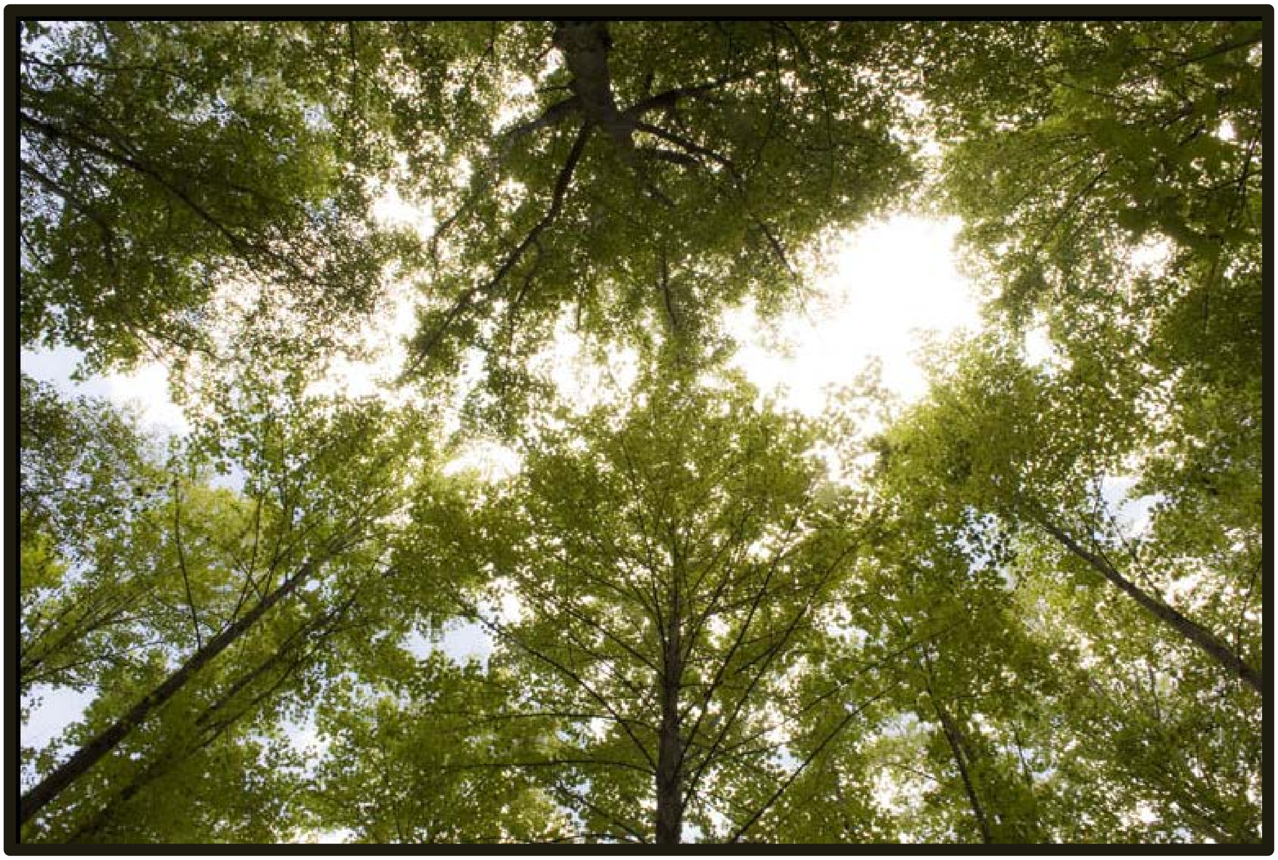
SECTION V:

Green Infrastructure Research and Supporting Documents

2010 Forest Canopy Assessment
Prince George's County, Maryland



Fall 2013

2010 Forest Canopy Assessment
Prince George's County, Maryland
2000 - 2010

Executive Summary

Prince George's County has long been a leader in the field of environmental conservation and a supporter of the principles of smart growth. In Prince George's County, the primary land use document is the 2002 *Prince George's County Approved General Plan*. In 2002, the General Plan contained a measurable objective that set canopy coverage goals countywide and within each growth policy tier for the first time. The goal states that the county should:

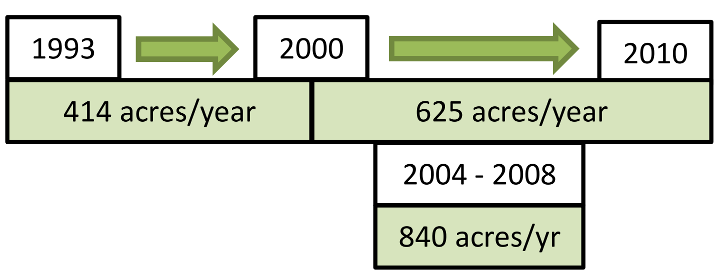
"Meet or exceed the following forest and tree cover goals within each Tier and countywide by 2025: Developed Tier – 26 percent; Developing Tier – 38 percent; Rural Tier – 59 percent and countywide – 44 percent."

This forest canopy assessment is being prepared in support of the General Plan Update. The purposes of this assessment are as follows:

- to report on regional trends in forest canopy loss
- to summarize the results of the 2000 *Forest and Tree Canopy Assessment*
- to analyze forest loss since 2000 using approved tree conservation plans
- to evaluate forest loss using a GIS approach for comparison
- to evaluate what has been accomplished to address forest canopy loss since 2002
- to make recommendations regarding future canopy goals

This analysis uses, as a baseline, the data from 2000 that were used to create the canopy coverage goals for the 2002 General Plan. Between 1993 and 2000, annual net losses were, on average, 414 acres per year (see the figure provided below) and between 2000 and 2010 the losses were 625 acres per year. Between 2004 and 2008, the average annual net losses were approximately 840 acres per year, more than double the average for the previous time period. For comparison purposes, the average annual loss for the 25-year implementation period for the forest canopy goal was estimated to be 310 acres per year in order to meet the stated goals.

Summary of Net Woodland Loss: 1993 – 2010



Net woodland loss = [existing acreage (year 2000)] minus [acres of clearing approved] plus [acres of planting approved]

Recommendations

The following actions are recommended based on the findings of this 2010 Forest Canopy Assessment:

1. Retain the countywide forest canopy goal of 44 percent in the new General Plan for the following reasons:
   - o the 2002 goals have a 25-year timeframe for assessment and only ten years have passed.
   - o the predictions made in the 2000 assessment are generally bearing true.
   - o the goal exceeds the statewide goal of 40 percent.

2. Prepare a comprehensive forest and tree canopy coverage strategy that addresses the goals and desired development pattern of the new General Plan. Consider including in the strategy canopy goals for designated areas in the new General Plan.

3. Continue effective implementation of the Woodland and Wildlife Habitat Conservation Ordinance including an increased emphasis on enforcement. Provide training where needed to staff conducting plan reviews, inspections, and other enforcement activities.

4. Focus on planting and maintaining urban tree canopy as new development shifts to more compact living areas.

5. Continue to monitor selected metrics to assist in future decision-making.

I. Introduction and Background

Prince George's County has long been a leader in the field of environmental conservation and a supporter of the principles of smart growth. Regulations related to forest loss are contained in the County Code. The county's Woodland Conservation and Tree Preservation Ordinance (WCO), adopted on November 21, 1989, later served as the state's model for the Forest Conservation Act of 1991, and is the primary tool for preventing forest loss when land development occurs. The WCO was updated in 2010 and renamed the "Woodland and Wildlife Habitat Conservation Ordinance" and can be found in Subtitle 25 of the County Code. The abbreviation of "WCO" is also used for the updated ordinance.

In Prince George's County, the primary land use document is the 2002 *Prince George's County Approved General Plan*. In 2002, the General Plan contained a measurable objective that set canopy coverage goals countywide and within each growth policy tier for the first time. The goal states that the county should:

"Meet or exceed the following forest and tree cover goals within each Tier and countywide by 2025: Developed Tier – 26 percent; Developing Tier – 38 percent; Rural Tier – 59 percent and countywide – 44 percent."

While the 2002 General Plan established what were labeled "forest and tree cover goals," these goals measured forest canopy only, not tree and forest canopy, because of the limitations of the technology available in 2000 when an "existing vegetation" geographic information system (GIS) layer was used. Unless quoting text from other published documents, for the purpose of this paper the term "forest and tree cover" is revised to "forest canopy" to reflect the limitations of the data gathering. In addition, the terms "woodlands" and "forests" are used interchangeably.

Forest and Tree Canopy Defined

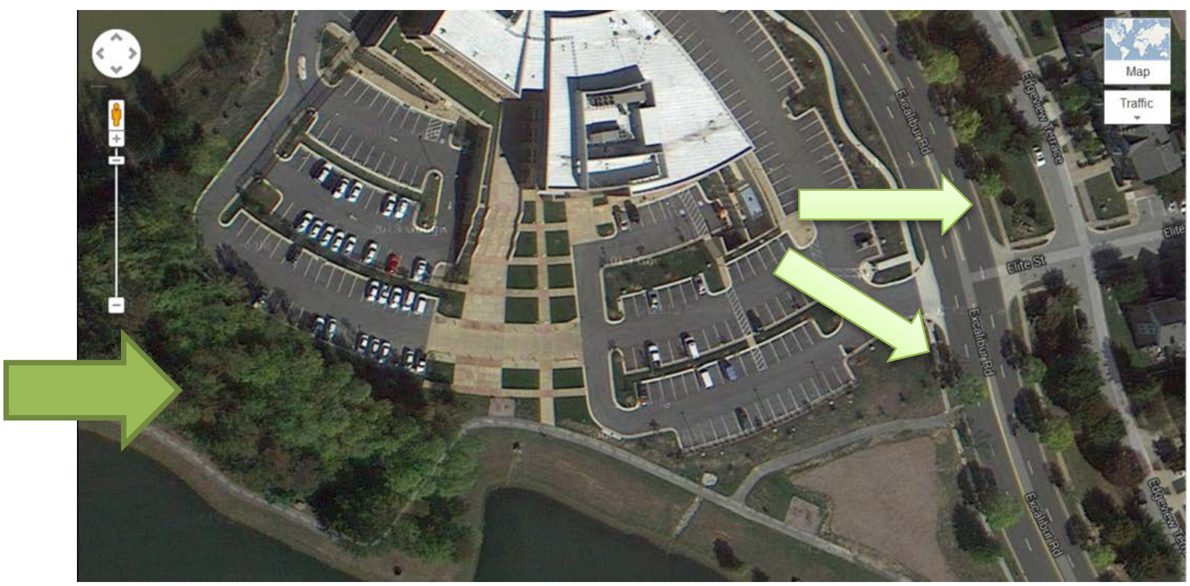


Figure 1. Bowie City Hall – forest canopy on the left and tree canopy on the right.

Forests are generally defined as areas dominated by trees and other woody or herbaceous plants covering a land area of 10,000 square feet or greater.
Forest functions include stabilizing soil; managing stormwater; providing wildlife habitat and forest products; and cleaning the air and water.

Tree canopy is generally defined as the area of land under single tree or small groups of trees that does not meet the definition of a forest.

Tree canopy functions include intercepting stormwater; controlling microclimate; and cleaning the air and water.

Put simply, forests are defined as areas dominated by trees and other woody or herbaceous plants covering a land area of 10,000 square feet or greater. The term used in the County Code is "woodlands" and is defined as:

> 25-118(b)(72) *"**Woodland**: A perpetual biological community dominated by trees and other woody or herbaceous plants covering a land area of 10,000 square feet or greater. This includes areas that have at least 100 trees per acre with at least 50 trees that are 2 inches or greater in diameter at breast height. This also includes areas that have been forest harvested where the stumps remain in place for future regeneration. The terms "woodland," "forest," and "forest cover" are synonymous and do not include orchards or other areas without multiple layers of woody and herbaceous vegetation."*

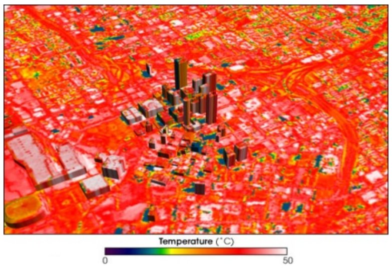


Figure 2: Higher urban temperatures caused by the "heat island effect" can be reduced by forest and tree canopy

"Woodland conservation" consists primarily of the preservation of existing forests, reforestation (the re-establishment of forests where they were recently removed) or afforestation (the re-establishment of forests where they have been absent for some time).

Forests provide numerous benefits called "ecosystem services" that include lower air temperatures, cleaner air, cleaner water, improved stormwater infiltration, reduced erosion, improved wildlife and fish habitat, and reduced water temperatures. Forests also produce wood for construction, edible plants, and other less tangible benefits such as improved personal well-being.

As the ecosystem services of forests are lost, the costs to human health are profound and include higher asthma rates because of lower air quality, increased costs for stormwater management (both the initial construction costs and the long-term maintenance costs), increased water purification costs, and reduced value of recreational experiences and forest products obtained from these areas.

The Tree Canopy Coverage Ordinance defines tree canopy as:

> *25-126(b)(1) "**Tree canopy**: The land area under the dripline of an existing tree or group of trees or the amount of credit provided for planting trees of a certain species and certain size at time of planting in conformance with the worksheet provided in the Technical Manual."*

Tree canopy coverage, especially in the built environment, is critical to human health by making the built environment more livable. A healthy tree canopy requires careful planning and maintenance – these elements need to be addressed in a comprehensive strategy for long-term healthy communities.

Assessment Purpose and Analysis

The 2010 forest canopy assessment was prepared as part of the pre-planning tasks for the General Plan Update. The purposes of this assessment are as follows:

- to report on regional trends in forest canopy loss
- to summarize the results of the 2000 Tree and Forest Canopy Assessment
- to analyze forest loss since 2000 using approved tree conservation plans
- to evaluate forest loss using a GIS approach
- to evaluate what has been accomplished to address forest canopy loss since 2002
- to make recommendations regarding future canopy goals

The questions raised by the 2010 assessment include the following issues that are addressed in more detail below:

1. *Should the canopy goals be adjusted to reflect current trends?*
2. *Should regulations be changed to address the unanticipated losses in canopy that are being reflected in the data?*
3. *Will the regulatory changes implemented in 2010 result in a shift in the trends reflected in this assessment?*
4. *Can shifts in land development types and patterns address the continued loss of forests?*

The recommendations of this assessment address the questions raised above as follows:

1. *Should the canopy goals be adjusted to reflect current trends?*

   The goals in the 2002 General Plan were to be measured over a span of 25 years. To date, only the first ten years of the evaluation period have been reported. Because the analysis only reflects the first ten years of the time period, and because a multitude of measures have been and could be put into place to curb these trends, this assessment recommends that the canopy goals remain the same for the General Plan Update as those contained in the 2002 General Plan. The title of the goals should be changed to "forest canopy goals" instead of "forest and tree cover goals" to reflect the data that was used in the past and the trends to be measured in the future.

2. *Should regulations be changed to address the unanticipated losses in canopy that are being reflected in the data?*

   The unanticipated losses occurred during the most active years for land development during the study period. Between 1993 and 2000, annual net losses were, on average, 414 acres per year. Between 2004 and 2008, the average annual net losses were approximately 840 acres per year, more than double the average for the 1993-2000 time period.

   In 2010, the County Code was amended to implement the recommended strategies in the 2002 General Plan and the 2005 *Countywide Green Infrastructure Plan*. It is anticipated that the effect of these strategies will be to reduce the rate of forest fragmentation and overall losses.

   No additional regulations are recommended as part of this study; however, a comprehensive canopy coverage strategy is needed to evaluate the existing regulations further. The General Plan Update intends to redirect development from previously undeveloped sites to redevelopment sites. If this shift is achieved, the annual forest losses will likely be reduced and additional regulations will not need to be adopted to meet the forest canopy goals. Additional attention is needed to address tree canopy coverage goals in urban areas.

3. *Will the regulatory changes implemented in 2010 result in a shift in the trends reflected in this assessment?*

   In 2010, many of the strategies in the 2005 Green Infrastructure Plan were implemented through the passage of a comprehensive package of updates to the County Code's environmental regulations related to land development.

   Moving forward, as more development applications are reviewed and approved under the updated regulations, the overall losses should trend downward, depending on the types, locations and patterns of development. For instance, development on large, wooded parcels will always result in significant forest losses; development on previously cleared and developed sites can reduce the total annual forest losses countywide.

4. *Can shifts in land development types and patterns address the continued loss of forests?*

   One of the basic principles of smart growth is to build in places where the public infrastructure (roads, sewers, schools, etc.) already exists and to not build where the expenditure of funds for public infrastructure is high. The General Plan Update recommends a shift from previous trends of clearing greenfield sites to a focus on developing sites that have been cleared and developed previously, resulting in a reduction in annual forest losses in the future.

Figure 3. Build here…near Metro, on previously developed sites

Figure 4. Avoid building here…away from public services…on "greenfield" sites (sites that have never been built on).

Previous Forest Canopy Assessment

In 2000, a forest canopy assessment was conducted that resulted in recommendations in the 2002 General Plan. The assessment resulted in the establishment of the first "forest and tree cover" canopy goals in the county as shown in Table 1.

Table 1. 2002 General Plan "Forest and Tree Cover" Canopy Goals*

	Canopy Goal (% of land area)
Developing Tier	26%
Developed Tier	38%
Rural Tier	60%
Countywide	44%

* The numbers do not add to 100 across the tiers or countywide because they are percentages of different land areas.

The study conducted for the 2002 General Plan used data up to the year 2000, and is referred to as "The 2000 Forest and Tree Canopy Assessment." The study used historical data from approved tree conservation plans (1993 – 2000) to predict the acreage of forests that would be lost to land development through the year 2025. Land development is not the only cause of forest loss; however, because there have been limited tools available to measure loss, and because this is an available data source, these data were used to predict future losses.

The method used to conduct the 2010 assessment was a replication of the 2000 assessment method that was used to create the canopy goals for the 2002 General Plan. The assessment used the 2000 vegetation GIS layer as a base layer and subtracted or added forest acreage as shown on approved tree conservation plans since 2000 (forest acreage shown to be cleared is subtracted and forest acreage to be planted is added). This information and past trends were then applied to predict future canopy coverage percentages. The 2000 assessment predicted canopy percentages to the year 2025; the 2010 assessment predicts canopy percentages to 2035. The 2010 assessment uses slightly different assumptions than those used in the original study in 2000 as noted in Section IV below.

