GULF COAST COMMUNITY URBAN FOREST ASSESSMENT

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ABSTRACT

This study was designed to use an urban forest inventory process and high-resolution aerial imagery (prior to hurricane Katrina) to assist in determining the land use and urban forest health assessment. The GIS based urban forest ecosystem analysis of the Gulfport, Mississippi indicated a 30% tree canopy cover and nearly 25% green space in 2001. This represents 20% urban forest canopy loss since 1990. The current health of this urban forest is under pressure from urban sprawl and soil compaction. Street tree inventory indicated that 63 % of the trees sampled (10% sampling) were Live Oaks (*Quercus virginiana*), 14.6 % Pecans (*Carya illinoensis*), 6.8% Water Oak (*Quercus nigra*), 4.9% Southern Magnolia (*Magnolia grandiflora*), 6.8% Southern Pines (*Pinus spp*), and 3.9% Crepe Myrtles and other small shrubs.

Keywords: *Gulf Coast, Urban Forest, Live Oak, Ecosystem, Hurricane Katrina*

INTRODUCTION

The urban forest covers a large and expanding area. Approximately 3.5% of the United States is currently classified as urban (urban areas). Nearly 25% is either located in or functionally tied to urban areas (i.e., greater metropolitan areas (*Nowak, et.al.)*. Urban and metropolitan areas have grown tremendously, with urban sprawl being a significant environmental concern of the 21st century. Between 1950 and 1990, metropolitan areas increased threefold, while between 1969 and 1994, urban areas doubled in size (*Dwyer, Nowak et.al.).* Substantial population growth outside urban and metropolitan areas continues to extend urban influences to forest resources across the landscape, particularly in places with considerable scenic and recreational value . Urban and metropolitan areas include substantial forest resources that have the potential for significantly improving the quality of the urban environment and the well-being of its residents. Across the United States, tree canopy cover in urban and metropolitan areas averages 27% and 33%, respectively, approaching the national average tree cover of 33%. With approximately 74.4 billion trees in metropolitan areas and 3.8 billion trees in urban areas, the magnitude of the urban forest resource should not be ignored (*Dwyer, Nowak et.al.)*. Urban forests can make a considerable difference in quality of life by directly influencing the daily lives of nearly 80% of the U.S. population. Further, what happens in urban areas can have a profound impact on urban forests and the extended exurban landscape. Considering the significance of the resource, urbanization and urban forests are likely to be especially significant in the 21st century (*Dwyer, Nowak et al*) . The increasing significance of urban influences across the United States calls for resource policy makers, planners, and managers at the national, regional, and local levels to bring cooperative attention to planning and management efforts to sustain urban forests. In 2001, more than half of the U.S. population lived along the coast, an area that represents only one fourth of the U.S. land mass. As a consequence, areas of the coastal zone are densely populated, ranging from 422 people per square mile in 2001 along the Atlantic Coast and 232 people per square mile in the coastal counties of the Great Lakes to 149.3 people per square mile along the Gulf Coast and 71.6 people per square mile along the Pacific Coast. In contrast, population density in the non-coastal portion of the United States was 48.1 people per square mile in 1998. From Texas to Florida, the Gulf coast region is rich with ecological resources that support the region's economic wealth. Over time, human activities from dam construction to shoreline development have dramatically altered natural landscapes, waterways, and ecological processes. Pressures from human activities remain the most important agents of ecological change in the region today. Over the century ahead, land-use changes are likely to increase as rapid population growth continues. As the Mississippi Gulf Coast caught the national headlines with its economic recovery in the 1990's, the three-county Gulf Coast region of Hancock, Harrison, and Jackson counties has often been cited as heralded as the economic "engine" of this change. Historically driven by the seafood, timber and tourism industries, the Coast economy today now runs the gamut from chemicals to computers, apparel to aerospace. Since 1992, the Mississippi Coast has experienced over $3.5 billion in new commercial and industrial development, added over 38,484 new jobs to the economy, and had its largest influx of residents in 20 years. The Coast now is home to over 12,000 businesses, the second highest concentration of businesses in the state, and is home to three of Mississippi's top five employers. The Coast's strategic location between the cities of New Orleans, Louisiana and Mobile, Alabama is unique – making it, simultaneously, an employment center, suburb, vacation destination, and transportation corridor. Covering a land area of nearly 1,800 square miles, the region is highlighted by more than 26 miles of white sand beaches along the Gulf of Mexico. Well-developed air, land, sea, and rail arteries provide access to nearly 75% of the United States population, as well as emerging Mexican and Latin America markets. With an estimated 11 million annual visits and over $3 billion in travel-related expenditures, the region has skyrocketed into the nation's third gaming destination with over $1.1 billion in gross gaming revenues in 2001.

