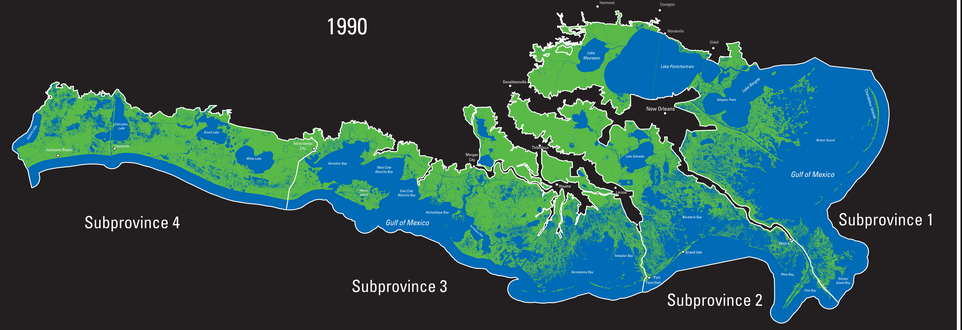
USGS
science for a changing world

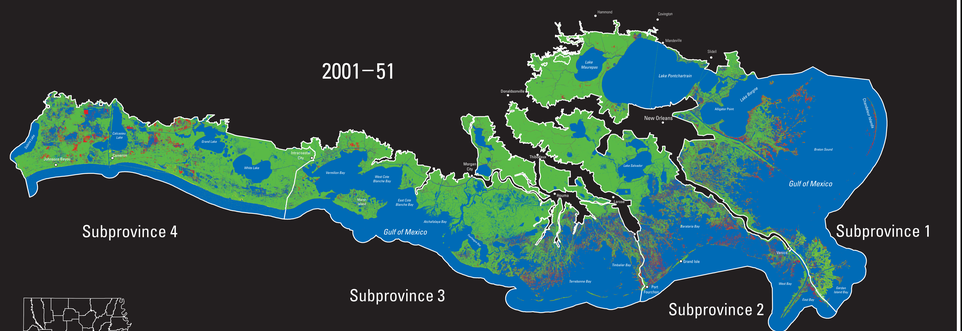
U.S. Department of the Interior
U.S. Geological Survey

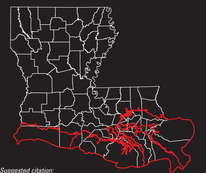
Scientific Investigations Map 3098

Modified Methodology for Projecting Coastal Louisiana Land Changes over the Next 50 Years

By Steve B. Hartley







Suggested citation:
Hartley, S.B., 2009, Modified methodology for projecting coastal Louisiana land changes over the next 50 years: U.S. Geological Survey Scientific Investigations Map 3098, 1 sheet, scale 1:750,000.

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

The background image represents data from 1990, 2001, 2004, and 2006 that are classified to land or water.

Introduction

The coastal Louisiana landscape is continually undergoing geomorphologic changes (in particular, land loss); however, after the 2005 hurricane season, the changes were intensified because of Hurricanes Katrina and Rita (Barras, 2006). These two hurricanes changed the landscape of coastal Louisiana, thus altering the projection of future land and water patterns. The U.S. Geological Survey (USGS) National Wetlands Research Center (NWRC) has assessed changes in land and water patterns in coastal Louisiana for many years by using Landsat Thematic Mapper (TM) satellite imagery (Barras, 2006). The purpose of this study is to provide information on potential changes to coastal Louisiana by using a revised methodology and by taking into account the catastrophic damage caused by Hurricanes Katrina and Rita. This study captures these patterns and projects land loss or gain rates over 50 years.