II. Trends in Regional Forest Canopy Loss

The loss of woodlands over time has been well documented in the region and the state. The Chesapeake Bay watershed was once 95 percent forested and now is only 55 percent forested as shown in Figure 1. According to Maryland's Strategic Forest Lands Assessment (October 2003), Maryland is a rapidly urbanizing state; over the last 50 years Maryland has lost an average of 7,200 acres of forest per year, primarily because of land development for urban uses. The Maryland Forest Resource Assessment of 2010 predicted that between 1990 and 2015 urban development is likely to increase by 48 percent resulting in continued loss of woodlands.

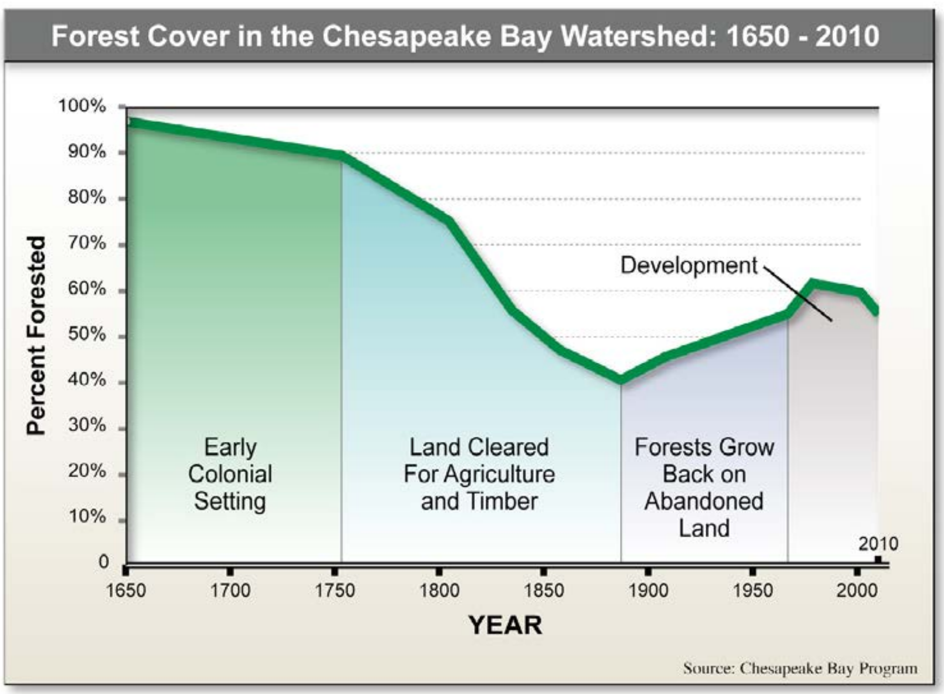


Figure 1. Forest cover in the Chesapeake Bay watershed from 1650 to 2010.
Source: Chesapeake Bay Program, Chesapeake Forest Restoration Strategy

III. Trends in Forest Canopy Loss in Prince George's County

In 2001, the Prince George's County Biennial Growth Policy Plan recommended the completion of an assessment of canopy coverage in order to set goals in the 2002 General Plan. As part of the General Plan's Technical Summary document, a forest canopy assessment was completed. Although it was completed in 2002, it is referred to as "The 2000 Forest and Tree Canopy Assessment" because this study utilizes data from 1993 to 2000.

One of the first trends evaluated in the 2000 Assessment was past forest canopy coverage using available data for the years 1938, 1965, and 2000. Because the technology used was limited to tracking forested areas, this data reflects only forest canopy and not forest and tree canopy. Table 2 shows the acreage of canopy coverage over time and Figure 2 shows the trends over time.

Table 2. Forest Cover Comparison (% acres by year studied)

	Year		
Growth Policy Tier	**1938**	**1965**	**2000**
Developed	36%	25%	25%
Developing	41%	44%	40%
Rural	51%	59%	61%
Countywide	43%	46%	45%

Note: All of the percentages were calculated using the growth policy tier boundaries in place in 2010.

Figure 2. Forest Losses in 1938, 1965 and 2000 by Growth Policy Tier

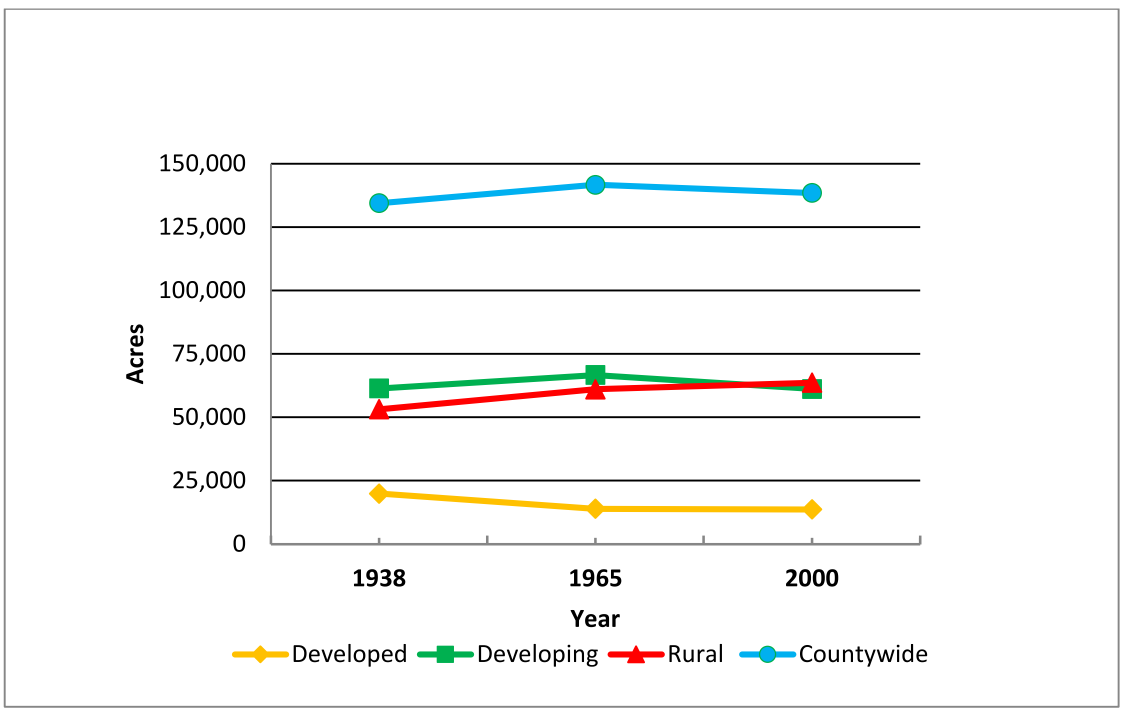


Figure 2 shows:

- The Developed Tier experienced a significant decline in forest canopy between 1938 and 1965 when this tier experienced rapid development. Although development continued between 1965 and 2000, the rates of development and forest removal declined.

- The Developing Tier experienced an increase in forest coverage between 1938 and 1965, consistent with regional trends, mainly due to the abandonment of agricultural land that naturally reverted into forests. This was offset by some development activity but the effect was an overall increase in the acreage of forest cover within this growth policy tier.

- The Rural Tier continues to be characterized by agriculture, forest conservation, and low density residential developments. In 2000, the Rural Tier passed the Developing Tier in total acres of forest.

The countywide trend shows there were more forests countywide in 2000 than were present in 1938, despite a decrease in forest canopy coverage from 1965 to 2000. However, the character and distribution of the remaining forests is vastly different in 2000 than in 1938. As is true for many communities that converted from rural communities to a suburban character from 1938 to 2000, forests have become increasingly fragmented with smaller blocks of forest remaining. Additionally, fewer large blocks of forest area remain in the more urbanizing segments of the county, where their benefits are most needed.

Throughout all the analyses contained in this and previous assessments, a margin of error should be assumed. With large data sets spanning large geographic areas such as Prince George's County's 485 square miles, margins of error of one to two percent can be expected. The figures contained in this and previous assessments should be considered broad analyses that were conducted for the purpose of providing a framework for policy decisions, not for setting specific or regulatory thresholds.

IV. Review of the 2000 Forest and Tree Canopy Assessment

The 2002 General Plan set forest canopy goals countywide and by growth policy tier. Table 3 provides the forest canopy percentages that existed in 2000 and the canopy goal set for that area in the 2002 General Plan. As noted above, only forest canopy, not forest and tree canopy, was measured because of technological limitations.

Table 3. Forest Canopy Percentages and Goals

	Canopy Coverage in 2000	General Plan Canopy Goal
Developed Tier	25%	26%
Developing Tier	40%	38%
Rural Tier	61%	60%
Countywide	45%	44%

Note: All of the percentages were calculated using the growth policy tier boundaries in place in 2010.

The canopy goals reflect the expected growth countywide and the desired development pattern of the 2002 General Plan. In the Developed Tier, the goal was set at slightly higher than the existing level to address the need for maintaining existing forest canopy coverage and to ensure a focus on tree planting throughout existing and redeveloping communities. Development was anticipated in the Developing Tier, so the canopy goal was set lower than what was existing in 2000. The Rural Tier goal was set at a percentage comparable to the existing canopy coverage to acknowledge past trends and in anticipation of additional conservation efforts adjacent to sensitive natural features.

In order to determine the appropriate goals for the 2002 General Plan, statistics from approved tree conservation plans (TCPs) from 1993 to 2000 were used to determine past trends, that were in turn used to predict future annual amounts of clearing, preservation, and planting through 2025. These data are contained in the woodland conservation database that is maintained by the Environmental Planning Section of the Prince George's County Planning Department of M-NCPPC. Within this database, there is a quantitative description of each TCP. Some of the data tracked includes:

- TCP number (year in which the TCP was accepted for review and a tracking number)
- The approval date
- The growth policy tier where the site is located
- The gross tract area
- The existing woodlands (in the floodplain and out of the floodplain)
- Amount of woodlands to be cleared (in and out of the floodplain)
- Amount of woodlands to be preserved (in and out of floodplain)
- Proposed acres of afforestation or reforestation

This provides the necessary data to perform the analyses regarding existing and projected preservation, planting, and clearing. In order to conduct these analyses, the following assumptions were applied:

- Data prior to 1993 was not used because the overall calculations were different and would not compare to data collected after 1993.

- Properties and activities exempt from the local requirements were not included: state properties (unless review was delegated to the county), properties in the Chesapeake Bay Critical Area, logging operations conducted more than five years ahead of land development, agricultural activities, clearing in public utility rights-of-way, and clearing associated with power generation stations.

- Acres of woodland cleared on properties less than 40,000 square feet in size, woodland cleared on properties with less than 10,000 square feet of woodlands at the time of application, and woodlands cleared as part of permit applications for clearing less than 5,000 square feet were not included in the net loss acreages because these sites are exempt from the requirements unless the property has a previously approved tree conservation plan.

- The clearing, protection, or conservation occurred within the same year as the original TCP approval. (In actuality, some sites may be cleared or planted in later years.)

- TCPs for off-site woodland conservation banks were not included in the calculations because this acreage is already accounted for in the calculations for net woodland loss.

- The acreages reported are based on the originally approved plan without accounting for revisions.

- The TCPs are implemented as approved with no variations to the approved limits of disturbance in the field.

- The growth policy tier designations that existed prior to final approval of the 2002 General Plan were used in this portion of the study because they were the only designations available at the time.

- The 2000 GIS vegetation layer representing forest canopy was correct and presented the baseline upon which the projections were based.

The forest canopy coverage annual net losses, based on approved tree conservation plans in the growth policy tiers and countywide from 1993-2000, are shown in Table 4. Annual net loss is calculated by taking the amount of existing forest, subtracting the amount cleared and then adding the acres planted. This calculation results in an average annual net loss of approximately 414 acres per year from 1993-2000.

Table 4. Acres of Woodland Loss Per Year

	1993	1994	1995	1996	1997	1998	1999	2000	Total	Avg.
Developed Tier	121	65	92	33	42	24	21	18	416	52
Developing Tier	153	423	546	305	305	250	251	182	2415	302
Rural Tier	25	116	28	103	11	3	158	32	476	60
Countywide	300	604	666	441	357	277	430	232	3307	414

In order to set canopy goals for 2025, projections needed to be made into the future. Using the following assumptions, the percentages of canopy coverage that were predicted to remain in future years are provided in Table 5:

- Based on past trends, it was assumed that the average annual woodland loss would remain constant for the first ten years (until 2010) and then decline by five percent per year because the area of woodlands available for clearing and preservation would be reduced over time.

- The future amount of forest canopy coverage due to existing tree growth was not factored into the projections because trees grow at different rates and predicting these growth rates over 25 years is difficult if not impossible.

Table 5. Percentage of Projected Canopy Coverage in Future Years From the 2000 Assessment

	2000	2010	2020	2025	GP Goals
Developed Tier	25%	25%	25%	24%	26%
Developing Tier	40%	39%	38%	37%	38%
Rural Tier	61%	58%	58%	58%	60%
Countywide	45%	43%	43%	42%	44%

The goals in the 2002 General Plan could have been set at the 2025 projected percentages; however, the goals were selected to be at higher levels than the predicted 2025 levels because it was assumed that the strategies contained in the 2002 General Plan and 2005 *Countywide Green Infrastructure Plan* would be implemented to address forest loss and fragmentation.

V. 2010 Forest Canopy Assessment

Using data from approved tree conservation plans from 2000 to 2010, and necessary adjustments to the data reported previously for the years 1993 to 2000, the methodology used in the 2000 canopy assessment was replicated. The same woodland conservation database was used with the same types of data being reported.

Study Assumptions

All of the assumptions from the 2000 Assessment were carried over into the 2010 study, with the following additions or changes:

- The 2000 Assessment did not account for revisions to the previously approved tree conservation plans. For the 2010 Assessment, because revisions become more important over time, adjustments that resulted from plan revisions were included in the year the revisions occurred.
- The growth policy tier designations as of July 2011 were used for this analysis. The tier boundaries changed as master and sector plans were approved between 2002 and 2010. The changes in the tiers are considered negligible in this study because of the large areas being evaluated.
- Whereas the 2000 Assessment assumed that the rate of woodland loss would remain constant for the first 10 years of the projection, given the recent economic downturn and the reduced levels of annual net loss of forests, the 2010 Assessment assumed that the backlog of approved plans that have not been implemented would be constructed first with no new losses in the first ten years. Because these acreages are already accounted for, they would not result in additional clearing in future years. This is a conservative assumption and was used because of the uncertainty of when the pace of development would return to normal levels.

- From 2020 to 2035 this assessment assumed that the annual woodland loss would decrease by five percent each year. This is the same assumption as in the 2000 Assessment, but is for a different time period.

2001-2010 Data Reported

The forest canopy coverage annual net losses based on approved tree conservation plans in the growth policy tiers and countywide from 2001-2010 are shown in Table 6. Annual net loss is calculated by taking the amount of existing forest, subtracting the amount cleared and then adding the acres planted.

Table 6. Annual Net Forest Loss (acres) 2001 - 2010

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Totals	Avg.
Developed Tier	77.9	20.8	44.3	18.7	109.7	108.8	166.9	166.3	-6.6	2.4	709.3	70.9
Developing Tier	363.7	475.4	512.1	1052.1	606.2	881.7	385.8	427.4	137.3	50.0	4891.5	489.2
Rural Tier	108.6	96.8	175.0	79.9	102.4	58.9	26.2	9.8	-12.0	2.7	648.4	64.8
Countywide	550.2	593.1	731.4	1150.7	818.2	1049.4	578.9	603.6	118.7	55.1	6249.3	624.9

(Note: negative numbers reflect situations where more planting occurred than clearing; figures are provided to one decimal place because some of the data reflects numbers in the single digits; rounding of numbers may result in minor discrepancies in the totals)

The time period depicted contains some years where development activity was robust and some years where activity tapered off. The reduction in forest canopy coverage lost in less robust years of development activity is not a result of better regulations or improved preservation techniques, but of fewer projects clearing fewer acres of forest countywide.

The resulting data shows a countywide average annual net loss of 648 acres per year from 2001-2010 as shown in Table 6, compared to the average annual net loss of 414 acres countywide from 1993-2000 as shown in Table 4. When reviewing the entirety of the data set from 1993-2010 the average annual net loss is approximately 531 acres. When the 1993-2000 data is adjusted for revisions to approved TCPs the annual average net loss is approximately 563 acres.

Based on the assumptions used in the 2000 study, the predicted average annual net loss of forests over the 25-year goal period was 310 acres per year. The study assumed that in the first ten years (from 2000 – 2010) the annual losses would reflect the previous trends of forest loss of 414 acres per year. The data show that from 2001-2010 the average annual net loss was 648 acres; however, after 2008 the annual loss dropped significantly.

Because of the economic downturn and the slowing of forest loss, future implementation of the environmental regulations passed in 2010 on all projects, and the recommended shift in development priorities, the predicted future annual losses of forests should not be as dramatic as those seen in the period from 2004 to 2008.

Projections to 2035

To project forest loss to 2035, the data from the approved TCPs through 2010 were used as a baseline. From 2010 to 2020 there was no assumed change in the percentage of woodlands in each tier and countywide (essentially a no net loss assumption based on a backlog of projects yet to be implemented). From 2020 until 2035 it was assumed that the annual forest loss would decrease by five percent each year because more new projects will be built in the future on already developed sites resulting in fewer acres of overall forest loss. In addition, during this time period there will be fewer acres of forests that remain.

Using these assumptions, the forest canopy coverage percentages contained in Table 7 are predicted. Figure 3 shows the existing and projected acreages of forests in each tier and countywide using the data from the previous trends analysis, the 2000 Assessment, the 2010 Assessment, and the predicted amount of forests in the future.

