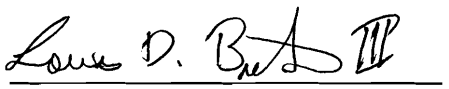
Expert Report

of

Louis D. Britsch III



U. S. Army Corps of Engineers, New Orleans District

Robinson v. United States, Civil Action No. 06-2268, E.D. La.

December 18, 2008

Qualifications

I am a geologist at the U.S. Army Corps of Engineers, New Orleans District. For the past 24 years I have worked in the deltaic plain of coastal Louisiana conducting research and studies focusing on the geomorphic development of the coast, land loss rates and causes, subsidence, and the engineering properties and characteristics of depositional environments. I have been actively involved in the planning and design of coastal restoration and protection projects as part of the Coastal Wetlands Planning Protection and Restoration Act, Coast 2050, and the Louisiana Coastal Area Study, all multi-agency projects with participation from numerous Federal, State, and local agencies. I contributed land loss data and analysis, borrow source identification, geologic history, and engineering geology data. I have published Corps technical reports, journal articles, and proceedings, and made presentations at numerous technical conferences on the subjects of land loss, subsidence, and geomorphic development of coastal Louisiana. As an employee of the U.S. Army Corps of Engineers, I am receiving no additional compensation for the preparation of this report. I have not testified as an expert witness at a trial or deposition in the past.

Opinions

This Expert Report discusses the geology of the area in the vicinity of the Mississippi River Gulf Outlet (MRGO) and the loss of land and habitats in the surrounding area. As detailed below, it is my opinion to a reasonable degree of scientific certainty that:

- The construction of the MRGO is only one of numerous factors which have contributed to land loss, habitat change, and salinity change in the study area.

- Large-scale logging operations in the late 1800's and early 1900's removed the large, old-growth baldcypress trees from the study area, prior to construction of the MRGO.

- The land loss rate trend for the study area (see Figure 2) is the same as that found in the Central Wetlands Unit (CWU) (see Figure 3), the Pontchartrain Basin as a whole, and in other basins along the Louisiana coast. Land loss rates and trends in the study area are not higher than in other areas of the Louisiana coast.

- Geomorphic and mapping data suggest that the trends of barrier island migration, degradation, and loss were in place since the late 1800's, well before construction of the MRGO, and continued after construction.

- The expert reports by Day and Shaffer (2008) and FitzGerald and others (2008) attempt to show that most of the land loss, habitat change, saltwater intrusion, barrier island degradation, etc. in the vicinity of the MRGO is due to construction and operation of the MRGO. Data presented within the following sections clearly show that numerous other processes and factors contributed to the changes within the study area, many which were active prior to construction of the MRGO.

Regional Geologic Setting

The geomorphic development of coastal Louisiana is closely related to shifting Mississippi River courses since the slowing of Holocene post-glacial sea level rise (Fisk, 1955; Frazier, 1967; and Coleman and Gagliano, 1964). The Mississippi River has changed its course several times during the last 7,000 years, leading to the development of the Mississippi River deltaic and chenier plains. The deltaic plain is composed of several major delta complexes, two of which (the Plaquemines/Modern and Atchafalaya) are still active. Dominant physiographic features of the deltaic plain include abandoned courses and distributaries and their associated natural levees, swamps, marsh, hundreds of lakes and bays, and barrier islands.

Recognition that the deltaic plain is formed by an orderly progression of events related to shifting Mississippi River courses led to the identification and characterization of the "delta cycle" (Scruton, 1960; Frazier, 1967). The "delta cycle" is a dynamic and cyclic process that alternates between periods of progradation and a subsequent transgression of deltaic headlands as deltas are abandoned and reworked by marine waters (Penland et al., 1988; Roberts, 1997). Figure 1 illustrates the stages in the development of a major delta lobe through its regressive and transgressive phases, from stream capture to submarine shoals. Many variables act to determine the phase of the "delta cycle" active at any one location. Time since initiation of stream capture (the age of distributaries), sediment supply, rate of accommodation space creation (the area available for deposition), relative sea level change, and rate of river discharge are some of the variables responsible for development of the deltaic plain (Roberts, 1997).

