Manatee County Urban Forest Canopy Analysis

2004 and 2009

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1.0 Introduction

The forest canopy within an urban area, such as a city or densely-populated county, is referred to as an urban forest canopy. Trees within the urban forest canopy include all of the trees within the urban area, including individual street trees, groups of trees within parks and other open spaces, coastal trees (i.e. mangroves) and trees within private property. These trees provide benefits to the residents of the city, including shade, energy savings, air and water quality improvements, carbon storage and sequestration, reduced crime, improved aesthetics and increased property values (Escobedo et al., Dec. 2009). With increased awareness of the potential effects of climate change, many local governments and non-profit groups are evaluating their urban forest canopies with the goal of preserving the existing canopy and providing support to programs designed to increase the coverage of trees within the community.

In 2009, Keep Manatee Beautiful (KMB) was awarded a Florida Division of Forestry Urban and Community Forestry Grant to perform an Urban Canopy Analysis for Manatee County, Florida. KMB contracted E Sciences, Incorporated (E Sciences) to perform the analysis.

KMB has undertaken the task of analyzing the environmental benefits of, and the effect of population changes and development on, Manatee County's forest canopy. Manatee County experienced steady population growth through the 1980s, 1990s and 2000s. Much of this growth in recent years has occurred in unincorporated areas, resulting in the conversion of agricultural or undeveloped lands into subdivided communities. According to a report by the US Census Bureau, the number of residents in unincorporated portions of the county grew by 25.9 percent between 2000 and 2009 while the overall population of the county grew by 20.6 percent. During that same time period, two of Manatee County's six municipalities (Anna Maria and Holmes Beach) had a net loss in number of residents while the other four municipalities (Bradenton, Bradenton Beach, Longboat Key and Palmetto) had minimal population growth.

The purpose of the project is to calculate the changes to the Manatee County forest canopy for two different years (2004 and 2009) and analyze the resulting effects on the quantity of the environmental benefits provided by the canopy. To perform this analysis, the forest canopy and other landcover types were delineated using the ERDAS 2010 software suite. Following classification of the county's landcover classes, scientists used CITYgreen software developed by American Forests to assign ecological and economic values to the canopy within three benefit areas: carbon storage and sequestration, air quality (air pollutant removal) and stormwater runoff reduction.

In the following sections of this report, the models used to calculate the value of trees and the resulting cost savings are presented. However, not all cost savings are incorporated into CITYgreen's models. For example, studies have shown that it is possible to reduce air conditioning costs by as much as 30 percent when trees are planted in the right place, generally the south side of the house. This is because solar heat absorbed through windows and roofs can be reduced by well-placed shade trees, thus reducing your air conditioner use (www.dnr.state.md.us and landscaping.sustainable sources.com). Shade and

6.0 References

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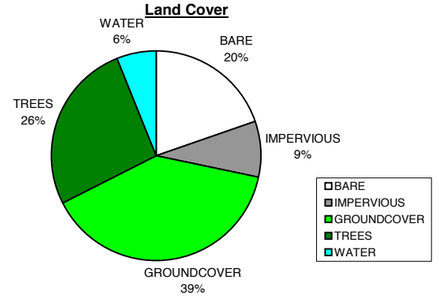
Unincorporated Manatee County Urban Landscape Functional Analysis

2004 to 2009 Comparison

Unincorporated Manatee County 2004, pop. 212,266

Land Cover



Agricultural or barren lands in 2004

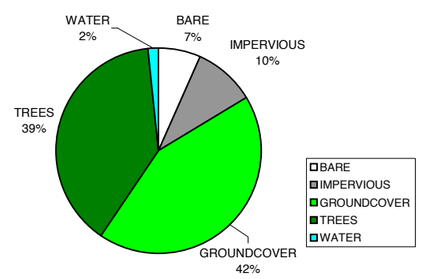
Many agricultural and/or barren areas such as the section of unincorporated Manatee County shown in this picture were developed as new neighborhoods between 2003 and 2009.

Environmental Statistics 2004

Total area (acres).....	463,754
Forest canopy (acres).....	121,228
Forest canopy (percent of total area).....	26
Carbon sequestration (tons per year).....	40,663
Total carbon stored (tons).....	5,222,978
Annual value of C removal.....	$2,033,150
(based on $50 per ton for removal)	
Additional storage needed (cubic feet).....	1,037,620,409
(if trees were replaced with impervious surface)	
Annual stormwater value.....	$180,928,949
(based on $2 per cu ft for construction of facilities)	
Total air pollution removal (pounds per yr)	15,471,954
Annual pollutant removal value.....	$40,367,228
(based on health care cost, lost tourism)	
**Total Annual Value..... **	**$223,329,327**

Unincorporated Manatee County 2009, pop. 234,191

Land Cover



New developments in 2009

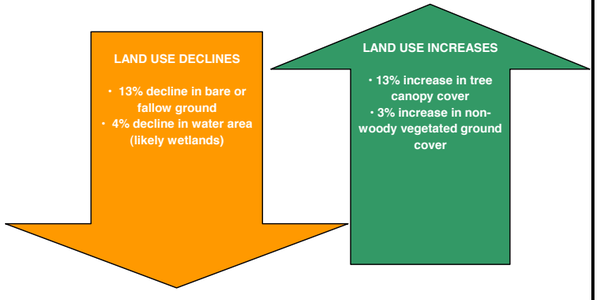
This type of land use change results in new roads and houses, but also new trees, landscape plants and sod. There is often a loss of wetlands associated with development.

Environmental Statistics 2009

Total area (acres).....	433,930
Forest canopy (acres).....	168,851
Forest canopy (percent of total area).....	39
Carbon sequestration (tons per year).....	56,614
Total carbon stored (tons).....	7,271,968
Annual value of C removal.....	$2,830,700
(based on $50 per ton for removal)	
Additional storage needed (cubic feet).....	906,153,726
(if trees were replaced with impervious surface)	
Annual stormwater value.....	$160,594,116
(based on $2 per cu ft for construction of facilities)	
Total air pollution removal (pounds per yr).....	21,541,657
Annual pollutant removal value.....	$56,203,429
(based on health care cost, lost tourism)	
**Total Annual Value..... **	**$219,628,245**

E Sciences analyzed 2004 and 2009 aerial photographs of unincorporated Manatee County using ERDAS Imagine 2010 and American Forests' CITYGreen. The most significant changes to land cover during this period include a reduction in agricultural and/ or vacant (bare) land, with an increase in tree canopy cover and impervious surface. There are two scenarios that could account for this type of land use change: 1) in 2004 the land was already cleared for development, but actual development (construction, landscape installation) did not occur until after 2004 and before 2009; or 2) farmland was converted to development. In the later scenario, despite the conversion of agricultural land use to residential land use, certain net environmental benefits are realized from the increased woody landscape plantings, which offset the effects of the additional impervious surfaces.