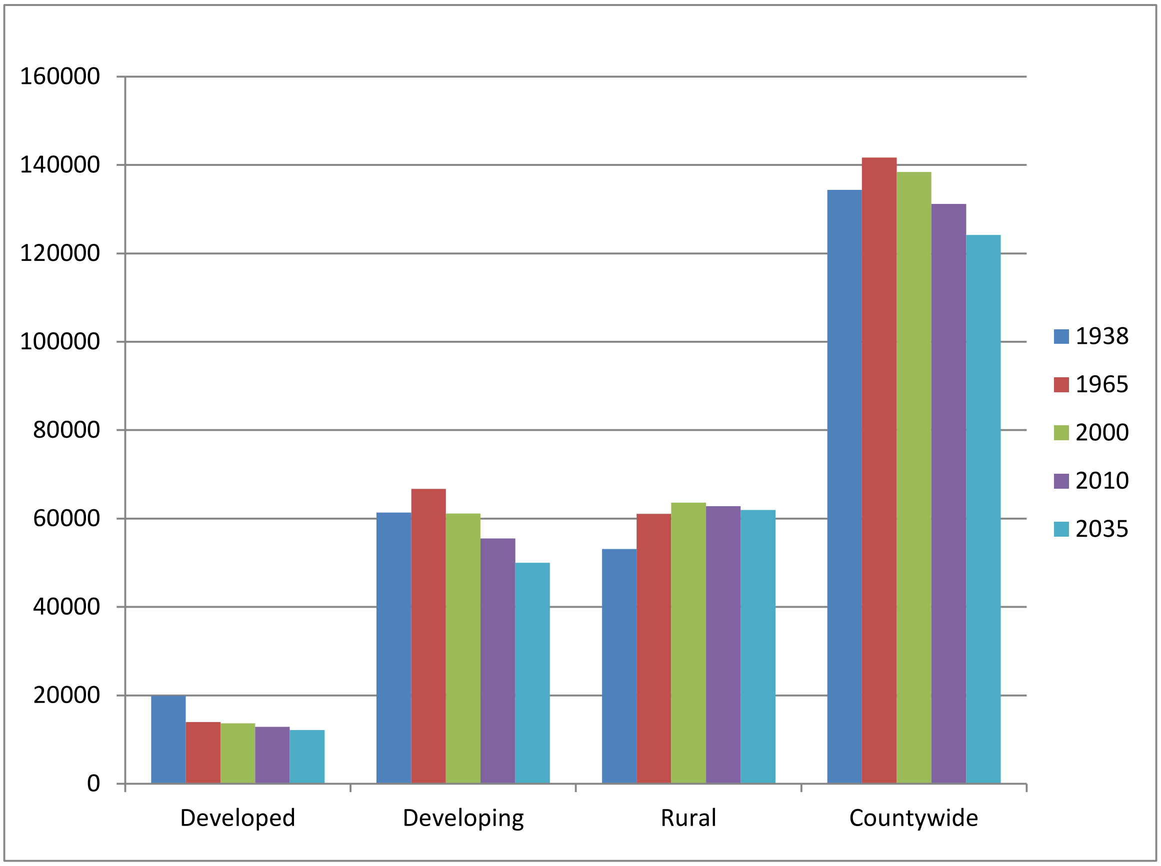
Table 7. Predicted Forest Canopy Coverage Percentages
2010 Assessment

	2010	2015	2020	2025	2030	2035	2002 GP Goals
Developed Tier	24%	24%	24%	23%	23%	22%	26%
Developing Tier	36%	36%	36%	35%	34%	33%	38%
Rural Tier	61%	61%	61%	60%	60%	60%	60%
Countywide	42%	42%	42%	41%	41%	40%	44%

Note: The 2010 Assessment used 2005 data as a starting point for the predicted future forest canopy, resulting in lower than predicted percentages in all categories than in the 2000 Assessment.

While it may be difficult to meet the forest canopy goals in the Developed and Developing Tiers given the predictions of this assessment, the Rural Tier will likely hold fast at 60 percent and the countywide forest canopy coverage will be at or above the state standard of 40 percent in 2035.

Figure 3. Previously Existing, Current and Projected Forest Acreages
By Tier and Countywide



In summary, the annual forest loss from 1993 to 2010 exceeded the predicted levels. However, because there have been several years of limited development, and reduced forest removal, and because the latter years of the predictions assume reduced loss, the total forest losses for the 25-year period (2000-2025) are likely to be close to the predicted levels. In the future 25-year period (2010-2035), if the trends continue and development shifts away from greenfield sites, the stated forest canopy goals can be met by 2035.

VI. Verification of Predicted Losses

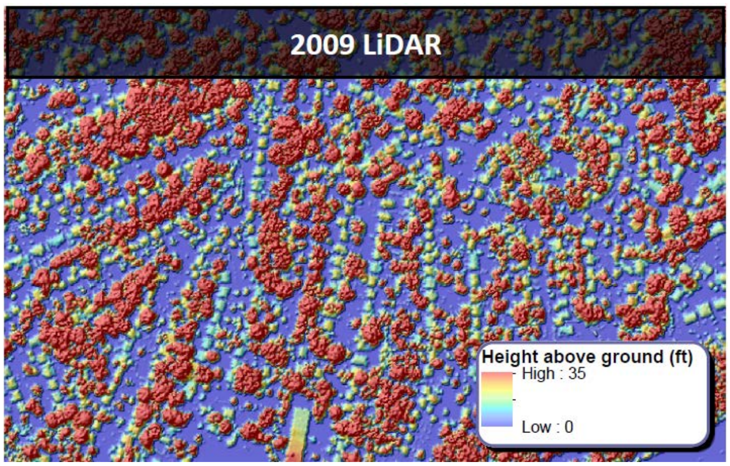
Technological advances between 2000 and 2010 were significant with regard to capturing forest canopy data using Geographic Information Systems (GIS). In 2000, the GIS layer used to establish the baseline was created using aerial photography and human interpretation. This methodology is difficult to accurately replicate because the data captured by one individual in one year can be very different than the data captured by another person in a different year. In 2010, the technology evolved to the point where high resolution aerial imagery and radar technology could be used to capture both forest canopy and tree canopy in a GIS layer. This methodology is more reliable and replicable because it relies on repeatable computer technology, and human error and differences in interpretation are removed from the analysis.

Using the new GIS methodology to evaluate the results of the predictions made in 2000 resulted in a comparison that was somewhat “apples to oranges” in nature because the technology improved considerably in the ten year span of the assessment. However, given that the areas being studied are large (the county is approximately 485 square miles in size) the methodology used to evaluate broad trends in forest canopy loss over time was deemed acceptable.

A study of "urban tree and forest canopy" was conducted in 2010 using a 2009 vegetation layer that was created using high resolution aerial imagery and LiDAR technology. LiDAR uses light and radar to measure the height of various objects and when combined with aerial imagery results in a very accurate forest and tree canopy delineation.

The 2010 study captured both forest and tree canopy, while the vegetation layer in 2000 captured only forest canopy. In 2010, according to the "urban tree and forest canopy study" the county contained 52 percent forest and tree canopy coverage: 44 percent forest canopy and 8 percent tree canopy.

Figure 4. Illustration of the Use of LiDAR in Detecting Tree Canopy



For the purpose of comparing forest canopy to forest canopy, the 2010 study was separated into forest canopy and tree canopy, using the definition of areas that can be used to meet the code requirement (areas of canopy that are 10,000 square feet or larger and are at least 50 feet wide).

Table 8. Comparison of Predicted Forest Canopy Coverage (2000 Assessment) and Mapped Forest Canopy Coverage (as of 2010)

	Predicted 2010 Forest Canopy Coverage	Mapped 2010 Forest Canopy Coverage	2025 Canopy Goal (% of land area)
Developed Tier	25%	27%	26%
Developing Tier	39%	39%	38%
Rural Tier	58%	59%	60%
Countywide	43%	44%	44%

Given the margin of error of one to two percent, the 2010 mapped forest canopy coverage data set validates the methodology used in the 2000 and 2010 Assessments to predict future conditions and verifies anticipated percentages. Moving forward, the GIS technology used in the 2010 mapped forest canopy coverage analysis should be used to measure changes in forest canopy over time.

VII. Forest and Tree Canopy Goals – Present and Future

The 2010 Forest Canopy Assessment evaluates the status of a 25-year goal only ten years into implementation. The annual acreage of forest loss shown on approved tree conservation plans between 2000 and 2010 exceeded what was predicted in the 2000 study (537 acres per year actual versus 414 acres per year predicted); however, if the annual forest canopy loss acreages are reduced over the remaining 15-year period, the goals should be attainable. The annual forest canopy loss acreages can be reduced by:

1. *Implementing the 2010 regulations regarding forest conservation:*
2. *Increasing enforcement efforts to curb unlawful and unnecessary forest clearing.*
3. *Implementing new General Plan priorities and policies that shift development away from forested parcels and onto properties that have been previously developed.*
4. *Increasing the focus on urban tree planting.*

These recommended methods to attain the forest canopy goals are discussed in more detail below.

1. *Implement the 2010 regulations regarding forest conservation.*

In 2010 the Prince George's County Code was amended to implement the recommended strategies in the 2002 General Plan and the 2005 *Countywide Green Infrastructure Plan*. The majority of the plans that were approved in 2010 and 2011 were not subject to such new requirements because of grandfathering provisions in the legislation. No additional regulations regarding forest canopy coverage are recommended as part of this study because the regulations adopted in 2010 should prove sufficient to curb previous trends of forest loss and fragmentation. Once these regulations are fully implemented and become the norm instead of the exception, the rate of forest and tree canopy coverage loss should decrease.

The current regulations, adopted as part of the Prince George's County Code in 2010 as a result of implementation strategies contained in the 2002 General Plan and 2005 *Countywide Green Infrastructure Plan*, include:

- The minimum area that can be used to meet the woodland requirement was increased from 2,500 square feet to 10,000 square feet to match the definition of a woodland. This should result in larger blocks of contiguous woodlands being preserved.

- The minimum width of areas used to meet the woodland requirement was increased from 35 feet to 50 feet for preserved areas.

- The minimum width of stream buffers was increased countywide from 50 feet for all regulated streams to 60 feet within the Developed Tier, 75 feet within the Developing Tier and 100 feet within the Rural Tier.

- The elements to be contained within a regulated stream buffer were revised to include all slopes 15 percent and greater into the buffer, or "primary management area." Previously, the slopes had to be on highly erodible soils or at a pitch of 25 percent or greater to be included within the regulated stream buffer.

- A new Tree Canopy Coverage Ordinance was adopted that requires certain properties to provide a minimum amount of tree canopy based on the zoning. More intense uses have a lower requirement because of the need to meet other requirements related to parking and traffic flow. Less intense uses where more land is available for tree planting, such as single-family detached housing, have a higher tree canopy requirement. Implementation of this ordinance will be key to meeting the canopy goals in the Developed Tier.

Moving forward, as more development applications are reviewed and approved under the updated regulations, the overall losses should trend downward, depending on the types, locations and patterns of development. Development on large, wooded parcels will always result in significant forest losses; development on previously cleared and developed sites can reduce the total annual forest losses countywide.

2. *Increase enforcement efforts to curb unlawful and unnecessary forest clearing.*

Regulations on land development activities require solid and defensible enforcement mechanisms. The Prince George's County Woodland and Wildlife Habitat Conservation Ordinance is the ordinance that enforces the state Forest Conservation Act. It states that clearing of more than 5,000 square feet of forest requires an approval in most instances. With the creation of the Department of Permitting, Inspections, and Enforcement, the county has demonstrated a commitment to focusing on enforcement of the regulations. Additional training of inspectors and review staff on the applicable environmental ordinances is recommended in order to more efficiently and effectively enforce the existing regulations.

3. *Implement priorities and policies that shift development away from forested parcels.*

The second method to reduce the annual forest acreage loss is to adopt and implement priorities and strategies in the General Plan Update to shift new development away from parcels that are currently forested and undeveloped. By increasing opportunities for redevelopment in already established areas versus continued growth on greenfield sites, not only will forest loss and fragmentation be reduced, but market demand can be met for multi-family housing located near transit. It is likely that the previous trend of clearing 500 to 800 acres of forests per year will not continue if priorities are shifted to the development of mixed use communities in locations where the supporting infrastructure already exists.

4. *Increase the focus on urban tree planting.*

Increasing the focus on greening the built environment will not only provide more tree canopy coverage overall, and bring with it all the associated benefits, but it will also make the new and redeveloping communities more livable with pleasant outdoor spaces to live, work, and play.

VIII. Conclusion

In order for Prince George's County to meet its overall economic, social, and environmental goals, it is imperative that the forest canopy goals be addressed and efforts continue to meet the state goals. The existing canopy goals should be maintained, and policies and strategies should be implemented to support these goals, in order to continue to increase the quality of life for citizens in Prince George's County.

In addition to supporting development in concert with the desired development pattern of Plan 2035, the following actions are recommended:

1. Retain the countywide forest canopy goal of 44 percent in the new General Plan for the following reasons:
    - the 2002 goals have a 25-year timeframe for assessment and only ten years have passed.
    - the predictions made in the 2000 assessment are generally bearing true.
    - the goal exceeds the statewide goal of 40 percent.
2. Prepare a comprehensive forest and tree canopy coverage strategy that addresses the goals and desired development pattern of the new General Plan. Consider including in the strategy canopy goals for designated areas in the new General Plan.
3. Continue effective implementation of the Woodland and Wildlife Habitat Conservation Ordinance including an increased emphasis on enforcement. Provide training where needed to staff conducting plan reviews, inspections, and other enforcement activities.
4. Focus on planting and maintaining urban tree canopy as new development shifts to more compact living areas.
5. Continue to monitor selected metrics to assist in future decision-making.

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CJ Lammers, Master Environmental Planner; Kim Finch, Woodland Conservation Program Coordinator; Taryn Sudol, Intern; Kate Fritz, Senior Planner; Barney Green, GIS Specialist III; John Groeger, Intern; and Colleen Shipley, Intern

Data Sources:

Prince George's County, Preliminary General Plan, Technical Summary, M-NCPPC, February 2002

Tracking Woodland Loss, 2000 – 2010, M-NCPPC, Taryn Sudol, December 2011

A Report on Prince George's County's Existing and Possible Tree Canopy, University of Vermont Spatial Analysis Lab, October 20, 2011

Photo Sources:

M-NCPPC, Department of Parks and Recreation; PGAtlas.com; Google Earth; ThinkGreenDegrees.com

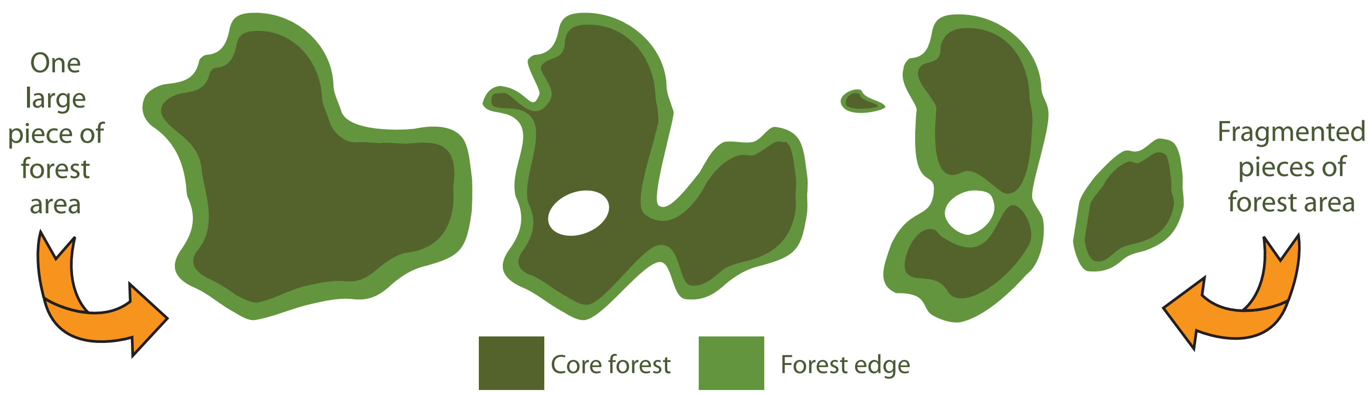
Forest Fragmentation in Prince George's County:
Measuring Forest Cores and Edges to Determine Fragmentation Trends

I. Overview

Forest blocks are large, contiguous areas of forest that are important, because they provide many ecological and socioeconomic benefits such as biodiversity, carbon storage, habitat for wildlife that require interior forest conditions, pollutant uptake, and processes critical to protecting our air, water, and soil. Forest fragmentation, or the breakup of forest blocks into smaller, more isolated remnants, is a constant threat to the health and vitality of the County's forests. As Figure 1 shows, fragmentation also results in an increase in forest edge and losses in the all-important core forests, producing additional negative effects as existing habitat and ecosystem services are disrupted.

"Edge effects" refer to the change in wildlife populations or community structure that occurs at the boundary of two habitats such as the boundary between a forest and urban area. An increase in edge facilitates the penetration of sunlight, wind, rain, and pollution into previously shaded interior forest areas which, in turn, causes a change in air temperature, soil moisture, and light intensity. With these microclimate changes come changes in plant species mix and, typically, the spread of non-native, invasive plants and animals along the new forest edge. In addition to changes in the forest ecosystem, numerous studies show increased damage to individual trees at or near the forest edges (tree failure and loss of major branches) because of the loss of tree canopy support from other trees at or near the forest edges, further threatening the integrity of the core forest.

Figure 1: Creation of forest edge as a result of forest fragmentation



Source: eSchoolToday, 2010

The purpose of this study is to evaluate the trends in forest fragmentation in Prince George's County over time and to present the possible negative ecological and environmental impacts associated with forest fragmentation. This study uses industry-accepted metrics including total core forests that meet the state's definition, total forest edge area, total edge length, and edge density. Forest edge is defined as the area of the forest that is within 100 feet of the forest edge.[1] Measuring changes in the amount of forest edge is one of the most commonly applied metrics for measuring forest fragmentation (Meneguzzo, 2006; Swift, 2010).

[1] Another method for calculating the forest edge area and core forest was developed to measure habitat for forest interior dwelling bird species (FIDS). This method measures forest edge as forested areas 300 feet or less from the nearest forest edge and core forest as area greater than 300 feet from the forest edge (Department of Natural Resources). FIDS measurement is specifically for the forest interior dwelling bird species habitat. The purpose of this study is to address the fragmentation of forests, not specifically habitat, which is why the 100-foot edge area is used instead of the FIDS buffer of 300 feet.

The GIS layers used in this study are those provided by The Maryland-National Capital Park and Planning Commission. It should be noted that while the data capture methods were similar in the years 1938, 1993, and 2000, the 2009 data set contains more precise delineations of forest and tree canopy coverage because of improvements in technology. Adjustments were made to the data sets used to provide a more cohesive comparison. This study is only intended to demonstrate broad trends—the data should not be used at a smaller scale than has been provided herein.

