GULF COASTAL URBAN FOREST HAZARD ASSESSMENT AND REMOTE SENSING EFFORTS AFTER HURRICANES KATRINA AND RITA[1]

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Introduction:

Trees add to our enjoyment of the outdoors. They contribute to the value of our properties and help us recover from our illnesses. Trees also have liabilities associated with them. They can cause injury to property and individuals. The key to reducing the liabilities is to recognize when a tree becomes hazardous and take actions to correct these hazards. Urban and community forestry and arboriculture are the specialized fields in urban and community forest management, from planting, maintenance (including pruning, fertilization, watering etc.) to hazardous tree removal and wood waste utilization. Hurricane Katrina and Rita have hit the Louisiana and Mississippi communities in many ways. Beside loss of lives, property damage, many trees are posing additional hazards in short-term and long-term. A "Hazard Tree" is a tree that has a structural defect that is likely to fail in whole or in part. This "Hazard Tree" also must be within a location where it can hit a target. This target could be a structure or person.

A. Louisiana Efforts:

The Southern University Ag Center's Urban and Community Forestry Program conducted a project to accomplish the following objectives:

- Hazard tree assessment and damage assessment using the established USDA-Forest Service and the International Society of Arboriculture guidelines and protocols.
- Engage minority and the impacted communities in hazard assessment and inventory of urban forest trees.
- Conduct tree inventory in minority and underserved communities impacted by the Hurricanes Katrina and Rita.
- Provide experiential learning for the undergraduate and graduate students.
- Provide research and educational opportunities for students who have been directly and indirectly affected by the Hurricanes.
- Create a GIS-based inventory database which can be used by the USDA-Forest Service and other federal, state and local governments for short-term and long-

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term planning.

Products :

- A Tree Inventory Database for selected impacted communities
- A Hazard Tree Assessment Report for selected impacted communities
- Generating GIS maps for the selected impacted communities
- Develop and print outreach Fact Sheets for the Communities
- Develop a Web-based project materials for the SU Ag Center web site
- One Graduate Student Report & Presentation

B. Remote Sensing Efforts in Coastal Areas of Louisiana and Mississippi:

Reported by American Forests —Gulf Coast counties along the path of Hurricane Katrina lost the greatest amount of tree canopy, and suffered the greatest impacts in terms of increased stormwater runoff and poorer air and water quality. American Forests just completed a 30,000 square mile regional assessment of the impacts Hurricane Katrina had in Louisiana, Mississippi and Alabama by comparing landcover from 2001 and 2006. The findings show that the greatest concentrated loss in tree cover was measured in St. Tammany and Washington Counties in LA and in Hancock, Pearl River, Lamar, Forrest, Stone and Harrison Counties in MS. These counties were directly in the path of the Hurricane. The loss in tree canopy also means a reduction in the environmental benefits that urban forests and other vegetation provides to these communities. The data compiled in this assessment not only provides the basis for the findings in this report, but is also prepared for on-going use by the cities, counties and states within the study area. Moderate resolution Landsat satellite imagery and Geographic Information Systems (GIS) software was used to 1) assess the change in landcover pre and post hurricane and the impacts these changes had on air and water and 2) update post-hurricane landcover data used by state forestry agencies for fire management. The study covers 23 counties in Louisiana, 20 counties in Mississippi, and 5 counties in Alabama. In August of 2005 Hurricane Katrina slammed into the Gulf Coast and changed the physical makeup of tens of thousands of square miles of land. Along with the human made infrastructure, natural systems such as forests and streams were damaged. Accounting for the impacts to the natural system in terms of wildfire susceptibility and ecosystem services losses is a necessary part of the recovery process, as is supporting local decision makers with the data and management tools they need to make good decisions about rebuilding the area. The data will provide local planning agencies with the base maps and technical modeling tools needed to rebuild their communities to take advantage of the ecosystem services that natural systems provide in terms of cleaner air and water and reduced stormwater runoff and erosion. The data will also be used to update wildfire risk in these predominately rural regions of the country. The updated digital data will be incorporated into a wild land fire risk model (Southern Fire Risk Assessment Software) that will quantify the effects of the storm damage on wildfire risk in the region, pinpointing areas where risk has increased. This will enable the US Forest Service, Southern Group of State

