Urban Tree Canopy Assessment

Township of Ocean, New Jersey 2002 and 2010

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Acronyms

AOI – Area of interest

APFO – The Aerial Photography Field Office

EPA – Environmental Protection Agency

FSA – Farm Service Agency

GEC – Global Ecosystem Center, LLC

GIS – Geographic Information System

L-THIA – Long-Term Hydrological Impact Assessment

NAIP – The National Agriculture Imagery Program

NRCS – Natural Resources Conservation Service

NJ – New Jersey

NJDEP GIS – New Jersey Department of Environmental Protection Bureau of Geographic Information Systems

UEA – Urban Ecosystem Analysis

UFORE – The Urban Forest Effects

USDA – United States Department of Agriculture

UT - Utah

UTCA – Urban Tree Canopy Assessment

Overview

This document describes the data, process, and findings of the Urban Tree Canopy Assessment (UTCA) conducted by the Global Ecosystem Center for Ocean Township, NJ. The data that is collected and analyzed to produce the UTCA findings is extensive and provides the community with facts and figures that go well beyond the contractual requirements of the UTCA. Details of these findings have been extensively documented in this report in the form of graphs and charts. These detailed findings will be provided to the community in the form of GIS data, but are not the focus of the report dialogue. The written part of the report will focus on the tree canopy.

Executive Summary

The findings of the analysis show that the existing tree canopy covered 35% of the Township in 2010, 1% lower than eight years earlier. However, after a careful inspection of the data from the imagery, it became apparent that significant changes in the Township's land cover had occurred just prior to the 2002 benchmark. The 2002 imagery revealed that considerable new construction of residential land was underway.

Although the tree cover may have been much higher prior to the 2002 benchmark, other land cover changes are considered in the UTCA calculations which reveal the impact of the loss of tree cover. The analysis revealed an increase of 9% in impervious surfaces and a 2% loss in open space, and both these factors are included in the engineering calculations for stormwater and water quality along with tree cover. The combined loss of tree cover and increase in impervious surfaces produced significant changes in the ecological services that were provided by the land cover even though the tree loss was only documented at 1%. The changes in land cover resulted in increased stormwater management costs and a decline in air and water quality. Detailed accountings of these changes are documented in the report's graphs and charts.

To reverse the negative impacts of these changes, which have a direct cost on infrastructure management, it is highly recommended that the tree cover in the Township be increased 5%. By increasing the tree canopy from 35% to 40%, significant financial and social benefits would result. In addition, these benefits should be evaluated as part of the growth, development and infrastructure maintenance implemented in the future by the Township.

The 40% tree canopy recommendation was determined by evaluating the structure of the Township (physical layout) as well as the business and social conditions that typically impact decision-making in similar communities. The 40% canopy target is considered well within the physical and social means of the community. In terms of the "bottom line", this assessment finds that increasing the tree canopy to 40% is a good financial investment for the Township.

Project Overview

The UTCA is a technical analysis of the tree cover in a community, which produces a detailed accounting of the land cover and the associated impacts on air and water resources. The UTCA is accomplished by classifying aerial imagery to land cover data using remote sensing technology. Ancillary data available from Federal agencies like the National Weather Service and the Natural Resource Conservation Service are combined with the land cover data to populate scientific and engineering algorithms that describe the functions of the landscape. GIS technology is used to calculate the dollar benefits of the landscape for managing stormwater and improving air and water quality. The assessment provides a wealth of information about the condition of the tree cover and the financial value it provides to the community.

This assessment focused on the tree canopy because the size and condition of the trees are barometers of the overall landscape. The size and health of the trees are a direct reading of the quality of the space they occupy. Simply stated, when the landscape is healthy, the trees are healthy and the condition of the trees can be determined by analyzing the tree canopy. The information derived from the assessment is important to the managers of suburban and urban communities because it has a direct impact on the budget. For example, trees moderate and reduce stormwater and the associated management costs; the more tree coverage the less need for building and maintaining stormwater management facilities.

This project developed a digital geospatial model of the Township's green infrastructure. The green infrastructure includes vegetative land cover and other ecological factors such as soil, air, and water. Policies and practices that enhance or diminish green infrastructure will greatly impact a city's ability to manage its stormwater and comply with clean air and water regulations. This project provides the Township with a technical analysis of its land cover and produces the data needed to calculate the ecosystem services produced by its green infrastructure

The GEC created a baseline land cover with the 2002 NAIP acquired from the NJDEP GIS and a land cover change analysis layer from 2010 NAIP imagery. The 2010 imagery was acquired directly from the NAIP imagery distribution center in Salt Lake City, UT. NAIP is a program administered by the Department of Agriculture through the Aerial Photography Field Office (APFO) in Salt Lake City. This imagery is vital to the UTCA because it is acquired during the agricultural growing season and therefore captures the vegetation in full leaf.

Definitions:

GIS *– Geographic Information System is a mapping platform that lets us visualize, question, analyze, interpret, and understand data to reveal relationships, patterns and trends* (ESRI, 2012).

Remote Sensing *– Remote sensing is the science of obtaining information about objects or areas from a distance, typically from aircraft or satellite (NOAA, 2011).*

Thematic Layer – *Geographic data layer, which organize the spatial and attribute data for a given set of cartographic objects in the area of interest.*

The image processing software used were ERDAS Imagine version 10 and Overwatch's feature extraction tool called Feature Analyst. The GEC has developed a methodology that involves several steps to

produce high-resolution land cover classification. Six land cover categories were classified from the imagery.

1. **Deciduous Trees** – Trees that shed leaves in the Fall season. Typical deciduous trees around the Township of Ocean include oak (northern red oak, white oak, willow oak etc), flowering dogwood, various maples, sycamore, etc.
2. **Evergreen Trees** – Trees that retain leaves all throughout the year. Typical evergreen trees around the Township of Ocean include white pine, Norway spruce, Serbian spruce, and various other coniferous trees.
3. **Impervious Surfaces** – All paved impervious surfaces including roads, sidewalks, driveways, buildings, etc.
4. **Open Spaces** – Pervious areas such as lawn, pastures, agricultural land, recreational and sport fields, etc.
5. **Water** – Water bodies including visible streams, rivers, ponds, lakes, ocean shorelines, reservoirs, and large recreational pools.
6. **Barren Land** – Bare ground with exposed soil including new construction sites, pit mines, beach, river and stream banks, and sand.

Urban Tree Canopy Assessment

The GEC assesses the health and benefits of urban ecosystems through a process called Urban Ecosystem Analysis (UEA). UEA documents the green infrastructure using GIS technology and calculates the ecosystem services produced. The Township of Ocean commissioned the GEC to conduct an UTCA with three project objectives: 1) Benchmark Ocean's latest canopy cover (2010), 2) conduct digital change detection for the years 2002 and 2010, and 3) produce ecosystem service analysis to calculate economic cost and benefit. The data and findings from this study can be used by the community to determine the best design and management of their green infrastructure.