As of 2009 the forest canopy in unincorporated Manatee County is responsible for sequestering 56,614 tons of carbon from the atmosphere every year. The gain of approximately 13 percent of tree canopy between 2004 and 2009 increased the annual carbon sequestration rate by over 15,000 tons per year. The forest is currently storing more than 7.2 million tons of carbon within the biomass of standing trees, which helps reduce atmospheric carbon that otherwise would contribute to climate change. These trees are also reducing air and water pollution by annually: a) removing 21,541,657 lbs of air pollutants, and b) filtering water through roots and leaves, thus performing stormwater management functions equivalent to $160,594,116 that otherwise would have had to be spent on constructing facilities to treat and store the same amount of stormwater. In total, Unincorporated Manatee County's urban tree canopy is providing environmental benefits worth $219,628,245 each year.



evapotranspiration, the process by which a plant actively moves and releases water vapor, can reduce surrounding air temperature by as much as nine degree Fahrenheit (www.energysavers.gov).

With the results provided within this report, KMB can examine planting priorities, tree preservation programs and landscape code requirements for new developments. KMB can use recommendations made within this report to provide evidence of the value of trees to residents, county and municipal staff and elected officials, and to help justify the costs associated with maintaining existing trees within the county and including trees and landscapes in new projects.

2.0 Methodology of Analysis

Aerial photographs for two different years (2004 and 2009) were acquired from the Southwest Florida Water Management District (SWFWMD) data library. The 2004 aerial photographs provided by the SWFWMD were color infrared images with one-meter resolution. The 2009 aerials provided by the SWFWMD were four-band images with one-foot resolution. Both of these data sets include a near-infrared layer. Near infrared wavelengths are not visible to the human eye but, when combined with visible wavelengths, allow scientists to better distinguish between different types of vegetation and between vegetated and non-vegetated landcover. While comparing identical sets of aerial photography would result in more accurate and efficient comparisons, data with the same quality as what was available for 2009 was not available for other years. Because the 2004 aerials were the oldest aerial photographs to include an infrared layer, they provided the best opportunity to accurately represent Manatee County's forest canopy for a reasonable comparison.

The aerial photographs for each study year were combined using a mosaic feature in ERDAS 2010. Supervised classifications were performed on the combined aerial images for each year using the ERDAS 2010. The classification for each year was run using distinct signatures developed for the aerial mosaics for each year. Signatures were developed by "training" the software to detect different landcover classes (ex: water, forest canopy, road) by giving it multiple representative examples of each type of class from throughout the county. Because of the different quality of the aerial photographs, distinct signatures were created to classify the aerial photographs for each study year.

Classified aerial images were verified by comparing the land use classifications at locations throughout the county against the aerial photographs. Modifications to the signatures were made where needed and the classification process was repeated until field and web research verifications of land areas throughout the county visually appeared to be 95 percent accurate. In some instances, these verifications helped determine that classifications that appeared to be erroneous were in fact accurate. For example, some classifications identified impervious surfaces within a field. During the field verification, scientists observed that the field had previously been prepared for development and then abandoned, and that there were paved areas within the field. Bridge structures, fences and agricultural trellises (i.e. those used in vineyards) were also correctly identified by the software as impervious structures.

Because of the difference in the quality of the aerial photographs for the two different study years, distinction between smaller subcategories of landcover classes was not consistent. Therefore, the following broad categories of landcover classes were used: tree canopy, other vegetative cover, bare ground, impervious surface and water. These categories are comparable to studies conducted by American Forests using CITYgreen software.

2. 1 Models

Once the classifications were verified, landcover classes were recoded for use in CITYgreen software. CITYgreen software uses landcover data, local data and models developed by the US Forest Service and the US Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) to estimate the ecological and economical values for the environmental services provided by the urban forest canopy. A brief description of each model is provided below.

Carbon Storage and Sequestration

Trees take in carbon dioxide through their leaves. The rate at which this occurs is the carbon sequestration rate. The carbon from the carbon dioxide is incorporated into the biomass of the tree and stored as wood. Carbon sequestration (annual rate) and total carbon storage values are provided in tons. Values of carbon sequestration and storage calculated by CITYgreen's software models are based on research performed by the US Forest Service. The economic values assigned to these functions are derived from the cost of preventing carbon emissions through emission control systems, such as the use of carbon scrubbers in carbon dioxide-emitting facilities.

While CITYgreen provides economic models to estimate the value of pollutant removal and stormwater management, they do not provide an estimate of the value of the carbon storage and sequestration provided by the urban forest canopy. There are many estimates of the cost of sequestering carbon available, depending on the source of the carbon and the method of removal. A Pew Center on Global Climate Change study performed by Stavins and Richards in 2005 and entitled *The Cost of U.S. Forest-based Carbon Sequestration* calculated a range of $25 to $75 per ton of carbon (this range increases to $30 to $90 for large-scale sequestration operations). Using $25 to $75 per ton as a general range, an average of $50 per ton was used to estimate the value of the carbon sequestration performed by this study.

Air Quality

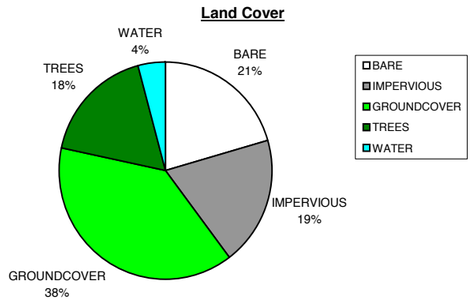
Tree leaves filter pollutants such as nitrogen dioxide (NO_2), sulfur dioxide (SO_2), ozone (O_3), carbon monoxide (CO) and particulate matter less than 10 microns (PM10) out of the atmosphere, resulting in cleaner air for breathing. CITYgreen uses air quality data from the closest available city (in the case of Manatee County the closest city with available data is Tampa, Florida) and the filtering capacity of the tree canopy to estimate the rate of removal for the above-referenced pollutants. Values for pollutant removal are provided in pounds removed per year. The model used by CITYgreen was developed by the US Forest Service. The economic values placed on this service are based on indirect costs associated with health care expenditures (i.e. hospital visits for respiratory ailments) and loss of tourist revenue

Palmetto Urban Landscape Functional Analysis

2004 to 2009 Comparison

Palmetto 2004 population 14,407

Land Cover



Forested section of Palmetto in 2004

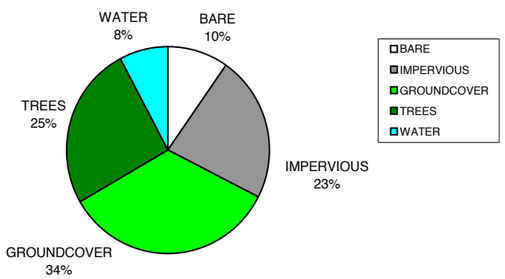
Some development in the City of Palmetto reduced tree canopy and ground cover.

Environmental Statistics 2004

Total area (acres).....	3,498
Forest canopy (acres).....	614
Forest canopy (percent of total area).....	18
Carbon sequestration (tons per year).....	206
Total carbon stored (tons).....	26,420
Annual value of C removal.....	$10,300
(based on $50 per ton for removal)	
Additional storage needed (cubic feet).....	3,669,410
(if trees were replaced with impervious surface)	
Annual stormwater value.....	$639,832
(based on $2 per cu ft for construction of facilities)	
Total air pollution removal (pounds per yr)	78,265
Annual pollutant removal value.....	$204,197
(based on health care cost, lost tourism)	
**Total Annual Value..... **	**$854,329**

Palmetto 2009 population 13,429

Land Cover



Canopy grow-out observed in 2009

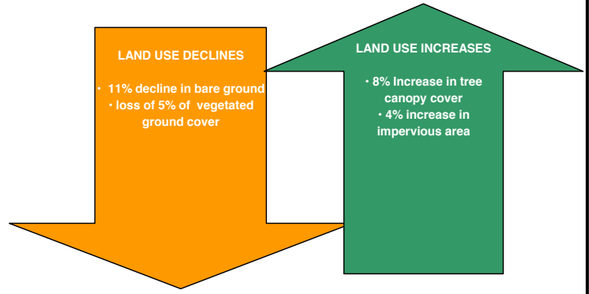
Tree canopy cover increased in 2009 from 2004 in many areas by growth of individual trees, as seen in this photo.

