areas (1700 acres), residential areas (4700 acres), and PROW (Public Right of Way) (2900 acres).

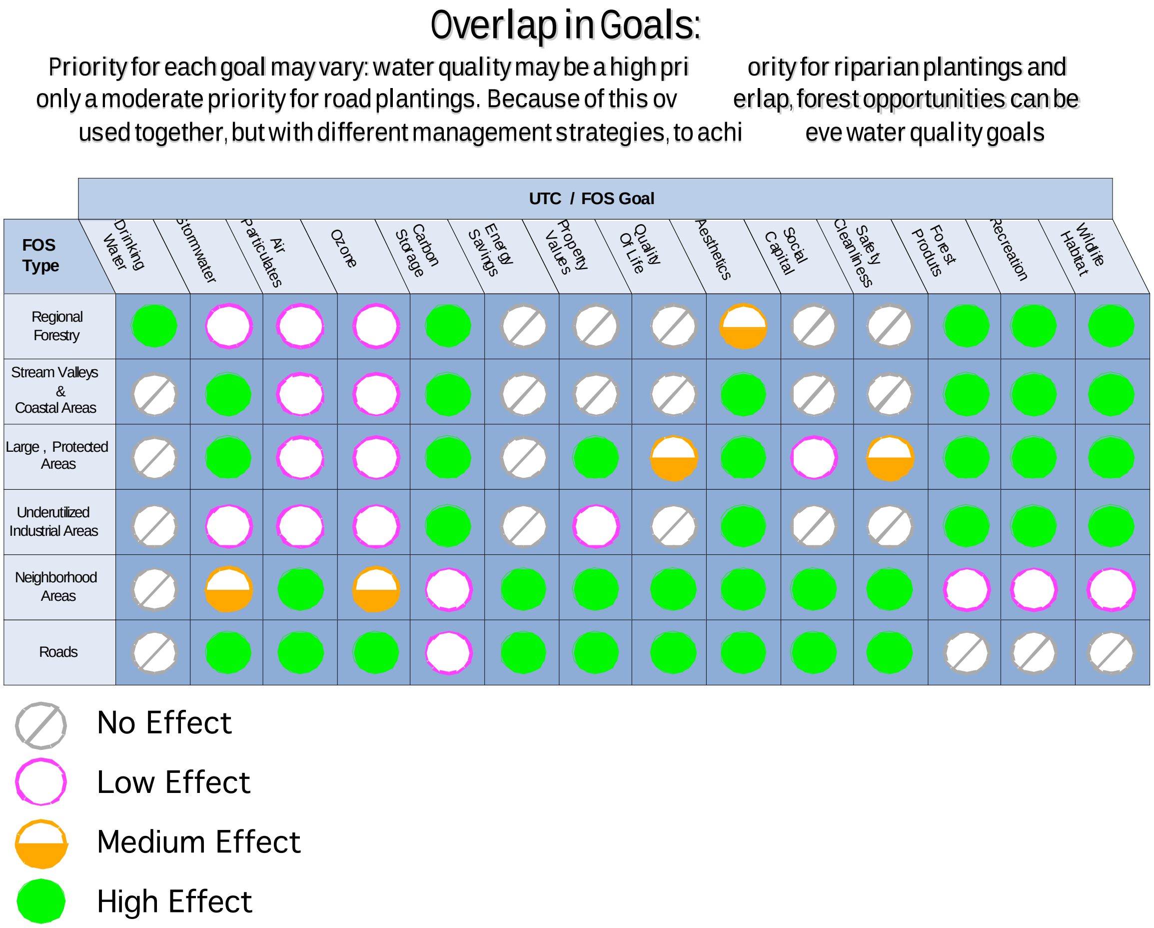


Figure 4.8. Goals overlap among FOS types. Several FOS can be used to achieve a specific goal. Alternatively, several goals can be met within an FOS type.

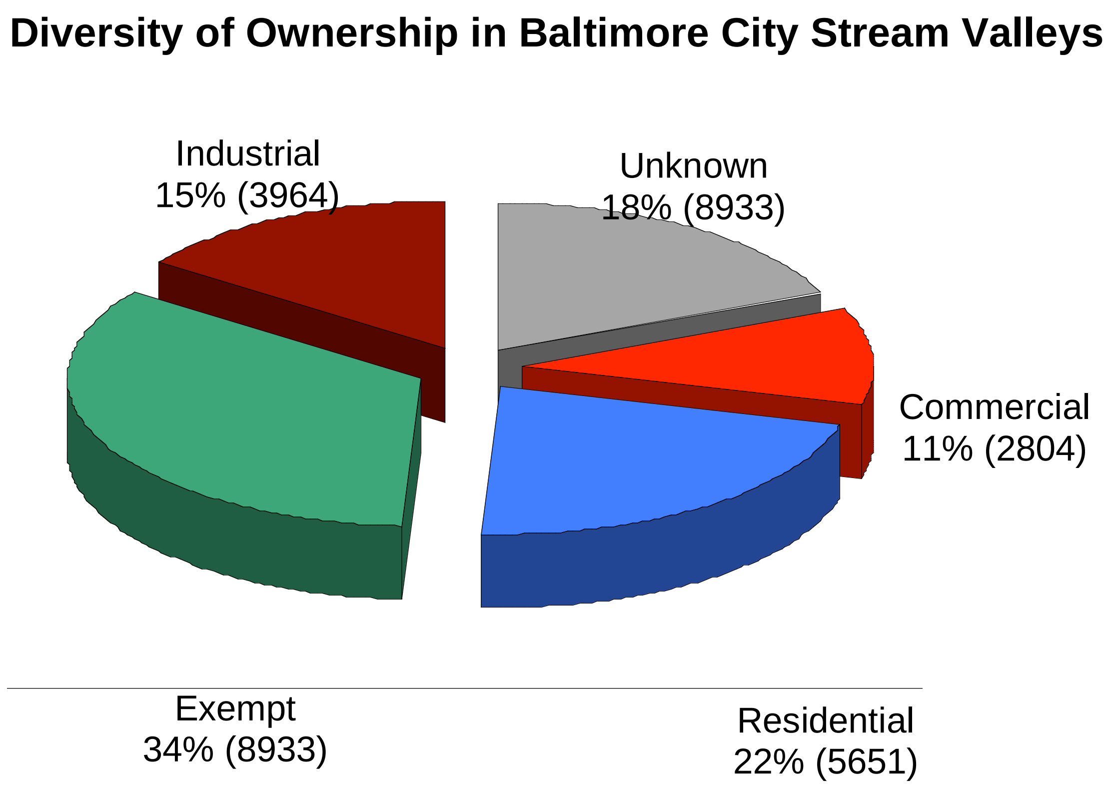


Figure 4-9. Area, in acres, of parcels by land use within stream valleys for the City of Baltimore. A FOS type can have multiple types of owners. And each ownership type can have different motivations for conserving or restoring stream valley UTC, for instance. UTC in stream valleys would require the greatest interaction with government/nonprofits (exempt) and residential land owners.