Foresters, and state agency fire chiefs to prioritize areas for managing vegetation for fuel reduction. The most evident changes occurred in the city of Gulfport, MS. The area lost 13% of its tree canopy and gained 12% shrub cover and 4% of its open space in the five year time span. At the same time the area only gained 4% urban (impervious surfaces) area. These changes indicate that hurricane damage rather than development caused the majority of the landcover changes. The city's 13% percent loss tree canopy increased the need to manage an additional 305,000 cubic feet of stormwater management, valued at $610,500. The loss of canopy also resulted in a 28,000 pounds loss of air pollution removal, valued at $68,000 annually; and a 10,700 ton loss of carbon storage and a 83 pound loss of carbon sequestration annually. In addition to the regional study, high resolution satellite imagery was analyzed of St. Louis Bay and a portion of Biloxi. "This study provides local leaders and state agencies with the data and software tools they need to rebuild their communities with an understanding of the natural conditions on the land," explains Gary Moll, senior vice president of the Urban Ecosystem Center at American Forests. "The base maps, wildfire fuel modeling and urban ecosystem analyses will provide the technical capacity needed by local planning agencies for modeling scenarios for land planning." American Forests will also provide technical assistance and training to agency personnel on the air, and water impacts and benefits produced by natural systems and train them to use software tools for making decisions. This project was sponsored by the USDA Forest Service. The Analysis was conducted by American Forests and Sanborn.

C. Reported by the SU NASA University Center for Coastal Zone Assessment and Remote Sensing :

This study was designed to determine the land use and urban forest health of Gulfport Mississippi after hurricane Katrina landfall. Aerial images data for city of Gulfport were digitally processed to generate a map of landscape elements. The Geographic Information System (GIS) processes and Principal Component Analysis (PCA) were used to determine the proportion of mapped landscape elements surrounding 14 randomly selected locations (tiles= 17x17 acre) where tree inventory data had been collected. Analyses indicated that the most important landscape elements in terms of explaining tree health were urbanized (high % inert) and green space (low % inert). PCA and Discriminant functions generated for these two elements were able to correctly distinguish between areas with high and low inert, representing the extent of urban sprawl characteristics, with an overall accuracy of 90%. Regression results found both %inert (low and high) to be predictive of tree health during the growing season. The analysis 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 the aftermath of hurricane Katrina. In 2006 the analysis indicated additional loss of 22% canopy cover for the same area.

Study site

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

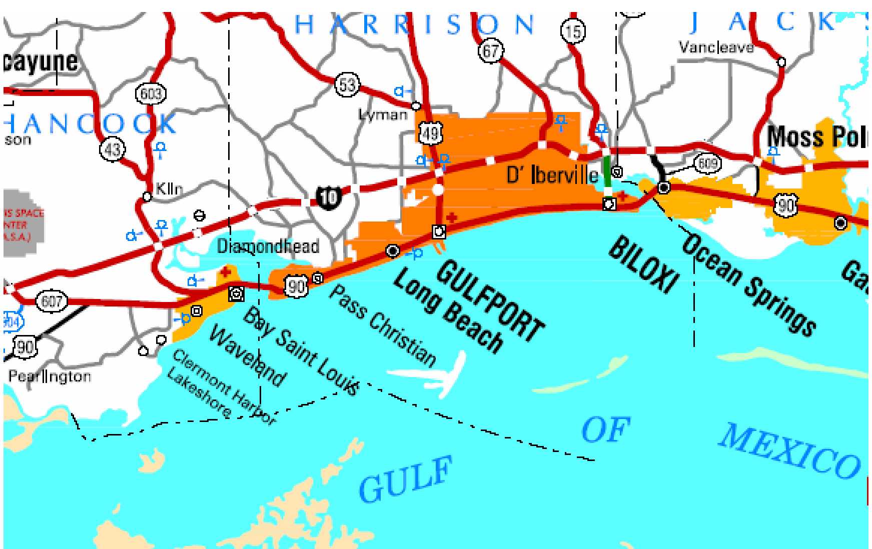

Figure 1. Mississippi Gulf Coast

Each individual tile (Fig 2) 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 2. An urban forest tile