Environmental Statistics 2009

Total area (acres).....	3,500
Forest canopy (acres).....	892
Forest canopy (percent of total area).....	25
Carbon sequestration (tons per year).....	299
Total carbon stored (tons).....	38,385
Annual value of C removal.....	$14,950
(based on $50 per ton for removal)	
Additional storage needed (cubic feet).....	5,416,343
(if trees were replaced with impervious surface)	
Annual stormwater value.....	$944,443
(based on $2 per cu ft for construction of facilities)	
Total air pollution removal (pounds per yr).....	113,708
Annual pollutant removal value.....	$296,670
(based on health care cost, lost tourism)	
**Total Annual Value..... **	**$1,163,591**

E Sciences analyzed 2004 and 2009 aerial photographs of the City of Palmetto in Manatee County using ERDAS Imagine 2010 and American Forests' CITYGreen. Changes to land cover during this period indicate a reduction in vacant (bare) land, with an increase in tree canopy and a decrease in other vegetated cover. Impervious surface levels increased slightly. This type of change in land use can be the result of growth of the tree canopy. An increase in canopy size provides net environmental benefits that are realized from the increased woody mass, which more than offset the effects of the additional impervious surfaces.

As of 2009 the Palmetto forest canopy is responsible for sequestering 299 tons of carbon from the atmosphere every year. The gain of approximately 278 acres of tree canopy between 2004 and 2009 increased the annual carbon sequestration rate by 93 tons. The forest is currently storing 38,385 tons of carbon within the biomass of standing trees, which helps reduce atmospheric carbon that otherwise would contribute to climate change. These trees are also reducing air and water pollution by annually: a) removing almost 113,700 lbs of air pollutants, and b) filtering water through roots and leaves, thus performing stormwater management functions equivalent to $944,443 that otherwise would have had to be spent on constructing facilities to treat and store the same amount of stormwater. In total, Palmetto's urban tree canopy is providing environmental benefits worth $1,131,257 each year.



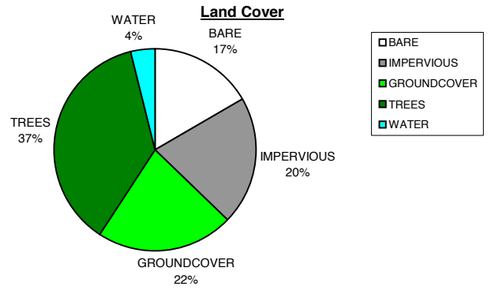
Longboat Key** Urban Landscape Functional Analysis

(area within Manatee County only)**

2004 to 2009 Comparison

Longboat Key 2004, Population 7,578

Land Cover



Urban/coastal section of Longboat Key in 2004

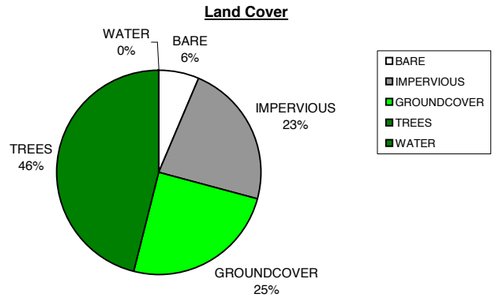
Already urbanized in 2004, the City of Longboat Key did not have large-scale land developments or similar land use changes.

Environmental Statistics 2004

Total area (acres)…..	1,096
Forest canopy (acres)…..	405
Forest canopy (percent of total area)…..	37
Carbon sequestration (tons per year)…..	136
Total carbon stored (tons)…..	17,440
Annual value of C removal…..	$6,800
(based on $50 per ton for removal)	
Additional storage needed (cubic feet)…..	4,369,940
(if trees were replaced with impervious surface)	
Annual stormwater value…..	$761,983
(based on $2 per cu ft for construction of facilities)	
Total air pollution removal (pounds per yr)	51,662
Annual pollutant removal value…..	$134,790
(based on health care cost, lost tourism)	
**Total Annual Value….. **	**$903,573**

Longboat Key 2009, Population 7,263

Land Cover



Same section of Longboat Key in 2009

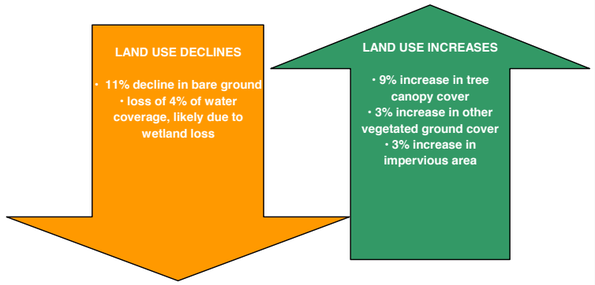
Some areas of existing trees have grown and filled out, while some areas of mangroves have expanded. Areas that were bare in 2004 have been planted, or have had natural recruitment of trees or other vegetation.

Environmental Statistics 2009

Total area (acres)…..	1,115
Forest canopy (acres)…..	512
Forest canopy (percent of total area)…..	46
Carbon sequestration (tons per year)…..	171
Total carbon stored (tons)…..	22,020
Annual value of C removal…..	$8,550
(based on $50 per ton for removal)	
Additional storage needed (cubic feet)…..	5,462,666
(if trees were replaced with impervious surface)	
Annual stormwater value…..	$952,520
(based on $2 per cu ft for construction of facilities)	
Total air pollution removal (pounds per yr)…..	65,229
Annual pollutant removal value…..	$170,187
(based on health care cost, lost tourism)	
**Total Annual Value….. **	**$1,131,257**

E Sciences analyzed 2004 and 2009 aerial photographs of the City of Longboat Key in Manatee County using ERDAS Imagine 2010 and American Forests' CITYGreen. Changes to land cover during this period indicate a reduction in vacant (bare) land, with increases in tree canopy and other vegetated cover, while impervious surface levels increased only slightly. Water (including wetlands) decreased. This type of change in land use can be the result of the conversion of empty lots to new developments with landscaping, growth of existing trees, and expansion of mangroves. In this scenario, despite the conversion of agricultural land use to residential land use, certain net environmental benefits are realized from the increased woody landscape plantings which more than offset the effects of the additional impervious surfaces.