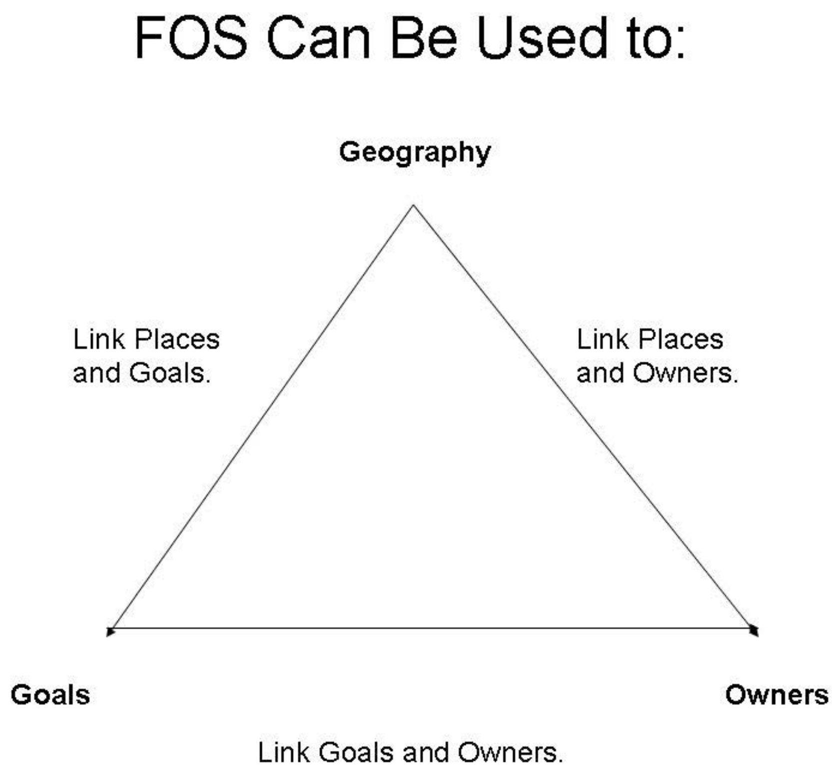


Figure 4-10. Overlap among FOS types in terms of geography, goals, and owners helps to answer important urban forestry questions:

- Where are certain UTC goals most important?
- Who owns the UTC vegetation in this place?
- Which owners are most often associated with which goals?

Applications of the FOS to Goal Setting

This section demonstrates potential applications of the Forest Opportunity Spectrum to UTC goal setting. These applications should not be considered an exhaustive list of the analyses that FOS has to offer, but rather an example of potential approaches. The FOS framework is user-definable, offering infinite ways to explore the opportunities for urban forestry. A set of GIS tools are being developed to assist communities in using the Forest Opportunity Spectrum. Please see the FOS Toolbox section for more details.

The Priority Planting Index

This analysis illustrates the connection between the Possible to the Preferable phase of the planning process. Communities may differ in their preferences and can adapt their analyses accordingly.

The priority planting index, developed by researchers at the US Forest Service Northeastern Research Station (D.J. Nowak et al), uses population density, tree stocking levels, and tree cover per capita to rank tree planting locations. The higher the index value, the higher the priority of the area for planting. Areas with high population densities, low tree stocking levels, and few trees per capita are ranked as high priority. The rationale is that these are the areas where increased tree cover will immediately benefit the greatest number of people.

Summary of index parameters:

- Population density: Population density is obtained from US census block group data. The greater the population density, the greater the priority for tree planting;
- Tree stocking levels: The percent of available space that is occupied by tree canopies. The lower the tree stocking levels, the greater the priority for tree planting; See the “GIS Methodology” section of this document for ideas on how to calculate existing and possible tree canopy cover.
- Tree cover per capita: This is the tree canopy area for a census block divided by the population of the census block (m^2/capita). The lower the amount of tree canopy cover per capita, the greater the priority for tree planting.

A customizable ArcGIS tool has been created to assist communities in using the Priority Planting Index. See the “FOS Toolbox” section for more information about these tools and where to find them.

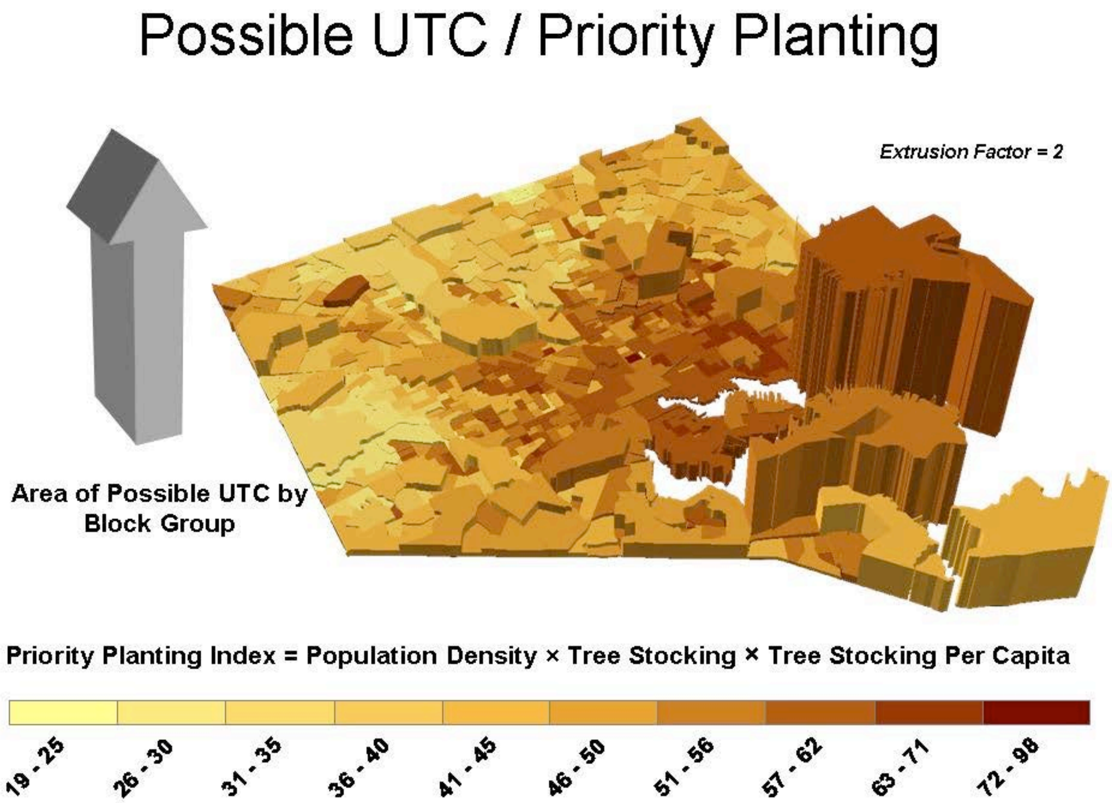


Figure 4-11. Census block group analysis of possible UTC and priority planting locations. Extruded on the z-axis is the area of possible UTC within each block group. The graduated color ramp corresponds to priority planting index (PPI) values. Higher PPI values indicate a greater need for tree plantings. Such information can be used to identify areas where there is the most available land to plant trees (high possible UTC) and the greatest need for tree plantings (high PPI).