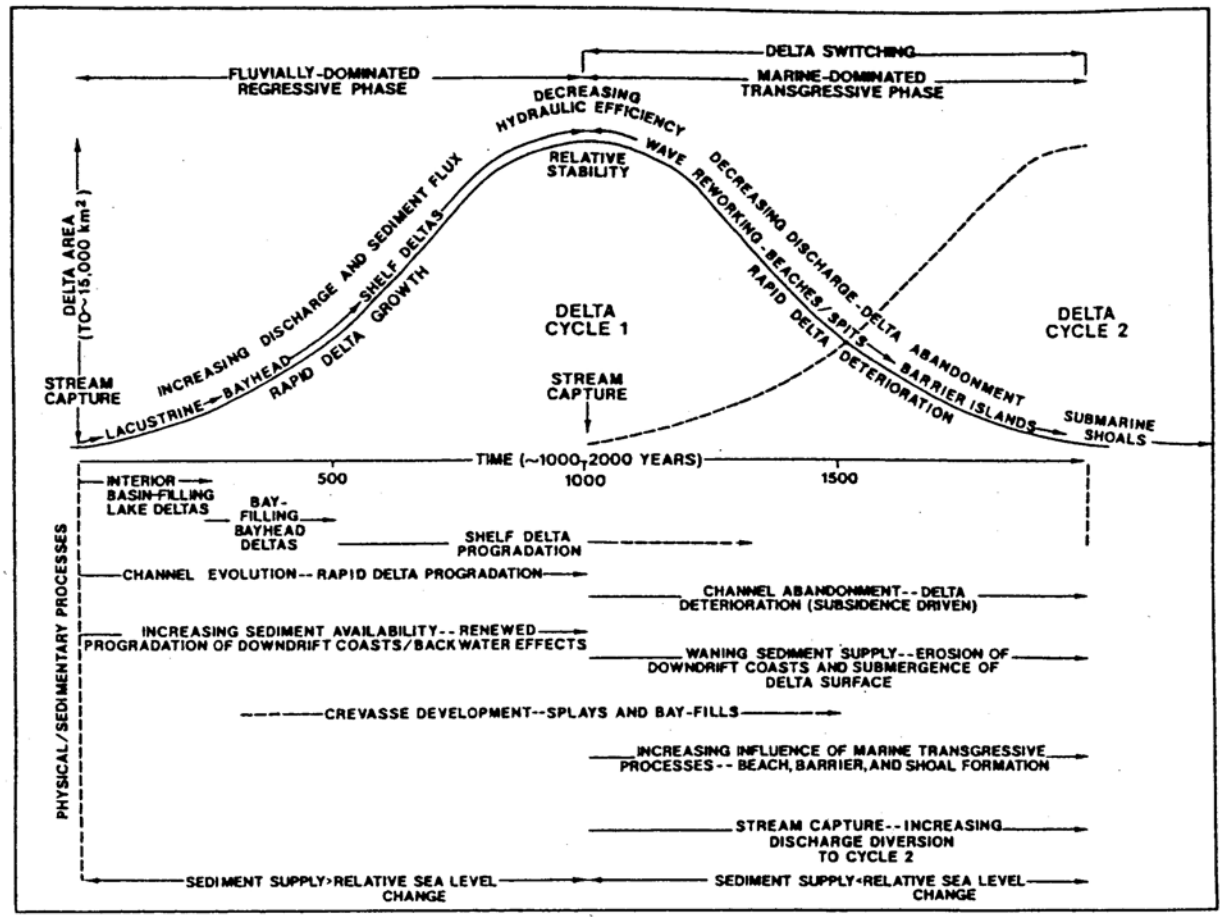


Figure 1. Conceptual model of the delta cycle showing growth and decay of individual delta lobes (from Roberts, 1997).

Throughout most of the last 7000 years the “delta cycle” has created more land by building deltas (regressive phase) than was destroyed by relative sea level rise and erosional processes (transgressive phase). Since the early 1900’s man has had a major influence on many of the key elements controlling the “delta cycle”. The Old River Control Structure has eliminated the delta switching process by maintaining the Mississippi River in its present course. Flood protection levees built in the early 1900’s confine the flow of the Mississippi River eliminating overbank flooding and the nutrients and sediments that accompany these floods. Also, the suspended sediment load of the Mississippi River has declined by approximately 50 percent between the 1930 to 1952 period and the 1963 to 1982 period (Kesel, 1988). This decline has been attributed to bank stabilization by revetments, dams constructed on the Missouri River and other large tributaries, and other erosion control measures.

As the natural delta-building process was restrained, relative sea level rise and erosion (transgressive processes) began to dominate the coastal landscape. Within this environment of diminished delta building, man began a period of extensive development in the coastal zone beginning in the early 1900’s. Man-made alterations to the natural landscape such as dredging of navigation and access canals, construction of roads and levees within the wetlands, and drainage

projects altered the natural hydrology compounding the negative effects of relative sea level rise and wetland erosion. Land loss rates exceeding 40 mi^2/yr (104 km^2) were documented for the 1958 to 1974 period with high rates of loss continuing today (Dunbar et al., 1992).

Coastal Louisiana is characterized by depositional environments and shoreline configurations representing various phases of the "delta cycle". Presently, most of the Louisiana coastal zone is in the marine-dominated, transgressive phase of the "delta cycle". Only the Modern and Atchafalaya Deltas are in the fluvially-dominated, regressive phase.

Study Area

The study area is shown in Figure 2. Its boundaries are based in part on the hydrologic units identified in the Coast 2050 report and professional judgment as to the limit of MRGO influence on land loss. Within the study area is the Central Wetlands Unit (CWU) shown in Figure 3.