As of 2009, the Longboat Key forest canopy is responsible for sequestering 171 tons of carbon from the atmosphere every year. The gain of approximately 107 acres of tree canopy between 2004 and 2009 increased the annual sequestration rate by 35 tons. The forest is currently storing 22,020 tons of carbon within the biomass of standing trees, which helps reduce atmospheric carbon that otherwise would contribute to climate change. These trees are also reducing air and water pollution by annually: a) removing almost 65,200 lbs of air pollutants, and b) filtering water through roots and leaves, thus performing stormwater management functions equivalent to $952,520 that otherwise would have had to be spent on constructing facilities to treat and store the same amount of stormwater. In total, Longboat Key's urban tree canopy is providing environmental benefits worth $1,131,257 each year.



based on poor air quality. These costs are developed for each state by economists at the Public Services Commission.

Stormwater Management and Additional Storage Needed

The urban tree canopy reduces peak stormwater flows during a storm event and cycles water from the soil into the atmosphere through transpiration. By incorporating trees into construction projects, municipalities and private developers can save money on stormwater management facilities. CITYgreen utilizes formulas and local rainfall, slope and soil type data from the NRCS to estimate runoff volume and the time of concentration and peak flow of storm events. The model used in CITYgreen is known as Technical Release 55 (TR-55) and is a commonly-accepted model to determine effects of landcover changes on stormwater runoff. The model analyzes runoff patterns during a single, 24-hour, average intensity storm event and estimates the additional stormwater storage capacity that would be needed (i.e., Additional Storage Needed) if the existing tree canopy was removed and replaced with impervious surfaces. Dollar values are estimates of the cost to construct and maintain the stormwater facilities required to manage stormwater in the absence of the tree canopy. CITYgreen assumes a standard default construction cost of $2 per cubic foot of water storage financed for 20 years at 6 percent interest. It should be noted that if the stormwater facilities sufficient to manage a site's stormwater are already constructed, planting trees will not result in an actual savings in stormwater costs.

3.0 Urban Canopy Summary

A CITYgreen analysis was conducted for each study year (2004 and 2009) on each of the six municipalities in Manatee County (Anna Maria, Bradenton, Bradenton Beach, Holmes Beach, Longboat Key - only the portion within Manatee County, and Palmetto) and on the portion of Manatee County (i.e., unincorporated Manatee County) that does not lie within any of the six municipal boundaries, for a total of seven analyses. The data for each study year at each study location was analyzed and the results were used to create one-page summary sheets. These sheets provide the results of this study and can be found in Section 5.0 of this report.

Based on this analysis, the urban forest canopy of Manatee County in 2009 is 176,223 acres, or 37 percent of the total land area of the county. As a comparison, the Urban Ecosystem Analysis conducted by American Forests in 2008 found that Miami Dade County had an urban forest canopy covering 18 percent of its total area in 2006. According the Broward County Climate Change Action Plan, Broward County currently has an urban forest canopy covering 13 percent of the county. Broward County has set 40 percent coverage as its goal. Forty percent is the urban forest canopy coverage recommended by American Forests.

Overall, there was a net increase of tree canopy in Manatee County over the study period (2004 to 2009). This is likely due to the growth of existing trees, including those overly pruned or damaged during the active 2004 hurricane season, and the fact that population growth within the county has primarily been focused within the unincorporated agricultural areas, where development replaces farm land rather than wooded areas. Developments include new buildings and roads (impervious surfaces), but also include

woody and herbaceous landscape vegetation. These landcover classes, along with impervious surfaces, saw increases throughout the county.

Table 1 below summarizes changes to Manatee County's urban forest canopy and populations between the study years for the County's incorporated and unincorporated areas. The incorporated areas include the six municipalities within Manatee County. The unincorporated areas are the areas that do not fall within a municipal boundary.

Table 1: 2009 Urban Forest Canopy Analysis of Manatee County

Municipality	Percent Coverage	2009 Population*	Percent Canopy Change Since 2004	Percent Population Change Since 2004*
Manatee County	37%	318,361	11%	7%
Unincorporated	39%	234,191	13%	9%
Incorporated	32%	84,170	8%	2%

*from US Census Bureau data

The six municipalities within Manatee County were analyzed for urban forest canopy area changes over the study period (2004 to 2009). Please see Table 2 below for a summary of the results:

Table 2: 2009 Urban Forest Canopy Analysis of Manatee County Municipalities

Municipality	Percent Coverage	2009 Population*	Percent Canopy Change Since 2004	Percent Population Change Since 2004*
Anna Maria	30%	1,831	-2%	-1%
Bradenton	33%	53,973	9%	1%
Bradenton Beach	27%	1,577	-4%	3%
Holmes Beach	35%	7,263	5%	-4%
Longboat Key	46%	5,119	9%	1%
Palmetto	25%	14,407	8%	7%

*from US Census Bureau data

Four of Manatee County's municipalities exhibited an increase in urban forest canopy during the study period. This may be due to canopy growth of existing trees, including those that were excessively pruned prior to, or damaged during the 2004 hurricane season, including mangrove communities, which are vital to protecting shorelines, especially during hurricanes and other storms. Other factors that may affect canopy cover are overmaturity, wrong tree planted in the wrong place, utility conflicts and previous injuries. KMB advocates for a tree inventory to identify the highest priority treatment needs on the ground and the budget required to meet these needs.

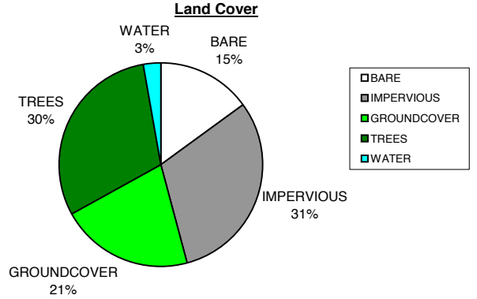
As indicated in Table 1, incorporated areas within Manatee County have a smaller percentage of urban forest canopies than the unincorporated areas of the County. However, Manatee County municipalities rate well overall when compared to other Florida cities in terms of urban forest canopy cover. A 2006 analysis of the City of Miami performed by American Forests found that the city's urban forest canopy

Holmes Beach Urban Landscape Functional Analysis

2004 to 2009 Comparison

Holmes Beach 2004 population 5,051

Land Cover



Urbanized section of Holmes Beach in 2004

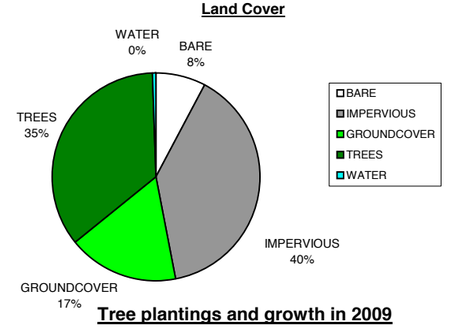
Already urbanized in 2004, the City of Holmes Beach did not have large-scale land developments or similar land use changes.