FOS Toolbox: GIS Tools for Strategic Urban Forests Assessment

The FOS Toolbox is a set of GIS tools that allow communities to apply the Forest Opportunity Spectrum to their own data. The tools were designed to use readily available data types (e.g. census block groups) and to streamline the assessment process by automating many of the geoprocessing steps. The tools run in ArcGIS 9.0 and higher and include detailed help and information files. Each of the tools is open-source and highly customizable, so communities can adapt them to meet their needs.

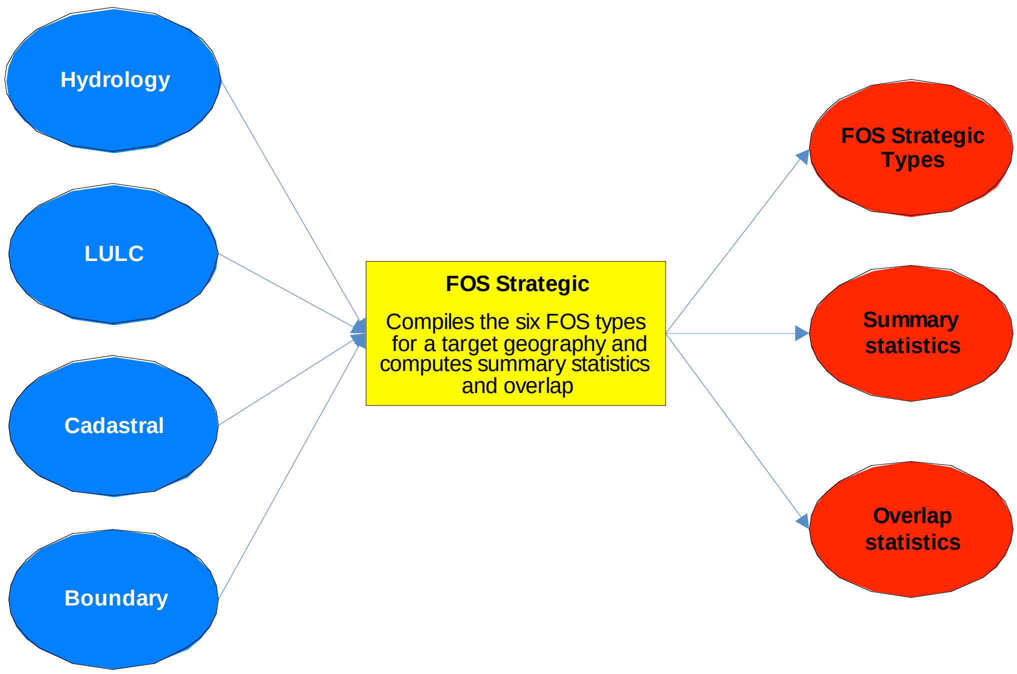


Figure 4-12. The FOS Strategic Tool assists communities in tallying up the land areas within each FOS type as well as the overlaps among them. This helps communities to strategically plan their efforts.

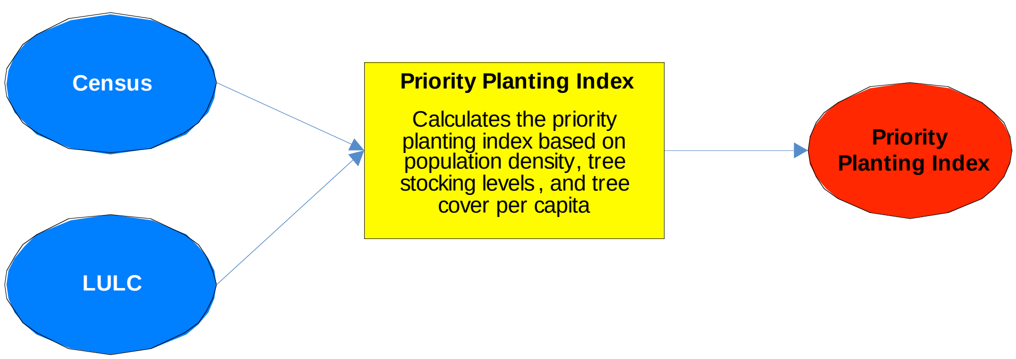


Figure 4-13. The Priority Planting Index uses population density, tree stocking levels, and tree-stocking-per-capita to facilitate areas where increased tree cover will immediately benefit the greatest number of people.