KEY FINDINGS:

- Over the study years of 1938, 1993, 2000, and 2009, the County's core forest acreage has decreased.
- Over the same period, the length of forest edge, the acreage of edge forest, and the forest edge density, have all increased.
- These metrics indicate that forest fragmentation is increasing in Prince George's County in the same way it is occurring in many growing communities.
- In 2009, the County contained more edge forests (51 percent) than core forests (49 percent) for the first time.

II. Introduction to Forest Fragmentation

Forests are an essential component of the natural landscape. In addition to providing a habitat for forest-dwelling species, the forests' "ecosystem services," such as lower air temperatures, cleaner air, cleaner water, improved stormwater infiltration, reduced erosion, and stable air and water temperatures, also provide numerous benefits to people. They also provide economic benefits as wood for construction, edible plants, and other less tangible benefits such as aesthetics and improved personal well-being. As forests are lost, so are the environmental and human benefits they provide. Additionally, when forests are lost to development, fewer trees are available to sequester carbon dioxide and other pollutants, and there are fewer places where stormwater can easily infiltrate into the ground (USDA, 2015).

As the ecosystem services of forests are lost, the costs to human health can be profound and can include higher asthma rates because of lower air quality, increased costs for stormwater management (both the initial construction costs and the long-term maintenance costs), increased water purification costs, and reduced value of recreational experiences and forest products (2010 Forest Canopy Assessment).

Figure 2: The benefits of forests and the effects of forest edge and fragmentation

Forest Benefits to People	Effects of Increased Forest Edge and Fragmentation
• Improved air quality • Carbon storage • Improved stormwater infiltration • Improved water quality (by reducing runoff and maintaining stable water temperature) • Reduced erosion • Stable wildlife habitat • Lower air temperature • Economic resources	• Smaller core forest area—habitat loss • Edge effects (change in sunlight, rainfall, and soil as the result of exposed edge) • Spread of invasive plants, animals, and insects that thrive at the forest edge; loss of species that require interior forest conditions; introduction of disease (e.g., Lyme disease from white-tailed deer) and insects from adjacent land uses **Leading to:** • Increase in species isolation • Decline in population size • Decline in species richness and viability • Decreased biodiversity • Extinction or blight • Increased stormwater management costs • Increased costs associated with pollution and climate change
Contiguous forest areas provide greater benefits to people, plants, and wildlife than fragmented forests	**Fragmentation weakens and degrades forest health by increasing "edge effects" and reducing core forest area, sometimes to the point of pest infestations or species extinction**

A recent study completed by the USDA Forest Service concluded that Prince George's County's 52 percent forest and tree canopy coverage provides the following measurable ecosystem services to people:

Forest Service	**Estimated Value**
Cleaner water:	**$12.8 billion annually**
Cleaner air:	**$21 million annually**
Less carbon:	**$16.6 million annually**

As forests become smaller and more fragmented, these ecosystem service values will be reduced, because small patches of forests do not function as well as larger, more contiguous blocks.

Loss of Forest Acreage

The *2010 Forest Canopy Assessment* showed predicted losses of forest canopy coverage based on approved tree conservation plans. The study concluded that with the implementation of the updated environmental regulations contained in the County Code that were updated in 2010, it will be possible to meet the *Plan Prince George's 2035 Approved General Plan* (Plan 2035) goal of maintaining the County's 52 percent forest and tree canopy coverage.

Loss of Habitat

Populations of many species are more viable in forest blocks than in forest fragments, resulting in fewer species of all types in a forest fragment than in an area of the same size in contiguous habitat. Smaller areas are also less likely to hold as many habitat types as larger areas. The farther apart habitat islands are from each other, the greater the impact, because fewer species will be able to migrate among them, leading to a decline in genetic diversity and potentially extinction. Numerous studies have documented that habitat loss is the most important factor influencing specie extinction (Fahrig, 1999; Swift, 2010). These studies and others agree that the magnitude of ecological impact due to habitat loss is exacerbated by the fragmentation of the remaining habitat (Didham, 2010).

Edge Effects

Forests weakened by fragmentation become more susceptible to damage and stress from insects, pests, and diseases and can degenerate into a condition of chronic ill health (USDA). This is because fragmentation causes changes in the flow of water, sunlight, and nutrients called "edge effects," which in turn impact the native species and ecosystems (Murcia, 1995). The influence of the edge effects (whether positive or negative, intense or mild) varies depending on the types of land use, the abruptness or gradient of the land use change, and the type of species being evaluated (Fahrig, 1999; Ewers, 2005). Figure 3 shows an abrupt edge from a new roadway through an existing forest. The abrupt edge exposes the forest to edge effects including increased sunlight, increased temperatures, wind, noise, litter, and more. The disruption can have devastating effects on species and plant communities that cannot adjust to changes, such as the level of sunlight, rain, and noise, and may either die out in the case of plants or be forced from their habitat in the case of mobile inhabitants (USDA, 2015).

Figure 3: Edge exposes the interior of forests to stressors

Stressors (sunlight, noise, wind, invasive plant species and others) can alter the natural landscape.
Source: USDA Forest Service, A Snapshot of the Northeastern Forests

Invasive Plant Species

The new edge also makes it easier for the entry of invasive plant species. Invasive plant species are highly adaptable, and these species may alter the forest landscape or disrupt native vegetation or specie populations in a relatively short time. Figure 4 shows an infestation of the invasive Kudzu vine. Kudzu can quickly alter a forest community and kill or damage other plants from its rapid growth. Native plants in the area are at an ecological disadvantage to the fast-growing invasive plants that can lead to the extinction of the native plants either locally or regionally. A more gradual edge has greater biodiversity and acts as a natural transitional area between land uses. Fragmented forests with highly irregular, convoluted boundaries are more likely to experience edge effects than adjacent habitats with less convoluted edges (Collinge, 1996).

Figure 4: Kudzu grows fast and dominates natural landscapes

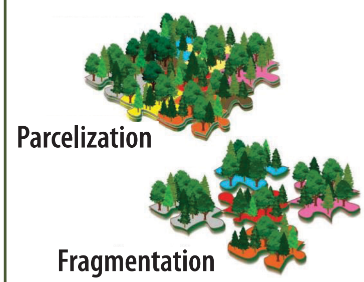
Photo by Kerry Britton

Parcelization

Exacerbating the effect on loss of habitat, edge effects, invasive species, and other threats is parcelization, which refers to the ownership of forest land by multiple owners. With control of forested land spread across multiple owners, shared management and long-term goals for forest conservation or coordination to deal with forest health issues, which may arise are, much less likely to occur.

Figure 5 shows a simplified rendering of how forest parcelization can quickly alter the forest landscape leading to fragmentation. In Maryland, as much as 76 percent of total forested acres are privately owned with most owners (75 percent of that total) owning woodlots of fewer than 10 acres. Additionally, small parcels of forest land are more likely to be converted to non-forest uses such as residential or other urban types of development (Maryland Department of Natural Resources, 2008).

Figure 5: From a Snapshot of the Northeastern Forests



Source: USDA Forest Service, Northeast Area (October 2005)

III. Methodology: Measuring Forest Fragmentation

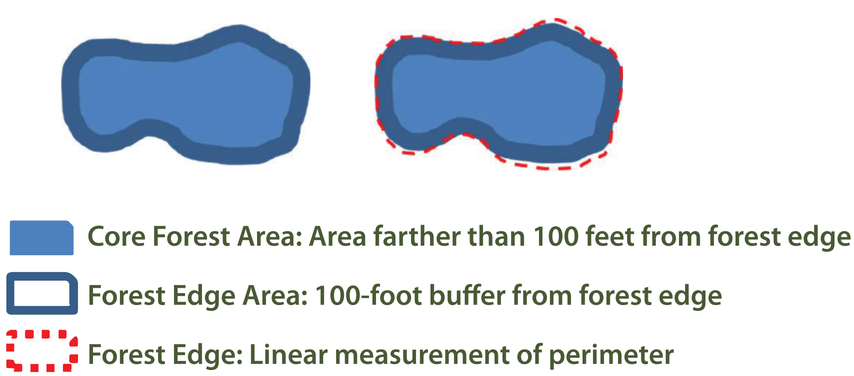
This report uses industry-accepted metrics to measure forest edge area, forest edge length, and forest edge density in the study years of 1938, 1993, 2000, and 2009. Fragmentation is indicated by increases in edge area, edge length, or edge density (Meneguzzo, 2006).

A. Measuring Edge Area

The USDA Forest Service uses the measurement of forest core areas that have forested buffers of at least 100 feet on all sides, with no minimum core area as shown in Figure 6 (USDA, 2000). The 100-foot-wide buffer is substantiated in a study by Rannet, et al, who found that the significant difference in the composition and structure of vegetation increased between 33 and 100 feet from the edge (Hellmund, 2006).

For this report, forest areas that met the definition of forest contained in the Code of Maryland (greater than 10,000 square feet and at least 50 feet wide) were used for analysis. The results are presented as total acres of forest core and edge and as the percentage of total area that is forest edge. GIS analysis of core and edge area relied on countywide forest and tree canopy coverage data from 1938, 1993, 2000, and 2009. The results section of this report discusses the increase in edge area, indicating that forest fragmentation is increasing over time.

Figure 6: Core Forest, Forest Edge Area, and Forest Edge Definitions



B. Measuring Edge Length

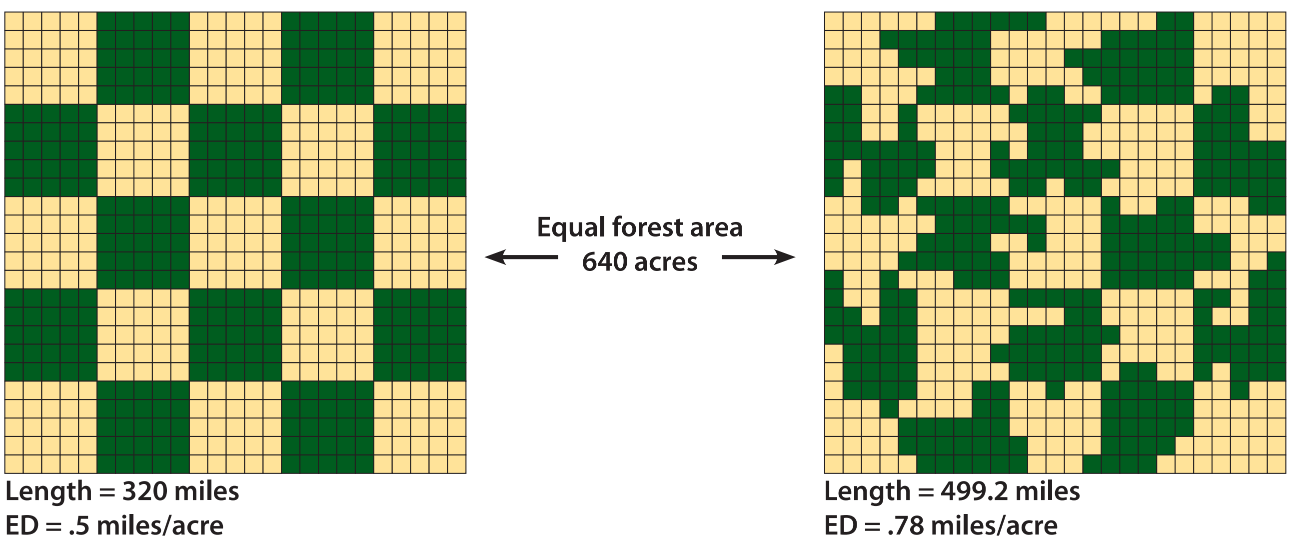
While the amount of edge (in absolute terms and as a percentage of overall forest area) is important, there are other ways to measure the complexity of the forest edge. Total edge length and edge density (ED) are two such metrics which are able to account for the shape and boundary of the forest area. Total edge is measured as the perimeter of forest area (see Figure 6, on previous page). Total edge was calculated in GIS by converting total length to area. This is important, because convoluted edges are more likely to experience the ill effects (Collinge, 1996). The results section of this study discusses the increase in edge length observed over the study period.

C. Measuring Edge Density

Edge density measurements can be used to evaluate the impacts of convoluted forest boundaries, which commonly occur after development occurs. Forest edge density, also known as perimeter/area ratio, is calculated as the length (in miles) of edge forest divided by the total forest acreage in the area being studied. The resulting ratio is the miles of forest edge per square mile of forest land (adapted from Meneguzzo, 2006). This ratio allows for a better understanding of the complexity of the forest edge.

A higher edge density ratio means that the proportion of edge to area is high and/or more convoluted. Figure 7 displays how fragmentation of forests causes an increase in the amount of edge and thus produces an increase in edge length and edge density. The results section of this study discusses the increase in edge density observed over the study period, indicating that forest fragmentation is increasing over time.

Figure 7: Edge Length and Edge Density as edges become fragmented (Adapted from EU 1994)



Equation 1: Edge Density

$$\text{Edge Density (ED)} = \frac{E}{A}$$

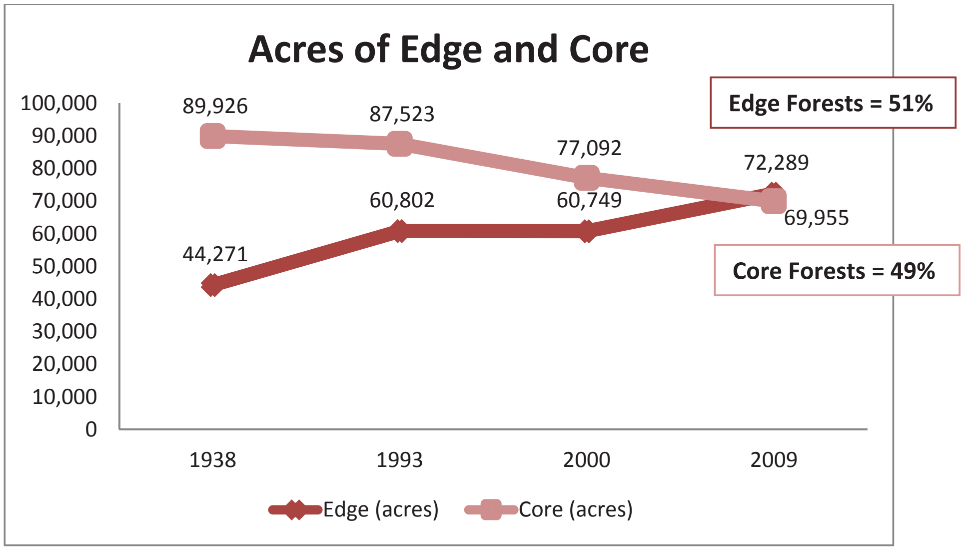
Where E equals total edge (miles) and A equals total area of forests (square miles)

IV. Results

A. Forest Edge Area

Figure 8 displays the total acreage of forest core and edge for each of the study years. Over the study period, the County has experienced a decrease in the acres of core forests and an increase in the acres of edge forests. While this is to be expected, as population growth and urbanization in the County have resulted in the clearing of forested areas for development, in 2009 (the most recent year for which data are available) the percent of total edge forests exceeded the total core forest acreage for the first time (51 percent edge forests to 49 percent core forests).

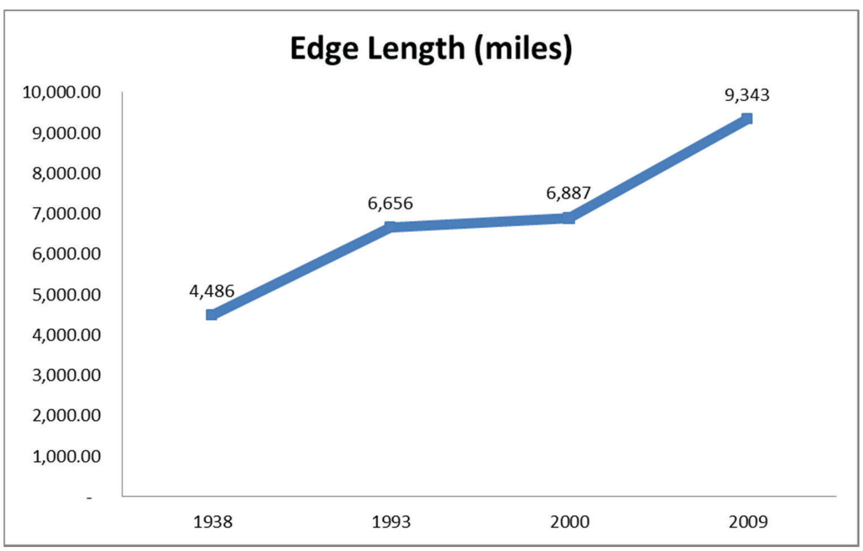
Figure 8: Acres of Edge and Core Over Study Years



B. Forest Edge Length

As forests become more fragmented, the length of their boundary increases. Over the study years, the County has experienced a clear increase in edge length. As edges increase, interior forests will face greater stress from neighboring land uses and invasive plant species.

Figure 9: Edge Length (miles)

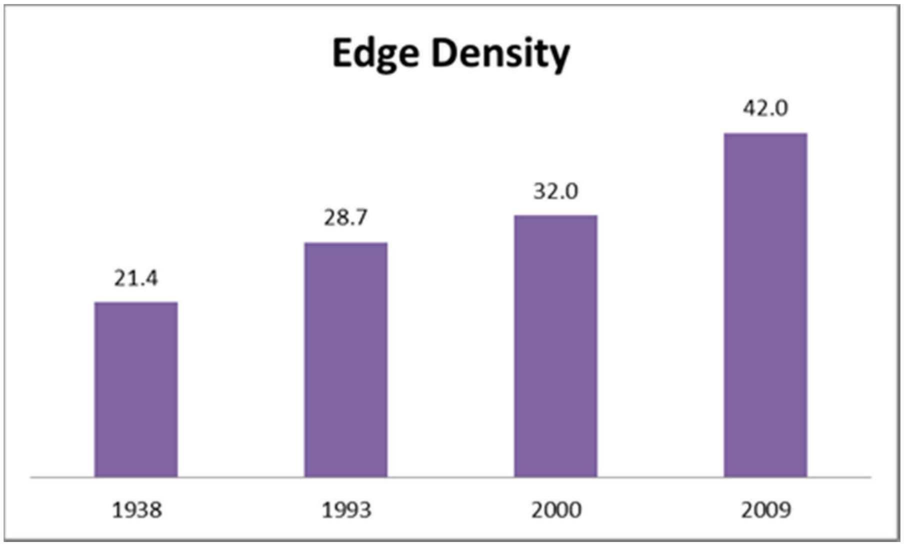


C. Forest Edge Density

Edge density is a metric that can be used to interpret the shape of the forest boundaries within an area. An increase in edge density indicates that the edge is becoming larger and more convoluted and, therefore, more susceptible to negative edge effects.