Environmental Statistics 2004

Total area (acres).....	1,001
Forest canopy (acres).....	301
Forest canopy (percent of total area).....	30
Carbon sequestration (tons per year).....	101
Total carbon stored (tons).....	12,956
Annual value of C removal.....	$5,050
(based on $50 per ton for removal)	
Additional storage needed (cubic feet).....	4,694,013
(if trees were replaced with impervious surface)	
Annual stormwater value.....	$818,491
(based on $2 per cu ft for construction of facilities)	
Total air pollution removal (pounds per yr)	38,330
Annual pollutant removal value.....	$100,136
(based on health care cost, lost tourism)	
**Total Annual Value..... **	**$923,677**

Holmes Beach 2009 population 5,119

Land Cover



Tree plantings and growth in 2009

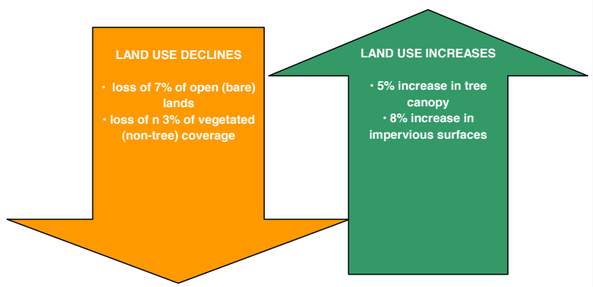
Land use changes occurring within the City primarily occurred on individual lots; removing or planting trees, expanding driveways, constructing new buildings or building additions on a small scale.

Environmental Statistics 2009

Total area (acres).....	992
Forest canopy (acres).....	351
Forest canopy (percent of total area).....	35
Carbon sequestration (tons per year).....	118
Total carbon stored (tons).....	15,096
Annual value of C removal.....	$5,900
(based on $50 per ton for removal)	
Additional storage needed (cubic feet).....	5,797,481
(if trees were replaced with impervious surface)	
Annual stormwater value.....	$1,010,902
(based on $2 per cu ft for construction of facilities)	
Total air pollution removal (pounds per yr).....	44,720
Annual pollutant removal value.....	$116,676
(based on health care cost, lost tourism)	
**Total Annual Value..... **	**$1,133,478**

E Sciences analyzed 2004 and 2009 aerial photographs of the City of Holmes Beach in Manatee County using ERDAS Imagine 2010 and American Forests' CITYGreen. Changes to land cover during this period reflect a general pattern of development; bare ground and non-woody vegetative land cover (including agriculture) decreased while impervious surfaces and trees increased. Water area showed a steep decline. This is likely due to development of wetlands or ponded farmland that were classified as water. Tree canopy cover actually showed a modest increase which could be somewhat due to discrepancies in aerial analysis but is also likely due to landscaping in new developments on former agricultural lands.

As of 2009 the Holmes Beach forest canopy is responsible for sequestering 118 tons of carbon from the atmosphere every year. The gain of tree canopy despite development activities has provided a net increase in carbon sequestration of 17 tons per year. The forest is currently storing more than 2,000 tons of carbon within the biomass of standing trees, which helps reduce atmospheric carbon that otherwise would contribute to climate change. The trees of Holmes Beach are also reducing air and water pollution by annually: a) removing almost 44,720 lbs of air pollutants, and b) filtering water through roots and leaves, thus performing stormwater management functions equivalent to $1,010,902 that otherwise would have had to be spent on constructing facilities to treat and store the same amount of stormwater. In total, Holmes Beach's urban tree canopy is providing environmental benefits worth $1,133,478 each year.

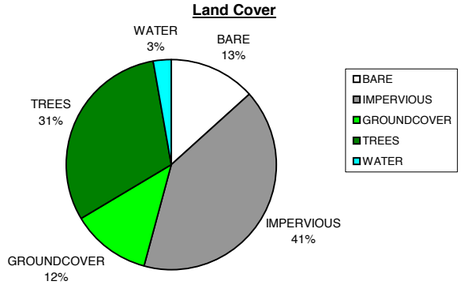


Bradenton Beach Urban Landscape Functional Analysis

2004 to 2009 Comparison

Bradenton Beach 2004 population 1,537

Land Cover



Urbanized section of Bradenton Beach in 2004

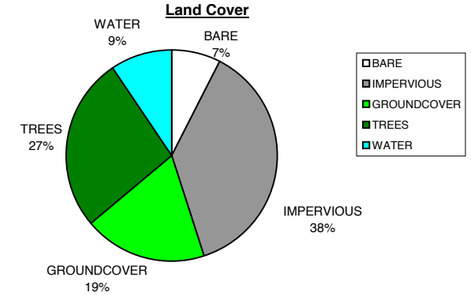
In 2004, Bradenton Beach was already very urbanized, with few options for land use changes other than redevelopment

Environmental Statistics 2004

Total area (acres).....	318
Forest canopy (acres).....	99
Forest canopy (percent of total area).....	31
Carbon sequestration (tons per year).....	33
Total carbon stored (tons).....	4,243
Annual value of C removal.....	$1,650
(based on $50 per ton for removal)	
Additional storage needed (cubic feet).....	1,152,112
(if trees were replaced with impervious surface)	
Annual stormwater value.....	$200,893
(based on $2 per cu ft for construction of facilities)	
Total air pollution removal (pounds per yr)	12,570
Annual pollutant removal value.....	$32,795
(based on health care cost, lost tourism)	
Total Annual Value.....	**$235,338**

Bradenton Beach 2009 population 1,577

Land Cover



Same section of Bradenton Beach in 2009

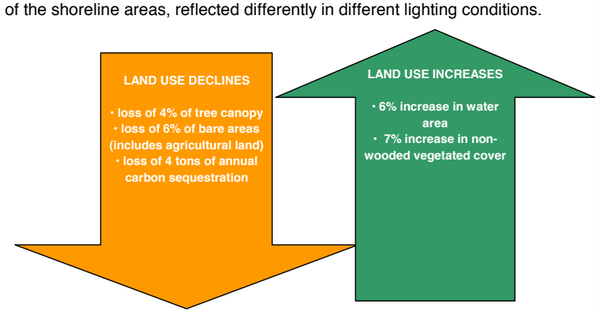
In 2009, land use remained largely unchanged, with land use changes largely restricted to minor actions (landscaping, new paving) on individual parcels.

Environmental Statistics 2009

Total area (acres).....	318
Forest canopy (acres).....	85
Forest canopy (percent of total area).....	27
Carbon sequestration (tons per year).....	29
Total carbon stored (tons).....	3,666
Annual value of C removal.....	$1,450
(based on $50 per ton for removal)	
Additional storage needed (cubic feet).....	986,820
(if trees were replaced with impervious surface)	
Annual stormwater value.....	$172,071
(based on $2 per cu ft for construction of facilities)	
Total air pollution removal (pounds per yr).....	10,861
Annual pollutant removal value.....	$28,337
(based on health care cost, lost tourism)	
Total Annual Value.....	**$201,858**

E Sciences analyzed 2004 and 2009 aerial photographs of the City of Bradenton Beach in Manatee County using ERDAS Imagine 2010 and American Forests' CITYGreen. Changes to land cover during this period appear to have been minimal, with the only major land use changes showing a decrease in bare ground by six percent and an increase vegetated ground covering by seven percent. These changes may be the result of small-scale activities (paving, landscaping) on individual parcels. The analysis indicated that the impervious cover actually dropped slightly (by three percent) and water surface area increased by six percent; this data may be the result of the difference in the aerial photos that were computer-analyzed (with higher quality aerials for 2009) and possibly some variations in photographic land use interpretation of the shoreline areas, reflected differently in different lighting conditions.