Methodology

The GEC uses a sophisticated methodology that combines engineering models with GIS and Remote Sensing technology for conducting UTCA. This methodology classifies land cover from aerial imagery and calculates ecosystem service that quantifies Stormwater Runoff, Water Quality, Air Quality, and Carbon Storage and Sequestration benefits provided by the tree cover. The formulas and process used are described in the "About the Urban Ecosystem Analysis" section below.

Data Processing

Data sets for the 2002 and 2010 imagery were mosaicked to form a uniform single imagery file. As the two data sets had different spatial resolutions, 2002 imagery was resampled to 1 meter resolution with identical geographic projection. Both imagery data sets were clipped to a 200 meter buffer of the Township's administrative boundary (Figure 1).

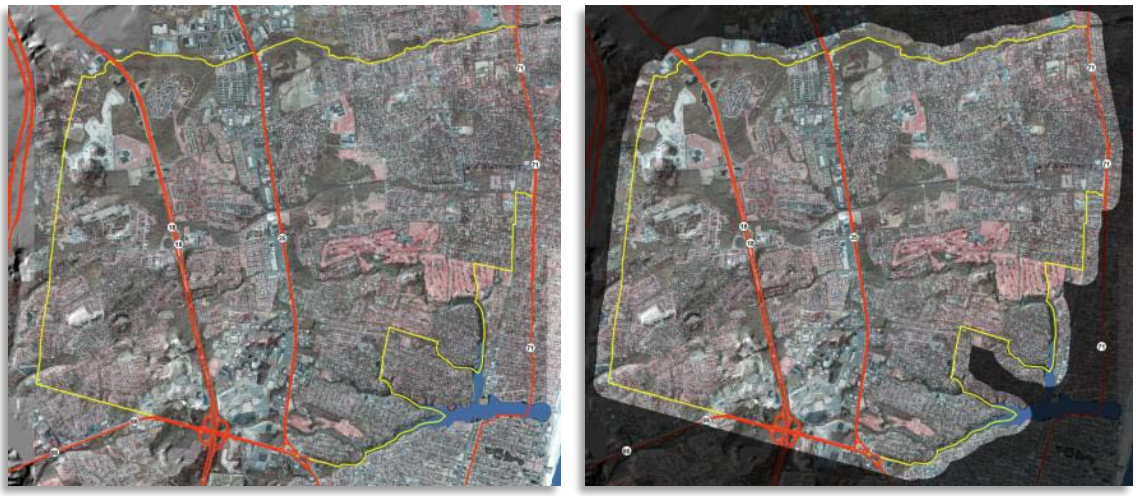


Figure 1: Mosaicked imagery (left) and clipped imagery (right).

Image Classification

The GEC conducted a pixel-based supervised classification on the 2002 baseline imagery for the Township of Ocean. The project area was extended 200 meters beyond its 11 square mile boundary. An analyst selected training sites within the imagery that were representative of the land cover classes of interest. For example, samples of impervious surfaces throughout the imagery were selected to extract the entire impervious surface category, which included buildings, sidewalks, driveways, roads, and other impervious surfaces. The sampling process and classification iteration were repeated to extract the land cover feature as accurately as possible (Figure 2).

Figure 2: Left – analyst's training sample of buildings (an impervious surface class). Right – classified land cover feature of the building.

Once all the land cover classes were extracted, a complete classified land cover layer for the year 2002 was established (Figure 3).

Figure 3: Complete classified land cover of the Township of Ocean 2002.

The GEC performed digital change detection between the years 2002 and 2010 to capture land cover changes that had occurred in the eight year period. The digital change detection process analyzes spectral imagery and calculates the changes in electromagnetic reflectance of each band to produce a thematic layer showing the likelihood of change. As 2002 imagery was leaf-off while 2010 was leaf-on, false spectral difference in tree category was evident. The GEC's remote sensing analyst tackled this issue with multiple iteration and custom threshold for each land cover category. Finally a binary layer, a thematic layer with only 2 values, 0 (false – no data) or 1 (true – data), was established. A binary layer showed the true change areas in white pixel value of 1 while no change areas in pixel value of 0 (Figure 4).

Figure 4: Binary change layer (right) created from digital change detection between 2002 and 2010 imagery.

With the binary change areas established, the 2010 imagery was clipped only to include the areas within the binary change layer. The process of sampling the training data was repeated for the change area imagery. These new training samples were used to produce a new classified land cover data set (Figure 5). This methodology of classifying only the change areas allows the classification to be consistent and cost-effective as it takes a fraction of the time to produce the update from existing land cover data.

Figure 5: Binary change layer (left), clipped imagery (middle), and classified change area (right).

Finally, the classified change area is overlaid on top of the existing land cover (2002) data to create a new updated classified land cover for the year 2010 (Figure 6). The newly created land cover data incorporates all the new land cover features as well as previous unchanged land cover classes seamlessly.

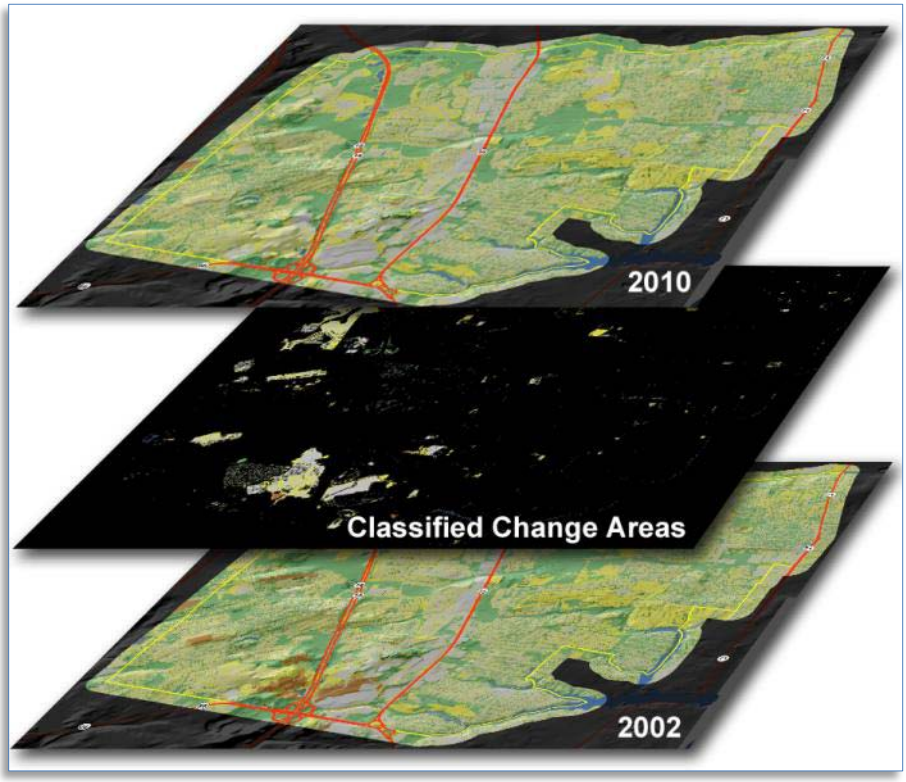


Figure 6: Conceptual diagram showing the development of updated land cover for the year 2010.