OBJECTIVES

The objective of this study was to use an urban forestry inventory process and historical (March 2001) & new high-resolution aerial imagery to assist in determining the extent and magnitude of Live Oak health.

- Establish a high resolution aerial photo base map over the 15 selected tile areas
- Provide a photographic record of Live Oak health since April 2001
- Allow easy input, interpretation and correlation of scientific field study data using GIS software.
- Prototype the use of a low cost high-resolution imagery collection method for the inventory and mapping process.
- Prototype the use of a Live Oak base map for the entire city of Gulfport.

METHODOLOGY

The following 15 aerial image tiles (Table 1) of the City of Gulfport (Fig 1 and 2) were randomly selected. A random number generator was used to select from approximately 430 images. Due to over lap in the photography a re-selection was made when two adjacent tiles were selected. A re-selection was also made when the tile did not reside in the current City of Gulfport City limits. Each tile, taken at 3650 ft altitude, covers an area approximately 4015 ft by 4015 ft (or 3521 x 3521 pixels) and encompasses approximately 370 acres. The pixel resolution is 1.14 ft.

Table 1: Study area image tiles

Rev B			Latitude (N)			Longitude (W)	
	Tile Number	Date	Deg	Min		Deg	Min
	1	4/2/2001	30	24.349		89	0.100
	2	4/2/2001	30	28.946		89	5.429
	3	4/2/2001	30	27.074		89	3.292
	4	4/2/2001	30	23.428		89	3.806
	5	4/2/2001	30	24.367		89	5.424
	6	4/2/2001	30	26.633		89	5.425
	7	4/2/2001	30	24.336		89	6.490
	8	4/2/2001	30	22.065		89	6.488
	9	4/26/2001	30	25.245		89	7.579
	10	4/26/2001	30	22.925		89	2.793
	11	4/2/2001	30	22.551		89	4.356
	12	4/2/2001	30	21.564		89	7.031
	13	4/2/2001	30	28.513		89	1.688
	14	4/2/2001	30	23.396		89	1.689
	15	4/2/2001	30	23.412		89	0.634