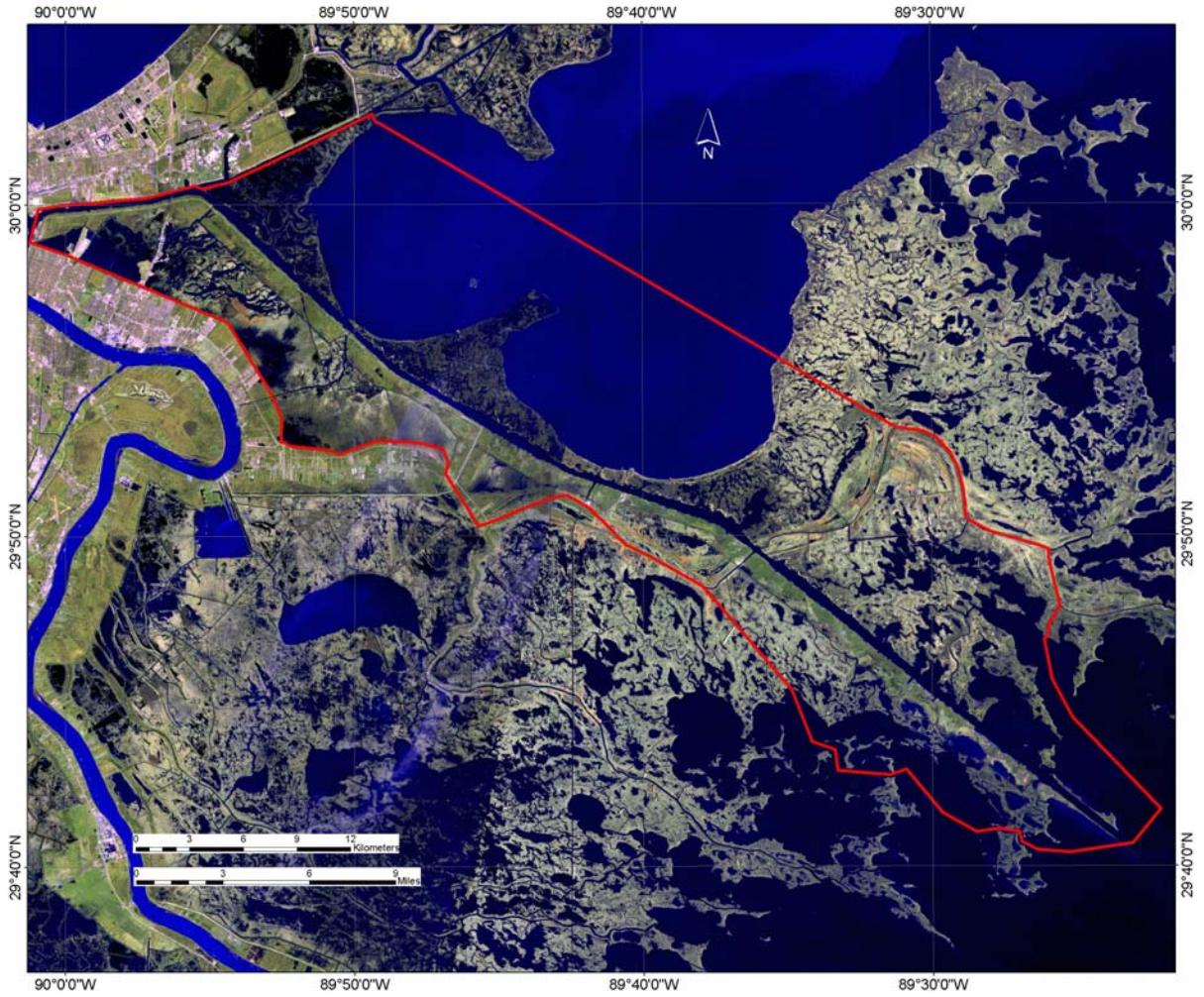


Figure 2. Study area, enclosed in red.