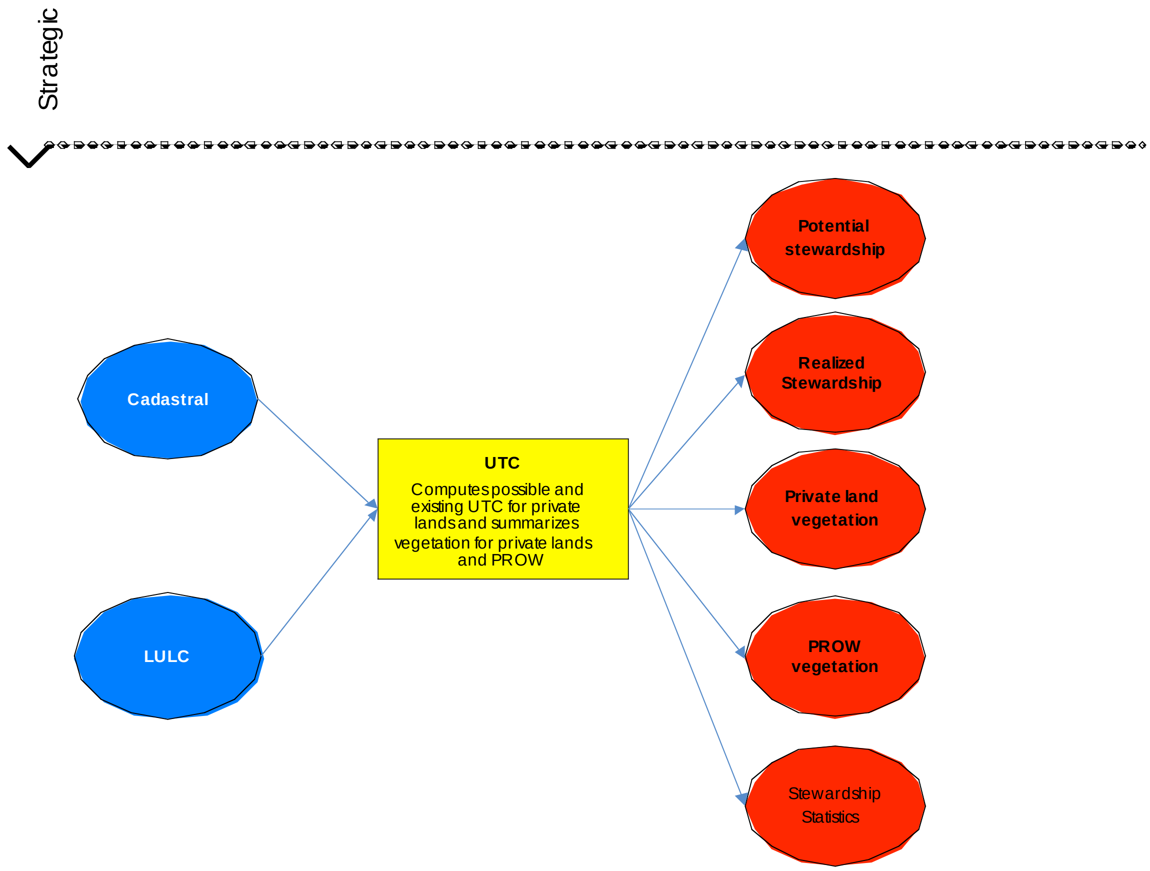


Figure 4-14. The FOS UTC tool automates many of the processing steps involved with computing possible and existing tree cover for a given geographic area.

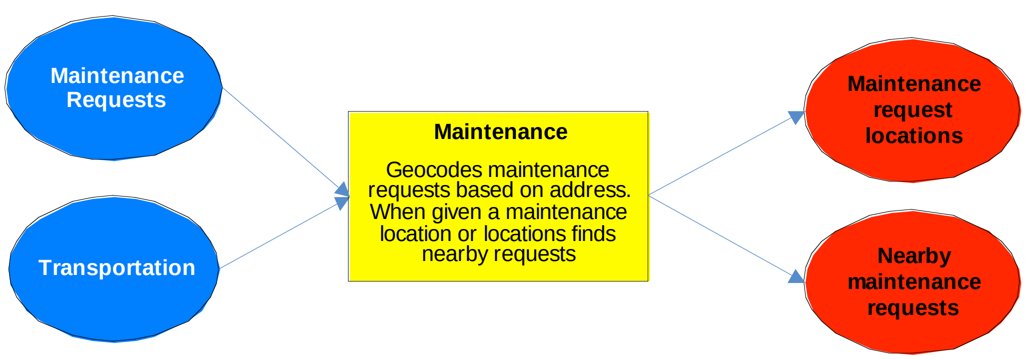


Figure 4-15. The FOS Maintenance tool facilitates geocoding the locations of tree maintenance service requests, and for a given service request finds other service requests within a specified driving time.

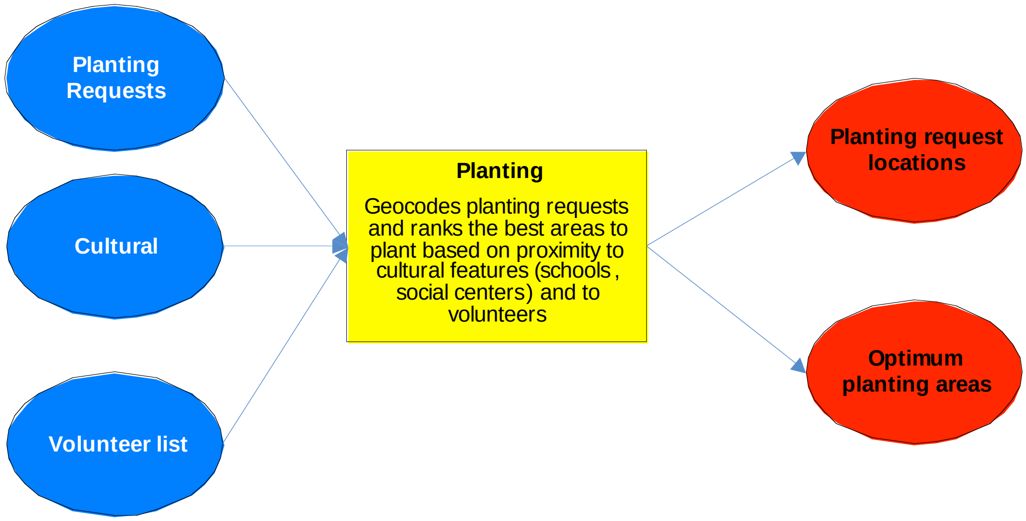


Figure 4-16. The FOS Planting tool assists managers in deciding where to focus planting efforts based on proximity to socially and culturally important features.

Visit the FOS website for the most up-to-date version of the FOS Toolbox along with tutorials at:

http://www.unri.org/fos/

CHAPTER 5: UTC GOAL SETTING EXAMPLES

A handful of communities in the Bay watershed have already committed to the adoption of urban tree canopy goals. These case histories are intended to provide a feel for how the process plays out in a real world setting. They are also intended to convey that while we have focused largely on technical issues, administrative concerns are fundamental to getting a UTC goal commitment and adoption.

BALTIMORE CITY

Timeline

On April 5, 2005, the UTC Goal Setting Process in Baltimore began with a letter of invitation sent by Maryland Department of Natural Resources (MD DNR) to Mayor O'Malley. The letter invited Baltimore to be one of the five communities referred to in the Chesapeake Executive Council's Directive of Expanded Riparian Forest Buffer Goals. In the letter, MD DNR committed to the provision of technical assistance in the event that the city accepted the invitation.

On August 2, 2005, at the City's request, a preliminary meeting was held at the Baltimore Department of Recreation and Parks (BDR&P) offices. The city wanted to review the roles and responsibilities of both parties, and more importantly, to get a better idea of what they were committing to.

On August 18, 2005, Mayor O'Malley responded by letter. His letter contained the following assignment:

1) Begin investigating the impacts of setting an Urban Tree Canopy (UTC) goal; and
2) Start work towards setting a reasonable goal for Baltimore City.