Figure 10 displays the change in edge density, calculated as total edge (in miles) divided by total forest area (in square miles). As expected, edge density is increasing over time, meaning that the edge component of the forest is making up a larger proportion of overall forest area in the County. The ratio is the miles of edge per square mile of forest land (Meneguzzo, 2006).

Figure 10: Edge Density (miles of edge per square mile of forest land)



V. Study Conclusions and Recommendations

Forests are valuable ecological, environmental, and economic resources that provide direct and indirect benefits to people. While normally the overall loss of forest area is the focus of concern, the threats from forest fragmentation can be just as devastating. There is no shortage of evidence showing that important habitats are lost and ecosystems are disrupted by the fragmentation of forests and increases in forest edge. Fragmentation of forests can reduce the amount of stable, core forest conditions that are essential to the survival of certain animal and plant species, while also providing the highest concentration of benefits to humans. Meanwhile, an increase in fragmentation also increases forest edge, which often invites invasive plant species into these valuable forest patches.

In addition to the physical fragmentation of forests, parcelization can also adversely impact the long-term health of forest patches. Parcelization can compromise the management and protection of large blocks of contiguous forests and can increase the risk of fragmentation. One owner within a contiguous block of forest can make a management decision that influences the integrity of the adjacent forested properties. In Maryland, as much as 76 percent of total forested acres are privately owned.

The creation of new forest edges is an unfortunate consequence of land development in forested areas. While the County has several strategies to maintain and preserve forest and tree canopy, special attention should be paid to the forested areas having the highest ecological value. Protecting large, contiguous blocks of forest and limiting edge effects in these blocks is essential to maintaining the ecological, environmental, and human benefits of these areas. Coordinating the management of forest area across multiple owners will also become increasingly important.

The research conducted as part of this study resulted in recommendations on ways to reduce and/or mitigate forest fragmentation. These ideas could be included in the Forest and Tree Canopy Strategy to be prepared as recommended by Plan 2035. Recommendations include:

- Evaluate the Woodland and Wildlife Habitat Conservation Ordinance and the erosion and sediment control regulations for ways to reduce forest fragmentation during the land development process.
- Prioritize the planting of newly created edges when forests are cleared. Planting newly created forest edges with a strip of caliper-sized trees could provide the shading and buffering effects needed to reduce the growth of invasive plants.
- Emphasize the retention of connectivity of forest blocks and patches when reviewing land development applications and selecting land for permanent protection.

Appendix A: Forest Fragmentation Study Methodology

This study evaluated forest core, forest edge length, and edge density using forest cover data from 1938, 1993, 2000, and 2009. The following five steps outline the methodology used for this analysis. It is important to reiterate that data capture methods used in the years 1938, 1993, and 2000 were different, and at different scales, than those used in 2009, which influenced the measurement in absolute terms and limited the ability to compare specific amounts directly. However, directional change and trends in how forest fragmentation is occurring could be ascertained from the data available.

Step 1: Create Forest Canopy Layers for 1938, 1993, and 2000

Amend the existing 1938, 1993, and 2000 "vegetation" layers to exclude pieces of canopy coverage that do not meet the definition of "woodlands" in the County Code (areas less than 10,000 square feet in size and less than 50 feet wide).

- Buffer in the polygons 25 feet with the results buffered out 25 feet. This provides a crude 50-foot-wide check on the data and removes features less than 50 feet wide. As a result, there is a slight loss of edge and smoothing of features. The loss is deemed insignificant at the countywide scale.
- So that only areas of forest 10,000 square feet or greater are included, polygons smaller than 10,000 square feet are removed.
- The result is a feature class of forest area greater than 10,000 square feet in size and at least 50 feet in width.

Step 2: Amend the 2009 Forest and Tree Canopy Data Layer

Amend the 2009 Forest and Tree Canopy layer to remove the "tree canopy" portions and keep only those areas that are considered forest (same steps as above). The 2009 FTC layer was previously divided into forest canopy and tree canopy, so this step only entails a capture of the forest canopy polygons.

Step 3: Create forest core and forest edge attributes in new forest layers

- The 1938, 1993, 2000, and 2009 forest layers are "buffered in" 100 feet. A "TYPE" field is added in the attribute table and entered as "edge."
- Next, the forest edge layer is joined to the original forest layer from Step 1. The "TYPE" field is amended for non-"edge" attributes as "core" to represent areas of forest core.
- This creates one forest layer that delineates forest edge and forest core.

Step 4: Calculate forest core and forest edge (acres)

- Forest core and edge are calculated using the "Summarize" function in ArcMap. Results are converted from square feet to acres.
- The results are calculated as a percentage of total forest edge and forest core for each study year.

Step 5: Calculate edge density

Forest edge density is calculated as the total length of forest edge in the County divided by the land area of the County (Meneguzzo, 2006).

$$\text{Edge Density (ED)} = \frac{E}{A}$$

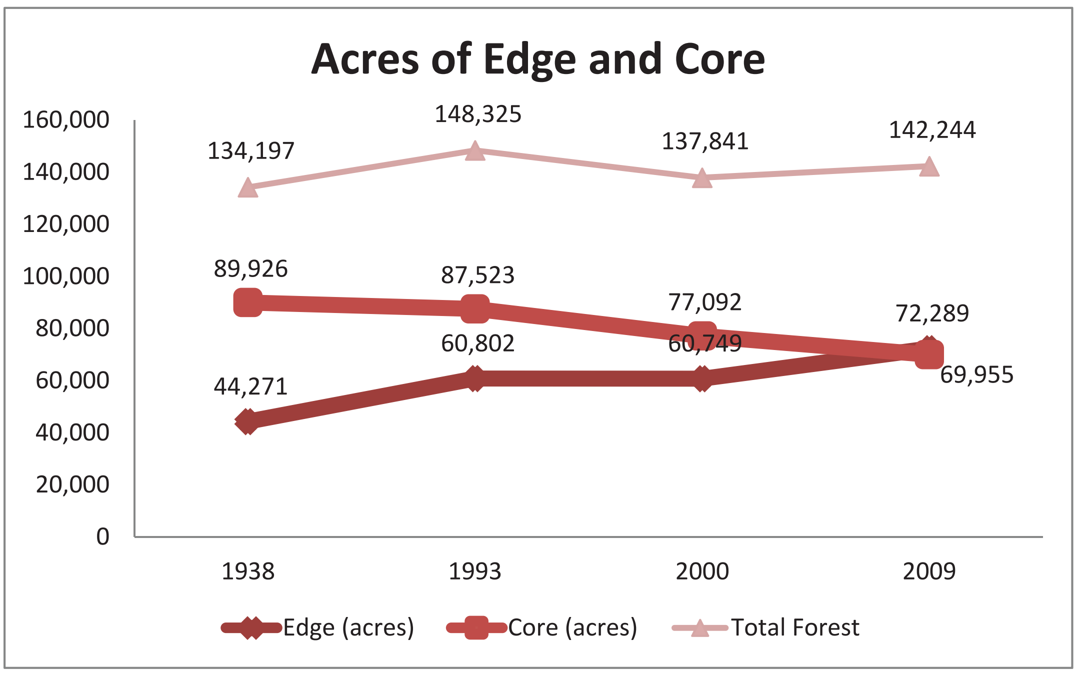
Where E= total edge (miles) and A= total area (ac)

Appendix B: Data Discussion

Existing countywide GIS layers for the study years 1938, 1993, 2000, and 2009 were used in this study. The accuracy of these data are limited by the prevailing technology used at the time of data capture. Vegetation layers for 1938, 1993, and 2000 were generated by manually digitizing aerial pictometry for each year. This method naturally leaves the data open to human inaccuracies. The 2009 data were derived from LiDAR data sets, which use radar technology and highly accurate satellite imagery. The difference in capture methods, scale, and technology between study years severely limits the ability to compare specific results over time (for example, to say that large forest blocks decreased by X acres between 1938 and 2009 would not be appropriate). Instead, this study provides a "snapshot" overview of forest fragmentation to demonstrate broad trends over time.

The improvement in the technology over time means that later data are more accurate than earlier data. Because of this, when data are compared across study years it appears that the total amount of forest area has increased over time (as displayed on the top Total Forest line in Appendix Figure 1). In reality, the total acreage of forests did not necessarily increase, for example from 2000 to 2009; rather, the ability to measure forest canopy countywide improved. Even with this increased ability to capture forest canopy coverage, the areas of core forest decreased over the time period of the study, validating the trend.

Appendix Figure 1: Forest edge and core acres compared to total forest area



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Summary of Water Quality Biological Assessment Studies Conducted in Prince George's County, Maryland

Introduction

The *Biological Assessment of Streams and Watersheds in Prince George's County* is a series of reports which characterize the annual results of two biological surveys over a 13-year period, resulting in a countywide assessment of water quality. These reports provide a snapshot of stream and watershed quality based on bioassessment surveys completed by Tetra Tech, Inc. under contract with the Prince George's County Department of the Environment (formerly the Department of Environmental Resources). Funding was also provided by The Maryland-National Capital Park and Planning Commission's Prince George's County Planning Department.

The reports measure water quality in three ways:

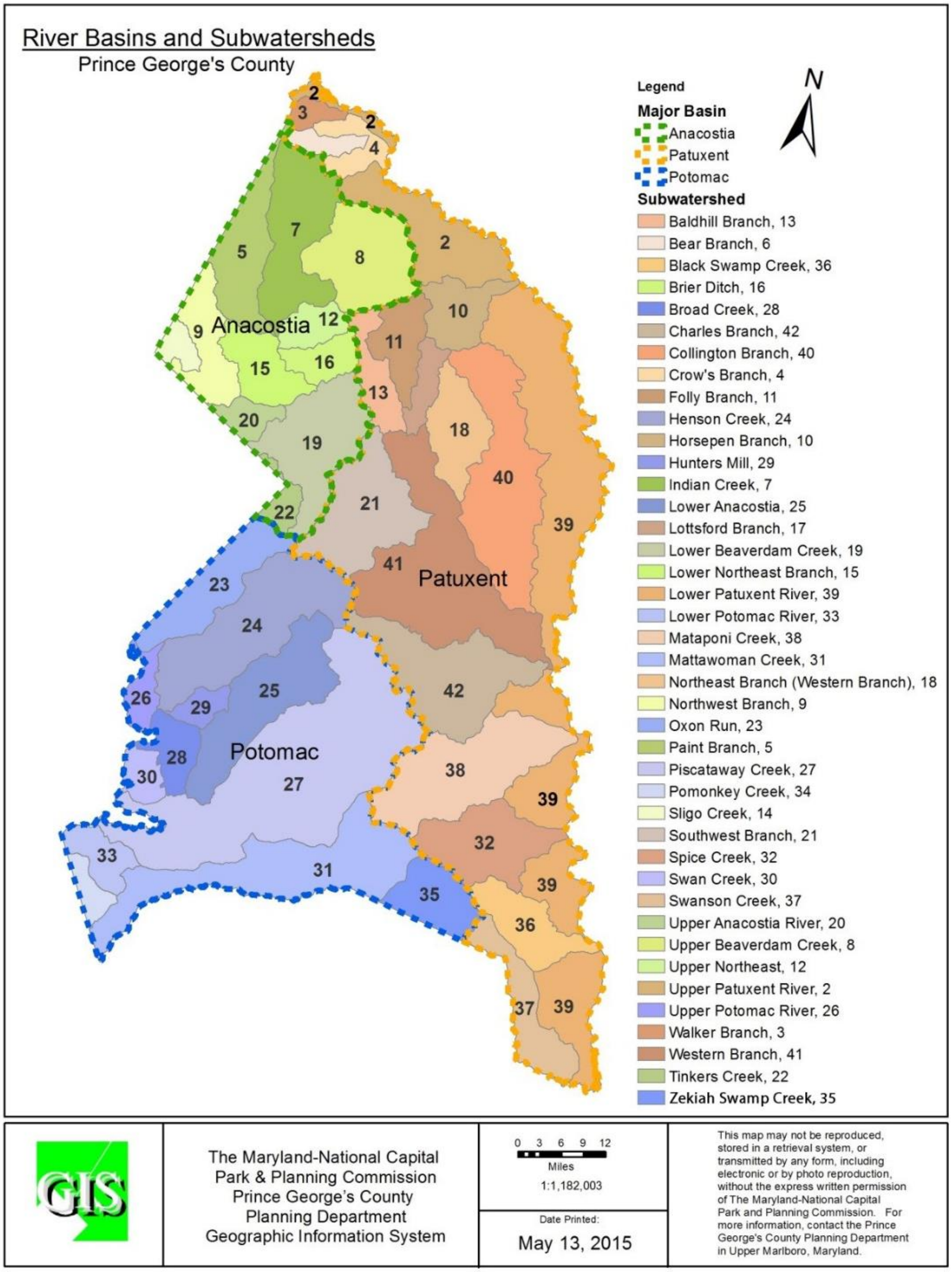
1. Estimates of degraded stream miles (percent) rely on an established protocol which extrapolates site-specific biological assessment results to the watershed or watershed group level.
2. Site-specific biological assessments are made based on the Benthic Index of Biotic Integrity (B-IBI), an established protocol which measures relative ecological degradation based on the abundance and diversity of aquatic macroinvertebrates (insects, crustaceans, and other small species whose presence can be used as indicators of water quality). The index score is translated to a narrative rating of good, fair, poor, or very poor for individual sample sites.
3. Visual-based physical habitat assessments are translated into physical habitat scores of comparable, supporting, partially supporting, or nonsupporting for individual sample sites based on an established protocol which rates the quality of riparian areas, overall stream stability and substrate condition, and reflect the potential of the stream to support healthy ecosystems.

The purpose of this summary is to present the results of the assessments completed to date in order to evaluate how the measurable objectives of the 2005 *Countywide Green Infrastructure Plan* (GI Plan) have or have not been met, and to make recommendations for future sampling and assessment of water quality in streams.

Background

Prince George's County is home to over 621 miles of known streams within three major river basins: the Patuxent River basin covers roughly the eastern half of the County, the Anacostia River basin covers the northwest portions, and the Potomac River basin covers the southwest portions. Map 1 displays the 3 river basins and 41 subwatersheds in the County, subwatersheds are numbered 2 through 42 which are consistent with the delineations used by the Prince George's County Department of the Environment.

Map 1: Prince George's County River Basins and Department of the Environment Subwatersheds



The water quality in the County's streams has been deteriorating over time but prior to the use of biological stream survey studies, a reliable and replicable method for measuring long-term stream and subwatershed health had not been established at the County level.[1]

The 2002 General Plan contains a measurable objective to address the important issue of water quality:

> "*Protect and enhance water quality in watersheds by, at a minimum, maintaining the 2001 condition ratings of all watersheds countywide.*"

The 2001 condition ratings were based on a model that was used to predict water quality ratings based on existing development and potential future development (based on existing zoning of vacant or underutilized parcels, using 42 subwatersheds numbered 1 through 42 in alphabetical order). The model's ratings were superseded in 2003 when the first round of the County's biological assessment of streams was released—representing the first data set based on actual stream sampling and not modeling. These data were used in the 2005 *Countywide Green Infrastructure Plan* to set two measurable objectives based on the Round 1 data; however, because the 41 watersheds had been previously reported as 42 watersheds in alphabetical order as part of the General Plan preparation process, the same numbering system was used in the Green Infrastructure Plan (42 subwatersheds numbered in alphabetical order). The watershed numbering used in Rounds 1 and 2 are provided in Map 1 and are consistent with the numbering and naming used by the Department of the Environment.

The two measurable objectives (numbered 5 and 6 in the GI Plan) addressed the need to improve the biological integrity and habitat ratings. They were similarly worded as follows:

> "By the year 2025, improve stream habitat in each major watershed to elevate the Benthic Index of Biological Integrity (IBI) rating [or habitat rating for objective 6] of the watershed by at least one category using as a baseline the 1999-2003 biological assessment of the streams and watersheds of Prince George's County completed by the Department of Environmental Resources."

The plan acknowledges that future sampling would be needed to measure the change in biological integrity or habitat over time:

> "Tracking this objective: The County has just completed its first round of five-year samplings covering all watersheds. As the rotating sampling efforts are completed in the future, the Benthic Index of Biotic Integrity [or habitat] rating will be compared to the previous rating to determine if the rating is higher, lower, or the same."

---

[1]*Water Resource Functional Master Plan*. 2010. Prince George's County Planning Department.

There have been several difficulties in tracking water quality conditions over time as summarized in this report. When the Green Infrastructure Plan is updated, it is recommended that a different set of measurable objectives be used that are consistent with the metrics used in other water quality reporting.

Overview of Data Collection

The Round 1 assessment was conducted between 1999 and 2003 and Round 2 was conducted between 2010 and 2013. Some sampling was conducted in the intervening years; however, these data are not contained within the rounds of data summarized by the consultant. The results of Round 1 were reported in the *Biological Assessment of Streams and Watersheds in Prince George's County Round 1, Year 3* (2003) report. The Round 2 results were reported in two documents, the *Biological Assessment of Streams and Watersheds in Prince George's County Round 2, Year 3* (2013) report and the *Biological Assessment* and *Biological Assessment and Monitoring of Streams and Watersheds in Prince George's County: A Summary of Results from Round 2.*

There were important differences in methodology for data collection between Round 1 and Round 2 and between the water quality sampling watershed designations and the GI Plan watershed designations. The sampling scale was changed between rounds in order to bring the Round 2 sampling selection into line with the state random-sampling design protocol. The numbering of subwatersheds in the Green Infrastructure Plan was inconsistent with the numbering in the Round 1 and Round 2 assessments because a previous modeling study in 2001, used in the preparation of the General Plan objectives in 2002, where a 42 watershed delineation and an alphabetical naming system were used.

Summary of Results

Before the results are summarized, it is important to note that the sampling is not done on the stream in the same location during each sampling cycle. Sampling sites are purposefully chosen in a random manner throughout each watershed in order to provide a broad characterization of the overall watershed. This is a contributing factor to the conclusion that Round 2 provides a better characterization of the watersheds, instead of providing a measure of change over time.

