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Land Area Change in Coastal Louisiana After the 2005 Hurricanes: Marsh Communities

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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.

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.

A standard methodology established in the Louisiana Coastal Area (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 in calculations of net land area change shown on the graph and in the tables. Fastlands comprise 1,870 mi² (4,325.30 km²) of the 14,588 mi² (37,782.92 km²) included in the entire LCA. The portion of the LCA used in this analysis (excluding the fastlands) is, thus, 12,918 mi² (33,457.62 km²).

The 2004 and 2005 data sets were combined with a data set containing marsh vegetation community types in order to identify new land-water changes within marsh communities (Chabreck and others, unpub. data, 2001). A similar methodology was used in Twilley and Barras (2004) to integrate marsh type information with land-water data classifications.

The portrayal of hurricane impacts on the map is based on interpretation of satellite imagery that was verified by several aerial assessments of impacted areas and by limited field investigations. The map depicts all gains or losses that occurred within the comparison interval. The graph and table 3, however, reference net area changes only and do not account for gross gains and losses between comparison dates. (The user is cautioned that these references to net changes in land area are subject to the data limitations described herein and that they merely capture snapshots of two points in time.)

Comparision of the 2004 and 2005 imagery showed a total increase in water area of 300 mi² (777 km²), but this measurement includes 83 mi² (214.97 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) is 217 mi² (562 km²). (Direct correlations of land and water area changes are assumed.)

The countwide 217 mi² (562 km²) area of new water occurring after the hurricanes 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) rearrangement of existing marsh areas moved 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.

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. Fresh and intermediate marsh communities located near to or east of the hurricane landfalls experienced detectable shearing at Landsat TM spatial resolutions. Brackish and saline marsh communities appear to be more resilient to shearing than fresh and intermediate marsh communities. Shears 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. Both hurricane surges 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 62 mi² (161 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.

Estimation of permanent losses from 2004 to 2005 cannot be made until several growing seasons have passed and the transitory impacts of the hurricanes are accounted for.

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Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA), 1993, Reports: Louisiana coastal wetlands restoration plan: Lafayette, La., U.S. Geological Survey, National Wetlands Research Center, http://www.lacoast.gov/reports/cwppr1993/index.htm, accessed August 9, 2006.

Louisiana Office of the State Registrar (LOSR), 2002, Title 43, Part I of the Titles of the Louisiana Administrative Code: Baton Rouge, La., http://www.state.la.us/osr/lac/lactitle.htm, accessed 8/09/2006.

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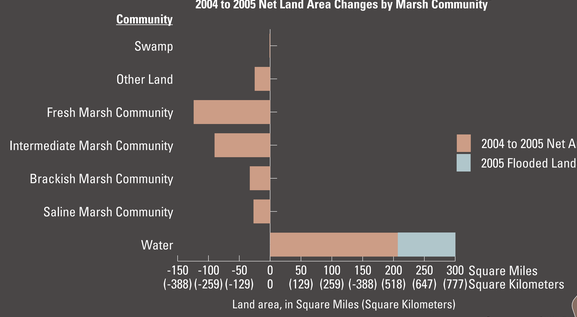
Twilley, R.R., and Barras, J., 2004, Formulation of the LCA ecosystem model, in Hydrodynamic and ecological modeling, Louisiana Coastal Area (LCA)—Louisiana ecosystem restoration plan, Vol.4, Appendix C, Chapter 2: http://www.lca.gov/appc.aspx, accessed August 9, 2006.



*2004 to 2005 net land decrease: 217 mi² (562 km²) after removing 83 mi² (214.97 km²) of flooded lands.