The letter also designated Connie Brown, BDR&P, as the City's point of contact. This was important as it established a specific client and an assignment.

On October 18, 2005, the first UTC goal setting meeting was held at BDR&P offices. The participants included Baltimore City, MD Department of Natural Resources, US Forest Service, University of Vermont Spatial Analysis lab, and the Parks and People Foundation. The group reviewed data and methods, agreed upon analyses to be conducted, and set a date to review the results and recommend a goal. The timeline called for:

1) An updating of data, methods, analyses, and subsequent report of results by December 15th, 2005;
2) The development of a goal recommendation in early January, and

3) A report to the City by the end of January so the City could have 45 – 60 days for review in order to make an announcement on a UTC Goal before Maryland Arbor Day (the first Wednesday in April), approximately one year from the date of the initial invitation.

On January 5, 2006, the final goal setting meeting was held at BDR&P offices. Participants reviewed and discussed data and analyses and agreed on a goal recommendation.

On January 19, 2006, the Baltimore City UTC Report (in the appendix of this document) was issued to the City along with a recommended goal. The report recommended that Baltimore City adopt a 46.3% UTC goal to be attained by 2030 - 2036, with remote sensing assessment of progress in attaining the UTC goal at 10-year intervals. This goal slightly exceeds the UTC targets associated with good water quality as established by Goetz (2003). It further recommended that the Baltimore Ecosystem Study (National Science Foundation and US Forest Service) and MD DNR Forest Service work with the City to:

1) Develop a comprehensive urban forest management plan, and
2) Monitor and assess the social and ecological benefits provided by changes in the City's UTC.

At this point it was up to the City to adopt the goal or another goal of their choosing.

On March 28, 2006, Baltimore became the first city in the Bay watershed to announce a UTC goal. It announced a goal of doubling the city's UTC over the next 30 years, from 20% to 40%. The City also announced that it will organize an inter-departmental cabinet and a citizen's panel to help write an Urban Forestry Management Plan to support the goal.

Results of the Baltimore UTC Assessment

The Baltimore UTC assessment revealed that the city's land area consists of 13% streets, 15% structures and 20% existing tree canopy (figure 5-1). This leaves 52% of the city's area available for possible tree planting. Possible planting locations were defined as all areas not currently occupied by roads or buildings. When the possible tree planting area is broken down by land use we find that only 8% of the possible planting area falls within the public right of way. The other 46% of the possible planting area falls within individual parcels (Figure 4-3). This means that the city will have to involve both public and private land holders in the goal setting process – planting street trees alone will not be enough to achieve the goal of doubling UTC.

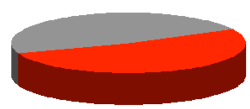
Land Cover	Percent of City Area	
Streets	13%	
Structures	15%	
Existing UTC	20%	
Possible UTC	52%	

Figure 5-1. Breakdown of Baltimore City land cover by streets, structures, existing UTC and possible UTC.

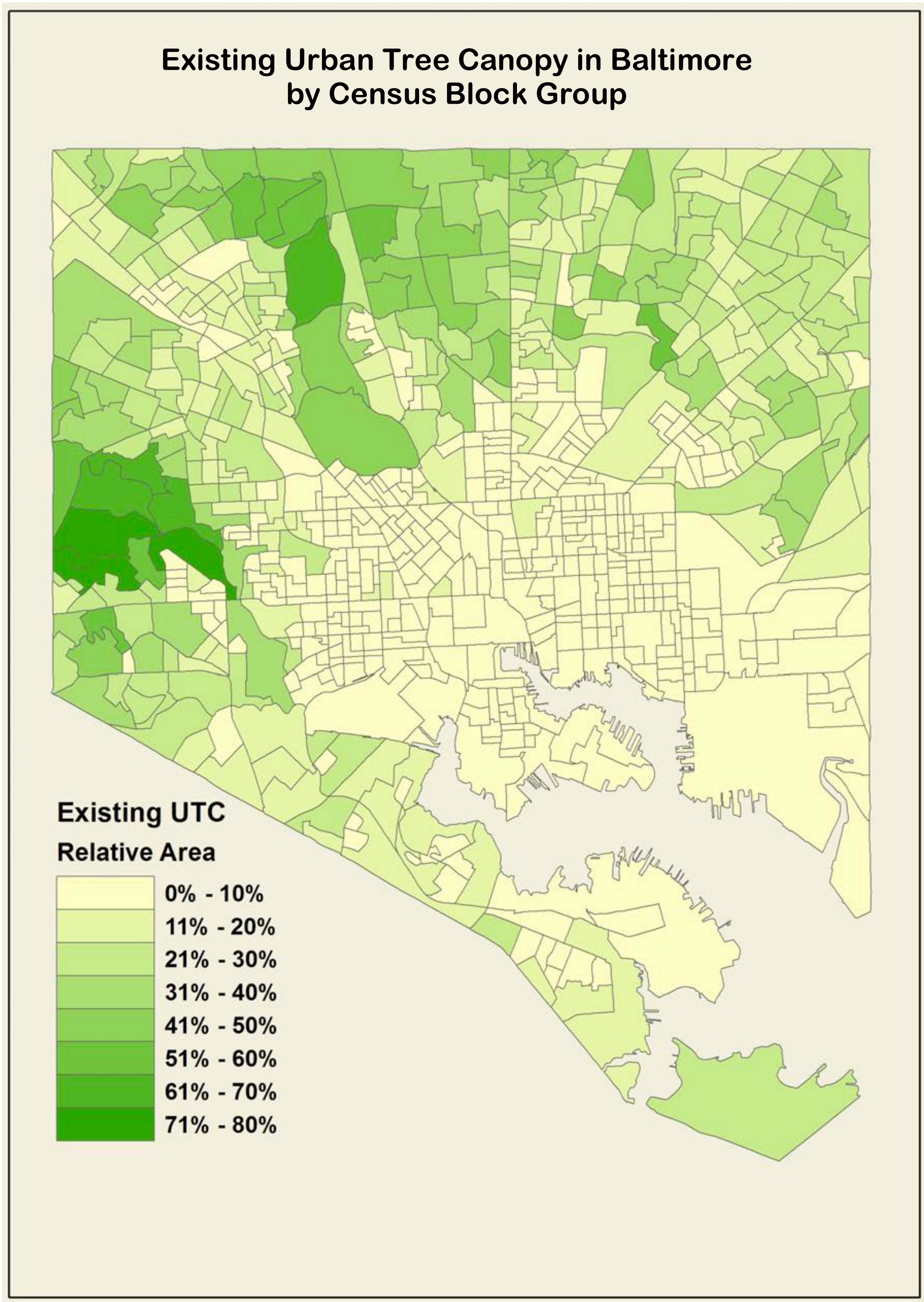


Figure 5-2. This map shows existing tree canopy in Baltimore City by census block group. Maps of this kind can help direct canopy enhancement efforts in the city.