Background

The Louisiana Coastal Area (LCA), Louisiana Ecosystem Restoration Study (Barras and others, 2003) used land loss or gain rates to project landscape changes over 50 years but noted the limitations of the methodology used to compute rate change (Barras and others, 2003). The projected landscape in the LCA study assumes that the historical events and processes contributing to land loss or gain would continue into the future at the same intensity and thus provided for extreme event years. The amount of land loss caused by the 2005 hurricane season, however, was 42 percent (562 km^2) (Barras, 2006, 2007) of the total land loss (1,329 km^2) that was projected for the next 50 years (Barras and others, 2003). To capture the landscape patterns caused by the 2005 hurricane season, Landsat 5 TM satellite imagery (from 2001, 2004, and 2006) provided by the USGS Center for Earth Resources Observation and Science was used. The imagery shows the differences in landscape patterns for before and after storm events.

Objective

The objective of this study is to capture the landscape changes that occurred after the 2005 hurricane season and extend those changes into the future by modifying the methodology of the LCA study.

Methodology

The methodology used to project land loss is similar to that used in the LCA study (Barras and others, 2003). The LCA methodology used existing historical data, derived from interpretation of aerial photography, and new data, based on classified Landsat TM satellite imagery, to assess current land loss and gain trends from 1978 to 2000 for coastal Louisiana and project those trends over 50 years. This study is designed to extend the LCA analysis by incorporating the massive amount of land loss evident after the 2005 hurricane season (Barras, 2006, 2007).

In the LCA study, 183 polygons were delineated by the Land Change Study Group (Barras and others, 2003) to compute geographic-specific change rates within areas thought to have similar erosion rates based on geomorphology of the area and whether or not the area was under active management. There are several consequences to this methodology. One consequence is that the LCA methodology caused areas in the mapping to turn entirely to water before a threshold was reached. Another consequence is that managed areas, which were considered as undergoing ambient erosion rates in the LCA methodology, actually did not undergo ambient erosion rates, or in some cases like Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA) projects, not until after the life cycle of the project (20 years).

To capture these anomalies, we used a similar methodology using classified Landsat TM satellite imagery from 1990, 2001, 2004, and 2006 to calculate the "background" or ambient land-water change rates but divided the Louisiana coastal area differently on the basis of (1) geographic regions ("subprovinces") and (2) specific homogeneous habitat types. Defining polygons by subprovinces (1, Pontchartrain Basin; 2, Barataria Basin; 3, Vermilion/Terrebonne Basins; and 4, the Chenier Plain area [Barras and others, 2003]) allows for a specific erosion rate to be applied to that area. Further subdividing the provinces by habitat type allows for specific erosion rates for a particular vegetation type to be applied. This revised methodology assumes that erosion rates for habitat types by subprovince are under the influence of similar environmental conditions (sediment depletion, subsidence, and saltwater intrusion).

Initially, the approach was to use the seven habitat types (four "marsh" types, one "swamp," one "other," and one "water") from a 2001 vegetation survey (Linscombe and others, 2001) within each of the four geographic provinces (Barras and others, 2003) of coastal Louisiana to produce a matrix of 28 unique polygons. These unique polygons would allow for comparable erosion rates to be applied to a specific region and habitat type. The final analysis consisted of 24 polygons because the habitat type "water" (Lakes Maurepas and Pontchartrain) was included only in subprovince 1 from the 2001 vegetation survey and because "swamp" was not found in subprovince 4. The final 24 polygons were then used to calculate a background change rate for three time periods (1990–2001, 1990–2004, and 1990–2006). Background change rates for each polygon were calculated by taking the difference in water or land, depending on loss or gain, among each time period and dividing it by the time interval. This calculation gives an annual change rate for each polygon per time period. Background change rates for each time period were then used to compute the projected change in each subprovince and habitat type (table 1) over 50 years by using the same compound rate functions used in the LCA study (Barras and others, 2003). The maps show only an approximation of where erosion may occur on the basis of intensity values of the Landsat TM imagery.

Table 1. Projected land loss by subprovince and habitat type.