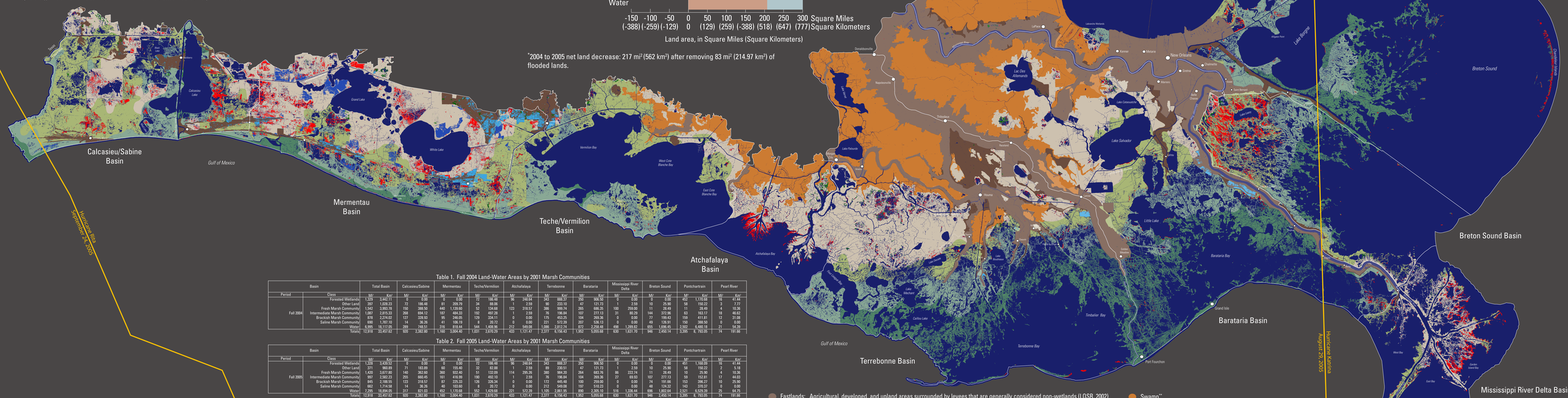


Table 1. Fall 2004 Land-Water Areas by 2001 Marsh Communities

Basin		Total Basin		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	Forested Wetlands	1,329	3,442.11	0	0.00	0	0.00	72	186.48	96	248.64	343	888.37	350	906.50	0	0.00	0	0.00	452	1,170.68	16	41.44
	Other Land	397	1,028.23	72	186.48	81	209.79	34	88.06	1	2.59	90	233.10	47	121.73	1	2.59	10	25.90	58	150.22	3	7.77
	Fresh Marsh Community	1,542	3,993.78	150	388.50	440	1,139.60	52	134.68	123	318.57	386	999.74	265	686.35	100	259.00	11	28.49	11	28.49	4	10.36
	Intermediate Marsh Community	1,987	2,915.32	268	694.12	187	484.33	102	497.28	1	2.59	76	196.84	107	277.13	31	80.29	144	372.96	62	163.17	18	46.62
	Brackish Marsh Community	878	2,274.02	127	328.93	95	246.05	129	334.11	0	0.00	175	453.25	104	269.36	0	0.00	77	199.43	159	411.81	12	31.08
	Saline Marsh Community	890	1,767.10	14	36.26	41	106.19	8	20.72	0	0.00	221	572.28	207	536.13	0	0.00	49	126.91	149	388.58	0	0.00
	Water	6,695	18,117.05	299	774.51	318	818.44	544	1,408.98	212	549.08	1,098	2,817.74	672	2,258.48	498	1,289.80	655	1,696.45	2,502	6,480.18	21	54.39
	Totals	12,918	33,457.62	930	2,382.80	1,160	3,004.40	1,031	2,670.29	433	1,121.47	2,377	6,156.43	1,952	5,055.68	630	1,631.70	946	2,450.14	3,395	8, 793.05	74	191.66

