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Land Area Change in Coastal Louisiana After the 2005 Hurricanes: A Historical Perspective (from 1956)

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Methodology

The U.S. Geological Survey (USGS) assessed changes in land and water coverage in coastal Louisiana within two months of Hurricanes Katrina and Rita (Aug. 29 and Sept. 24, 2005, respectively) by using Landsat Thematic Mapper (TM) satellite imagery. The purpose of this study is to provide preliminary information on land-water area changes in coastal Louisiana shortly after both hurricane landfalls and to serve as a regional baseline for monitoring wetland recovery following Hurricanes Katrina and Rita.

Historical land-water conditions in 1956 were represented by a data set including wetland habitat classifications interpreted from large-scale panchromatic aerial photographs (Wicker, 1980). The area covered by the 1956 habitat data is based on the Louisiana Coastal Zone Boundary (CZB) as defined in the State and Local Coastal Resources Management Act of 1978 (Act 361). The CZB only partially overlaps the Louisiana Coastal Area (LCA), with a common area of 12,272 mi² (31,784.48 km²), which is 2,316 mi² (5,998.44 km²) less than the 14,588 mi² (37,782.92 km²) comprising the entire LCA.

The USGS Center for Earth Resources Observation and Science (EROS) provided multiple Landsat images of coastal Louisiana that were acquired immediately before and after the hurricane landfalls. Land-water conditions before the storms were represented using imagery acquired between October 13 and November 7, 2004. A series of seven Landsat TM scenes acquired between October 16 and October 25, 2005, provided a snapshot of land-water area changes after the storms. The 2004 and 2005 data sets were matched to the 1956 data covering the common area of the CZB and LCA to ensure compatible comparisons between data sets.

A standard methodology established in the LCA Study (Barras and others, 2003) and in Morton and others (2005) was used to classify land-water conditions and identify changes between 2004 and 2005. According to Louisiana coastal use regulations (LOSR, 2002), fastlands are developed and agricultural areas surrounded by levees that are generally considered non-wetlands; thus, they were excluded from the trend analysis in the LCA Study. Likewise, they are not included here in calculations of net land area change shown on the graph and in the tables. Fastlands comprise 837 mi² (2,167.83 km²) of the 12,272 mi² (31,784.48 km²) included in the common area of the CZB and LCA (1956, 2004, and 2005 data, respectively). The portion of the LCA (excluding fastlands) used in the trend analyses of historical changes between 1956 and 2004 and after the 2005 hurricanes is, thus, 11,435 mi² (29,616.65 km²). This area is 1,483 mi² less than the 12,918 mi² (33,457.62 km²) comprising the entire LCA, excluding fastlands.

The depiction of land-water changes on the map is based on three data points representing two time periods: 1956 to 2004 (historical) and 2004 to 2005 (before and after the hurricanes). The 1956 to 2004 comparison provides historical land-water changes over a 48 year interval. Intervening land-water changes, during the 1956 to 2004 period, such as those caused by prior hurricanes or other events, are not specifically identified. The 2004 to 2005 period represents land-water changes occurring over a period of approximately one year rather than decades and primarily analyzes the immediate impacts of the two hurricanes.

All measurements of area changes provided in the tables and graph list net changes only and do not account for gross gains and losses between comparison dates. The 1956 to 2004 comparison showed a net increase in water area of 1,149 mi² (2,975.91 km²). The net increase in water area in the LCA (excluding fastlands) from 2004 to 2005 was 295 mi² (764.28 km²). This latter measurement, however, includes 77 mi² (200.18 km²) of flooded lands consisting of flooded burned marsh and flooded agricultural and developed areas occurring after the hurricanes. Adjusting for these flooded lands, the estimated increase in water area (and decrease in land) from 2004 to 2005 is 218 mi² (564.10 km²). (Direct correlations of land and water area changes are assumed.)