Quality Assurance/Quality Control

Each data layer went through a rigorous process of quality assurance/quality control (QA/QC) check lists. In addition, each classified land cover data were processed in customized graphic models to ensure the best classification for each land cover. To minimize the human error and inconsistency, almost all the edits were made using graphic models and automated processes. After all the edits and issues were addressed, data layers were set up for the UEA process to produce UTCA results.

UTCA Results

Over the eight year period, the Township of Ocean has seen a significant growth in urban areas. The change detection process showed that a total of 363 acres of land cover had changed between 2002 and 2010. The tree cover declined by 1% while impervious surfaces increased by 9%.

Specific Land Cover Change Findings

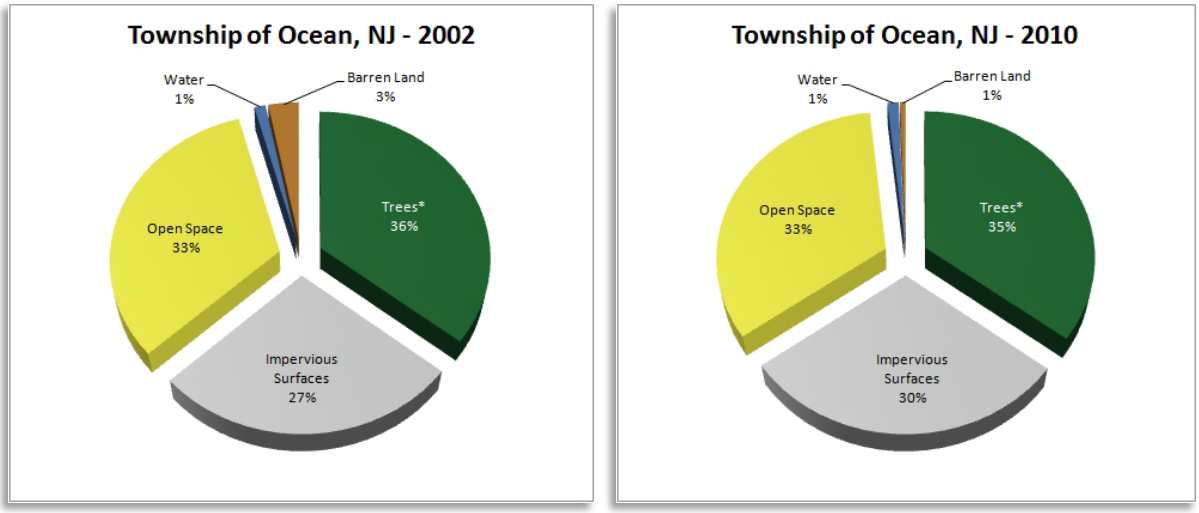
Most of the changes were seen in the western and southern parts of the Township. Almost all of these changes were urban development that included residential housing, new open spaces, and multi-family unit residential. Although the new developments were evident in 2010, imagery analysis suggested that most of them were started in 2002. The 2002 imagery showed the clearings of these soon to be new urban areas (Figure 7).

Figure 7: 2002 imagery shows the beginning of the construction (left). Completed construction (right).

The land cover (2002) and the land cover change (2010) analyses showed physical changes in land cover land use in the Township of Ocean (Stat 1).

Township of Ocean, NJ - Land Cover Land Use Statistics						
	Areas in Acres					
	Trees*	**Impervious Surfaces**	**Open Space**	**Water**	**Barren Land**	**Total Area**
Year 2002	2503.8	1936	2288.6	80.6	217.9	7026.9
Year 2010	2480.3	2093.3	2332	81.1	40.2	7026.9

** Trees category includes both deciduous and evergreen classes.*



Stat 1: Land cover land use statistics of Township of Ocean for the year 2002 and 2010.

Using the classified land cover data for 2002 and 2010, the UEA process was used to calculate the ecosystem services' value provided by the canopy. This analysis showed that the Township had a 36% tree canopy coverage in 2002, which decreased to 35% in 2010. Although there were new trees added by 2010 in newly developed areas, some old tree coverage had been removed by 2010 (Figure 8). UEA results shows that the Township's 36% canopy coverage had great economic impact on the stormwater runoff. As of 2002, the Township's then existing tree canopy saved over 26 million cubic feet of stormwater runoff while storing 107,742 tons of carbon. Ecosystem Service table (Table 1) below describes the savings for the year 2002 and 2010. Details of analytical process are described in "About the Urban Ecosystem Analysis" section.

Township of Ocean 2002 - 2010 - Ecosystem Services By Land Use									
Area of Study	**Total Area**	**Trees***	**Trees***	**Air Pollution Removal**	**Air Pollution Removal Value**	**Carbon Stored**	**Carbon Sequestered**	**Stormwater Saved❖**	**Stormwater Value @ $2 per ft^3**
	Acres	**Acres**	**%**	**lbs/yr**	**$**	**Tons**		**ft^3**	**$**
Township of Ocean 2002	7,027	2,504	36%	299,077	$810,848	107,742	839	26,298,120	52,596,240
Township of Ocean 2010	7,027	2,480	35%	296,265	$803,226	106,730	831	26,289,520	52,579,039

** Trees include deciduous and evergreen trees.*
❖ Savings based on runoff calculation if all trees removed.

Table 1: Ecosystem Services showing the benefits provided by tree canopy to Township.