Table 2. Fall 2005 Land-Water Areas by 2001 Marsh Communities

Basin		Total Basin		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 2005	Forested Wetlands	1,329	3,439.52	0	0.00	0	0.00	72	186.48	96	248.64	343	888.37	350	906.50	0	0.00	0	0.00	451	1,168.09	16	41.44
	Other Land	371	960.89	71	183.89	60	155.40	32	82.88	1	2.59	89	230.51	47	121.73	1	2.59	10	25.90	58	150.22	2	5.18
	Fresh Marsh Community	1,430	3,637.80	140	362.60	360	932.40	51	132.09	114	295.26	380	984.20	264	683.76	86	222.74	11	28.49	10	25.90	4	10.36
	Intermediate Marsh Community	997	2,582.23	255	660.45	161	416.99	190	492.10	1	2.59	76	196.84	104	269.36	27	69.93	107	277.13	59	152.81	17	44.03
	Brackish Marsh Community	845	2,188.55	123	318.57	87	225.33	139	359.94	0	0.00	172	445.48	100	259.00	0	0.00	74	191.66	153	396.27	10	25.90
	Saline Marsh Community	662	1,714.58	14	36.26	40	103.60	8	20.72	0	0.00	212	549.08	197	510.23	0	0.00	48	124.32	143	370.27	0	0.00
	Water	7,295	18,894.05	317	821.03	432	1,118.88	552	1,429.68	221	572.39	1,105	2,861.95	690	2,305.10	516	1,336.44	686	1,802.64	2,521	6,529.39	25	64.75
	Totals	12,918	33,457.62	930	2,382.80	1,160	3,004.40	1,031	2,670.29	433	1,121.47	2,377	6,156.43	1,952	5,055.68	630	1,631.70	946	2,450.14	3,395	8, 793.05	74	191.66

Table 3. Fall 2004 and Fall 2005 Land-Water Area Net Changes by 2001 Marsh Communities

Basin		Total Basin		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 to Fall 2005	Forested Wetlands	-1	-2.59	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	-1	-2.59	0	0.00
	Other Land	-26	-67.34	-1	-2.59	-21	-54.39	-2	-5.18	0	0.00	-1	-2.59	0	0.00	0	0.00	0	0.00	0	0.00	-1	-2.59
	Fresh Marsh Community	-122	-315.98	-10	-25.90	-80	-207.20	-1	-2.59	-9	-23.31	-6	-15.54	-1	-2.59	-14	-36.25	0	0.00	-1	-2.59	0	0.00
	Intermediate Marsh Community	-90	-233.10	-13	-33.67	-26	-67.34	-12	-31.08	0	0.00	0	0.00	-3	-7.77	-4	-10.36	-37	-95.83	-4	-10.36	-1	-2.59
	Brackish Marsh Community	-33	-85.47	-4	-10.36	-8	-20.72	-3	-7.77	0	0.00	-3	-7.77	-4	-10.36	0	0.00	-3	-7.77	-6	-15.54	-2	-5.18
	Saline Marsh Community	-28	-72.52	0	0.00	-1	-2.59	0	0.00	0	0.00	-9	-23.31	-10	-25.90	0	0.00	-1	-2.59	-7	-18.13	0	0.00
	Water	300	777.00	28	72.52	138	352.24	8	20.72	9	23.31	19	49.21	18	46.62	18	46.62	41	106.19	19	49.21	4	10.36
	Totals																						

*Includes the 83 mi² (214.97 km²) of flooded lands consisting of flooded burned marsh and flooded agricultural and developed areas. Adjusting for these flooded areas, the net increase in water area (decrease in land) is 217 mi² (518 km²).

N

Scale 1:250,000

10 0 10 20 30 40 Kilometers

10 0 10 20 30 40 Miles

- 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.
- 2004 to 2005 New Water Areas (Decreased Land Areas)[1]: Includes flooded marsh, sheared marsh, eroded marsh, and scoured marsh.
- 2004 to 2005 New Land Areas[1]: 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

[1]Data were filtered to depict areas of loss and gain greater than 2.7 acres (1.1 ha) in size to remove background noise and to increase confidence in the depicted trends.

- Swamp**
- Fresh Marsh**
- Intermediate Marsh**
- Brackish Marsh**
- Saline Marsh**
- Other Land**: Includes agricultural areas, developed areas, and upland areas.
- Fall 2005 Water

**Incorporates 2005 land areas classified by 2001 marsh communities.

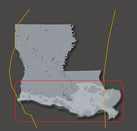


Image Source:
Landsat 5 Thematic Mapper satellite imagery is provided by the USGS Center for Earth Resources Observation and Science (EROS).

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 2006-11-0500

Open-File Report 2006-1274

U.S. Department of the Interior
U.S. Geological Survey