The distribution of new water areas after Hurricanes Katrina and Rita varied coast-wide but followed a similar pattern in the southeastern and southwestern portions of Louisiana. Shores were often located in marshes fringing areas where land area decreased from 1956 to 2000 (Barras and others, 2003); but they also occurred in historically stable areas such as in the upper Breton Sound basin, the lower Pearl River basin, the marshes bordering the east bank of Freshwater Bayou in the southwestern Teche/Vermilion basin, and the marsh just north of Johnsons Bayou and south of the Sabine National Wildlife Refuge in the Calcasieu/Sabine basin.

Hurricane Rita's surge removed remnant marsh from areas with historical land loss caused by the rapid collapse of the marsh surface during the mid-1960s to the mid-1970s in western Barataria basin and in central and eastern Terrebonne basin (Morton and others, 2005). Surge impacts increased in severity westward to Rita's landfall near Johnsons Bayou. Similar patterns were observed on the west bank of Freshwater Bayou, due east of Pecan Island in the southwestern Teche/Vermilion basin; south of Sweet Lake in the Mermentau basin; due east of Deep Lake in the Mermentau basin; and north of Mud Lake in the Calcasieu/Sabine basin. Hurricane Katrina's surge had similar impacts in areas of historical land loss in the Pontchartrain basin, along the north shore of Lake Pontchartrain and in the Labranche wetlands; however, shears and scoured marsh were also present between the more historically stable area of the Gulf Intracoastal Waterway and the west shoreline of Lake Borgne, just east of Alligator Point. Remnant contiguous marsh located between areas of historical loss and the Gulf of Mexico shoreline on the eastern side of the Mississippi River Delta was also removed by Hurricane Katrina's surge. Hurricane surge from both storms caused shears in stable marsh areas that were often associated with the expansion of existing small ponds but were also observed in areas of contiguous marsh where vegetation was either partially or completely removed.

The surge-induced flooding present in the Chenier Plain in the fall of 2005 prevents definitive quantitative comparison with historical changes, although some areas where marsh material was removed by storm surge could be identified by imagery review. For example, the increase in water area of 64 mi² (165.76 km²) between 2004 and 2005 in the Mermentau basin reflects some decreases in land area directly caused by Hurricane Rita's surge. This area also included persistently high water levels in some places that precluded their definitive identification as either flooded marsh or as marsh removed by storm surge.

The coastwide 218 mi² (564.10 km²) area of new water occurring after the hurricanes within the common LCA contains: (1) land losses that may be permanent, caused by direct removal of wetlands by storm surge; and (2) transitory water area increases caused by the following: (a) remnant flooding of marsh and impounded areas; including agricultural and developed areas, (b) removal of floating and submerged aquatic vegetation, (c) scouring of marsh vegetation, and (d) water level variations caused by normal tidal and meteorological variation between images. The new land occurring after the hurricanes contains land gains caused by the following: (1) wrack deposition, (2) vegetamorphosis of existing marsh areas caused by storm surge, (3) aquatic vegetation that is possibly misclassified, and (4) water level variations caused by normal tidal and meteorological variation between images. These transitory gains and losses are included in calculations of net land area change.

Estimation of permanent losses cannot be made until several growing seasons have passed and the transitory impacts of the hurricanes are accounted for.

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1956 to 2004 and 2004 to 2005 Net Land Area Changes*

*The 1956 to 2004 net land decrease is 1,149 mi² (2,975.91 km²). The 2004 to 2005 net land decrease is 218 mi² (564.62 km²), which slightly varies from the 217 mi² given elsewhere in this report. The variation results from matching the CZB (1956) and LCA (2004 to 2005) data sets, as discussed in this methodology.