Figure 1: Mississippi Gulf Coast

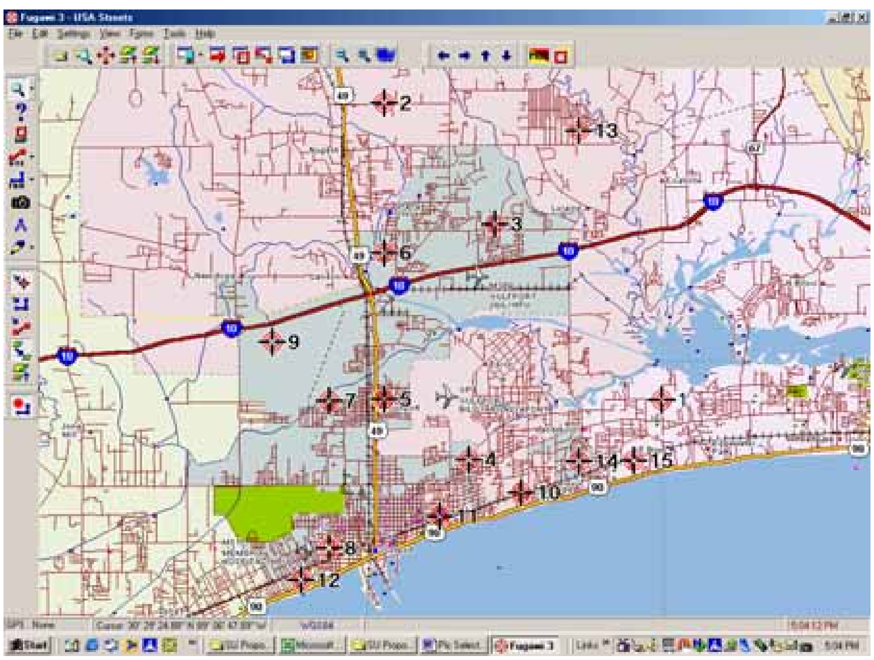

Figure 2: locations of the 15 tiles

Each individual tile (Fig 3) was approximately 4015 ft x 4015 ft. A random number generator was used to select fourteen one acre plots within the tile. The Figure shown below is a representation of a single tile divided into a 17 x 17 matrix (289 polygons) with the fourteen 1 acre plots selected and shown as shaded areas. The plots were planned to be circular; however, software limitations dictated using square plots. The plot that is crosshatched is the center of the tile with the Latitude and Longitude position indicated in Table 1. The plots were named according to their location along the X and Y axis.

Figure 3: An urban forest tile

Principal component analysis

The following describes the Principal Component Analysis (PCA) technique as used on Tiles 1-15. The Principal Component Analysis is an image transformation method that is used for a variety of purposes in Remote Sensing and GIS applications including data compression and change detection. In general the bands of a multi-spectral image usually do not contain completely independent information. More likely, there will be some degree of correlation between bands, indicating they share common elements of information. If the reflectance levels for a set of pixels for two bands of interest are plotted, in what is commonly referred to as "band space" the following plot is obtained. Each of the axis represents reflectance in the spectral band. In our case, for our photography and analysis needs, band 1 is brightness and band 2 is green. Each image pixel was plotted by placing its location at the intersection of its value on each band. This reveals a high level of correlation between the bands. (i.e. if a pixel has a high value on band 1 it is likely to have a high value on band 2). Since the bands are correlated they do not carry independent information. One can predict the reflectance of a pixel on one band from the reflectance value on the other. This confirms there is some degree of redundancy in the information they carry. It is this redundancy that the principal components seek to remove when it is used for the purpose of data compression. The principal components transformation is a linear transformation that can be described as a weighted linear combination. It produces a new set of bands (called components) by multiplying each of the bands by a weight and adding the results.

e.g. $C= w1B1 +w2B2 + w3B3….wnBn$

The weights in the transformations are the eigenvectors. The results of the principal components transformation process can be thought of as a mathematical determination of a new set of axis in band space such that the resulting images are: 1) uncorrelated with one another and 2) ordered in term of their explanatory power. Usually component 1 (CI) is oriented along the axis of the largest variation and component 2 (CII) is by definition perpendicular to component I and is oriented in the direction of lesser variation. For this analysis a PCA was used to assist in finding the classes of data that had a very bright reflectance in the green band. For this analysis principal component one is brightness and principal component is the green band.

Script files sequence

All PCA and supervised classification processing were accomplished using the ELAS program and script files. The following describes the script files sequence used to process the images. First, the area of the tile selected for analysis was determined. In developing the prints and in the negative scanning processing some edge effects were apparent. These were trimmed from the electronic image before processing. Next, the raw data was converted to principal components as discussed above and a principal component plot was generated. From this plot the classes exhibiting the greatest variation were easily identified. The ELAS software was then used to identify and number 50 plus classes of pixels. The exact number of classes varied with each tile. A tabulation of the number of pixels per class, percent, cum percent, mean, median and standard deviation was generated. Next, the statistics were obtained. The statistic file was rearranged to obtain the decreasing means for Band 2 (green). Then a maximum likelihood classifier was performed and 2-space color plots (band 1 = brightness verses band 2 = green) and were generated. Next, the means of each class and number of samples in each signature were tabulated and then the means, standard deviation and number of samples (pixel by pixel) were tabulated. Finally, the frequency distribution of classes was tabulated. Once the PCA was performed, a supervised classification (with ground truthing) was used to determine the classes of interest, i.e. oaks, thin oaks, other trees, grass, water, inert shadow and beach. The classes determined in the Principal Component Analysis were group into major classes. This was accomplished by reviewing the photography and comparing it to the PCA class. Each PCA class was identified by type (i.e. bare soil, mowed grass, thin oaks, tin roof, roads, shadow, etc..). Similar types of ground features were grouped together and then these groups were reduced to 7 major classes. The frequency distribution of the 50 plus classes, the reduction down to 7 classes, and the surface cover classification details were documented (e.g. Table 2).