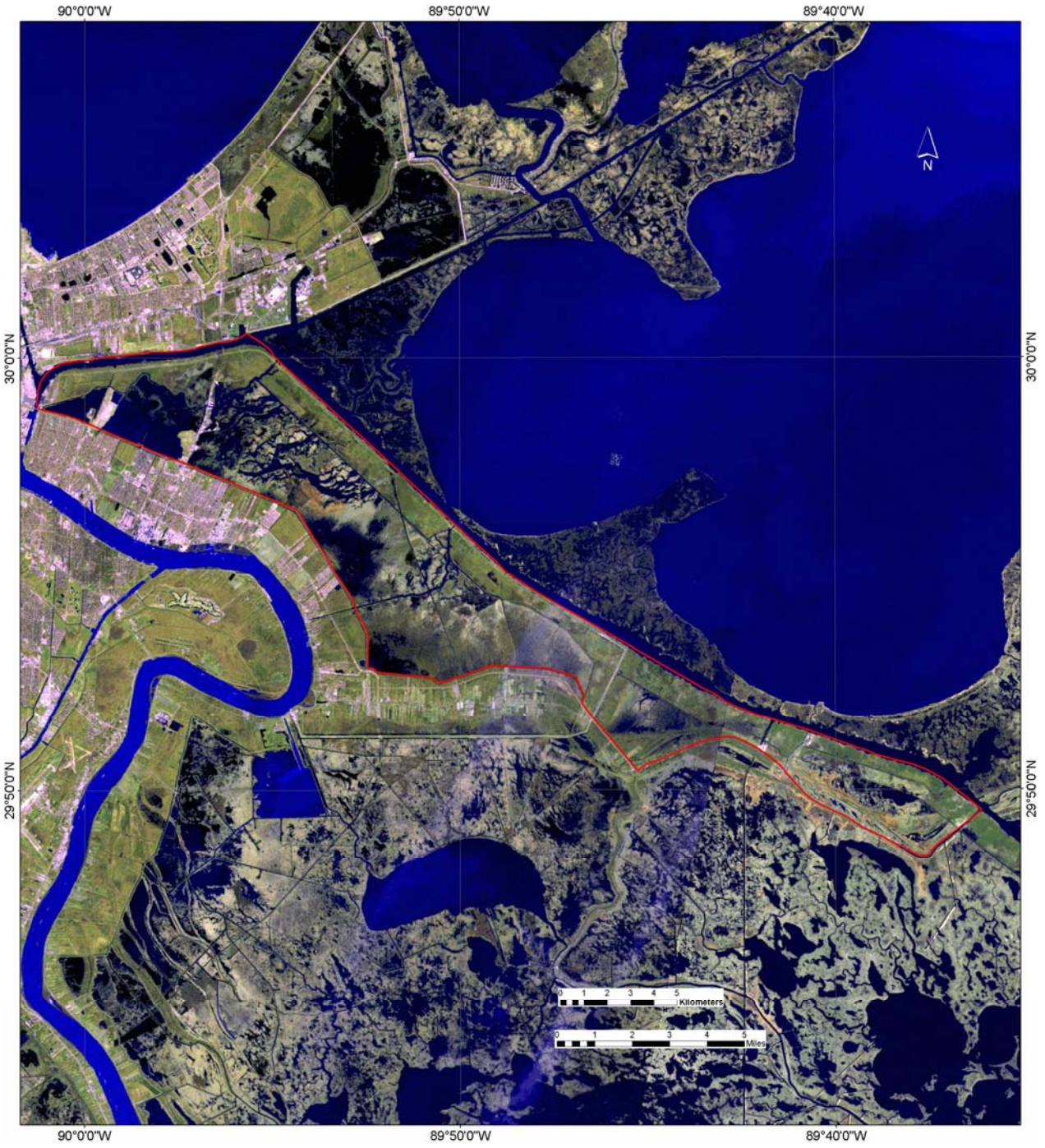


Figure 3. Location of Central Wetlands Unit, enclosed in red.

Geologic Setting of Study Area

The study area is part of the St. Bernard delta complex which began depositing deltaic sediments in the study area approximately 4000 years ago (Frazier, 1967). Prior to the initiation of delta growth, the entire study area was open water. Major distributaries of the St. Bernard Delta which contributed sediment to the study area were Bayous Bienvenue, LaLoutre, Sauvage, and Terre Aux Boeufs. Dominant physiographic features include abandoned distributaries and their associated natural levees, swamp, marsh, and Lake Borgne. Natural levee deposits border the Mississippi River and Bayou LaLoutre in the study area. Natural levee deposits have higher elevations and firmer soils than the surrounding environment allowing woody vegetation to develop.

The entire St. Bernard delta, of which the study area is a part, is in the marine domininated/transgressive phase of the "delta cycle" (see Fig. 1) (Roberts, 1997). During this phase, delta abandonment takes place and the processes of subsidence, erosion, and marine transgression dominate the landscape. The result is land loss, submergence, habitat change (driven mainly by elevation decrease and salinity increase), and an increase in water area. The St. Bernard delta complex has been in this marine dominated/transgressive phase since approximately 2300 years ago when the Bayou LaLoutre distributary was abandoned, eliminating the major source of sediment for this delta (Frazier, 1967). The Teche and Lafourche deltas of the deltaic plain to the west of the St. Bernard delta are also in the marine-dominated phase and have both experienced high relative rates of land loss, submergence, and habitat change.

Land Loss

Land loss rates and patterns have been well documented in coastal Louisiana (Gagliano et al. 1981; Britsch and Kemp 1990; Barras et al. 1994; and Britsch and Dunbar 2006). It is widely accepted that land loss is the result of the complex interaction of numerous natural and man-made factors (Turner and Cahoon 1987; Boesch et al. 1994; and Penland et al. 2001). For this report, land loss area was calculated for the study area using data from the Corps Land Loss Study (Britsch and Dunbar 2006).

The purpose of the Corps Land Loss Study was to document on maps the land loss that has occurred in coastal Louisiana during 5 successive time intervals beginning in the 1930's. The land loss mapping was accomplished by compariing 6 vintages of aerial photography from which the change in land/water area was delineated.[1] During the mapping process, land loss was considered to be any land area present in the 1930's photography that was interpreted as water on later photographic coverage's. This includes loss from man-made causes as well as loss due to

[1] The 6 vintages of photography include: 1932-33 U.S. Coast and Geodetic Survey Air Photo Compilation Sheets (T-sheets), 1956-58 Tobin Surveys black and white photo mosaics, 1974 NASA color IR, 1983 National High Altitude Program color IR, 1990 NASA color IR, and 2001 NASA color IR. Land loss mapping was conducted at a scale of 1:62,500. The T-sheets were used as a base on which areas of land loss were delineated. Where T-sheets were not available, the USGS quadrangle published closest to 1932 was used.

natural processes. Most of the loss classified as man-made is the result of dredging activity. Oil and gas location canals and waterways designed to aid navigation account for the majority of man-made loss. All land loss not the direct result of man's activities was considered natural loss. Once an area was designated as loss, it remained loss regardless of any subsequent changes in later time intervals. Therefore, if an area was lost in one time interval and later became land by accretion, filling, or drainage it would still be shown as loss for the period when the loss occurred. Land gain was not mapped as part of this study. For these reasons, the land loss map shown in Fig. 4 may not fully reflect the actual land/water area in 2001. Completed land loss maps were converted to digital data by optical scanning, and the number of acres lost in each time period were calculated**.** Map errors that may be present are a function of the quality of the base maps, photo quality, scale modifications, computer errors, and human error.