Determining the urban forest canopy cover

Fifteen tiles each covering approximately 0.58 square miles were randomly selected from the 2001 and 2006 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 geo-referenced and formatted to be used in ESRI ArcView GIS. 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 were classified. In addition, 210 random one acre plots were established. The plots for this study were exported from the GIS software ArcView.

Results and Discussion

The following tables and figures summarize the findings of the aerial analysis (i.e. remote sensing) for each tile by plots (Table 2) and for the complete 15 tiles (Figure 3 and Table 3). Oaks (*Quercus spp*.) occupy an average of 13.16% of the 15 tiles. Declining (thin) oaks occupy 7.64% of the surface cover while other tree species (e.g. *Pinus spp., Magnolia spp., Lagerstroemia spp.)* occupy an average of 8.90% of the 15 tiles. Grass covers an average of 24.98%, water 10.78%, and inert/shadow/beach occupies an average of 36.53% of the 15 tiles. Inert/shadow/beach type holds the greatest average percentage of surface cover of the 15 tiles, followed in second by grass, third- oaks, fourth- water, fifth- other trees, and lastly- thin oaks.

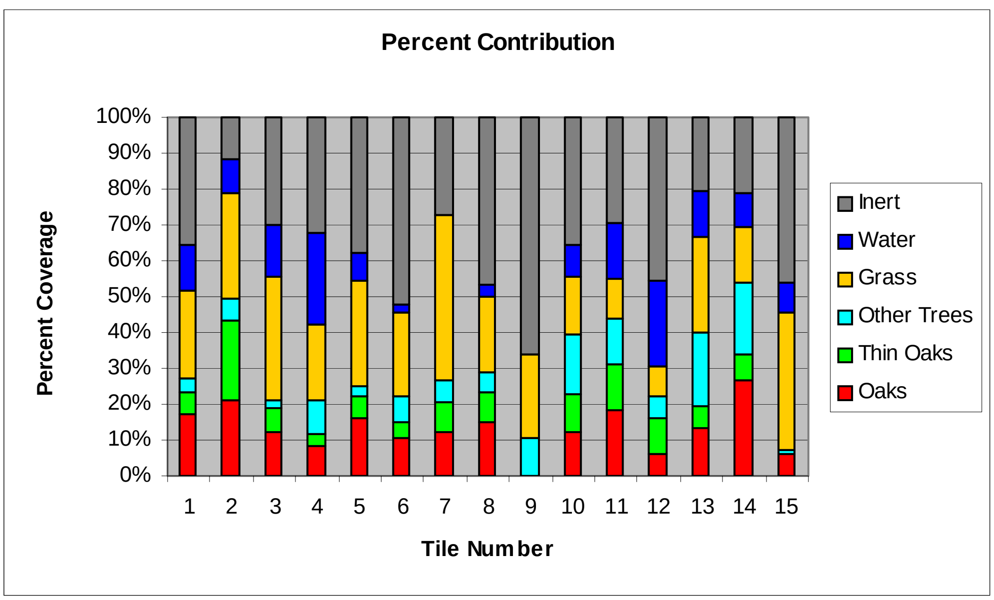

Figure 3. Percent contribution in each tile by different land-use land-cover for 2001.

Table 2. Analysis of tile by plots for 2001.