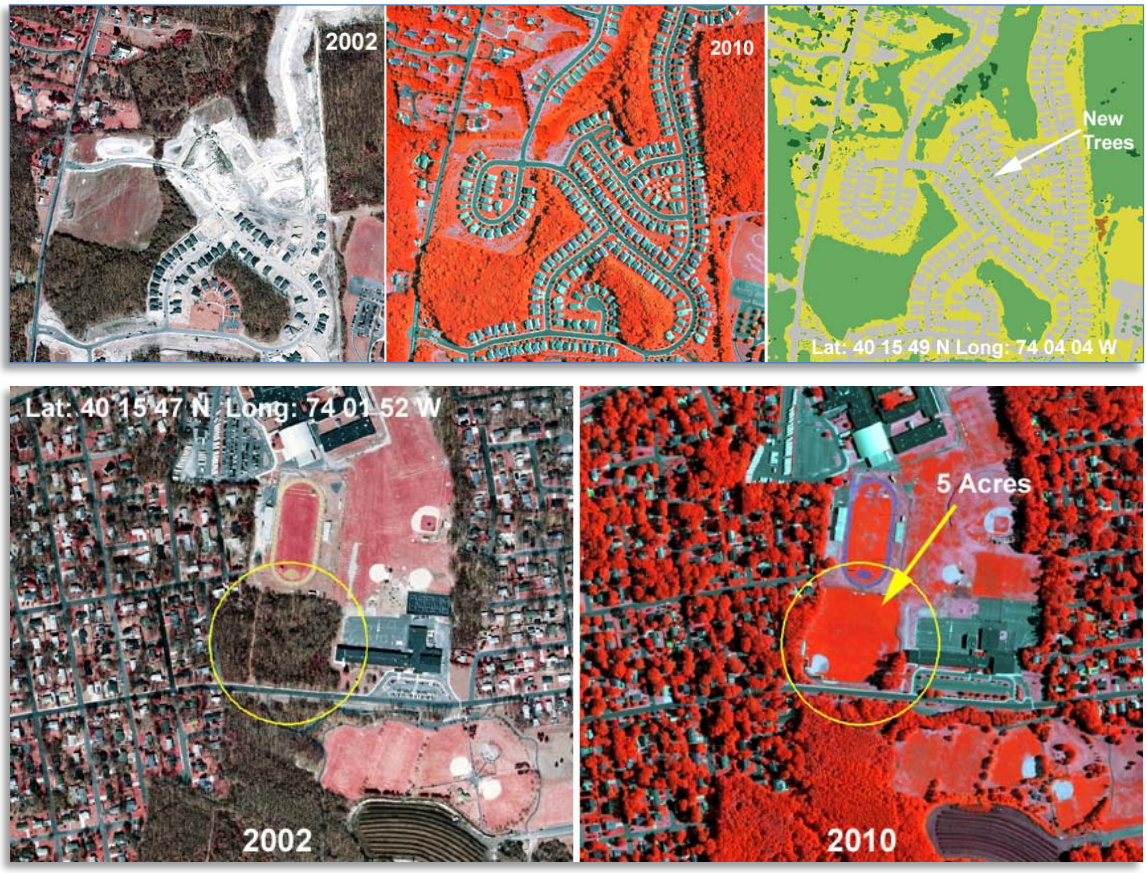


Figure 8: Addition of new trees (above) and removal of old trees (below)

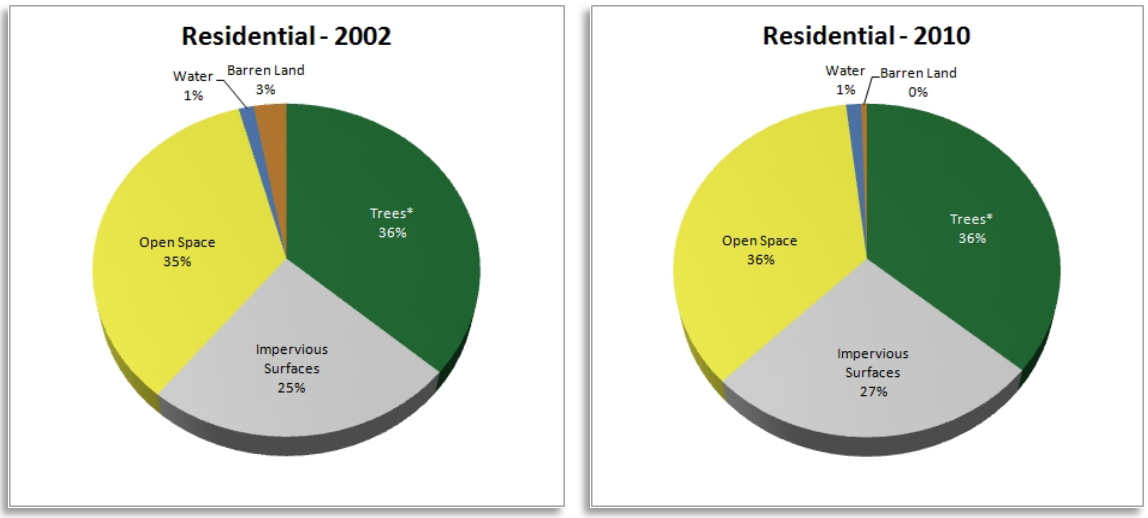
During the eight year time frame, tree canopy had saved hundreds of thousands of dollars removing air pollutants. With its 36% canopy coverage, the Township of Ocean saved 299,077 pounds of pollutants in 2002 while saving was down a modest 296,265 pounds in 2010 annually. Trees improve air quality by removing nitrogen dioxide (NO_2), sulfur dioxide (SO_2), carbon monoxide (CO), ozone (O_3), and particulate matter 10 microns or less (PM_{10}) in size.

UTCA by Subdivisions

UEA was conducted for several administrative boundaries within the Township of Ocean. Six zoning areas – 1) Commercial, 2) Commercial-Shopping, 3) Industrial, 4) Office and Research, 5) Park (Joe Palaia Park), and 6) Residential were created by generalizing the Township's existing zoning map (Map 4).

The biggest change was seen on the Barren Land categories in Residential zoning. Within the Residential zone, 170 acres of barren land decreased to 30 acres between 2002 and 2010, which accounted for most of the urban residential development. Imagery analysis shows that most of the Barren Lands category in 2002 was cleared land for new residential development. The Tree category also declined in the Residential zone by 17 acres (Stat 2).

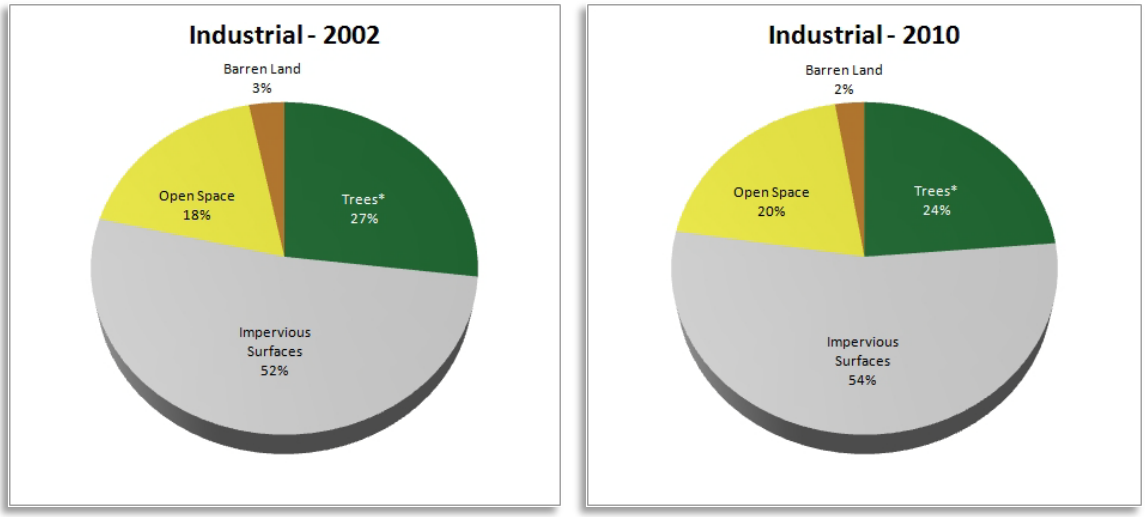
Township of Ocean, NJ – Residential Land Cover Land Use Statistics						
	Areas in Acres					
Year	Trees*	Impervious Surfaces	Open Space	Water	Barren Land	Total Area
2002	2115.1	1424.3	2030.1	77.5	169.6	5816.6
2010	2098.4	1542.8	2067.7	77.9	29.7	5816.5
* *Trees category includes deciduous and evergreen classes.*						



Stat 2: Land cover land use change between 2002 and 2010 in residential zones.