The land loss map for the MRGO study area is shown in Fig. 4. Land loss acreage for each time period was calculated. Land loss data shows that a total of approximately 29,796 acres of loss occurred between the 1932 and 2001. Of this total, approximately 6,277 acres were lost during the 1932 to 1958 period, prior to the construction of the MRGO (see Figure 4). For the period 1958 to 2001, a total of approximately 23,519 acres were lost[2]. This equates to an average loss rate of 547 acres per year for the 1958 to 2001 period. The land loss rate was highest for the 1958 to 1974 period and decreased during the 1974 to 2001 period. This same trend in the land loss rate is found in the CWU, the Pontchartrain Basin as a whole, and in other basins along the Louisiana coast. Land loss rates and trends in the study area are not higher than in other areas of the Louisiana coast.

[2] Land loss from the original footprint of the MRGO accounts for approximately 3,250 acres of this total.

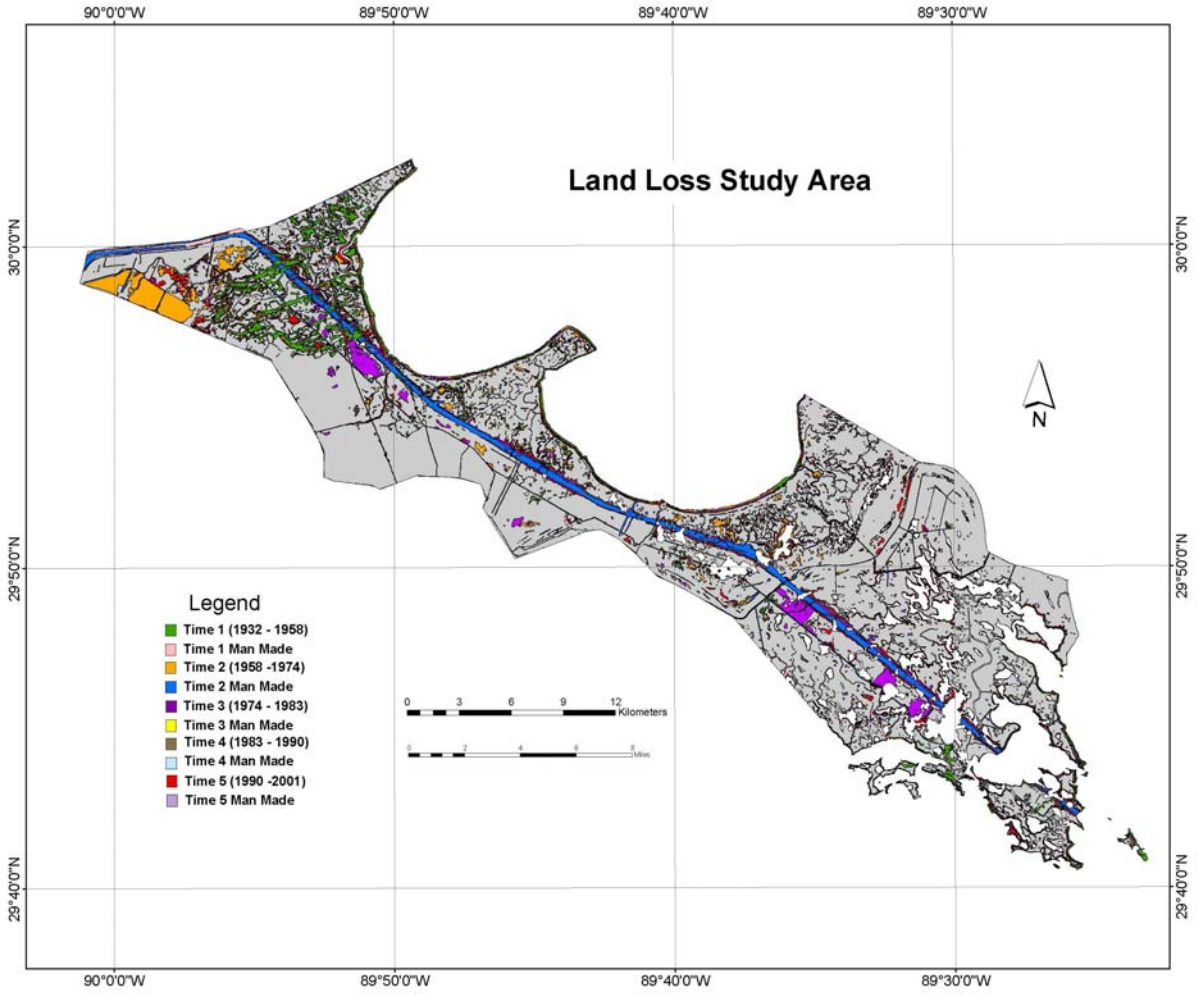


Figure 4. Land loss map of the MRGO study area. From Britsch and Dunbar 2006.