ANNAPOLIS

Timeline:

On January 12, 2005, the Maryland Department of Natural Resources (MD DNR) sent a written invitation to Annapolis Mayor Ellen Moyer. The letter invited Annapolis to be one of the five (5) communities referred to in the previously noted directive, and committed MD DNR to the provision of technical assistance in the event that the city accepted the invitation. On January 28, 2005, Mayor Moyer accepted, making Annapolis the first city in the Bay watershed to commit to setting a tree canopy goal.

On November 4, 2005, the initial goal-setting meeting was held at Annapolis City Hall. Attendees reviewed data and methods, agreed upon certain analyses and set a date to review results and recommend a goal. The timeline called for:

1) An updating of data, methods, analyses, and subsequent report of results by May 26th, 2005;
2) The development of a goal recommendation in June 2006, and
3) A report to the City by the end of June to provide the basis for a locally-determined UTC goal.

The City called for two primary units of analysis: lands inside the Critical Area (within 1000’ of tidal waters of the Chesapeake Bay) v. outside the Critical Area; and, by ward.

The UTC assessment for Annapolis has been completed and the report is pending.

Results of the Annapolis UTC Assessment

The Annapolis UTC assessment revealed that the city has 41% tree cover (Figure 5-3). This is substantially more than Baltimore City due in part to a larger percentage of residential land use in Annapolis. Most existing UTC is on private land, particularly residential land, which has more tree cover than all other land uses combined. The majority of land where new tree planting is possible (possible UTC) is found in the residential, commercial, and exempt commercial land use categories. Of these, only the exempt commercial category includes some public land. Furthermore, these possible planting areas are dispersed throughout the city, rather than in a few large tracts. Annapolis will have to work with private land owners, particularly home owners, if it hopes to significantly increase UTC.

Land Cover	Percent of City Area
Public Rights of Way	12%
Structures	10%
Existing UTC	41%
Possible UTC	37%

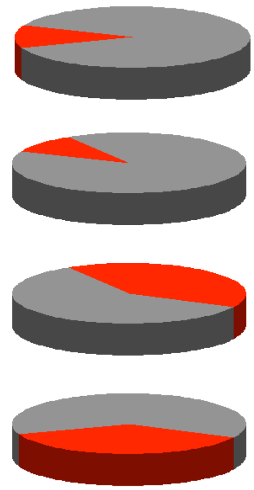


Figure 5-3. Breakdown of Annapolis land cover by public rights of way, structures, existing UTC and possible UTC.

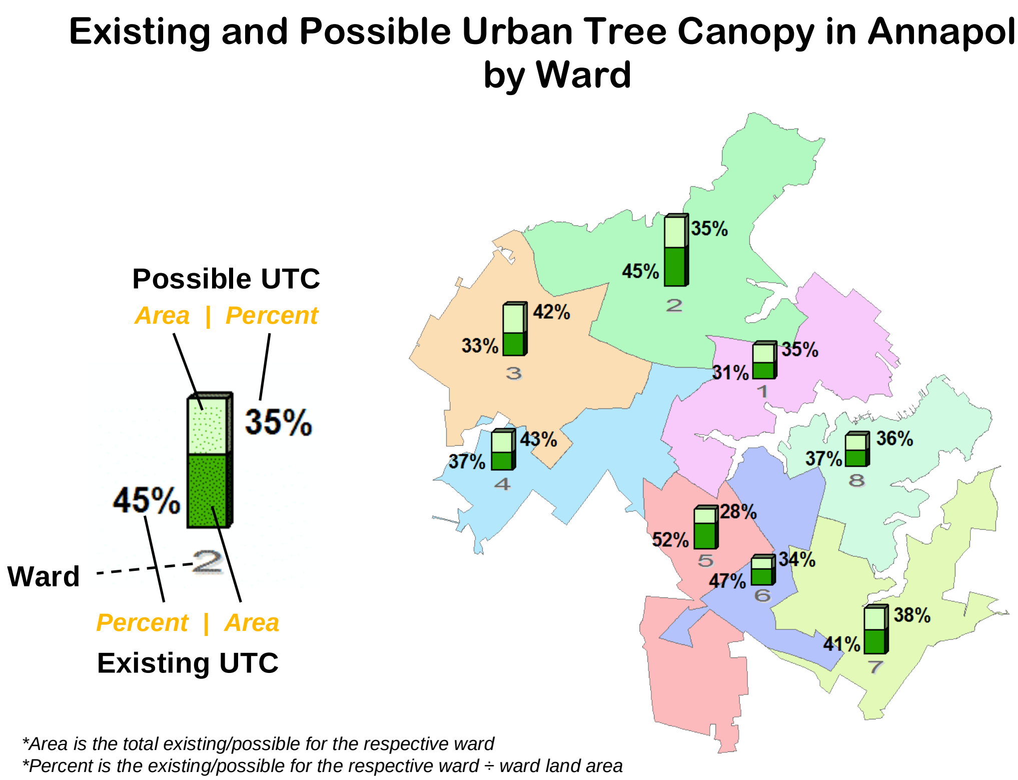


Figure 5-4. Existing and possible UTC by ward, for the City of Annapolis. This graphic is useful for depicting total in addition to relative amounts of existing and possible UTC.

Helping Communities Establish UTC Goals - Summary of Steps:

1. Identify your client. This is very important, particularly in large cities – you have to know who you are providing the report for.
2. Invite participation. This should be done formally (in writing) and be extended to an authority that is able to direct fulfillment of the commitment (Mayor or Council).
3. Meet with the client and identify needs. Agree on tools (GIS data, etc.) and how they will be shared. Agree on methods to be used and units of analysis (neighborhood, ward, land use type, etc.).
4. Perform analysis.
5. Meet with client and share results. Determine client needs for the report (items to be included and excluded).
6. Provide client with a report of findings and a goal recommendation.
7. Client will review by whatever process they establish and announce a goal.
8. Commit to provision of technical assistance for implementation.

Glossary:

Active sensor - An active sensor is a measuring instrument that generates a signal, transmits it to a target, and receives a reflected signal from the target. Information concerning the target is obtained by comparison of the received signal with the transmitted signal. Radar systems used to track airplanes are an example of an active sensor.