	2001–51		2004–54		2006–56	
	km^2	km^2/yr	km^2	km^2/yr	km^2	km^2/yr
Subprovince						
1	388.1	7.8	387.6	7.8	642.9	12.8
2	365.7	7.3	392.4	7.8	391.4	7.8
3	394.9	7.9	303.9	6.1	417.2	8.3
4	237.5	4.8	87.5	1.8	738.6	14.8
Totals	1,386.2	27.8	1,171.4	23.5	2,190.1	43.7
Habitat type						
Fresh	124.1	2.5	8.9	0.2	787.3	15.7
Intermediate	326.0	6.5	303.3	6.1	570.8	11.4
Brackish	298.9	6.0	306.3	6.1	377.2	7.5
Saline	573.8	11.5	509.1	10.2	430.6	8.6
Swamp	63.4	1.3	43.8	0.9	24.2	0.5
Totals	1,386.2	27.8	1,171.4	23.5	2,190.1	43.7

Actively managed areas and the CWPPRA areas were not masked out and dealt with separately as in the LCA study. The reason for not masking out managed areas is because those areas have the same opportunity for influence by a large disturbance event, such as those that occurred during the 2005 hurricane season. Other reasons not to mask out managed areas include natural subsidence, sediment depletion, saltwater intrusion, and wave erosion, which are still ongoing events in these areas even though they are considered managed.

Results

The maps show projected land changes based on the revised methodology and inclusion of damage by Hurricanes Katrina and Rita. The map at the top left shows land and water areas for 1990; the map at the bottom left shows a 50-year projection for land loss for 2001 (before the 2005 hurricane season) to 2051; upper right shows 2004 (before the 2005 hurricane season) to 2054; and bottom right shows 2006 (after the 2005 hurricane season) to 2056. Comparison of projected land change values between the LCA study and this study shows that this revised methodology—that is, using a reduced polygon subset (reduced from 183 to 24) based on habitat type and subprovince—can be used as a quick projection of land loss. The LCA study showed a total projected loss of 1,329 km^2 over the next 50 years using a time period from 1978/90 to 2000, while this study projects a loss of 1,386.3 km^2 using a time interval of 1990–2001, a difference of about 1.15 km^2/year. The small difference between these projected numbers can be attributed to a couple of factors. The first is the different time intervals used to calculate change rates. The second is the exclusion of managed areas.

Projected land loss decreases from 1,386.3 km^2 using the 1990–2001 time interval to 1,171.4 km^2 using the 1990–2004 time interval (table 1). This decrease in projected land loss demonstrates that land loss was decreasing before the 2005 hurricane season, which could be attributed to the effects of CWPPRA projects or imagery used for 2004 having lower water levels. This decreasing trend was reversed after the 2005 hurricane season. Projected land loss increased to 2,190.1 km^2 (table 1) using the 1990–2006 time interval erosion rates, thus showing the massive amount of projected land loss caused by inclusion of the 2005 hurricane season. Barras (2006) cautioned about using the immediate posthurricane imagery because of persistently high water levels in some places that precluded their definitive identification as either flooded marsh or as marsh removed by the storm surge. He stated that estimates of permanent losses cannot be made until several growing seasons have passed and the transitory impacts of the hurricanes are accounted for (Barras, 2006). Therefore, the projected land loss for the period 2006–56 is only a preliminary analysis.

Land change projections show an increase in land loss in subprovinces 1 and 4 (fig. 1). Projected province 1 increases can be attributed to Hurricane Katrina, and projected subprovince 4 increases can be attributed to Hurricane Rita (Barras, 2007). Projected land loss by habitat shows that fresh and intermediate marshes may erode faster than would brackish and saline marshes (fig. 2). The reason for this is that Hurricane Katrina's path intersected the fresh and intermediate marshes of the Mississippi River Delta, while Hurricane Rita's path left thousands of acres of fresh and intermediate marsh inundated for months because of impoundments (Louisiana Department of Wildlife and Fisheries, Fur and Refuge Division, 2007).

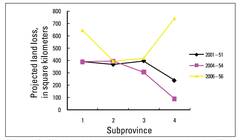


Figure 1. Projected land changes over the next 50 years by subprovince.