Table 2: Major classes for tile 4

Tile 4 – Table of Major Classes, Type, Color Assignment & Coverage Area					
Major Class	**Type**	**Color Assignment**	**PCA Class**	**% coverage entire tile**	**Acres**
1	Oaks	Red	9,29,30,33,35	10.58%	39.70
2	Thin Oaks	Green	18,19	4.82%	18.09
3	Other Trees	Cyan	1,2,5,7,8	12.26%	45.99
4	Grass	Yellow	6,11,13,14,17	27.31%	102.46
5	Water	Blue	31,56	33.26%	12.48
6	Inert / Shadow/ Beach	Gray	3,4,10,12,15,16,20-28,32,34,36-46,49-55,57	41.71%	156.51

Determining the urban forest canopy cover

Fifteen tiles each covering approximately 0.58 square miles were randomly selected from the 2001 70mm aerial photographs. A Principal Component Analysis (PCA) technique was performed on each of the fifteen tiles to group like pixels into approximately 50 plus classes. Next a supervised classification technique was used to group the 50 plus classes into the following 7 classes of interest, oak trees, thinning oaks, other trees, grass, water, inert/shadow, and beach. Next fourteen one-acre plots were randomly selected on each tile and the surface classification results were tabulated. The original imagery tile, PCA classes and the supervised classification plots were georeferenced and formatted to be used in ESRI ArcView GIS Version 3.0. Plots, including enlarged plots contained in this report were exported using the export feature of ArcView. The selected approach of using a PCA to reduce classes, followed by a supervised classification, was necessary due to the diversity of surface features in the urban environment of the City of Gulfport and the desire to isolate and identify Live oak trees. The selection of 15 tiles from an available 430 tiles was semi-randomly accomplished. When adjacent tiles were randomly selected they were eliminated. This was done to prevent duplication of information, since the aerial photography contains approximately 30 % overlap. In addition some ground truthing was required. It was also practical to perform a PCA and subsequent surface cover classification on the entire tile (370 acres – total of 5550 acres) prior to selecting the one acre plots. The one acre plots were created by sub dividing the tile into a 17 x 17 matrix and using a random number generator to select 14 one acre plots. Thus a total of 210 one acre plots were selected in the City of Gulfport. The results were then tabulated to identify up to 7 major classes of interest. Since the City of Gulfport is about 120 square miles approximately 7 percent of the surface will be classified. In addition, 210 random one acre plots will have been established. The plots in this report are exported from the GIS software ArcView. Where possible, the data user or reader is encouraged to utilize the GIS software and data files to study particular areas of interest. Plotted information, such as contained herein, is useful but does have viewing limitation.

RESULTS

The urban forest ecosystem analysis of the Gulfport, Mississippi indicated a 30% tree canopy cover and nearly 25% green space in 2001. This represents 20% urban forest canopy loss since 1990. The current health of this urban forest is under pressure from urban sprawl and soil compaction.

Table 4.0 summarizes the surface coverage of the oaks, thin oaks and other tree class as percent of total tree coverage (not tile coverage). This table is sorted by percent thin oaks. Figure 4.0 illustrates the average tree coverage. The average percent coverage for oaks was found to be 44.94 %, 23.49 % for thin oaks, and 31.57 % for other trees.

Table 4: Declining and healthy oaks as percent total tree coverage.

Table - Oak and Thin Oaks as percent of total tree coverage					
Tile	**Total Trees as % of Tile**	**Oaks**	**Thin Oaks**	**Total Oaks**	**Other Trees**
			(as percent of total tree coverage)		
9	10.61%	0.00%	0.00%	0.00%	100.00%
15	7.32%	79.77%	0.00%	79.77%	20.23%
14	53.87%	49.50%	13.33%	62.83%	37.17%
13	39.82%	33.59%	15.90%	49.49%	50.51%
4	27.66%	38.26%	17.43%	55.69%	44.31%
6	22.39%	46.21%	20.56%	66.77%	33.23%
1	27.10%	63.64%	23.20%	86.84%	13.16%
5	25.16%	63.73%	24.08%	87.81%	12.19%
10	39.31%	30.62%	27.70%	58.32%	41.68%
11	44.12%	41.78%	29.13%	70.91%	29.09%
8	28.72%	52.72%	29.24%	81.97%	18.03%
3	21.03%	59.37%	29.44%	88.81%	11.19%
7	26.88%	44.70%	32.68%	77.38%	22.62%
12	22.35%	27.43%	44.07%	71.50%	28.50%
2	49.40%	42.71%	45.65%	88.35%	11.65%
	Avg	**44.94%**	**23.49%**	**68.43%**	**31.57%**