Automated Feature Extraction - The identification of geographic features and their outlines in remote-sensing imagery through postprocessing technology that enhances feature definition, often by increasing feature-to-background contrast or using pattern recognition software. (ESRI GIS Dictionary, http://support.esri.com)

Bottom-Up Canopy Assessments - Bottom-up approaches uses data collected on the ground, frequently a plot-based sampling scheme to measure tree canopy cover. In this approach, the amount of tree canopy cover that falls within study plots is extrapolated and taken to represent the urban tree canopy cover as a whole. This on-the-ground method may be most appropriate for very small communities, such as a homeowner's association or a school district's properties. Plot data can be collected using the US Forest Service's i-Tree tools and methods at www.itreetools.org.

Chesapeake Bay Program (CBP) - The Chesapeake Bay Program (CBP) is a partnership between federal and state agencies, non-profit organizations, and academic institutions whose aim is to protect and restore the Chesapeake Bay.

Chesapeake Executive Council – A legislative body serving Maryland, Pennsylvania, and Virginia. The Executive Council establishes the policy direction for the restoration and protection of the Chesapeake Bay and its living resources. A series of Directives, Agreements and Amendments signed by the Executive Council set goals and guide policy for the Bay restoration. The CEC consists of the Governors of Maryland, Pennsylvania, and Virginia, the Administrator of the U.S. Environmental Protection Agency, the Mayor of the District of Columbia and the Chair of the Chesapeake Bay Commission.

Color Infrared (CIR) – An example of multispectral data that includes part of the visible light spectrum as well as the near infrared. CIR is especially useful for vegetation mapping.

Ecosystem Services – The benefits that people obtain from ecosystems. These benefits may be environmental, social, or economic. Examples of environmental outcomes include the protection of streams, reduced stormwater runoff, reduced ozone concentrations, and increased carbon sequestration. Social outcomes may include improved human health, buffers for wind and noise, increased recreational opportunities, and neighborhood beautification. Economic outcomes can include reduced heating and cooling costs and increased property values.

Existing UTC - Any piece of land in the city that was covered by UTC at the time of satellite data acquisition.

Forest Opportunity Spectrum (FOS) - The Forest Opportunity Spectrum provides a framework for organizing data, as well as for asking and answering urban forestry related questions. This framework can assist decision-makers as they decide what their tree canopy goal will be and what actions they can take to achieve that goal.

Forest Opportunity Types – FOS allows forest opportunity types to be user defined. For example, Baltimore City identified six major FOS types: regional forestry, riparian forests, large parks, abandoned industrial areas, neighborhood areas, and roads (which includes street trees). Forest Opportunity Types are most often defined by and associated with specific issues identified by government agencies, non-profits, businesses, and community groups. FOS types overlap in geography, goals, and ownership.

Geographic Information Systems (GIS) - Acronym for *geographic information system*. An integrated collection of computer software and data used to view and manage information about geographic places, analyze spatial relationships, and model spatial processes. A GIS provides a framework for gathering and organizing spatial data and related information so that it can be displayed and analyzed. (ESRI GIS Dictionary, http://support.esri.com)

Geoprocessing - A GIS operation used to manipulate GIS data. A typical geoprocessing operation takes an input dataset, performs an operation on that dataset, and returns the result of the operation as an output dataset. Common geoprocessing operations include geographic feature overlay, feature selection and analysis, topology processing, raster processing, and data conversion. Geoprocessing allows for definition, management, and analysis of information used to form decisions. (ESRI GIS Dictionary, http://support.esri.com)

IKONOS - A commercial satellite that collects high-resolution imagery at 1- and 4-meter resolution. It offers multispectral (MS) and panchromatic (PAN) imagery. IKONOS launched on September 24, 1999, and provides imagery beginning January 1, 2000. Imaging, Inc. distributes IKONOS imagery under the product name CARTERRA.

LIDAR - LIght Detection And Ranging sensors are active sensors that collect extremely detailed elevation data by way of a laser. By emitting pulses from the laser, then sensing the time it takes for the pulse to return, the height of objects on the ground can be inferred. A relative surface DEM generated from LIDAR data can greatly complement imagery when performing a UTC assessment as it allows for features that have similar spectral and textural properties, to be differentiated based on height. LIDAR can be particularly useful in separating trees from shrubs and buildings from parking lots.

Manual Interpretation - Human interpretation is generally considered the most accurate method of extracting features from imagery, however it is extremely time consuming.

Multispectral Data - Data that spans several parts of the EM spectrum is referred to as multispectral data. Color infrared (CIR) imagery is an example of multispectral data. It displays light from part of the visible spectrum as well as near infrared (NIR).

Near Infrared (NIR) - Having a NIR (near infrared) band can assist in distinguishing tree and vegetation types (broadleaf vs. conifer vs. grass), impervious surface types (concrete vs. asphalt), and other features (forests vs. forested wetlands). NIR can also be used to assess vegetation condition. This makes NIR data invaluable for natural resource management.

Nutrient Pollution - Although nutrients, such as nitrogen and phosphorus, are essential to all plant life within the Chesapeake Bay, an excess of these same nutrients can be harmful. This is called "nutrient pollution". Excessive nutrient levels in aquatic systems can lead to harmful algal blooms, reduced sunlight for submerged aquatic vegetation, and low oxygen conditions that can kill fish and other aquatic life. As the use of the land has changed and the watershed's population has grown, the amount of nutrients entering the Bay's water has increased tremendously leading to many environmental problems in the Bay and its tributaries.

Passive sensor - Passive sensors record waves of electromagnetic (EM) energy that are either emitted or reflected from an object.

Possible UTC - Where is it biophysically *feasible* to plant trees? This is the first step in the assessment process. It is not concerned with costs, logistics or the fact that tree planting may not be appropriate or desirable in some locations. For the Baltimore UTC assessment, all land that was not covered by water, a road, or a building was considered a "possible" planting location.

Potential UTC - Where is it economically *likely* to plant trees? Which areas have regulatory constraints that conserve tree cover or have incentive supports for adding tree cover? Which areas are most cost-effective for achieving water quality or other goals?

Preferable UTC - Where is it socially *desirable* to plant trees? For example, where will tree cover make neighborhoods more attractive? Where will tree cover address other issues such as cooling and cleaning the air?

PROW (Public Right Of Way) - Any sidewalk, planting strip, alley, street, or pathway, improved or unimproved, that is dedicated to public use. The term includes any strip of land over which public facilities such as highways, railroads, or power lines are built.

Radiometric Resolution - Radiometric Resolution is the number of brightness levels that the remote sensing technology can sense. The higher the radiometric resolution, the better the sensor will be able to distinguish objects with similar spectral properties. Most remote sensors, such as Landsat, yield 8-bit data (2^8) where each pixel has a possible value of 0-255. Newer sensors are capable of collecting data at a much higher resolution.