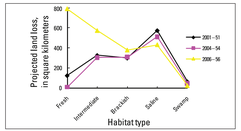


Figure 2. Projected land changes over the next 50 years by habitat type.

References

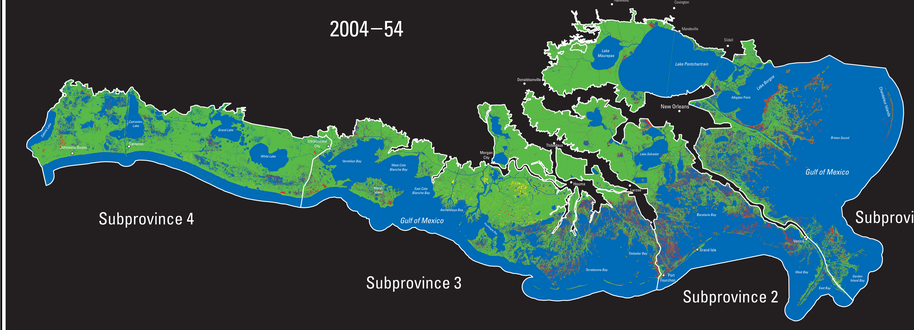
Barras, J., Beville, S., Britsch, D., Hartley, S., Hawes, S., Johnston, J., Kemp, P., Kinler, Q., Martucci, A., Porthouse, J., Reed, D., Roy, K., Sapkota, S., and Suhayda, J., 2003, Historical and projected coastal Louisiana land changes—1978–2050, appendix B of Louisiana Coastal Area (LCA), Louisiana Ecosystem Restoration Study: U.S. Geological Survey Open-File Report 2003–334, 39 p., accessed Sept. 16, 2006, at http://pubs.er.usgs.gov/usgspubs/ofr/ofr03334.

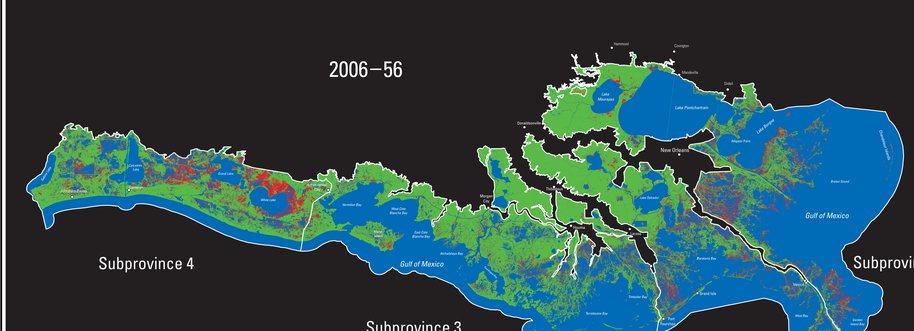
Barras, J.A., 2006, Land area change in coastal Louisiana after the 2005 hurricanes—a series of three maps: U.S. Geological Survey Open-File Report 06–1274.

Barras, J.A., 2007, Satellite images and aerial photographs of the effects of Hurricanes Katrina and Rita on coastal Louisiana: U.S. Geological Survey Data Series Report 07–281.

Linscombe, G., Chabreck, R.H., and Hartley, S.B., 2001, 2001 Louisiana coastal marsh-vegetative type map (database): Louisiana Department of Wildlife and Fisheries, Fur and Refuge Division, and the U.S. Geological Survey National Wetlands Research Center, accessed Sept. 16, 2006, at http://brownmarsh.net/data/lll_8.htm.

Louisiana Department of Wildlife and Fisheries, Fur and Refuge Division, 2007, Louisiana's Alligator Management Program: Gator Notes, v. 2, no. 1, accessed Feb. 25, 2009, at http://www.wlf.louisiana.gov/pdfs/experience/April%202007%20Newsletter.pdf.





Scale 1:750,000

20 10 0 20 40 60 80 Kilometers

20 10 0 20 40 60 80 Miles

N

EXPLANATION

- Land loss
- Land gain
- Land
- Subprovince boundary