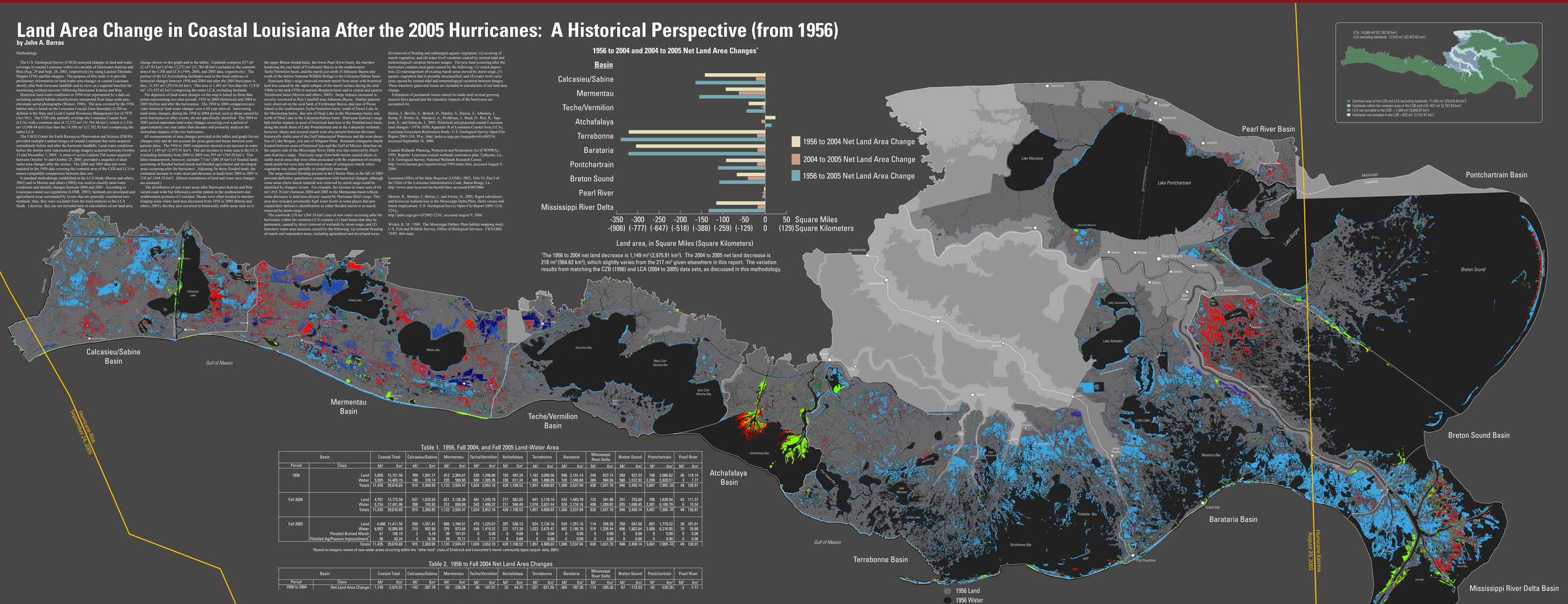

Table 1. 1956, Fall 2004, and Fall 2005 Land-Water Area

Basin		Coastal Total		Calcasieu/Sabine		Mermentau		Teche/Vermilion		Atchafalaya		Terrebonne		Barataria		Mississippi River Delta		Breton Sound		Pontchartrain		Pearl River	
Period	Class	Mi²	Km²	Mi²	Km²	Mi²	Km²	Mi²	Km²	Mi²	Km²	Mi²	Km²	Mi²	Km²	Mi²	Km²	Mi²	Km²	Mi²	Km²	Mi²	Km²
1956	Land	9,850	15,151.50	769	1,991.71	913	2,364.67	520	1,346.91	192	497.28	1,162	3,009.58	846	2,191.14	246	637.14	358	927.22	798	2,066.82	46	119.14
	Water	1,585	14,465.15	146	378.14	220	569.80	504	1,305.36	238	611.24	695	1,800.05	520	1,346.80	284	994.56	588	1,522.62	2,289	5,928.53	3	7.77
	Totals	11,435	29,616.65	915	2,369.85	1,133	2,934.47	1,024	2,652.16	428	1,108.52	1,857	4,809.63	1,366	3,537.94	630	1,631.70	946	2,450.14	3,087	7,995.33	49	126.91
Fall 2004	Land	4,701	12,175.59	627	1,623.93	821	2,126.39	481	1,245.79	217	562.03	841	2,178.19	542	1,403.78	132	341.88	291	753.69	706	1,828.54	43	111.37
	Water	6,734	17,441.06	288	745.92	312	808.08	543	1,406.37	211	546.49	1,016	2,631.44	824	2,134.16	498	1,289.82	655	1,696.45	2,381	6,166.79	6	15.54
	Totals	11,435	29,616.65	915	2,369.85	1,133	2,934.47	1,024	2,652.16	428	1,108.52	1,857	4,809.63	1,366	3,537.94	630	1,631.70	946	2,450.14	3,087	7,995.33	49	126.91
Fall 2005	Land	4,406	11,411.54	599	1,551.41	689	1,784.51	473	1,225.07	207	536.13	824	2,134.16	524	1,357.16	114	295.26	250	647.50	687	1,779.33	39	101.01
	Water	6,952	18,005.68	310	802.90	376	973.84	548	1,419.32	221	572.39	1,033	2,675.47	842	2,180.78	516	1,336.44	696	1,802.64	2,400	6,216.00	10	25.90
	Flooded Burned Marsh*	41	106.19	2	5.18	39	101.01	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
	Flooded Ag/Pasture Impoundment*	36	93.24	4	10.36	29	75.11	3	7.77	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