Causes of Loss

As mentioned previously, it is often a combination of processes acting at different time and spatial scales that combine to cause loss. For this reason it is often difficult to isolate just one process responsible for an area of loss. For this report I will focus on what I conclude were the primary processes of loss in the study area from 1958 to 2001. Primary processes include direct removal, erosion, and submergence. These same processes were identified in a land loss classification study of the Mississippi River deltaic plain by Penland et al. (2001) (Attached as Appendix A). The main types of direct removal in the study area include dredging of navigation and access canals. Erosion includes natural (wind generated) and navigation (boat wakes) waves, and channel flow (suspension and conveyance by water). Submergence includes mainly natural subsidence (downward displacement of the land surface) and altered hydrology (changes in flow patterns and water surface elevation due to a number of actions such as canal dredging, levee and road construction, and impoundment acting individually or in combination with each other and the natural geomorphic features). Many of the features responsible for altering the

hydrology in the study area were constructed prior to the MRGO. An example of road, levee, and canal construction in the Central Wetlands Unit (CWU) prior to the MRGO is shown in Fig. 5.

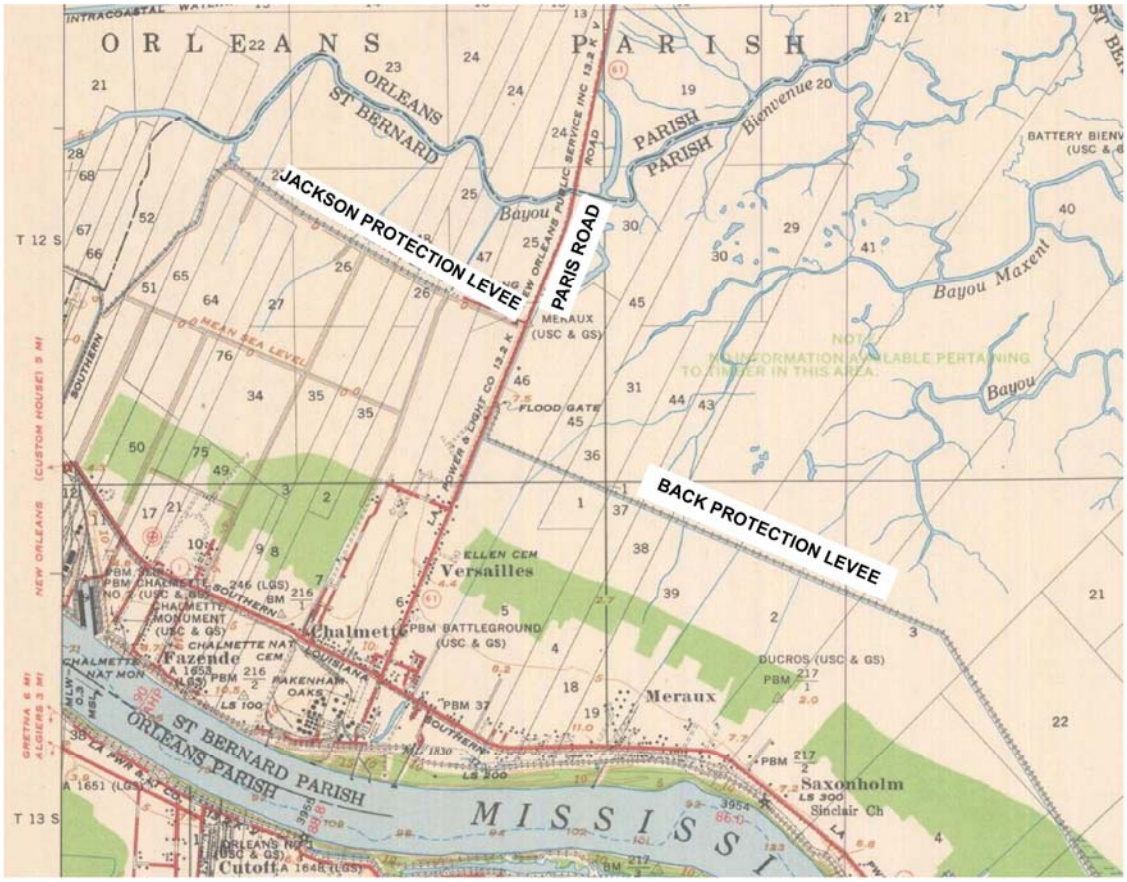


Figure 5. Portion of 1942 Corps of Engineers topographic map showing active development in the CWU. Paris Road, Jackson Protection Levee, Back Protection Levee, and canals dredged for construction material (shown in blue, parallel to the Back Protection Levee) all contributed to altering the hydrology in this area.

Direct land loss from dredging the initial footprint of the MRGO channel was approximately 3,250 acres (U. S. Army Corps of Engineers, 1999). Subsequent erosion of the banks due to wind waves, boat wakes, and channel flow totaled approximately 3,836 acres for the 1958 to 2001 period (see Fig. 4). Altered hydrology due to a pre-MRGO impoundment is shown in Fig. 6. The total loss for this one area is approximately 1,628 acres. Erosion from natural waves along the Lake Borgne shoreline accounts for approximately 1,415 acres (see Fig. 4). Shoreline erosion rates in Lake Borgne were documented by Zganjar and others (2001) for the period 1930 to 1995. Transects were taken at two minute intervals of longitude and latitude around the Lake. For those transects on the southern shoreline of Lake Borgne closest to the MRGO, the rates of shoreline erosion were higher for the 1930 to 1960 period than for the 1960 to 1995 period,

except for one transect. This data shows that shoreline erosion rates along the south shore of Lake Borgne were higher pre-MRGO (an average of 3.8 meters per year for the transects) than post-MRGO (an average of 1.6 meters per year). The remaining loss in the study area (approximately 13,390 acres) is due mainly to shoreline erosion by natural waves on the numerous ponds and bays in the study area and submergence due to altered hydrology from a combination of canal and channel dredging, levee and road construction, and natural subsidence.