Tile 4 – One Acre Plot Coverage (Percent)							
		Oaks	Thin Oaks	Other Trees	Grass	Water	Inert/Shadow
		Red	Green	Cyan	Yellow	Blue	Grey/Beach
Plot	Number	1	2	3	4	5	6
1	X3Y3	9.104%	8.200%	11.879%	44.128%	3.965%	22.724%
2	X2Y7	6.295%	4.628%	8.268%	31.921%	2.828%	46.060%
3	X4Y10	25.686%	9.448%	33.542%	16.423%	4.781%	10.120%
4	X4Y15	2.864%	1.347%	0.218%	4.676%	1.487%	89.408%
5	X5Y6	1.209%	2.114%	3.183%	80.313%	0.887%	12.294%
6	X7Y3	9.800%	9.546%	69.581%	10.350%	0.185%	0.537%
7	X9Y5	15.611%	5.366%	50.393%	24.208%	1.218%	3.204%
8	X9Y15	20.538%	14.037%	3.473%	17.537%	15.345%	29.069%
9	X11Y12	0.317%	0.128%	0.376%	13.643%	0.084%	85.452%
10	X13Y16	15.301%	7.704%	2.090%	15.644%	8.194%	51.068%
11	X14Y9	0.152%	0.546%	1.200%	8.651%	0.358%	89.092%
12	X14Y12	9.233%	2.395%	12.225%	30.885%	2.156%	43.107%
13	X15Y7	0.331%	0.570%	0.755%	12.801%	0.570%	84.971%
14	X17Y14	16.546%	8.400%	17.866%	27.726%	4.151%	25.313%

The urban forest ecosystem analysis of the Gulfport, Mississippi indicated a 30% tree canopy cover and nearly 25% green space in 2001 (Table 3 and Table 4). This represents 20% urban forest canopy loss since 1990. The current health of this urban forest is under pressure from the aftermath of hurricane Katrina and soil compaction. The current analysis indicated additional 20% canopy cover loss since hurricane Katrina.

Table 3. Urban forest coverage

Summary of Coverage by Tile (percent)						
	Oaks	Thin Oaks	Other Trees	Grass	water	Inert/Shadow
	Red	Green	Cyan	Yellow	Blue	Grey
Tile	1	2	3	4	5	6
1	17.25%	6.29%	3.57%	24.53%	13.04%	35.32%
2	21.10%	22.38%	5.75%	29.80%	9.30%	11.69%
3	12.49%	6.19%	2.35%	34.63%	14.06%	30.28%
4	10.58%	4.82%	12.26%	27.31%	33.26%	41.71%
5	16.04%	6.06%	3.07%	29.32%	7.57%	37.95%
6	10.35%	4.60%	7.44%	23.32%	1.80%	52.49%
7	12.02%	8.78%	6.08%	45.96%	0.00%	27.16%
8	15.14%	8.40%	5.18%	21.03%	3.75%	46.50%
9	0.00%	0.00%	10.61%	23.04%	0.20%	66.16%
10	12.04%	10.89%	16.38%	15.98%	9.21%	35.51%
11	18.43%	12.85%	12.84%	10.91%	15.44%	29.53%
12	6.13%	9.85%	6.37%	8.40%	23.71%	45.55%
13	13.38%	6.33%	20.11%	26.79%	12.77%	20.62%
14	26.66%	7.18%	20.02%	15.49%	9.33%	21.32%
15	5.84%	0.00%	1.48%	38.26%	8.23%	46.18%
Average	**13.16%**	**7.64%**	**8.90%**	**24.98%**	**10.78%**	**36.53%**

Table 4. Declining (Thin) oaks

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%**

Literature Cited

[1] Dwyer, J.F., D.J. Nowak, M.H. Noble, and S.M. Sisinni. 2000. *Connecting people with ecosystems in the 21'' century: an assessment of our nation's urban forests.* General Technical Report PNW-GTR-490, U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Portland, OR.

[2] Nowak, D.J., M.H. Noble, S.M. Sisinni, and J.F. Dwyer. 2001a. Assessing the U.S. urban forest resource. *Journal of Forestry*. 99(3): 37-42.