Trees also declined in Industrial zone by almost 5 acres. These changes in canopy and other land cover features had significant impact on the Township's green infrastructure. Tables 3 and 4 below show the land cover land use distribution and their impact on ecosystem services for each year.

Township of Ocean, NJ – Industrial Land Cover Land Use Statistics						
	Areas in Acres					
Year	Trees*	Impervious Surfaces	Open Space	Water	Barren Land	Total Area
2002	41	79	27.6	0	4.8	152.4
2010	36.1	82	30.3	0	4	152.4
* *Trees category includes deciduous and evergreen classes.*						

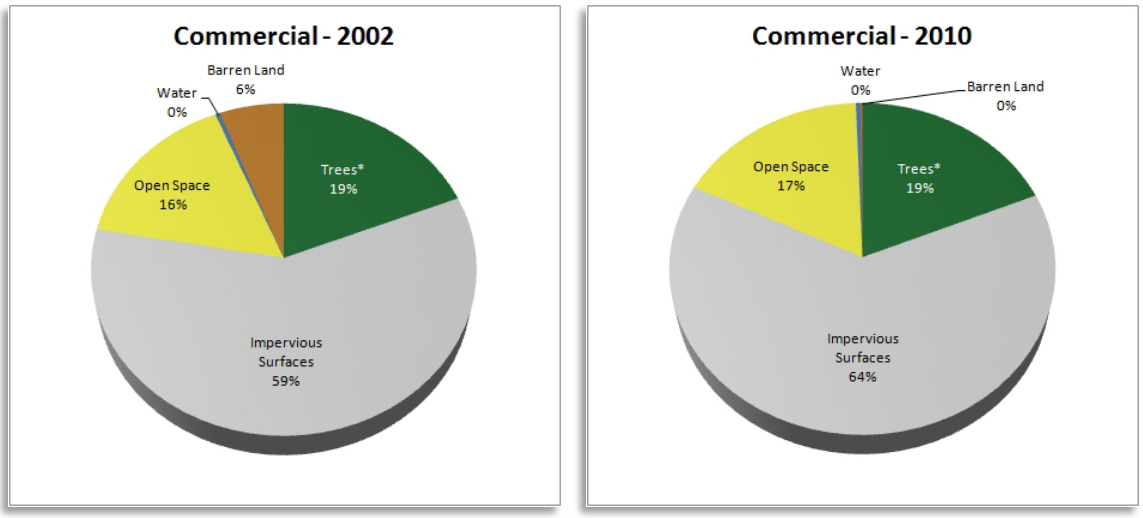


Stat 3: Land cover land use change between 2002 and 2010 in industrial zones.

Commercial areas, including shopping, has increased by 35 acres between 2002 and 2010. Nearly 38 acres of Barren Land category in two commercial zones suggested that new construction had begun in 2002 (Stat 4 and 5).

Township of Ocean, NJ – Commercial Land Cover Land Use Statistics						
	Areas in Acres					
Year	Trees*	Impervious Surfaces	Open Space	Water	Barren Land	Total Area
2002	108.6	336.7	91.7	2.5	33	572.5
2010	107.2	363.3	98.6	2.4	0.9	572.5

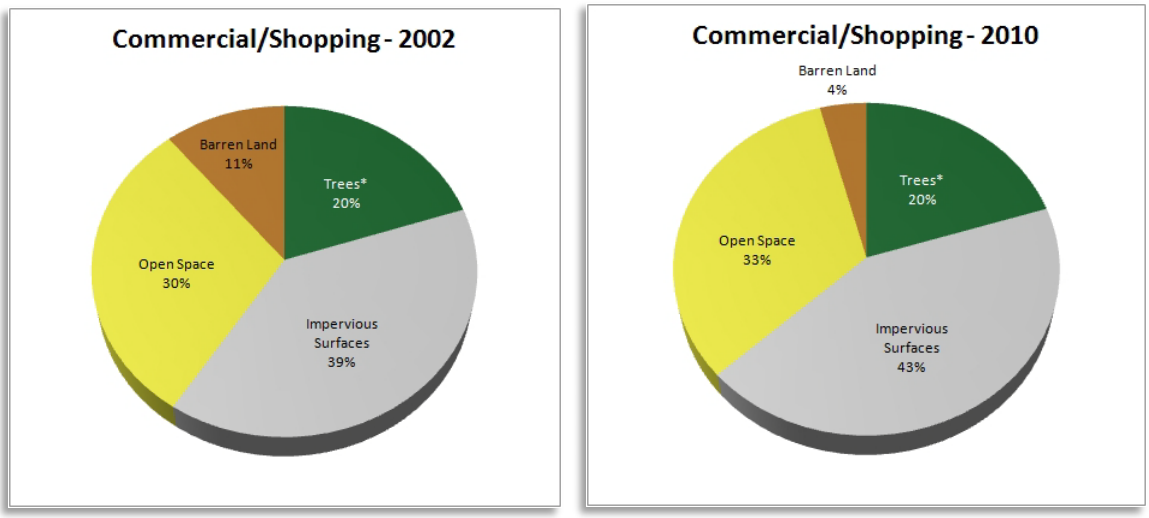
* *Trees category includes deciduous and evergreen classes.*



Stat 4: Land cover land use change between 2002 and 2010 in commercial zones.

Township of Ocean, NJ – Commercial-Shopping Land Cover Land Use Statistics						
	Areas in Acres					
Year	Trees*	Impervious Surfaces	Open Space	Water	Barren Land	Total Area
2002	8.6	16.9	12.9	0	4.7	43.1
2010	8.7	18.6	14.1	0	1.8	43.1