As of 2009 the Bradenton Beach forest canopy is responsible for sequestering over 29 tons of carbon from the atmosphere every year. The loss of 14 acres of forested lands between 2004 and 2009 reduced the annual sequestration rate by 4 tons. The forest is currently storing more than 3,600 tons of carbon within the biomass of standing trees, which helps reduce atmospheric carbon that otherwise would contribute to climate change. These trees are also reducing air and water pollution by annually: a) removing almost 11,000 lbs of air pollutants, and b) filtering water through roots and leaves, thus performing stormwater management functions equivalent to $172,071 that otherwise would have had to be spent on constructing facilities to treat and store the same amount of stormwater. In total, Bradenton Beach's urban tree canopy is providing environmental benefits worth $201,858 each year.



covered 21 percent of the city. A 2006 survey conducted by the University of South Florida, University of Florida (UF) and the Hillsborough County Extension Service found that City of Tampa Bay has urban forest coverage of 28 percent. A study conducted by the UF/ Institute of Food and Agricultural Sciences (IFAS) Extension found that Pensacola and its surrounding urbanized areas have an urban forest canopy coverage of 13 percent, while Gainesville, a more rural community, had a forest cover of 51 percent in 2006. This data is summarized below in Table 3.

Table 3: Urban Forest Canopy Analyses of Other Florida Municipalities

Municipality	Percent Coverage	2009 Population*	Study Year
Miami	21%	433,136	2006
Tampa Bay	28%	343,890	2006
Pensacola	13%	53,752	2006 - 2008
Gainesville	51%	116,616	2006

*from US Census Bureau

Environmental Function Analysis

Using CITYgreen software, scientists evaluated Manatee County's urban forest canopy for the following environmental benefits: carbon storage and sequestration, air pollutant removal, and stormwater management. The results based on the 2009 urban forest canopy can be seen in Tables 4, 5 and 6.

Table 4 below indicates that the Manatee County urban forest canopy is sequestering 58,308 tons of carbon from the atmosphere every year. The trees that make up the urban forest canopy have sequestered and are currently storing 7,489,448 tons of carbon, which is an increase of 2,102,513 tons since 2004. It should be noted that if these trees are burned, or die and decay, the carbon is released back into the system. This occurs quickly when wood is burned or slowly if the trees decay. The re-use of trees in wood products allows the carbon to remain stored. The amount of carbon stored in existing trees makes the preservation of mature existing trees critical to the continued removal of carbon dioxide from the atmosphere.

Table 4: Carbon Storage and Sequestration Benefits for Manatee County (in tons)

Municipality	Percent Coverage	Carbon Sequestration	Carbon Storage	Change in Carbon Storage Since 2004
Anna Maria	30%	47	6,042	-329
Bradenton	33%	1,030	132,271	35744
Bradenton Beach	27%	29	3,666	-577
Holmes Beach	35%	118	15,096	2140
Longboat Key	46%	171	22,020	4580
Palmetto	25%	299	38,385	11965
Unincorporated	39%	56,614	7,271,968	2,048,990
Total	**37%**	**58,308**	**7,489,448**	**2,102,513**

The County's tree canopy is removing harmful pollutants such as NO_2, SO_2, O_3, CO and PM10 from the atmosphere based on the coverage of the urban forest canopy. This is especially important in the urban areas, where people, cars and industry are concentrated. More pollutants are removed from the air when there is more canopy (i.e. more leaves) to take in the compounds. The total amount of the pollutants studied being removed by Manatee County's urban forest every year based on the urban forest canopy in 2009 is 22,463,496 pounds. Because of the increase in urban canopy area over the study period, 6,018,771 more pounds of these pollutants are being removed each year from the County's breathable air since 2004.

Table 5: 2009 Air Pollutant Removal Benefits for Manatee County (pounds per year)

Municipality	Percent Coverage	NO_2	SO_2	O_3	CO	PM10	Total
Anna Maria	30%	1,397	3,004	7,260	626	5,633	17,920
Bradenton	33%	30,140	65,761	158,921	13,700	123,301	391,823
Bradenton Beach	27%	835	1,823	4,405	380	3,418	10,861
Holmes Beach	35%	3,440	7,505	18,138	1,564	14,073	44,720
Longboat Key	46%	5,018	10,948	26,457	2,281	20,527	65,231
Palmetto	25%	8,747	19,084	46,119	3,976	35,782	113,708
Unincorporated	39%	1,657,051	3,615,381	8,737,177	753,205	6,778,843	21,541,657
Total	**37%**	**1,706,628**	**3,723,506**	**8,998,477**	**775,732**	**6,981,577**	**22,185,920**

Table 6 below shows the amount of additional water management capacity that would be required if existing trees were to be replaced with impervious surface. These numbers are based on calculations that incorporate canopy information and local data on two-year, 24-hour rainfall data, rainfall type and soil types from the NRCS. The rainfall data is an average over a 100-year period and is provided by the NRCS on a map that breaks down the information to the County level in the US. For the purpose of the CITYgreen model, this level of accuracy is sufficient.

Table 6: Stormwater Management Benefits for Manatee County 2009

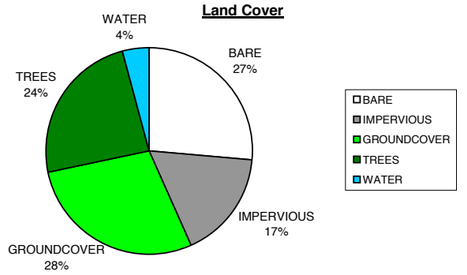
Municipality	Percent Coverage	Additional Storage Needed ft^3	Two-year, 24-hour Rainfall (inches)
Anna Maria	30%	2,298,502	4.75
Bradenton	33%	33,722,310	4.75
Bradenton Beach	27%	1,152,112	4.75
Holmes Beach	35%	5,797,481	4.75
Longboat Key	46%	542,666	4.75
Palmetto	25%	5,416,343	4.75
Unincorporated	39%	906,153,726	4.75-5
Total	**37%**	**955,083,140**	**-**

ft^3 = cubic feet

Bradenton Urban Landscape Functional Analysis
2004 to 2009 Comparison

Bradenton 2004 population 53,180

Land Cover



Section of Bradenton in 2004 including golf course

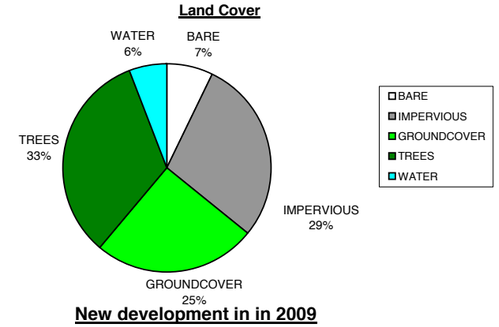
While the majority of the City was urban in 2004, some open space areas existed within the City such as the golf course on the left-hand side of the picture (included in the groundcover land use category).