For example, the IKONOS and QuickBird satellites gather 11-bit (2^{11}) data, allowing for improved feature recognition when compared to traditional 8-bit data.

Resolution – see Spatial Resolution, Radiometric Resolution, Temporal Resolution, and Spectral Coverage

Riparian Zone – This is the area of vegetation around streams. In less urbanized systems, the riparian zone is extremely important for water quality. This area of vegetation captures and processes pollutants before they can make it into surface waters. In urban areas, however, riparian zones are often less effective at removing pollutants. One reason is that urban streams tend to be deeply incised, causing the riparian zone to be disconnected from the stream below. Secondly, the streams in many urban areas have been functionally replaced with storm sewers.

Smart Growth - This term has many definitions depending on the context. According to the US Environmental Protection Agency:

> *Smart growth is development that serves the economy, the community, and the environment. It changes the terms of the development debate away from the traditional growth/no growth question to "how and where should new development be accommodated." Smart Growth answers these questions by simultaneously achieving:*
>
> - *Healthy communities -- that provide families with a clean environment. Smart growth balances development and environmental protection -- accommodating growth while preserving open space and critical habitat, reusing land, and protecting water supplies and air quality.*
> - *Economic development and jobs -- that create business opportunities and improve local tax base; that provide neighborhood services and amenities; and that create economically competitive communities.*
> - *Strong neighborhoods -- which provide a range of housing options giving people the opportunity to choose housing that best suits them. It maintains and enhances the value of existing neighborhoods and creates a sense of community.*
> - *Transportation choices -- that give people the option to walk, ride a bike, take transit, or drive.*

Spatial Resolution - Spatial Resolution is the "pixel size" associated with the data. For reference, it generally takes at least 4 pixels to identify a feature. So, while Landsat imagery, with its 30 square-meter resolution, may be adequate for measuring large areas of intact forest it will do a poor job of identifying street trees in urban areas. This is why the Chesapeake Bay Guidelines suggest a minimum resolution of one-meter or better. As spatial resolution increases so does the storage size of the data.

Spectral Coverage - Spectral Coverage is another consideration for data acquisition. Certain features and properties of land cover may be more distinguishable in different bands of the electromagnetic spectrum. For instance, the inclusion of a NIR (near infrared) band is optimal for classifying vegetation data as the majority of EM energy reflected by vegetation is in the NIR portion of the spectrum.

Strategic Urban Forests Assessment (SUFA): UTC assessment process using high-resolution remote sensing imagery. A vegetation mask is created from the NIR-to-Red, (Band4:Band3) ratio image. A texture image of the resulting ratio image is produced to separate UTC vegetation from non-UTC vegetation pixels (separate trees from other vegetation). The resulting image provides for quantification of existing UTC and non-UTC vegetation.

Stormwater Runoff – Surface water that fails to infiltrate the soil after a rainstorm. In developed watersheds it flows off roofs and pavement into storm drains which may feed directly into streams; Stormwater carries pollutants from urban areas directly into local waterways. By slowing, intercepting, and treating rainfall, trees can help reduce the volume of pollution-carrying stormwater runoff.

STRATUM (Street Tree Resource Analysis Tool for Urban forest Managers) - STRATUM is a street tree management and analysis tool for urban forest managers that uses tree inventory data to quantify the dollar value of annual environmental and aesthetic benefits. Using an existing inventory of street trees, this software allows managers to evaluate current benefits, costs, and management needs.

Temporal Resolution - Temporal Resolution represents the time frequency for the data. This component of data quality recognizes that it is not just the image quality that matters, but also when the information was acquired. The Chesapeake Bay Program Guidelines recommend that the data used in UTC assessment be less than five years old. In some communities, where rapid change or development is taking place, a much higher temporal resolution may be required (i.e. data that is less than one year old) to accurately reflect the extent of current tree canopy.

Three Ps - When moving from a canopy assessment to an implementation plan, it is useful to separate the process into a sequence of steps. This allows the task to be broken into manageable components and prevents each step from being bogged-down by details that belong in later stages of the process. The Three Ps, Possible, Potential, and Preferable, provide a useful sequence for structuring the goal setting and implementation process. (See Possible, Potential, and Preferable for more information).

Top-Down Canopy Assessments - Top-down approaches use remote sensing data, such as satellite imagery, to quantify the extent of tree cover. For most communities, a top down approach is recommended. This guide focuses on a top-down approach for several reasons. First, the Chesapeake Bay Program guidelines are based on tree cover and extent which are readily assessed using top-down methodologies. Second, percent cover is easy to conceptualize and communicate. Third, remote sensing makes it easy to track progress over time. Lastly, these methods are well documented and have been used successfully here and elsewhere.

Urban Forests - Urban forests include the trees in our yards, parks, public spaces, and along our streets. Though we don't often think of them as forests, they provide many forest benefits, such as cleaner air and water. In addition to environmental benefits, urban forests increase property values, reduce home energy costs, block UV radiation, buffer wind and noise, provide shade and beautify our neighborhoods.

Urban Sprawl - The unplanned, uncontrolled spreading of urban development into areas adjoining the edge of a city.

Urparian - Urparian describes the vegetated areas around roads and sidewalks. The term comes from combining urban and riparian to form a single word. In less urbanized systems, the corridor around streams (the riparian zone) is extremely important for water quality. This area of vegetation captures and processes pollutants before they can make it into surface waters. In urban areas, however, riparian zones are often less effective at removing pollutants. One reason is that urban streams tend to be deeply incised, causing the riparian zone to be disconnected from the stream below. Secondly, the streams in many urban areas have been functionally replaced with storm sewers. In this context, the soil and vegetation around roads and sidewalks is the new riparian zone. By increasing tree canopy in the urparian zone, we can return some of the environmental benefits of riparian areas to urban systems.

Urban Tree Canopy (UTC) - Urban tree canopy (UTC) is the layer of leaves, branches, and stems of trees that cover the ground when viewed from above.

Watershed - This is the area that drains to a common waterway, such as a stream, lake, estuary, wetland, or the ocean. The Chesapeake Bay Watershed stretches across six states and includes all of the areas that eventually drain into the Bay.

Appendix

Sample Letter to Mayor/Community Leader

Fact Sheets

- FOS
- UTC
- Remote Sensing

Baltimore UTC Report

Internet Resources

Forest Service Tools

UFORE (Urban Forest Effects Model) http://www.ufore.org/

iTree (Tools for assessing and managing community forests)
http://www.itreetools.org/

Urban Watershed Forestry Manual Series

Part 1: Methods for Increasing Forest Cover in a Watershed
Part 2: Conserving and Planting Trees at Development Sites
Part 3: Urban Tree Planting Guide
http://www.na.fs.fed.us/watershed/publications.shtm