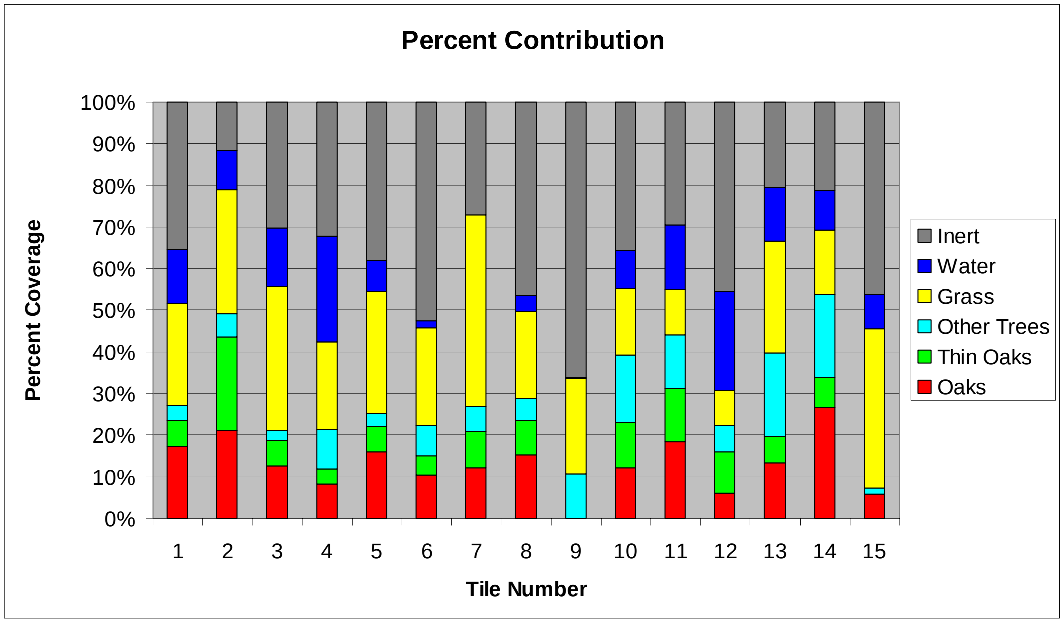

Figure 4.0: Percent land-use coverage by tile location (numbers)

Figure 5.0: GIS-based land-use map of Gulfport, Mississippi

CONCLUSION

Across the United States, tree canopy cover in urban and metropolitan areas averages 27 percent and 33 percent, respectively, approaching the national average tree cover over all lands of 33 percent. This case study of the Gulfport, Mississippi representing the Gulf Coastal communities of the United States indicates average tree canopy cover of 30% . However, this represents a 20% tree canopy loss since 1990. Tree inventory and urban forest ecosystem analysis reveals possible impacts from urban sprawl and soil compaction. The impacts of other environmental factors such as drought and extreme climatic events in the coastal areas should not be ignored. The magnitude of the urban forest resource in the Gulf Coastal region of the United States is substantial. Urban forests can make a considerable difference in the quality of life of these communities. What happens in Gulf Coastal urban areas can have a profound impact on forests and forestry across the urban to wilderness landscape. The increasing extent and significance of urban influence in the Gulf Coastal and other communities of the United States call for resource policymakers, planners, and managers at national, regional, and local levels to focus their attention on forest resources in urban settings. The Gulf Coastal urban forests can undergo significant change with the growth, development, and succession of their biological components over time. Urban forest management practices need to be applied urgently to reduce the impacts of urban sprawl and human induced pressure. To sustain the growth and development of urban forest resources much more powerful and swift human-induced factors need to be considered. Coupled with the relatively slow rate of tree growth and plant succession, the swift human forces for change make the dynamics of the urban forest particularly challenging for managers and users. The expansion and development of urban areas in the Gulf Coastal areas could bring important changes in urban vegetation and other urban resources. Alterations to the distribution of land uses, intensity of urbanization, and population characteristics in these urban areas result in different combinations of ground cover, increased or decreased opportunities for tree establishment and growth, changing environmental conditions, and general urban forest health.

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