Environmental Statistics 2004

Total area (acres).....	9,249
Forest canopy (acres).....	2,243
Forest canopy (percent of total area).....	24
Carbon sequestration (tons per year).....	751
Total carbon stored (tons).....	96,527
Annual value of C removal.....	$37,550
(based on $50 per ton for removal)	
Additional storage needed (cubic feet).....	23,474,002
(if trees were replaced with impervious surface)	
Annual stormwater value.....	$4,093,141
(based on $2 per cu ft for constuction of facilities)	
Total air pollution removal (pounds per yr)	285,939
Annual pollutant removal value.....	$746,032
(based on health care cost, lost tourism)	
**Total Annual Value..... **	**$4,876,723**

Bradenton 2009 population 53,973

Land Cover



New development in in 2009

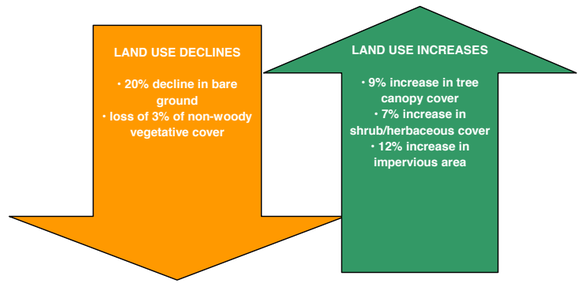
By 2009, some of the open spaces within the City, such as the golf course on the left, had been filled. This reduced the land in the groundcover category, and added impervious cover and additional water areas.

Environmental Statistics 2009

Total area (acres).....	9,256
Forest canopy (acres).....	3,074
Forest canopy (percent of total area).....	33
Carbon sequestration (tons per year).....	1,030
Total carbon stored (tons).....	132,271
Annual value of C removal.....	$51,500
(based on $50 per ton for removal)	
Additional storage needed (cubic feet).....	33,722,310
(if trees were replaced with impervious surface)	
Annual stormwater value.....	$5,880,129
(based on $2 per cu ft for constuction of facilities)	
Total air pollution removal (pounds per yr).....	391,823
Annual pollutant removal value.....	$1,022,290
(based on health care cost, lost tourism)	
**Total Annual Value..... **	**$6,953,919**

E Sciences analyzed 2004 and 2009 aerial photographs of the City of Bradenton in Manatee County using ERDAS Imagine 2010 and American Forests' CITYGreen. Changes to land cover during this period indicate a large decrease in vacant (bare) land (which includes fallow crop land), along with a 3% decrease in grass and other vegetation covered lands. Accompanying these decreases is an increase of 12% of impervious cover, with a 9% increase in tree cover. This type of change in land use can be the result of the conversion of large areas of barren land or even farmland to housing and commercial developments with significant landscaping. In this scenario, despite the conversion of agricultural land use to residential land use, certain net environmental benefits are realized from the increased woody landscape plantings which more than offset the effects of the additional impervious surfaces.

As of 2009 the Bradenton forest canopy is responsible for sequestering 1,030 tons of carbon from the atmosphere every year. The gain of approximately 830 acres of tree canopy between 2004 and 2009 increased the annual sequestration rate by 279 tons. The forest is currently storing 132,271 tons of carbon within the biomass of standing trees, which helps reduce atmospheric carbon that otherwise would contribute to climate change. These trees are also reducing air and water pollution by annually: a) removing almost 391,823 lbs of air pollutants, and b) filtering water through roots and leaves, thus performing stormwater management functions equivalent to $5,880,129 that otherwise would have had to be spent on constructing facilities to treat and store the same amount of stormwater. In total, Bradenton's urban tree canopy is providing environmental benefits worth $6,953,919 each year.

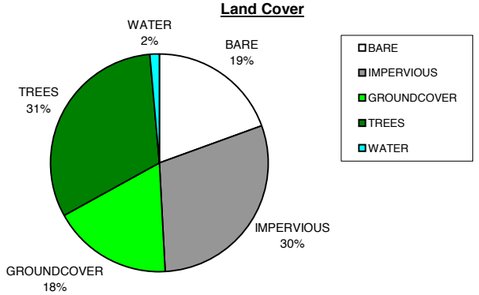


Anna Maria Urban Landscape Functional Analysis

2004 to 2009 Comparison

Anna Maria 2004 population 1,853

Land Cover



Built-out section of Anna Maria in 2004

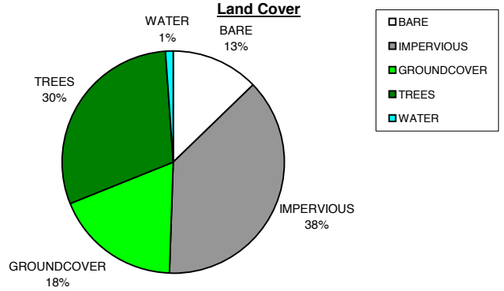
Already urbanized in 2004, the City of Anna Maria did not have large-scale land developments or similar land use changes.

Environmental Statistics 2004

Total area (acres)…..	468
Forest canopy (acres)…..	148
Forest canopy (percent of total area)…..	31
Carbon sequestration (tons per year)…..	50
Total carbon stored (tons)…..	6,371
Annual value of C removal…..	$2,500
(based on $50 per ton for removal)	
Additional storage needed (cubic feet)…..	2,324,333
(if trees were replaced with impervious surface)	
Annual stormwater value…..	$405,292
(based on $2 per cu ft for construction of facilities)	
Total air pollution removal (pounds per yr)	18,871
Pollutant removal value…..	$49,236/ yr
(based on health care cost, lost tourism)	
Total Annual Value…..	**$457,028**

Anna Maria 2009 population 1,831

Land Cover



Same section of Anna Maria in 2009

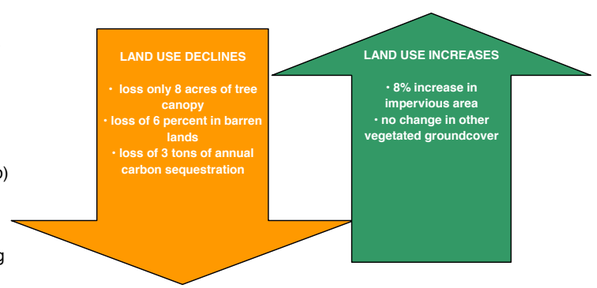
Land use changes occurring within the City primarily occurred on individual lots; removing trees, expanding driveways, constructing new buildings or building additions on a small scale.

Environmental Statistics 2009

Total area (acres)…..	468
Forest canopy (acres)…..	140
Forest canopy (percent of total area)…..	30
Carbon sequestration (tons per year)…..	47
Total carbon stored (tons)…..	6,042
Annual value of C removal…..	$2,350
(based on $50 per ton for removal)	
Additional storage needed (cubic feet)…..	2,298,502
(if trees were replaced with impervious surface)	
Annual stormwater value…..	$400,788
(based on $2 per cu ft for construction of facilities)	
Total air pollution removal (pounds per yr)…..	17,899
Pollutant removal value…..	$46,700/ yr
(based on health care cost, lost tourism)	
Total Annual Value…..	**$449,828**

E Sciences analyzed 2004 and 2009 aerial photographs of the City of Anna Maria in Manatee County using ERDAS Imagine 2010 and American Forests' CITYGreen. Changes to land cover during this period include an eight percent increase in impervious surface cover (i.e. buildings and roadways) with a relatively small decrease (one percent) in tree canopy. This, correlated with the loss of bare ground and sod (which may include vacant lots) indicates that new development may have been targeted toward unforested lands and that trees lost by new development may have been at least in part compensated for by new plantings.