* *Trees category includes deciduous and evergreen classes.*

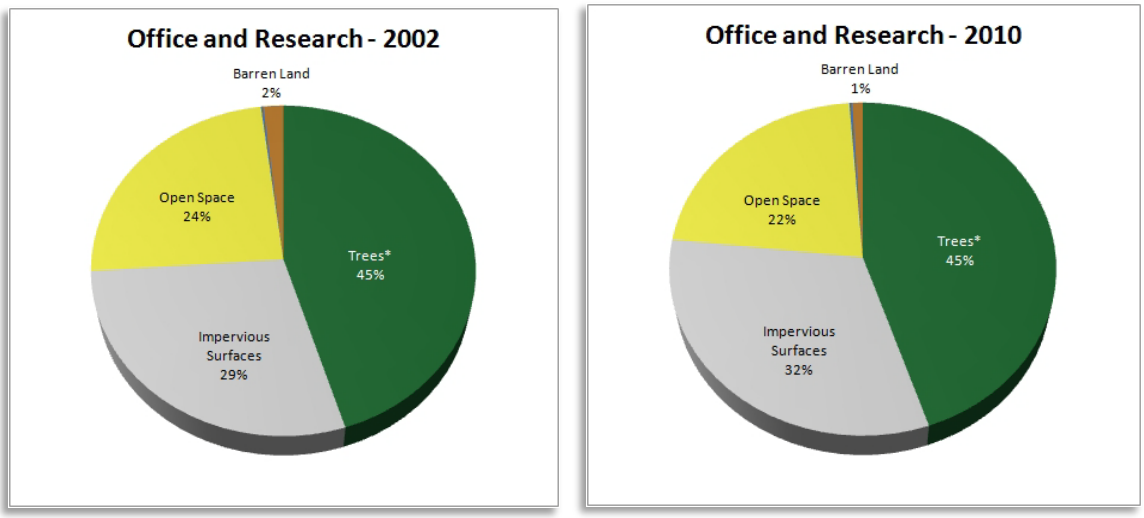


Stat 5: Land cover land use change between 2002 and 2010 in commercial shopping zones.

The Township has seen its impervious surfaces increase in office and research zone by nearly 8 acres between 2002 and 2010. Most of the increases were on open spaces and barren land categories (Stat 6).

Township of Ocean, NJ – Office and Research Land Cover Land Use Statistics						
	Areas in Acres					
Year	Trees*	Impervious Surfaces	Open Space	Water	Barren Land	Total Area
2002	105.7	67.3	56.5	0.5	4.2	234.2
2010	105	74.8	51.7	0.6	2.2	234.2

Trees category includes deciduous and evergreen classes.

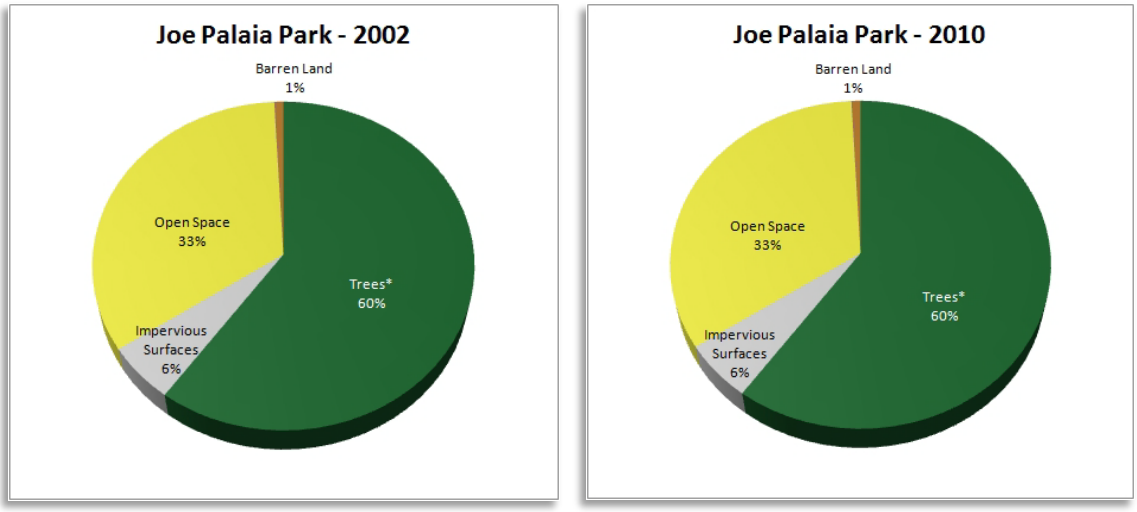


Stat 6: Land cover land use change between 2002 and 2010 in office and research zones.

The land cover change analysis allowed even a small change in land cover and land use in the Township. In Joe Palaia Park, a small change in impervious surfaces was captured. An increase in impervious from open space was extracted (Stat 7).

Township of Ocean, NJ – Joe Palaia Park Land Cover Land Use Statistics						
	Areas in Acres					
Year	Trees*	Impervious Surfaces	Open Space	Water	Barren Land	Total Area
2002	124.7	11.7	69.8	0.1	1.6	207.9
2010	124.7	11.9	63.6	0.1	1.6	207.9

Trees category includes deciduous and evergreen classes.



Stat 7: Land cover land use change between 2002 and 2010 in Joe Palaia Park.

Establishing the land cover land use data layers allows tree cover to be analyzed in specific zoning categories. As part of the UTCA the GEC created a vector zoning map which allowed the land cover data to be assessed by zoning category, i.e. quantifying the tree canopy by each block or parcel (Map 5 – 8).

Recommendations

The datasets and analytical results GEC produced provide valuable information regarding the Township's existing land cover, and how it has changed between the eight year period. Along with detailed mapping of the tree resource and other land cover, this report provides calculations of the ecosystem services produced by the imagery analyses. Analyzing the imagery datasets for 2002 and 2010 and UTCA results, GEC recommends the following guidelines to improve, maintain, and manage the Township's natural environment.

Revitalize the Urban Core

As indicated by land cover and change analyses, most of the changes in the Township's land cover between 2002 and 2010 occurred in western and southern parts. Almost all of the changes were urban development. The data can be used to develop a long-term plan for the development of parks, promenades, and other green spaces. Boosting tree canopy not only offers aesthetic appeal and shade for human comfort, but also reduces stormwater runoff and filters water pollutants to protect water quality.

Modeling different green infrastructure scenarios on development projects allows planners and developers to weigh different percentages of land cover against meeting local regulations. Incentives could be given to developers who increase tree canopy cover to help satisfy clean air and water regulations.

Increase Tree Cover in the Neighborhood

The overall canopy coverage in the Township of Ocean is 35% as of 2010. While 35% could be considered good, a 40% goal is recommended. Increasing the average canopy coverage by 5% is not only achievable, but also a good financial investment for the community. The opportunity for the Township to increase tree canopy by encouraging residents to take action on their property and to increase their maintenance on public property is substantial.

The newly developed residential areas give the Township an opportunity to increase tree canopy, reduce management costs (stormwater management for example) and engage residents in community improvement. Areas that were developed in the last 20 years generally have an expanding tree canopy because the trees are growing rapidly. This fact was demonstrated by the analysis, and can be significantly improved by engaging residents in tree maintenance and planting efforts, for example: mulching, trimming and planting trees. Improving the tree canopy in residential areas not only improves the quality of life for the residents, but also reduces the cost of infrastructure management to the community at large for issues like stormwater management. The greening of the Township's various zonings can be used as an outreach and education tool for the entire community.