	Totals	11,435	29,616.65	915	2,369.85	1,133	2,934.47	1,024	2,652.16	428	1,108.52	1,857	4,809.63	1,366	3,537.94	630	1,631.70	946	2,450.14	3,087	7,995.33	49	126.91

*Based on imagery review of new water areas occurring within the "other land" class of Chabreck and Linscombe's marsh community types (unpub. data, 2001).

Table 2. 1956 to Fall 2004 Net Land Area Changes

Basin		Coastal Total		Calcasieu/Sabine		Mermentau		Teche/Vermilion		Atchafalaya		Terrebonne		Barataria		Mississippi River Delta		Breton Sound		Pontchartrain		Pearl River	
Period	Class	Mi²	Km²	Mi²	Km²	Mi²	Km²	Mi²	Km²	Mi²	Km²	Mi²	Km²	Mi²	Km²	Mi²	Km²	Mi²	Km²	Mi²	Km²	Mi²	Km²
1956 to 2004	Net Land Area Change	-1,149	-2,975.91	-142	-367.78	-92	-238.28	-39	-101.01	25	64.75	-321	-831.39	-304	-787.36	-114	-295.26	-67	-173.53	-92	-238.28	-3	-7.77

Table 3. Fall 2004 to Fall 2005 Net Land Area Changes

Basin		Coastal Total		Calcasieu/Sabine		Mermentau		Teche/Vermilion		Atchafalaya		Terrebonne		Barataria		Mississippi River Delta		Breton Sound		Pontchartrain		Pearl River	
Period	Class	Mi²	Km²	Mi²	Km²	Mi²	Km²	Mi²	Km²	Mi²	Km²	Mi²	Km²	Mi²	Km²	Mi²	Km²	Mi²	Km²	Mi²	Km²	Mi²	Km²
Fall 2004	Net Land Area Change	-295	-764.05	-28	-72.52	-132	-341.88	-8	-20.72	-10	-25.90	-17	-44.03	-18	-46.62	-18	-46.62	-41	-106.19	-19	-49.21	-4	-10.36
to	Flooded Burned Marsh*	41	106.19	2	5.18	39	101.01	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Fall 2005	Flooded Ag/Pasture Impoundment*	36	93.24	4	10.36	29	75.11	3	7.77	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
	Adjusted Net Land Area Change**	-218***	-564.62	-22	-56.98	-64	-165.76	-5	-12.95	-10	-25.90	-17	-44.03	-18	-46.62	-18	-46.62	-41	-106.19	-19	-49.21	-4	-10.36