These same processes of loss are acting throughout coastal Louisiana and are responsible for the high rates of land loss experienced along the coast.

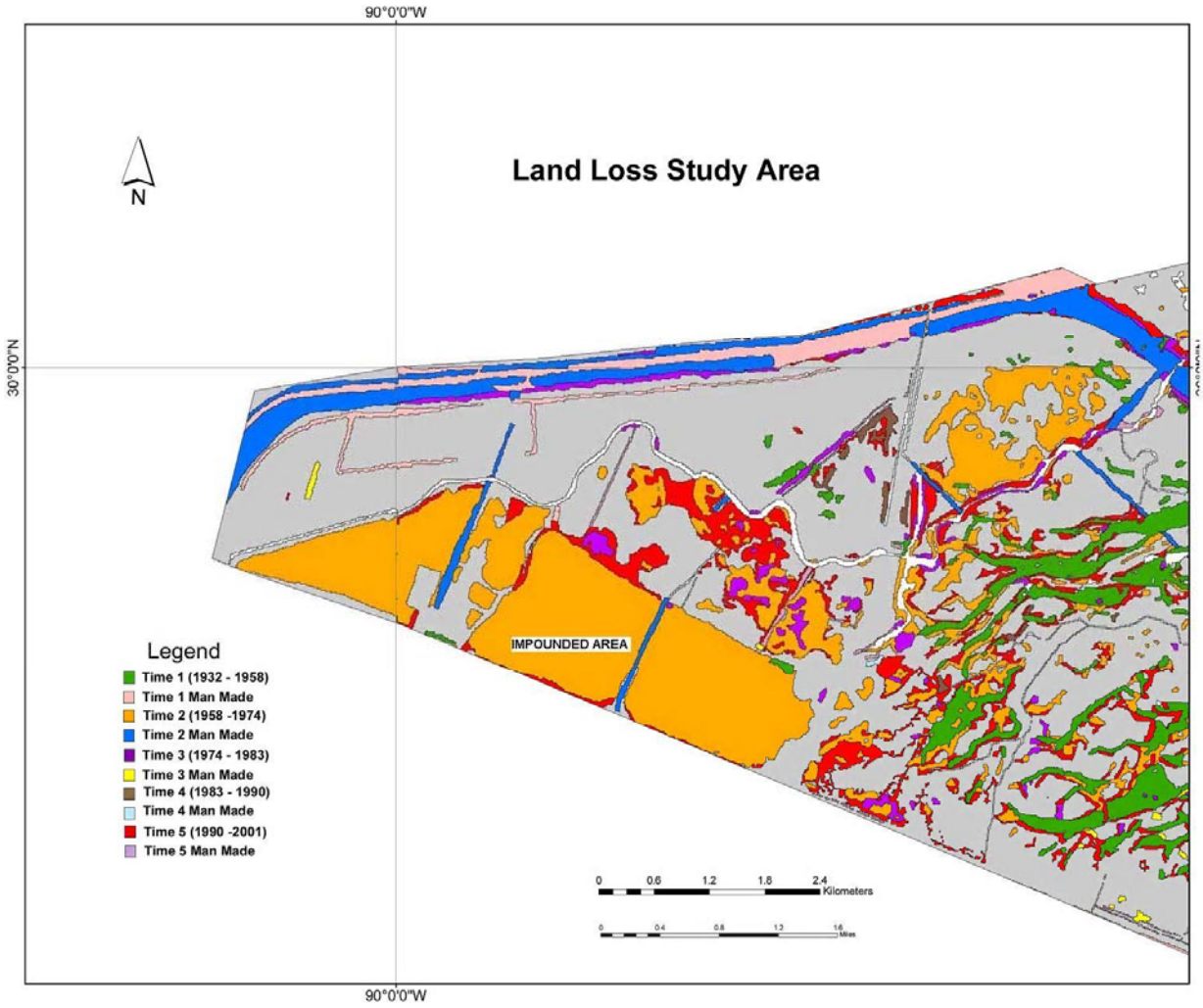


Figure 6. Impoundment (rectangular area with orange color code) constructed prior to 1942. Land loss did not occur until the 1958 to 1974 period.

Swamp Habitat

The area of swamp in the study area exists on the outer limits of the natural levee deposits adjacent to the Mississippi River and part of Bayou LaLoutre. The swamp environment was generally most extensive when the width and elevation of the natural levee was at its maximum; usually at or near the time of river and stream abandonment. Natural, long-term (100's of years), relative subsidence rates for this portion of the deltaic plain range from 0.5 to 0.7 feet per century based on radiocarbon data (CEI 1972; Corps unpublished data). As the natural levees subside, the area of forest and swamp decreases as the elevation of the land surface decreases (Fisk 1960) (see Figure 7). This process is partially responsible for the loss of swamp in the study area and is most evident on Bayou LaLoutre, east of Yscloskey, where most of the natural levee has subsided to an elevation that cannot support trees. Elevation change is an important driver of habitat change, not only for swamp, but also for marsh habitats (see Fig. 7).