Between Round 1 and Round 2 the number of watersheds containing greater than 50 percent degraded miles increased from 15 percent to 18 percent. Notable increases in degraded stream miles (greater than a 25 percent increase) were reported in the Paint Branch, Horsepen Branch, and Black Swamp Creek subwatersheds; and in the Upper Northeast Branch/Lower Northeast Branch/Brier Ditch, and the Walker Branch/Crow's Branch/Bear Branch watershed groups. On average, the number of degraded stream miles in these watersheds and watershed groups increased by approximately 47 percent between sampling rounds. The results showed that two watersheds, Paint Branch and Oxon Run, had 100 percent of their stream miles degraded in Round 2. The only statistically significantly change between rounds, as reported by the consultant, was in the Paint Branch watershed where percent of degraded stream miles increased from 37.6 percent in Round 1 to 100 percent in Round 2. Notable decreases in degrade stream miles were reported in the Upper and Lower Anacostia (Watts Branch) watershed and the Southwest Branch watershed.

The increases and decreases in degraded stream miles, over such a short time frame and with limited sample sizes, are most likely to be corrections to the base information and a greater clarification of actual stream conditions. They are less likely to reflect actual changes in, or trends regarding, water quality.

The lack of statistically significant change in water quality measures demonstrate that water quality in the County has not changed considerably since the early 1990s. According to Tetra Tech, this is not necessarily because efforts of the County (and others) to improve water quality have failed but rather that the additional water quality stressors have outpaced restoration efforts:

> "…restoration and protection activities may have been overtaken by new stressors and sources introduced by ongoing development, expansion of areas of disturbance and urban/suburban areas, and aging infrastructure. This suggests that the County's investment in environmental management may be assisting the watersheds in "holding their own" in the face of ongoing development, increased population, aging infrastructure, and new and unknown stressors and has helped prevent conditions from being even worse, thus allowing a partial statement of success to be made. There is substantial additional effort needed if aquatic biological conditions (as the principal indicator of watershed health) are to move in the desired direction. The assessment similarities suggest that stressor management, whether in the form of stormwater (or other) best management practices (BMP), control of chemical pollution as toxics or nutrient input, or enhancement of physical habitat conditions, has been insufficient to reduce stressor loads to the degree necessary for biological recovery."[2]

The 2005 *Countywide Green Infrastructure Plan* contains two measurable objectives that use the Round 1 data as a baseline. Objectives 5 and 6 state the goal of elevating the B-IBI rating and the visual physical habitat rating of each watershed by one narrative rating by 2025. Because the objectives are intended to be assessed in 2025, the data collected in 2010-2013 is only about 10 years into the 20-year evaluation period. In addition, water quality takes a long time to correct itself even if significant changes in land use patterns have occurred, which is not the case. Based on the Round 2 results it appears that that Objectives 5 and 6 may not be met by 2035. The lack of significant difference may also suggest that the timeframe between sampling periods was too short and/or that the results reported in Round 2 confirm the results found in Round 1.

Ongoing and consistent data collection will enable the County to characterize watersheds over longer periods of time. Staff recommends that future water quality assessments continue to use established state protocols and to utilize methods that will allow comparisons over time. This may include replacing water quality measures of B-IBI and physical habitat rating with percent degraded stream miles as a more appropriate measure of water quality for watersheds and watershed groups.

[2] *Biological Assessment and Monitoring of Streams and Watersheds in Prince George's County*. Summary of Round 2. 2010-2013.

Measured Results

Percent of Degraded Stream Miles

Percent of degraded stream miles and percent change between rounds were reported within individual watersheds and, when the number of sampling locations was too small, the subwatersheds were grouped. The results are shown in Table 1.

While the percentage of degraded stream miles increased in some watersheds and decreased in others between Round 1 and Round 2, these changes were not statistically significant except for the Paint Branch watershed, which reported a 62.4 percent increase in degraded stream miles. Spice Creek and Black Swamp Creek showed an increase of 14.3 percent and 74.8 percent of degraded stream miles; however, since these subwatersheds had 0 stream miles sampled in Round 1 there is no ability to report the percent change accurately.

Table 1: **Estimates of Biologically Degraded Stream Miles.**
Assessments based on the Maryland Biological Stream Survey's Benthic-Index of Biotic Integrity (B-IBI). The watershed identification numbers are in parenthesis. This table is from the *Biological Assessment and Monitoring of Streams and Watersheds in Prince George's County Round 2, Year 3* Report (2013).

[See next page for Table 1.]

Table 1: **Estimates of Biologically Degraded Stream Miles**

Major Basin	Watershed	Stream miles (1st-4th order) Total	Round 1 (%)	Round 2 (%)	Change (%)
Anacostia	Paint Branch (05)	17.00	37.6	100	62.4
	Indian Creek (07)	20.40	58.3	44.5	-13.8
	Upper Beaverdam Creek (08)	16.30	62.6	71.5	8.9
	Northwest Br. + Sligo Creek (09+14)	11.90	100.0	100	0.0
	Upper Northeast Br. + Lower Northeast Br. + Brier Ditch (12+15+16)	15.10	74.2	99.9	25.7
	Lower Beaverdam Crk (19)	16.20	91.4	71.4	-19.9
	Upper Anacostia River + Lower Anacostia River (Watts Branch) (20+22)	6.70	100.0	67	-33.0
Patuxent	Upper Patuxent River (02)	43.90	62.4	52.6	-9.8
	Walker Br. + Crow's Br. + Bear Br. (03+04+06)	13.40	29.9	59.9	30.0
	Horsepen Br. (10)	9.90	33.3	74.7	41.4
	Folly Br. + Baldhill Br. + Lottsford Br (11+13+17)	15.00	65.3	83.4	18.1
	Northeast Br. (Western Br.) (18)	9.90	74.7	49.8	-24.9
	Southwest Br. (21)	17.30	89.0	57.1	-32.0
	Spice Creek (32)	16.00	0.0	14.3	14.3
	Black Swamp Creek 36)	10.60	0.0	74.8	74.8
	Swanson Creek (37)	15.90	25.2	14.3	-10.9
	Mataponi Creek (38)	24.20	18.2	0	-18.2
	Lower Patuxent River (39)	65.90	54.9	57.1	2.2
	Collington Branch (40)	29.20	58.2	33.3	-24.9
	Western Branch (41)	38.30	33.4	50	16.6
	Charles Branch (42)	24.50	20.0	40	20.0
Potomac	Oxon Run (23)	10.90	100.0	100	0.0
	Henson Crk. + Broad Crk. + Hunters Mill Crk. (23+28+29)	30.90	85.1	71.5	-13.7
	Tinkers Crk. (25)	16.60	66.9	71.4	4.5
	Upper Potomac River + Swan Crk. + Lower Potomac (26+30+33)	8.10	39.5	24.9	-14.6
	Piscataway Creek (27)	56.90	14.9	37.5	22.5
	Mattawoman Creek (31)	35.60	46.1	26.7	-19.4
	Pomonkey Crk. and Zekiah Swamp Crk. (34+35)	12.59	24.6	40	15.4

The number of watersheds containing greater than 50 percent degraded miles increased from 15 percent in Round 1 to 18 percent in Round 2. Compared to Round 1, Round 2 showed that the percentage of biologically degraded stream miles was 52 percent countywide, a three percent increase from Round 1 (Table 2).[3] At the basin level, 79 percent, 53 percent, and 47 percent of stream miles in the Anacostia, Potomac, and Patuxent basins, respectively, are classified as having degraded water quality in the Round 2 report. This is an increase of 7 percent in the Anacostia River basin and 2 percent in the Potomac and Patuxent basins from the first assessment.

[3]*Biological Assessment and Monitoring of Streams and Watersheds in Prince Georges' Coun*ty. Round 2, Year 3. 2013.

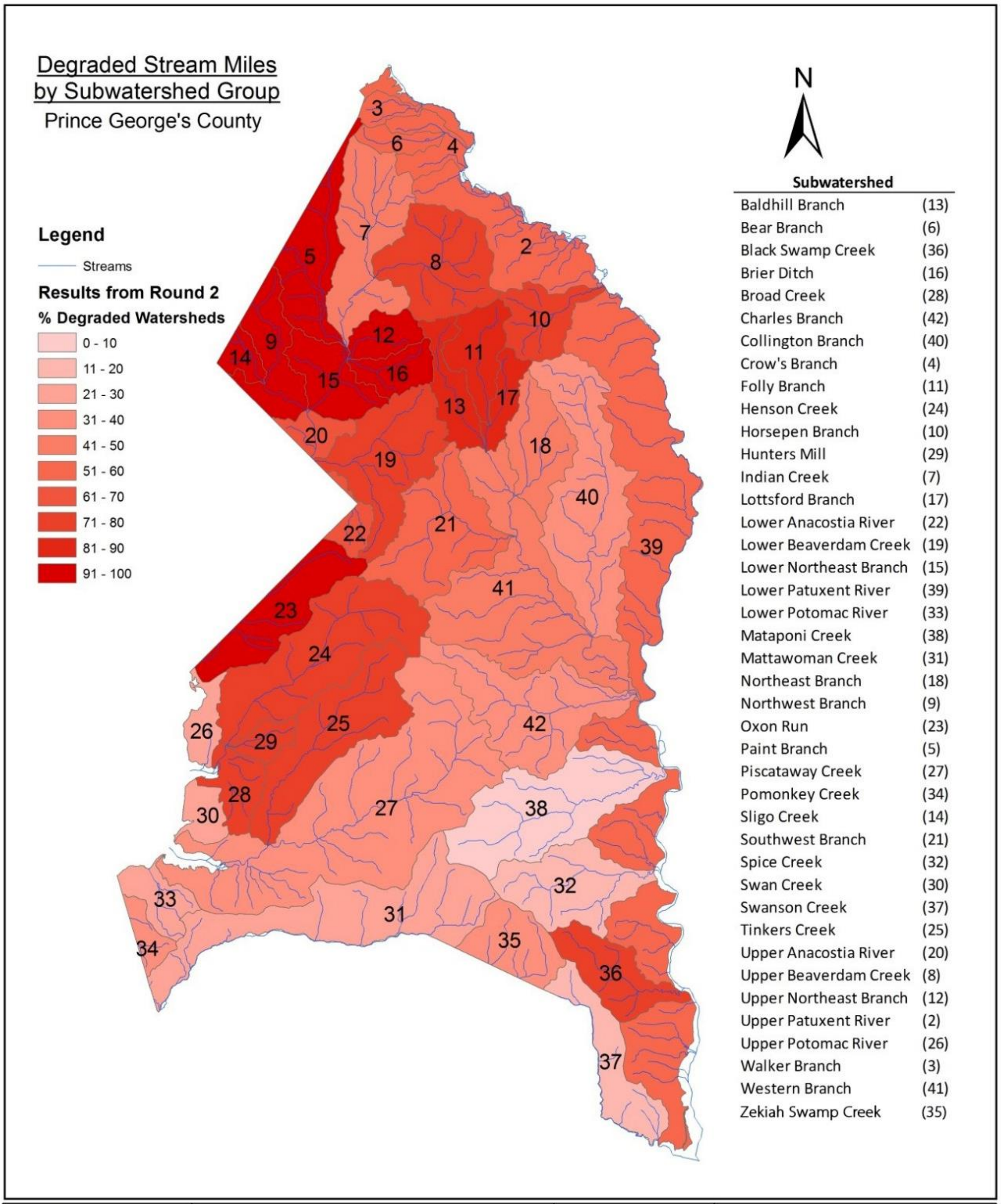
Table 2: **Change in Round 1 (1999-2003) and Round 2 (2010-2013) Percent Degraded Stream Miles**

	Anacostia	Patuxent	Potomac	County
Round 1	72%	51%	45%	49%
Round 2	79%	53%	47%	52%
Percent Change	7%	2%	2%	3%

Map 2 displays degraded stream miles in each subwatershed or subwatershed group by 10 percent gradient categories. The map shows that, as expected, there was a higher percentage of degraded stream miles within the Anacostia and Patuxent River basins.

[See next page for Map 2.]

Map 2: Percentage Degraded Stream Miles in Round 2



The Maryland-National Capital
Park & Planning Commission
Prince George's County Planning Department
Geographic Information System

0 0.65 1.3 1.95 2.6
Miles
1:229,642

Date Printed:
May 13, 2015

Benthic-Index of Biotic Integrity (B-IBI) and Physical Habitat Quality Assessment

Water quality assessment for B-IBI are reported as a narrative rating of good, fair, poor, or very poor. Physical habitat quality assessments are reported as narrative ratings of comparable, supporting, partially supporting, or nonsupporting based on points scored in the visual-based physical habitat survey.

Objectives 5 and 6 in the *Countywide Green Infrastructure Plan* were to elevate the B-IBI and physical habitat ratings by at least one narrative rating by 2025 (using Round 1 results as a baseline). For the purposes of the Green Infrastructure Plan, the physical habitat ratings were converted to use the good, fair, and poor narrative labels for ease of comparison.

Table 3: Narrative Ratings

	Benthic-Index of Biotic Integrity (B-IBI)	Visual-Based Physical Habitat Quality
What Does it Measure?	Measured type and frequency of benthic insects	Assessment of stream's capacity or potential to support healthy biota
Narrative Ratings	Good Fair Poor Very poor	Comparable Supporting Partially supporting Nonsupporting

Round 2 results showed no statistically significant changes in the narrative ratings from those reported in Round 1 (see the table in Appendix A: Mean B-IBI and Habitat Rating by Watershed Number and Watershed Group Results from Round 1 and Round 2). Ten years into the implementation cycle and Objectives 5 and 6 of the 2005 GI Plan have not been met.

In both rounds, the ***average countywide water quality rating using the B-IBI was POOR*** and the ***average physical habitat was PARTIALLY SUPPORTING***. In Round 2 no watersheds were rated as good, only 10 percent were rated as fair using the B-IBI. The majority, 51 percent and 39 percent respectively, for a total of 90 percent, were rated as poor or very poor (Table 4). Using the visual-based habitat quality, only 17 percent of watersheds were found to be supporting while the majority, 46 percent and 37 percent, for a total of 83 percent, were classified as partially supporting or nonsupporting (Table 5).

Table 4: Results of B-IBI from Round 2 by Watershed

	Count	Percent
Good	0	0%
Fair	4	10%
Poor	21	51%
Very Poor	16	39%

Table 5: Results of Visual-based Physical Habitat Quality Assessment from Round 2 by Watershed

	Count	Percent
Comparable	0	0%
Supporting	7	17%
Partially Supporting	19	46%
Nonsupporting	15	37%

The time period between rounds reflects roughly half of the 20-year timespan planned to meet the objectives in the Green Infrastructure Plan. Because water quality changes cannot be observed in short time periods even if significant land use changes occur, water quality monitoring should be continued at the subwatershed level into the future to measure changes over time.

Recommendations

The lack of a statistical changes between the results of Round 1 and Round 2 can be viewed as demonstrating that measures taken to change land cover conditions and improve water quality have not been effective thus far. Ongoing development, increasing population, aging infrastructure, and other factors are not going to improve this situation without significant changes. It appears that additional effort is needed if aquatic biological conditions (as the principal indicator of watershed health) are to move in the desired direction.[4] However, it is still important to note that efforts at sediment or stormwater discharge control, pollution prevention, trash pickup, and engendering community stewardship have likely had some local successes and associated benefits which may not be reflected in the data yet. Local or small scale activities such as these, if applied at broad scales in a rigorous manner, can collectively lead to overall healthier watersheds.

The Round 2 report contained no recommendations. Recommendations were provided in a supplementary report by the consultant. In their *Biological Assessment and Monitoring of Streams and Watersheds in Prince George's County: A Summary of Results from Round 2,* Tetra Tech provides the following recommendations to improve water quality methods and strengthen future water quality assessments.

Tetra Tech Recommendations:

1. ***Continue routine and consistent watershed-scale biological monitoring into the future.***
   Judging effectiveness of countywide watershed management and the cumulative effects of water quality improvement strategies requires routine monitoring of biological conditions conducted consistently over an extended timeframe.
2. ***Continue efforts to improve overall ecological conditions.***
   To make investment more effective, a Targeted Linkage Analysis is recommended to help better understand the links between the stressors causing impairment and their sources so that it will elevate confidence in prioritization and design of restoration and protection measures.

[4] *Biological Assessment and Monitoring of Streams and Watersheds in Prince George's County*. Summary of Round 2. 2010-2013.

3. ***Perform source-stressor-response linkage analysis.***
   A focused effort is recommended so that understanding gained from the linkage analysis and biological assessment results can be used to enhance decision making in prioritizing watersheds for protection/restoration, and to specify the kinds of management activities that would be most appropriate.
4. ***Enhance prioritization of watersheds, and restoration and protection activities, by integrating knowledge from linkage analyses.***
   Prioritization of restorative efforts is needed to address the Watershed Implementation Plan (WIP) requirements. Targeted analysis would allow the County to spend money more wisely, meeting both the regulatory requirements, and improving biological conditions of the streams and rivers.
5. ***Use biological assessment results and linkage analyses as input to Total Maximum Daily Load (TMDL) implementation and WIP.*** [No additional explanation of this recommendation was provided.]

Staff Recommendations

After reviewing the Round 1 and Round 2 results and Tetra Tech's recommendations, staff recommends the following actions moving forward:

- The Round 2 assessments should be used as the baseline assessments for water quality monitoring moving forward.
- Long-term, consistent sampling and monitoring methods should be carried out for the next 20 years to provide the data needed for an accurate assessment of water quality changes over time.
- The GI Plan update should shift from using watershed narrative ratings to assess trends to degraded stream miles as the measure for comparative purposes over time to be more consistent with the WIPII reporting.
- A better connection is needed between data collection and decision-makers regarding water quality so that the data collected are used for making water quality improvement decisions.
- The individual sampling site data from both rounds should be used to better evaluate where water quality improvements should be focused.
- Water quality monitoring should be continued at the subwatershed level or subwatershed group level to measure stream water quality over time. The groupings of subwatersheds should remain consistent with those used in Round 2.

Sources:

Tetra Tech. Biological Assessment and Monitoring of Streams and Watersheds in Prince George's County. Summary of Round 1. 1999-2003.

Tetra Tech. Biological Assessment and Monitoring of Streams and Watersheds in Prince George's County. Summary of Round 2. 2010-2013.

Tetra Tech. Biological Assessment and Monitoring of Streams and Watersheds in Prince George's County: A Summary of Results from Round 2.

GIS Data Layers also provided by Tetra Tech.