*Based on imagery review of new water areas occurring within the "other land" class of Chabreck and Linscombe's marsh community types (unpub. data, 2001).
**Adjusted to account for 41 mi² (106.19 km²) of flooded burned marsh and 36 mi² (93.24 km²) of other flooded lands that were included in the initial change analysis.
***Given as 217 mi² elsewhere in this report. The slight variation results from matching the CZB (1956) and the LCA (2004 to 2005) data sets, as discussed in the methodology.

Table 4. 1956 to Fall 2005 Net Land Area Changes

Basin		Coastal Total		Calcasieu/Sabine		Mermentau		Teche/Vermilion		Atchafalaya		Terrebonne		Barataria		Mississippi River Delta		Breton Sound		Pontchartrain		Pearl River	
Period	Class	Mi²	Km²	Mi²	Km²	Mi²	Km²	Mi²	Km²	Mi²	Km²	Mi²	Km²	Mi²	Km²	Mi²	Km²	Mi²	Km²	Mi²	Km²	Mi²	Km²
1956 to 2005	Adjusted Net Land Area Change*	-1,367	-3,540.53	-164	-424.76	-156	-404.04	-44	-113.96	15	38.85	-338	-875.42	-322	-833.98	-132	-341.88	-108	-279.72	-111	-287.49	-7	-18.13

*Adjusted to account for 41 mi² (106.19 km²) of flooded burned marsh and 36 mi² (93.24 km²) of other flooded lands that were included in the initial change analysis.

Scale 1:250,000

10 0 10 20 30 40 Kilometers

10 0 10 20 30 40 Miles

N

1956 Land
1956 Water
Fastlands: Agricultural, developed, and upland areas surrounded by levees that are generally considered non-wetlands (LOSR, 2002) and that are excluded from calculations of net land area change.
LCA Area Not Included in the 1956 Data Coverage
1956 to 2004 Land Loss*: Based on direct comparison of 1956 and 2004 land-water data.
1956 to 2004 Land Gain*: Based on direct comparison of 1956 and 2004 land-water data.
2004 to 2005 New Water Areas (Decreased Land Areas)**: Includes flooded marsh, sheared marsh, eroded marsh, and scoured marsh.
2004 to 2005 New Land Areas**: Includes wrack, compressed marsh, and aquatic vegetation that is possibly misclassified. These areas are included in calculations of net land area change.
2005 Flooded Burned Marsh Areas: Based on imagery review of areas classified as burned marsh within a month to a few weeks before Hurricane Rita's landfall.
2005 Flooded Agricultural and Developed Areas: Based on imagery review of new water areas occurring within the "other land" class of Chabreck and Linscombe's marsh community types (unpub. data, 2001).
Basin Boundary: These boundaries include the shared area between the hydrologic basins defined by CWPPRA (1993) and the boundary of the LCA study (Barras and others, 2003).
Hurricane Track

*Data were filtered to depict larger areas of loss and gain greater than 3.5 acres (1.4 ha) in size and to remove noise and increase the confidence of the depicted trends.
**Data were filtered to depict areas of loss and gain greater than 2.7 acres (1.1 ha) in size to remove noise and to increase confidence in the depicted trends.

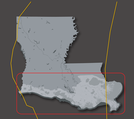

Image Source:
Landsat 5 Thematic Mapper satellite imagery is provided the USGS Center for Earth Resources Observation and Science (EROS).

The background land-water image represents data from October 16, October 18, October 23, and October 25, 2005, that is classified by types of land and water coverage

Internal Map ID: USGS-NWRC 2006-11-0498

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