The most fundamental recommendation is to Increase the Township's tree cover to 40% over the next 7 to 10 years. The plan to do this should include planting new trees, extending the life of existing trees and protecting existing stands of trees during new development. It is recommended that the community set tree cover goals for each of the zoning categories established by the Township and documented in this assessment. The specific goals need to be determined by the Township and a process for achieving them determined. The biggest opportunity to increase the tree canopy is in suburban areas but there is also an opportunity to increase tree cover on industrial and business properties.

The following targets, which have been used by other communities in the Mid-Atlantic and northeastern part of the country, may be helpful in setting tree cover targets for specific zoning areas.

- 40% tree canopy overall
- 50% tree canopy in suburban residential zones
- 25% in industrial zones
- 15% in the central business zones

To assess the effectiveness of the programs you put in place to increase the tree cover, conduct a second UTCA in 3 to 5 years. In order for the second assessment to be effective at providing useful data for measuring success or failure, the second assessment must use the same remote sensing methodology as described in this document. After the reassessment, adjust your efforts to meet the 40% target.

Establish a Green Infrastructure Framework

One of the advantages of UEA analysis is the ability to perform hypothetical scenarios to calculate potential cost and benefits based on land cover land use change. The GEC conducted a scenario modeling with 40% canopy coverage. The 5% increase in canopy was added to the open space category and remaining land cover categories remained the same. The UEA result showed that the Township of Ocean can potentially save 546,259 cubic feet (1.1 million dollars at $2 per cubic feet) just in stormwater runoff alone. In addition, the Township can save over a hundred thousand dollars in air pollution and over 14 thousand tons in carbon (Table 2).

Township of Ocean Scenario Modeling - Ecosystem Services By Land Use

Area of Study	Total Area	Trees*	Trees*	Air Pollution Removal	Air Pollution Removal Value	Carbon Stored	Carbon Sequestered	Stormwater Saved❖	Stormwater Value @ $2 per ft^3
	Acres	Acres	%	lbs/yr	$	Tons		ft^3	$
Township of Ocean (Scenario)	7,027	2,811	40%	335,742	$910,255	120,951	942	-546,259	-1,092,518

* *Trees include deciduous and evergreen trees.*
❖ *Savings based on runoff calculation if all trees are removed.*
† *Decreased runoff due to 5% increase in trees*

Table 2: Ecosystem Services and scenario model showing the benefits of canopy coverage.

The Township should vigorously pursue green infrastructure options for managing stormwater, air and water quality. Green infrastructure development options should be incorporated into the Township's overall infrastructure management strategy. The green infrastructure dataset produced by the GEC for this UTCA should be incorporated into the Township's GIS and used along with the gray infrastructure data for daily decision-making.

UTCA Tables

Township of Ocean, NJ - Land Cover Land Use Statistics By Zoning												
		Areas in Acres and Percentage										
Area of Study	**Year**	**Trees***	**Tree %**	**Impervious Surfaces**	**Impervious Surfaces %**	**Open Space**	**Open Spaces %**	**Water**	**Water %**	**Barren Land**	**Barren Land %**	**Total Area**
Residential	2002	2115.1	36.36%	1424.3	24.49%	2030.1	34.90%	77.5	1.33%	169.6	2.92%	5816.6
	2010	2098.4	36.08%	1542.8	26.52%	2067.7	35.55%	77.9	1.34%	29.7	0.51%	5816.5
Commercial	2002	108.6	18.97%	336.7	58.81%	91.7	16.02%	2.5	0.44%	33	5.76%	572.5
	2010	107.2	18.73%	363.3	63.47%	98.6	17.23%	2.4	0.42%	0.9	0.16%	572.4
Commercial - Shopping	2002	8.6	19.95%	16.9	39.21%	12.9	29.93%	0	0.00%	4.7	10.90%	43.1
	2010	8.7	20.14%	18.6	43.06%	14.1	32.64%	0	0.00%	1.8	4.17%	43.2
Joe Palaia Park	2002	124.7	59.98%	11.7	5.63%	69.8	33.57%	0.1	0.05%	1.6	0.77%	207.9
	2010	124.7	59.98%	11.9	5.72%	69.6	33.48%	0.1	0.05%	1.6	0.77%	207.9
Industrial	2002	41	26.90%	79	51.84%	27.6	18.11%	0	0.00%	4.8	3.15%	152.4
	2010	36.1	23.69%	82	53.81%	30.3	19.88%	0	0.00%	4	2.62%	152.4
Office and Research	2002	105.7	45.13%	67.3	28.74%	56.5	24.12%	0.5	0.21%	4.2	1.79%	234.2
	2010	105	44.81%	74.8	31.92%	51.7	22.07%	0.6	0.26%	2.2	0.94%	234.3

** Trees category includes both deciduous and evergreen classes.*

Table 3: Land cover land use distribution by zoning boundaries.

Township of Ocean 2002 - 2010 - Ecosystem Services By Zoning										
Area of Study	**Year**	**Total Area**	**Trees***	**Trees***	**Air Pollution Removal**	**Air Pollution Removal Value**	**Carbon Stored**	**Carbon Sequestered**	**Stormwater Saved❖**	**Stormwater Value @ $2 per ft^3**
		Acres	**Acres**	**%**	**lbs/yr**	**$**	**Tons**		**ft^3**	**$**
Residential	2002	5,816.6	2,115.1	36.4%	252,649	$684,976	91,017	709	21,347,502	$42,695,004
	2010	5,816.6	2,098.4	36.1%	250,657	$679,574	90,299	703	21,341,080	$42,682,160
Commercial	2002	572.5	108.6	19%	12,975	$35,177	4,674	36	1,583,413	$3,166,827
	2010	572.5	107.2	18.7%	12,808	$34,725	4,614	36	1,592,531	$3,185,062
Commercial - Shopping	2002	43.1	8.6	20.0%	1,031	$2,796	372	3	102,261	$204,523
	2010	43.1	8.7	20.2%	1,037	$2,812	374	3	102,686	$205,373
Joe Palaia Park	2002	207.9	124.7	60.0%	14,896	$40,385	5,366	42	1,080,799	$2,161,597
	2010	207.9	124.7	60.0%	14,900	$40,396	5,368	42	1,081,194	$2,162,387
Industrial	2002	152.4	41	26.9%	4,900	$12,284	1,765	14	568,368	$1,136,735
	2010	152.4	36.1	23.7%	4,317	$11,705	1,555	12	502,990	$1,005,979
Office and Research	2002	234.3	105.7	45.1%	12,625	$34,229	4,548	35	1,189,510	$2,379,020
	2010	234.3	105	44.8%	12,546	$34,014	4,520	35	1,226,677	$2,453,354

* *Trees include deciduous and evergreen trees.*

❖ *Savings based on runoff calculation if all trees are removed.*

Table 4: UTCA results and ecosystem services by zoning boundaries.

Graphic Maps

Map 1: Land cover analysis for the year 2002.

Map 2: Land cover analysis for the year 2010.