Prepared by:

M-NCPPC staff including CJ Lammers, Project Manager, and Angela Martinez, University of Maryland Graduate Research Assistant.

Appendix A

Mean B-IBI and Habitat Rating by Watershed Number and Watershed Group
Results from Round 1 (1999-2003) and Round 2 (2010-2013) Sampling. Watershed numbers correspond to Department of the Environment watershed ID. Table reprinted from *Biological Assessment and Monitoring of Streams and Watersheds in Prince George's County Round 2, Year 3 Report* (2013).

Narrative Ratings:
B-IBI Rating: G=good, F=fair, P=poor, VP=very poor
Physical Habitat Rating: C=comparable, S=supporting, PS=partially supporting, NS=non-supporting

Basin	Watershed (watershed no.)	B-IBI Score (Narr)		Habitat (Narr)	
		R 1	R2	R1	R2
Anacostia	Paint Br. (5)	2.9(P)	2.3 (P)	88 (NS)	115 (PS)
	Indian Crk. (7)	2.5(P)	2.8(P)	104 (PS)	116 (PS)
	Upper Beaverdam Crk. (8)	2.8(P)	2.4(P)	104 (PS)	121 (PS)
	Northwest Br. + Sligo Crk. (9+14)	1.6(VP)	1.9(VP)	97 (NS)	109 (PS)
	Upper Northeast Br. + Lower Northeast Br. + Brier Ditch (12+15+16)	2.4(P)	1.8(VP)	101 (PS)	97 (PS)
	Lower Beaverdam Crk. (19)	2.3(P)	2.4(P)	90 (NS)	103 (PS)
	Upper Anacostia R.+Lower Anacostia R. (20+22)	2.1(P)	2.8(P)	92 (NS)	99 (PS)
	Mean	**2.5(P)**	**2.4(P)**	**98 (NS)**	**110 (PS)**
Patuxent	Upper Patuxent R. (2)	2.4(P)	2.9(P)	115 (PS)	120 (PS)
	Walker Br. + Crows Br. + Bear Br. (3+4+6)	2.8(P)	2.2(P)	108 (PS)	105 (PS)
	Horsepen Br. (10)	2.8(P)	2.9(P)	96 (NS)	139 (S)
	Folly Br.+Baldhill Br.+lottsford Br. (11+13+17)	2.6(P)	2.6(P)	124 (PS)	108 (PS)
	Northeast Br. (Western Br.) (18)	2.8(P)	3.0(F)	125 (PS)	106 (PS)
	Southwest Br. (21)	2.4(P)	2.7(P)	106 (PS)	121 (PS)
	Spice Crk. (32)	4.0(G)	3.6(F)	106 (PS)	117 (PS)
	Black Swamp Crk. (36)	4.2(G)	2.6(P)	141 (S)	126 (PS)
	Swanson Crk. (37)	3.4(F)	3.9(F)	128 (S)	147 (S)
	Mataponi Crk. (38)	3.4(F)	3.5(F)	107 (PS)	144 (S)
	Lower Patuxent R. (39)	2.8(P)	2.6(P)	98 (NS)	122 (PS)
	Collington Br. (40)	3.0(F)	3.1(F)	107 (PS)	132 (S)
	Western Br. (41)	2.8(P)	2.9(P)	103 (PS)	122 (PS)
	Charles Br. (42)	3.3(F)	3.3(F)	167 (C)	123 (PS)
	Mean	**3.0(F)**	**3.0(F)**	**110 (PS)**	**124 (PS)**
Potomac	Oxon Run (23)	1.1(VP)	2.3(P)	68 (NS)	104 (PS)
	Henson Crk.+Broad Crk.+Hunters Mill Crk. (24+28+29)	2.1(P)	2.8(P)	110 (PS)	111 (PS)
	Tinkers Crk. (25)	2.4(P)	2.8(P)	99 (NS)	129 (S)
	Upper Potomac R.+Swan Crk.+Lower Potomac R. (26+30+33)	2.5(P)	3.6(F)	125 (PS)	131 (S)
	Piscataway Crk. (27)	3.7(F)	3.4(F)	128 (S)	125 (PS)
	Mattawoman Crk.(31)	2.8(P)	3.4(F)	123 (PS)	149 (S)
	Pomonkey Crk.+Zekiah Swamp Crk. (34+35)	3.6(F)	2.8(F)	142 (S)	135 (S)
	Mean	**2.8(P)**	**3.1(F)**	**117 (PS)**	**127 (S)**
	County Mean	**2.8 (P)**	**2.9 (P)**	**109 (PS)**	**122 (PS)**

THE ECONOMIC VALUES OF NATURE: AN ASSESSMENT OF THE ECOSYSTEM SERVICES OF FOREST AND TREE CANOPY

Prince George’s County, MD | April 2015

THE ECONOMIC VALUES OF NATURE

Introduction

Forests and trees provide multiple benefits to the people who live and work near them. In Prince George's County, Maryland, 52 percent of the county's 485 square miles are covered by forest and tree canopy. This natural resource is an integral part of the infrastructure of the community and provides benefits to both people and the environment called "ecosystem services": cleaner air, cleaner water, reduced greenhouse gas emissions and cooler communities.

The information provided in this report is the result of an evaluation of the economic value of the ecosystem services the forest and tree canopy provides and the associated dollar value of these services to the county. For the purposes of this study, the forest and tree canopy has been separated into forest canopy coverage (wooded areas a minimum of 10,000 square feet and at least 50 feet in width equals 44 percent) and tree canopy coverage (small fragments of woods or individual trees equals 8 percent).

Assessment Methodology

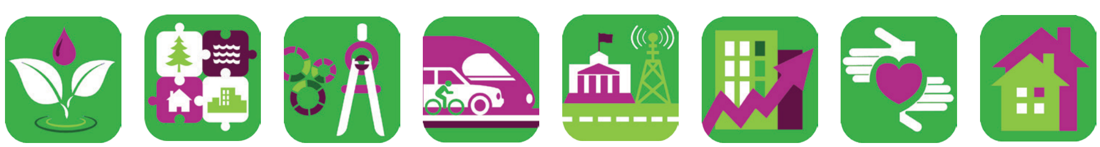
In 2011, the Spatial Analysis Laboratory at the University of Vermont (UVM) measured the county's forest and tree canopy coverage. Using high resolution remote sensing data from 2009 that was able to capture individual trees as short as 6 feet tall, UVM determined that the county contains 160,947 acres of forest and tree canopy coverage, equivalent to 52 percent of the county.

In 2013, the United States Department of Agriculture (USDA) Forest Service Northern Research Station calculated the ecosystem service values of the county's forest and tree canopy. The team used the USDA Forest Service i-Tree model (www.itreetools.org) to measure the economic values provided by the county's forest and tree canopy (cleaner air and water, reduced emissions and cooler communities). The modeling system known as i-Tree was developed by the USDA Forest Service and is widely used across the U.S. The system uses local tree, environmental, and population data to estimate various ecosystem services and values derived from forests and trees.

Key Findings

This study marks the first time that the values and benefits of Prince George's County's forest and tree canopy coverage have been quantified. Following are some of the study's key findings regarding the economic value of the county's 52 percent forest and tree canopy coverage:

- The county's forest and tree canopy improves air quality by removing more than **5,100 metric tons** of air pollutants per year–a service worth **$21 million** annually. (See pages 3 and 4)



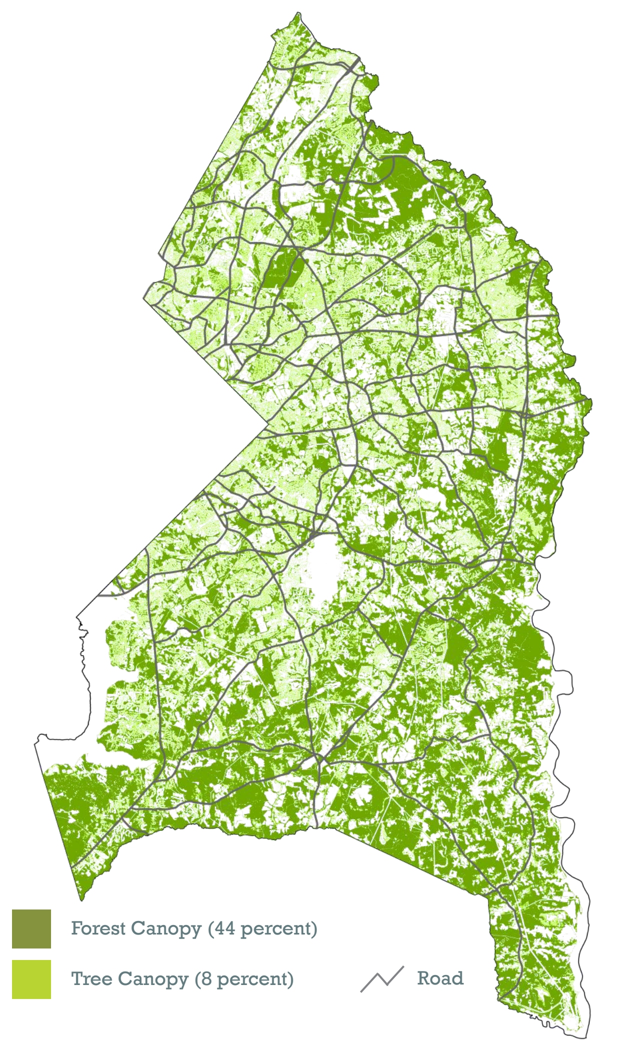
Plan Prince George's 2035 Approved General Plan icons from left to right: *Natural Environment; Land Use; Community Heritage, Culture, and Design, Transportation and Mobility; Public Facilities; Economic Prosperity; Healthy Communities; Housing and Neighborhoods. For each value discussed in this report, the associated* ***Plan 2035*** *icons are displayed at the top of the page.*

- Prince George's County's forests and trees help prevent water pollution by reducing the amount of polluted runoff by **4.3 billion gallons** per year. Removing pollutants from the same amount of runoff would cost the county approximately **$12.8 billion** annually. (See pages 5 and 6)
- Each year, the county's forest and tree canopy absorbs **211,000 metric tons** of carbon–a service worth **$16.6 million** annually. (See pages 7 and 8)
- The amount of carbon stored over the lifetime of the forest and tree canopy is estimated to be **5 million metric tons**, valued at **$395 million**. This is equivalent to the carbon dioxide emitted by five coal burning power plants. (See pages 7 and 8)
- The forest and tree canopy also helps keep communities cool by shading homes, breaking up urban "heat islands," and releasing water vapor into the air. In areas where more forests and trees are present, summer temperatures can be reduced by up to **1 degree** Fahrenheit. Direct shading of the ground and release of water through tree leaves can result in temperature reductions of **9 to 13 degrees**. (See pages 9 and 10)

These findings demonstrate the economic value of preserving and enhancing the county's existing 52 percent forest and tree canopy coverage.

> "The nation behaves well if it treats the natural resources as assets which it must turn over to the next generation increased, and not impaired, in value."
> — Theodore Roosevelt

Prince George's 2009 Forest and Tree Canopy Coverage



CLEANER AIR

How Values Are Measured

In the American Lung Association's recent *State of the Air 2013* report, the county received an ozone grade of F and a particle pollution grade of C for the number of days annually with unhealthy air. Poor air quality is not just a county issue; the entire Washington metropolitan area is designated by the U.S. EPA as a non-attainment area for not meeting regional air quality standards for ozone (O_3) and fine particulate matter ($PM_{2.5}$). However, there have been significant improvements in air quality over the past decade due to stricter regulations to cut pollution from sources such as vehicles and power plants.

Forests and trees play important roles in cleaning the air and making communities healthier places to live. Trees, forests, and urban green infrastructure practices, such as green roofs, help improve air quality by reducing air temperatures, removing gaseous pollutants, and filtering out fine particles that can enter the lungs and cause serious health problems. By providing shade and releasing water into the air, trees lower air temperatures and reduce the amount of power that needs to be generated, resulting in reduced pollution from power plants.

Prince George's County's forest and tree canopy removes 5,100 metric tons of pollutants per year - a service worth $21 million annually.

The insulation properties of green roofs and – to a smaller extent green walls – similarly limit air pollutants from power plants by improving energy efficiency in buildings.

The USDA Forest Service has developed a series of tools to evaluate the air pollution removal capacity of forests and trees for several common air pollutants regulated by the Clean Air Act. These include carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3), inhalable coarse particles (PM_{10}), fine particulate matter ($PM_{2.5}$), and sulfur dioxide (SO_2). These tools were applied to evaluate how effective the county's forest and tree canopy is at removing them. Overall, it was determined that the forest and tree canopy removes **5,100 metric tons** of pollutants annually–a service worth **$21 million** a year. Within the county's 27 municipalities, trees provide annual air pollution removal benefits of **$3.9 million**.

Related Strategies

While it is difficult to address air quality in the county because it is a regional issue, the 2005 *Approved Countywide Green Infrastructure Plan* contains several strategies to address local air quality. The Green Infrastructure Plan Update should include strategies that can result in improved air quality by increasing appropriate forest preservation and tree planting. Consideration should be given to increasing tree planting in highly populated areas and enhancing urban tree planting strategies. These strategies should favor low-maintenance, long-lived tree species that support biodiversity and that are not pollution sensitive.

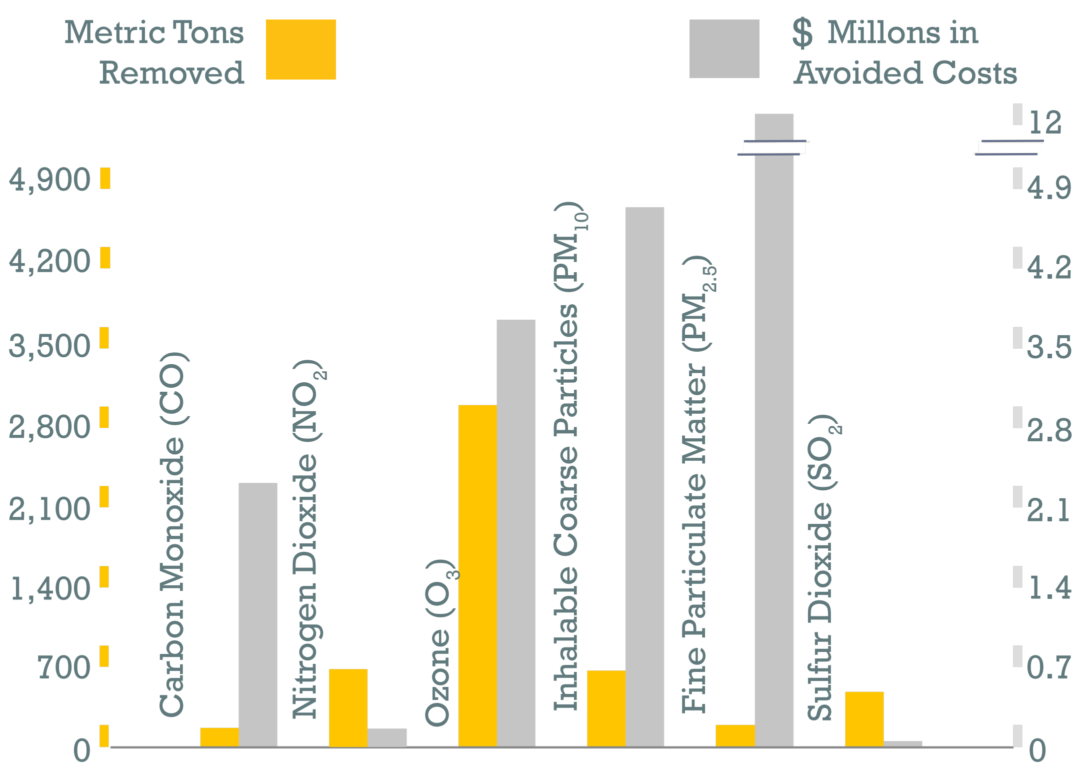
Process

The analysis of annual pollution removal capacity and values of Prince George's County's forest and tree canopy were prepared by the USDA Forest Service, Northern Research Station. This process involved: deriving local hourly data for weather, upper air and surface meteorology, and pollution; deriving forest area data and location-related values; generating annual pollution removal amounts using i-Tree; and generating values based on local incidence of adverse health effects.

Data and Sources

- Local weather station data on air pressure, temperature, wind speed, and relative humidity for year 2008.
- Local air pollution monitoring station data for year 2008.
- 2009 Urban Tree Canopy (UTC) land cover dataset, derived from University of Vermont, Spatial Analysis Laboratory.
- Percent evergreen tree cover derived from National Land Cover Data (NLCD) data and leaf area index values sourced from Modis Satellites and field data (for urban areas).

HOW WELL DOES THE COUNTY'S 52 PERCENT FOREST AND TREE CANOPY CLEAN THE AIR EVERY YEAR?



CLEANER WATER

How Values Are Measured

When it rains, a large amount of water is intercepted by the leaves and bark, allowing the water to slowly evaporate back up into the air, be absorbed by the tree, or be released into the ground over time. Depending on the size and species, a mature deciduous tree can intercept up to 760 gallons of water per year, while a mature evergreen can intercept more than 4,000 gallons annually. Multiplied by the number of trees in a community, the amount intercepted can be significant.

Prince George's County's existing forest and tree canopy reduces stormwater runoff by **4.3 billion gallons** per year, which is enough to fill more than 6,500 olympic-sized pools. That amounts to saving **$12.8 billion** annually on stormwater treatment costs.

Reducing stormwater runoff has multiple benefits. Large amounts of runoff can change stream flow, increase flooding, erode stream banks and channels, destroy fish habitat, and impact water quality. From a public health perspective, nonpoint source pollution from polluted stormwater runoff has been linked to chronic and acute illnesses from exposure through drinking water, seafood, and contact recreation.

> Prince George's County's forest and tree canopy reduces the amount of polluted runoff by 4.3 billion gallons per year, saving the county roughly $12.8 billion annually.

The solution to excessive stormwater runoff is more complex than just planting more trees or adding more green spaces. Increasing tree plantings, improving forest reserves, and preserving undisturbed vegetative cover are valuable components of an integrated strategy to reduce polluted urban stormwater runoff.

Related Strategies

The 2005 *Approved Countywide Green Infrastructure Plan* established a countywide green infrastructure network of streams, wetlands, buffers, forests and other areas of countywide significance that are critical to decreasing the amount of stormwater runoff and pollutants that reach local waters. In addition, recent updates to the county's stormwater regulations are encouraging a more comprehensive, smaller-scale approach to controlling polluted runoff.