As of 2009 the Anna Maria forest canopy covers 30% of the city and is responsible for sequestering 47 tons of carbon from the atmosphere every year. The loss of 8 acres of forested lands between 2004 and 2009 reduced the annual sequestration rate by 3 tons. The forest is currently storing more than 6,000 tons of carbon within the biomass of standing trees, which helps reduce atmospheric carbon that otherwise would contribute to climate change. These trees are also reducing air and water pollution by annually: a) removing almost 18,000 lbs of air pollutants, and b) filtering water through roots and leaves, thus performing stormwater management functions equivalent to $400,788 that otherwise would have had to be spent on constructing facilities to treat and store the same amount of stormwater. In total, Anna Maria's urban tree canopy is providing environmental benefits worth $449,828 each year.



Economic values can be applied to the environmental benefits provided in the preceding tables. Table 7 below shows the dollar values of the environmental benefits provided by Manatee County's urban forest canopy in 2009.

Table 7: Annual Value of Urban Forest Benefits Based on 2009 Canopy

Municipality	Percent Coverage	Carbon Sequestration	Air Pollutant Removal	Stormwater Management	Total Benefits
Anna Maria	30%	$2,350	$46,700	$400,778	$449,828
Bradenton	33%	$51,500	$1,022,290	$5,880,129	$6,953,919
Bradenton Beach	27%	$1,450	$28,337	$172,071	$201,858
Holmes Beach	35%	$5,900	$116,676	$1,010,902	$1,133,478
Longboat Key	46%	$8,550	$170,187	$952,520	$1,131,257
Palmetto	25%	$14,950	$204,198	$944,443	$1,163,591
Unincorporated	39%	$2,830,700	$56,203,429	$160,594,116	$219,628,245
Total	**37%**	**$2,915,400**	**$57,791,817**	**$169,954,959**	**$230,662,176**

It should be noted that the cost to provide carbon sequestration by a CO_2 removal system (ex: by using a carbon scrubbing technology) is saved by planting trees. In addition, increased health costs as a result of air pollution and mitigation efforts costs required as a result of climate change are reduced by planting trees. Also, as noted above, trees planted where there are already sufficient stormwater management facilities will not save the general public money. The purpose of calculating and sharing these figures is to demonstrate the market value of the functional benefits that trees provide.

When analyzed for carbon sequestration and storage, air pollutant removal and stormwater management, Manatee County's urban forest canopy provides the equivalent $230,662,176 in environmental benefits to its residents.

4.0 Conclusions and Recommendations

With an urban forest canopy covering 37 percent of its area, Manatee County is close to meeting the 40 percent target set by American Forests for urban forest coverage and has significantly more canopy coverage than other counties for which similar studies have been performed within the state of Florida. Unincorporated areas have canopy coverage of 39 percent, which is an increase of 11 percent since 2004. Manatee County's incorporated areas have a combined urban forest cover of 32 percent, which is higher than that of Miami, Tampa Bay and Pensacola. Canopy coverage in four of Manatee County's six cities, including its two largest, has increased by as much as nine percent since 2004.

These positive results reinforce the need for Manatee County to protect and increase the area of the urban forest canopy. Below are conclusions and recommendations for the unincorporated and incorporated portions of the county.

Unincorporated areas

Changes to landcover in the unincorporated areas of the county and population data from the US Census Bureau indicate that there has been growth in new housing construction in agricultural areas. Between 2004 and 2009, vegetated fields, agricultural areas and bare ground (i.e. vacant lots, grass fields or fallow crop land) decreased while impervious areas showed modest increases and tree cover and shrub cover typically increased. Water coverage, which includes some areas of wetlands, decreased. These landcover changes are likely due to home and roadway construction and the installation of landscape vegetation in new developments that were constructed on former crop land/bare ground during this period. These results are consistent with population trends noted above.

These results would suggest that new development can actually produce positive environmental benefits when trees and landscapes are included in the development and when any existing trees are preserved. It can also save money. As noted above, including trees in the development can reduce the need for some stormwater management facility construction. KMB should continue to work with the Manatee County government and developers to ensure that new developments incorporate both appropriate landscape vegetation in new projects, as well as preservation of existing stands of trees to provide positive environmental benefits to the residents.

Incorporated areas

In only two municipalities (Anna Maria and Bradenton Beach) was there a decrease in tree canopy over this time period. As noted above, most municipalities experienced flat population growth or even a small decline over this period. Development within the municipalities was likely limited during the study period. Increases in tree canopy in the other municipalities are likely a result of mature tree growth, the planting of new trees, and growth of mangrove forests along the coastal portions of the municipalities. Decreases in canopy may be the result of mature urban trees being lost to storms or bad maintenance practices, loss of trees to new development, or the loss of mangrove forest to storms or development.

Tree protection is important in any community, and the landscape codes for each municipality should reflect a commitment to preserve mature trees and to plant new trees when developing new projects. Often, developers remove mature trees because they can create more lots or larger homes without them. However, mature trees provide more environmental benefit than new trees. Because they have more leaves and more woody mass, mature trees sequester and store more carbon, filter more air pollutants and reduce more peak stormwater flow than new, smaller trees. Additionally, larger, mature trees provide shade for pedestrian walkways and for buildings, encouraging less usage of cars and reducing building energy costs.

Older trees in municipalities face difficult conditions, including poor soils that become compacted over time, injury from lawn mowers, weed whackers or other mechanical means and/or root injury due to digging or trenching. Public trees (i.e. street trees, median trees and park trees) must be properly maintained by municipal maintenance staff. Trees within private property should also be protected by the landscape code. Property owners should be educated about the importance of a substantial, healthy forest

canopy, which includes all of the trees in the county – including those on private lands. Trees that are removed from both private and public lands within the municipalities should be replaced with enough trees so that there is no net loss of total canopy.

The focus of tree conservation measures may differ based on whether you are in a suburban or urban environment. Suburban and rural areas may do best to focus on requirements for tree plantings and preservation for new developments. Urban areas may do best to focus on maintaining existing trees, which, due to more stress from impervious surfaces and competing issues such as utility lines, require maintenance such as pruning, pest management and fertilization.

Urban areas can also greatly benefit from revitalization projects that conserve existing trees and introduce new trees into cityscapes with few or no trees. Studies have shown that, because trees create a positive environment that attracts and welcomes consumers, pedestrians tend to shop and linger longer along tree lined streets. Placing a value on trees in a retail setting is challenging; however, in a national study conducted by the University of Washington, consumers' rating of business districts was quantified. The results indicated the consumers' rating for categories such as quality of products and amenities were higher for districts with street trees and other landscaping. For example, survey respondents were asked to specify a price for a "basket" of 15 items ranging from a bouquet of flowers to sports shoes. The survey participants consistently priced goods **11 percent higher** for items from a landscaped area vs. a "no-tree" district. The results were similar for parking, where survey respondents indicated they were willing to pay higher prices in well-landscaped districts. This suggests greater revenues from parking could offset the cost of parking space loss, a concern often expressed by merchants. In the words of the report: Trees make a difference! (www.cfr.washington.edu).

5.0 One-Page Urban Forestry Analysis Reports

The following pages include one-page reports for each of the six municipalities, and unincorporated Manatee County. These sheets can be used to highlight changes that have occurred between the study years 2004 through 2009, communicate the environmental value of the urban forest canopy, and document the monetary value of these environmental benefits.