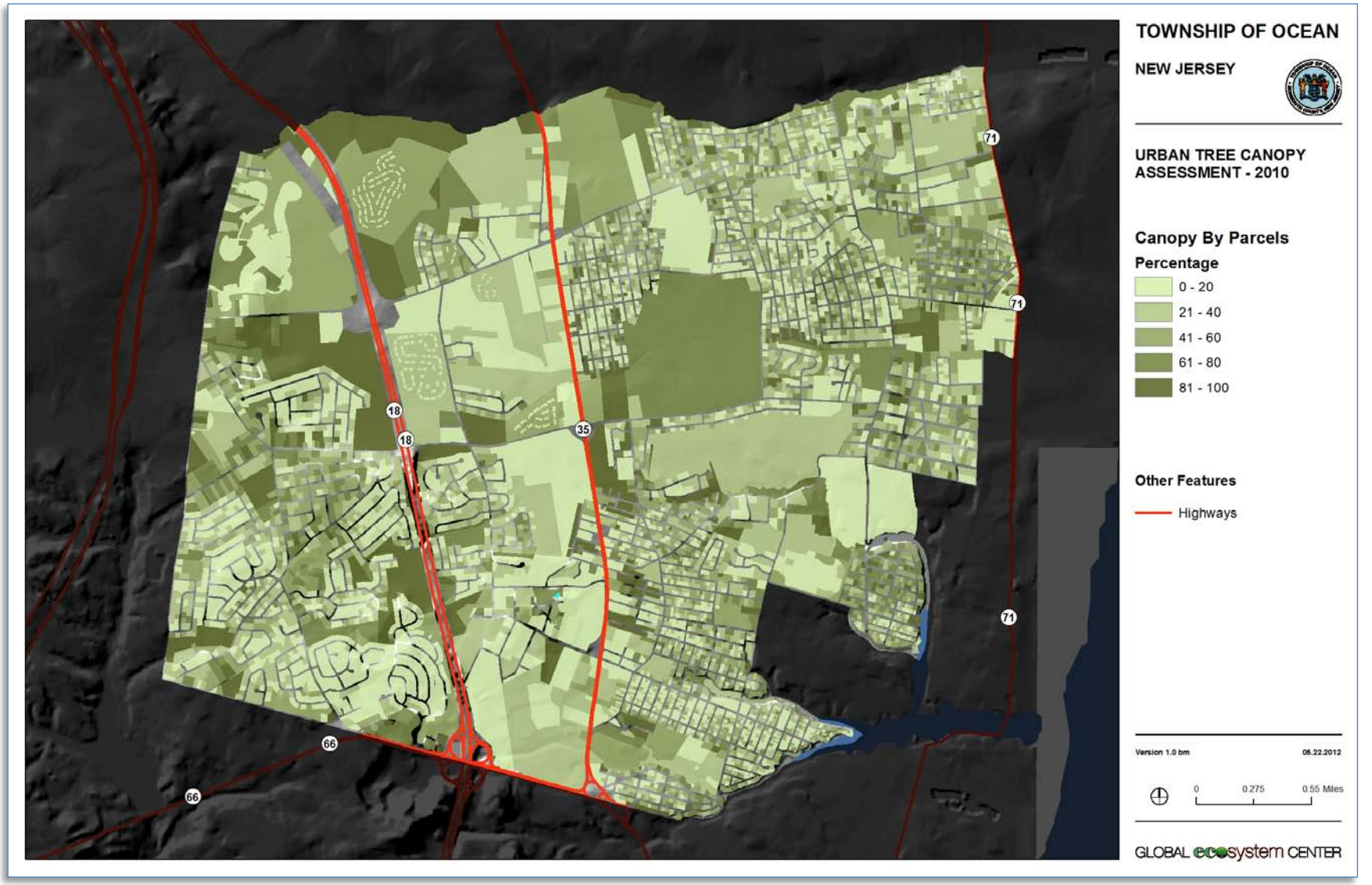
Map 3: Land cover change analysis for the year 2002 and 2010. Map showing the change areas.

Map 4: Zoning boundaries of the Township.

Map 5: Township's canopy coverage for the year 2002 by blocks.

Map 6: Township's canopy coverage for the year 2010 by blocks.

Map 7: Township's canopy coverage for the year 2002 by parcels.



Map 8: Township's canopy coverage for the year 2010 by parcels.

About the Urban Ecosystem Analysis

The GEC performed the Urban Tree Canopy Assessment process using land cover data and scientific and engineering models using the baseline (2002) land cover data and land cover update data (2010) with 1 meter spatial resolution. The method of combining geospatial data with scientific and engineering models defines the UEA process and analysis.

The Center has been in operation for 28 years and was previously known as Urban Ecosystem Center. Prior to becoming the Global Ecosystem Center, it was an operating unit at the non-profit organization American Forests. The staff, philosophy, and system analysis methodology have not changed.

GEC's Urban Ecosystem Analysis is based on the assessment of "ecological structures" – unique combinations of land cover and land use patterns. Each combination performs ecological functions differently and is therefore assigned a different value. For example, a site with heavy tree canopy provides more stormwater reduction benefits than one with a light tree canopy and more impervious surfaces.

The following analytical models were incorporated to produce the UEA results.

TR-55 for Stormwater Runoff

The stormwater runoff calculations incorporate volumes of runoff formulas from the Urban Hydrology of small Watersheds model (TR-55) developed by the U. S. Natural Resources Conservation Service (NRCS), formerly known as the U.S. Soil Conservation Service. Don Woodward, P.E., a hydrologic engineer with NRCS, customized the formula to determine the benefits of trees and other urban vegetation with respect to stormwater management. For greater accuracy, a stormwater analysis was conducted for each Planning District and values were then added together to provide stormwater runoff for the cities across the United States.

http://www.hydrocad.net/tr-55.htm

L-THIA for Water Quality

Using values from the U.S. Environmental Protection Agency (EPA) and Purdue University's Long-Term Hydrological Impact Assessment (L-THIA) spreadsheet water quality model, NRCS developed the water quality model. This model estimates the changes in the concentration of the pollutants in runoff during a typical storm event given the change in the land cover from the existing trees to a no-tree condition. This model estimates the event's mean concentration of nitrogen, phosphorus, suspended solids, zinc, lead, cadmium, chromium, chemical oxygen demand (COD), and biological oxygen demand (BOD). Pollutant values are shown as a percentage of change.

https://engineering.purdue.edu/mapserve/LTHIA7/

UFORE Model for Air Pollution and Carbon

UEA uses formulas from a model developed by David Nowak, Phd, of the USDA Forest Service. The model estimates how many pounds of ozone, sulfur dioxide, nitrogen dioxide, and carbon monoxide, are deposited in tree canopies as well as the amount of carbon sequestered. The urban forest effects (UFORE) model is based on data collected in 55 U.S. cities. Dollar values for air pollutants are based on averaging the externality costs set by the State Public Commission in each state. Externality costs are the indirect costs to society, such as rising health care expenditures as a result of air pollutants' detrimental effects on human health.

http://www.nrs.fs.fed.us/pubs/jrnl/2008/nrs_2008_nowak_001.pdf

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