The Green Infrastructure Plan Update should include strategies to promote and encourage the use of green stormwater infrastructure such as trees, rain gardens, conservation landscaping, and living infrastructure such as green roofs and walls.

Process

Stormwater runoff reduction was evaluated by the USDA Forest Service, Northern Research Station using the i-Tree Hydro model. This model estimates the effects of the forest and tree canopy and impervious cover percentages on hourly stream flow values for a watershed, as well as changes in water quality using hourly runoff estimates and mean and median national event mean concentration values.

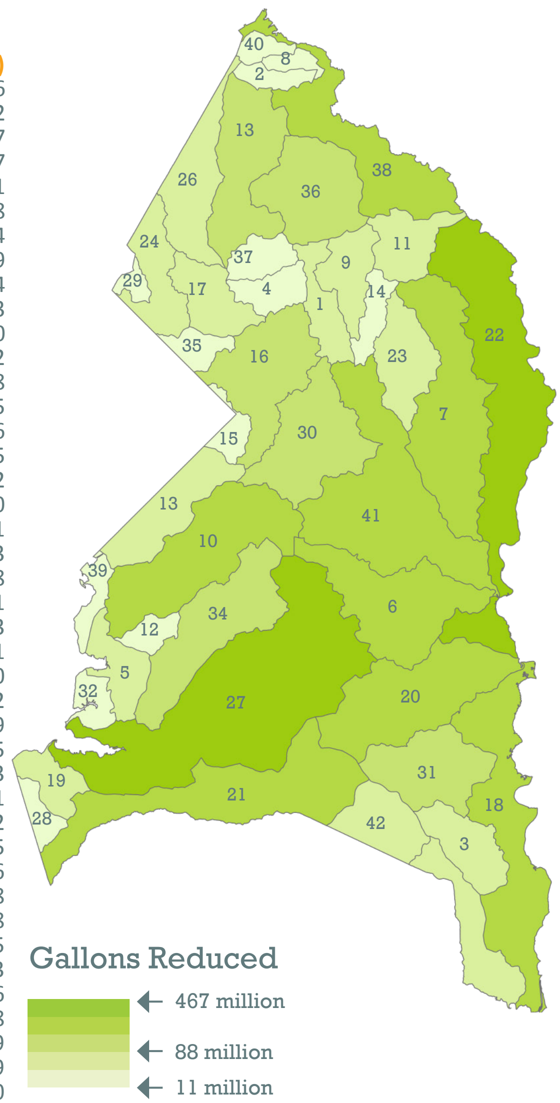
The i-Tree Hydro model was calibrated using hourly stream flow data to yield the best fit between modeled and measured stream flows for one watershed within the coastal plain. After calibration, the model was run a number of times under various forest and tree canopy and impervious cover scenarios to determine the impact on stream flow. Average runoff effects per unit of canopy and impervious cover from this modeled watershed were then applied to the watersheds in the county.

Data and Sources

- Hourly stream flow and digital elevation model data from the Rock Creek Gauging Station.
- Local weather station data.
- 2009 UTC land cover dataset, derived from University of Vermont, Spatial Analysis Laboratory.

WITHIN EACH WATERSHED, HOW MANY GALLONS OF POLLUTED RUNOFF DOES THE FOREST AND TREE COVER CAPTURE?

Watershed	Gallons Reduced (millions)	Annual Value (millions)
1. BALDHILL BRANCH	49.67	$146
2. BEAR BRANCH	17.45	$52
3. BLACK SWAMP CREEK	66.68	$197
4. BRIER DITCH	39.52	$117
5. BROAD CREEK	51.07	$151
6. CHARLES BRANCH	169.01	$498
7. COLLINGTON BRANCH	191.24	$564
8. CROWS BRANCH	13.09	$39
9. FOLLY BRANCH	58.96	$174
10. HENSON CREEK	190.82	$563
11. HORSEPEN BRANCH	64.30	$190
12. HUNTERS MILL	21.18	$62
13. INDIAN CREEK	128.23	$378
14. LOTTSFORD BRANCH	28.69	$85
15. LOWER ANACOSTIA RIVER	22.46	$66
16. LOWER BEAVERDAM CREEK	134.04	$395
17. LOWER NORTHEAST BR (ANA)	41.24	$122
18. LOWER PATUXENT RIVER	203.52	$600
19. LOWER POTOMAC RIVER	51.12	$151
20. MATAPONI CREEK	184.02	$543
21. MATTAWOMAN CREEK	236.57	$698
22. MIDDLE PATUXENT RIVER	319.05	$941
23. NORTHEAST BRANCH (WB)	65.33	$193
24. NORTHWEST BRANCH (ANA)	68.19	$201
25. OXON RUN	88.05	$260
26. PAINT BRANCH	85.58	$252
27. PISCATAWAY CREEK	467.49	$1,379
28. POMONKEY CREEK	28.64	$85
29. SLIGO CREEK	11.08	$33
30. SOUTHWEST BRANCH	132.68	$391
31. SPICE CREEK	102.34	$302
32. SWAN CREEK	25.59	$75
33. SWANSON CREEK	79.91	$236
34. TINKERS CREEK	145.23	$428
35. UPPER ANACOSTIA RIVER	22.94	$68
36. UPPER BEAVERDAM CREEK	133.79	$395
37. UPPER NORTHEAST BR (ANA)	61.98	$183
38. UPPER PATUXENT RIVER	174.82	$516
39. UPPER POTOMAC RIVER	23.09	$68
40. WALKER BRANCH	16.51	$49
41. WESTERN BRANCH	247.25	$729
42. ZEKIA SWAMP CREEK	74.60	$220



REDUCED GREENHOUSE GAS EMISSIONS

How Values Are Measured

Greenhouse gases are those gases in the atmosphere that trap and retain heat. Since the late 1700s, the amount of greenhouse gases in the atmosphere has continued to increase. This rise is considered one of the leading causes of climate change and severe weather occurrences.

One of the most abundant greenhouse gases in the atmosphere is carbon dioxide (CO_2). Forests and trees can help reduce the amount of CO_2 in the atmosphere by absorbing carbon from the air and storing it in their roots, trunks, branches, and leaves. They do this in two ways: first, by absorbing carbon from the atmosphere via the process of photosynthesis as trees grow, and second, by storing carbon or "sequestering" it in solid form in trunks and branches for the duration of the tree's life.

In Prince George's County, the USDA Forest Service estimated that the amount of carbon absorbed by its forests and trees is about **211,000 metric tons** per year with an associated value of **$16.6 million**. This is the equivalent of removing more than 161,000 vehicles from the road annually, or the carbon dioxide emissions from the annual energy use of more than 39,000 homes.

The amount of carbon stored over the canopy's lifetime is approximately **5,035,000 metric tons** with an associated value of **$395 million**. That amount is the equivalent of offsetting the carbon dioxide emissions from consuming almost 87 million gallons of gasoline, or the emissions from 5 coal fired power plants.

Related Strategies

Prince George's County has prepared a draft Climate Action Plan (CAP) to address the challenges of climate change. It identifies ways to reduce greenhouse gas production from various activities, including transportation and land use. Strategies include ensuring that the county's forest and tree canopy is maintained, if not increased; identifying opportunities to promote and provide technical assistance on sustainable practices; and the greening of streets and rights-of-way. Because the amount of carbon removed and stored increases with healthier, longer-lived trees, specific strategies should be put into place to ensure forest and tree health and longevity.

Process

Forest and tree carbon absorption and storage estimates were determined by the USDA Forest Service using the following steps: Urban tree field data from 28 cities and 6 states were used to determine the average carbon density per unit of canopy coverage. These data were then applied to countywide forest and tree cover measurements to estimate the total carbon absorbed and stored annually.

The county's forest and tree canopy absorb enough carbon each year to offset the greenhouse gas emissions of 161,000 passenger vehicles a year…and store more carbon than that emitted by 5 coal-fired powerplants.

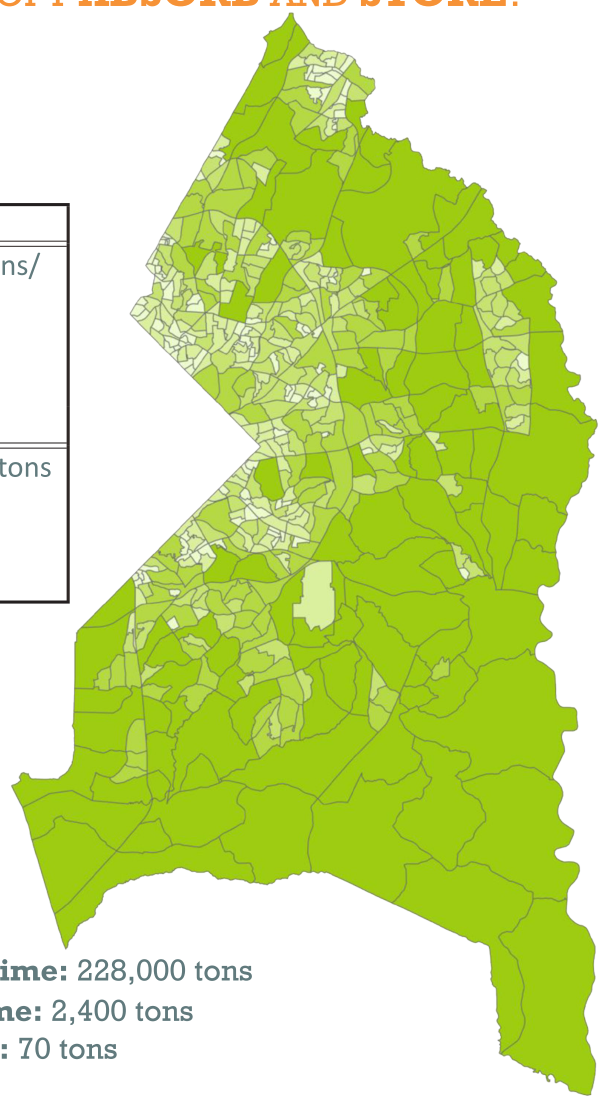
Data and Sources

- Field data and model analyses from several comparable cities and states to estimate sequestration per unit of tree cover.
- 2009 UTC land cover dataset by the University of Vermont, Spatial Analysis Laboratory.
- Percent evergreen (coniferous) derived from the 2006 and 2010 NLCD land cover.

A single tree can **absorb** as much as **48 pounds of carbon** dioxide **per year**, and can sequester 1 ton of carbon dioxide by the time it reaches 40 years old.

HOW MUCH ATMOSPHERIC CARBON DOES THE COUNTY'S FOREST AND TREE CANOPY **ABSORB** AND **STORE**?

Measure	Value
Annual amount of **carbon absorbed** during growth process	211,000 metric tons/year $16,600,000/year
Amount of **carbon stored** for the duration of the canopy's life	5,035,000 metric tons $395,218,000



← **Annual:** 9,600 tons **Lifetime:** 228,000 tons
← **Annual:** 100 tons **Lifetime:** 2,400 tons
← **Annual:** 3 tons **Lifetime:** 70 tons

COOLER COMMUNITIES

How Values Are Measured

Urban trees, green roofs, vegetated landscapes, and forest canopy help keep communities within a healthy temperature range. Trees and vegetation cool the air by releasing water to the air and by absorbing heat energy. "Oasis effects" of 9 to 13 degrees Fahrenheit have been measured as a result of direct shading of the ground surface and release of water through tree leaves. Other studies have found that trees can reduce the temperature of asphalt by up to 36 degrees and vehicle cabin temperatures by up to 47 degrees Fahrenheit.

The cooler air temperatures experienced in areas with more canopy coverage can have significant positive impacts on human health. During heat waves, communities with ample canopy and vegetative cover stay cooler during the day, which is the time when heat is most likely to reach dangerous levels for human health. Even on regular summer days, trees help temper neighborhood heat. Trees, green roofs, and vegetated areas all contribute to the reduction of heat transmitted to buildings. Scientists have estimated that strategically planting trees and vegetation for shade can reduce a building's annual energy use by up to 25 percent.

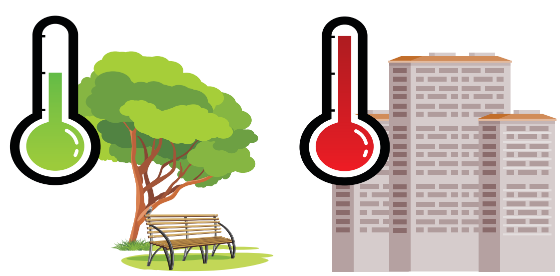
By taking stock of the canopy and other vegetative cover, strategies to increase tree plantings and green spaces can be developed to reduce the urban heat island effect in targeted areas.

Related Strategies

Over the past decade, the ability to measure and evaluate the role forests, trees, and other vegetation play to help lowering urban temperatures has markedly increased. The strategic placement of trees around buildings, impervious areas, and throughout the community matters in terms of energy reduction, cooling, and other benefits.

Plan Prince George's 2035 has identified a greater need for carefully planned and designed urban green and open spaces that provide multiple ecosystem services. Establishing tree planting and retention strategies to not only increase the urban tree canopy but to target increases in vegetation in areas where temperatures are highest could greatly enhance the health benefits and quality of life in affected communities. Combined with information on age, income, and other factors, measures can also focus on ensuring that Prince George's County's communities are treated equitably with regard to tree canopy coverage.

Studies have found that trees can reduce surface asphalt temperatures by up to 36°F and vehicle cabin temperatures by up to 47°F.



Process

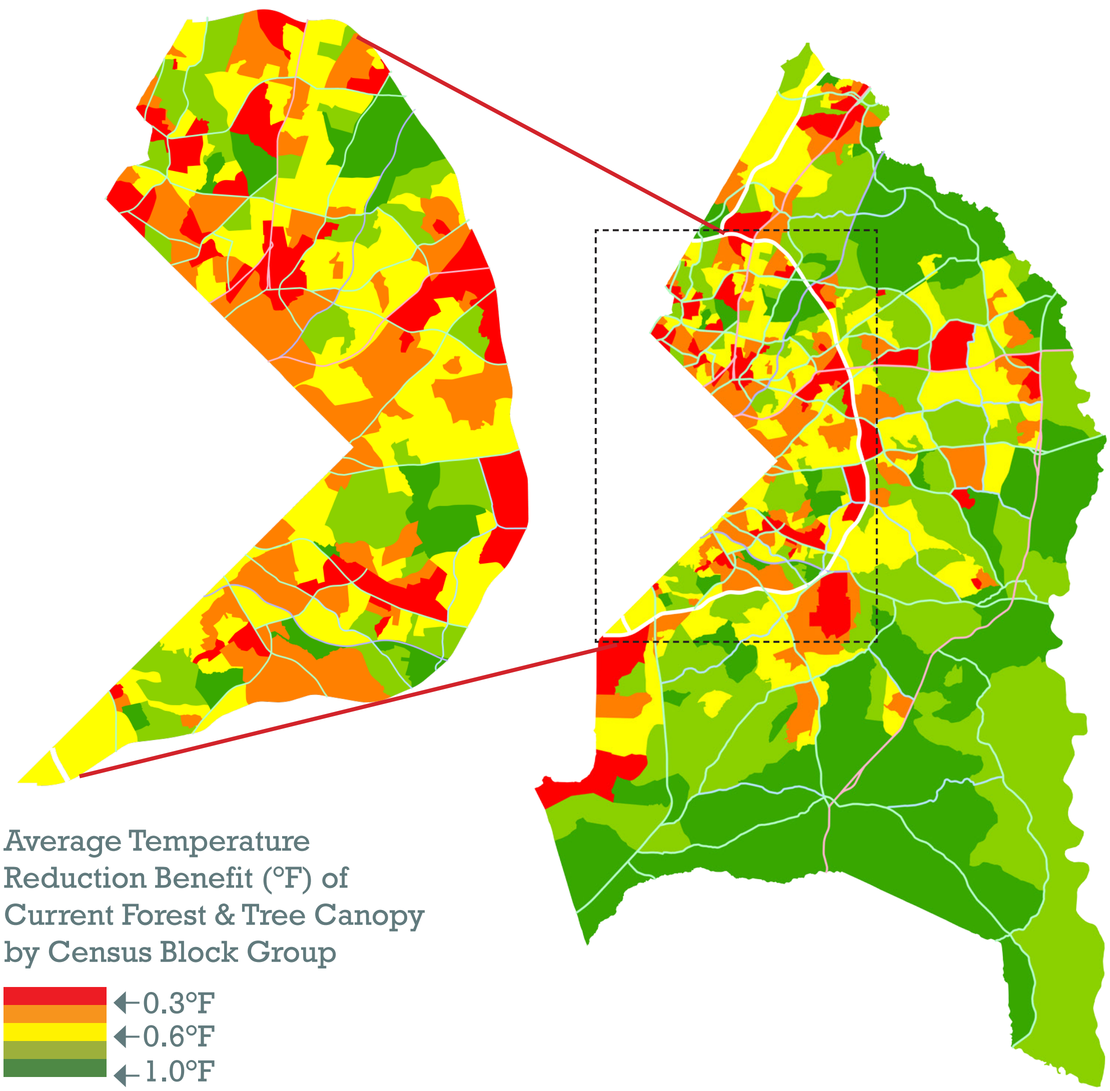
The average temperature reduction values of Prince George's County's forest and tree canopy were prepared by the USDA

Forest Service, Northern Research Station. The process for determining temperature reduction values involved several steps, including: generating land cover and elevation predictor variables; analyzing county weather data; and generating a map showing average temperature reduction values by census block group.

Data and Sources

- 2009 UTC land cover dataset, derived from University of Vermont, Spatial Analysis Laboratory.
- USGS National Elevation Dataset.
- Prince George's County, MD, weather station data for select days between June 1 and August 31, 2008.

WHAT PORTIONS OF THE COUNTY ARE MOST IN NEED OF ADDITIONAL FOREST AND TREE CANOPY COVERAGE TO INCREASE PROTECTION FROM SUMMERTIME HEAT?



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For Additional Information

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http://www.princegeorgescountymd.gov/sites/dpie/Pages/default.aspx

Prince George's County Department of the Environment: 301-883-5810
http://www.princegeorgescountymd.gov/sites/environmentalresources/Pages/default.aspx

Prince George's Planning Department's Planning Information Services: 301-952-3208
http://www.pgplanning.org/Planning_Home.htm

Prince George's Planning Department's Environmental Planning Section: 301-952-3650
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