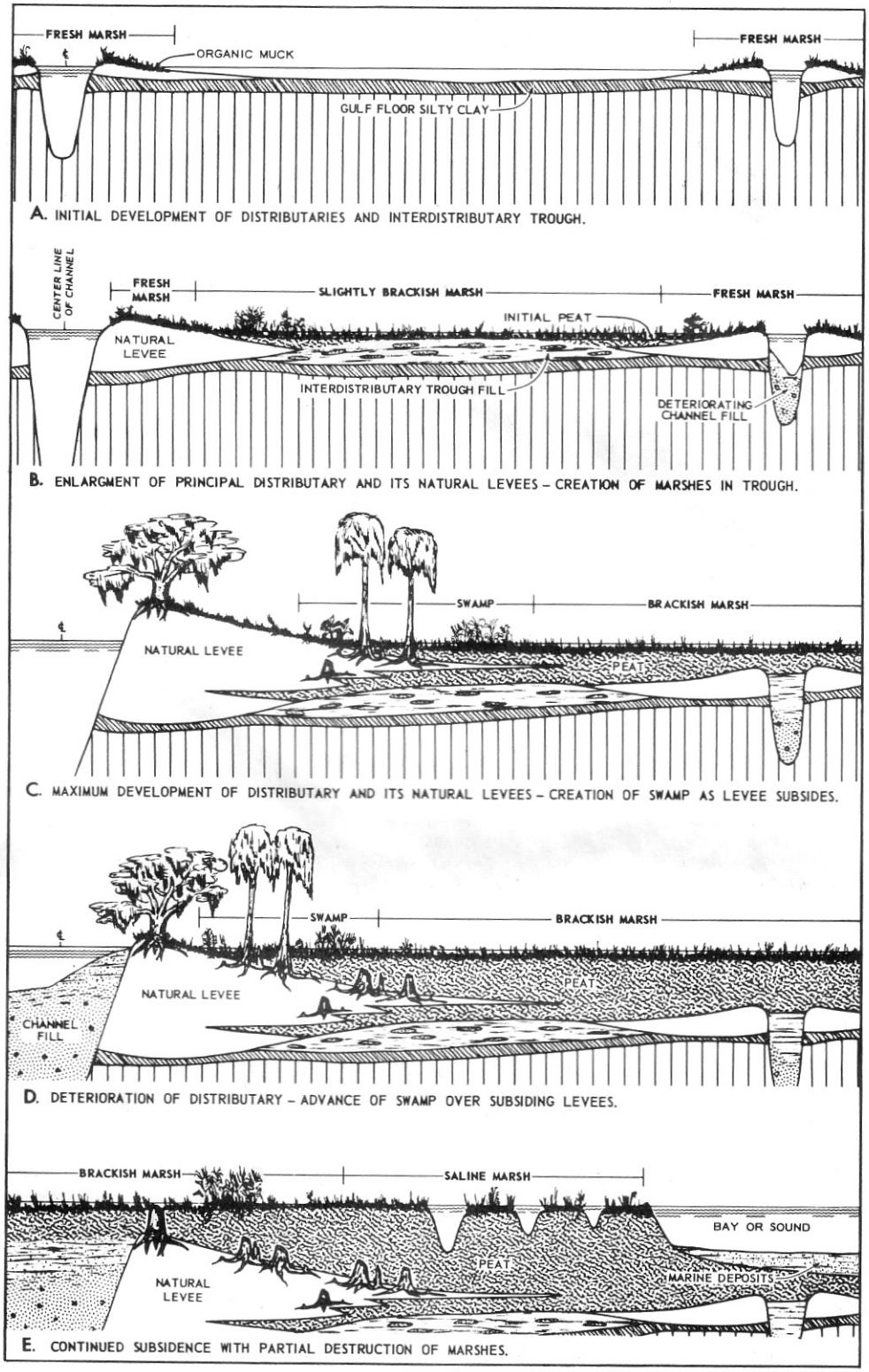


Figure 7. Typical sequence of natural levee development and decline. Habitats develop, shift, and are lost as the natural levee and surrounding environments develop and then subside. From Fisk (1960).

Also, many of the processes responsible for land loss have been identified as causes for the degradation and loss of swamp. They include altered hydrology and direct removal of trees by logging. Examples of all these activities took place in the CWU prior to construction of the MRGO and led to degradation and destruction of swamp habitat. Figure 5 shows construction of the Jackson and Back Protection Levees which isolated the swamp between the Mississippi River and the Back Protection Levees from any water exchange outside the levee system. The back protection levee cutoff the natural sheetflow of rainwater from the natural levee to the swamp. Instead, the runoff is pumped into the wetlands at point sources, restricting this valuable source of freshwater to a small area near the discharge locations. In addition, Paris Road altered the hydrology of a large area in the northwestern portion of the CWU. Also, a large pipeline canal and several access canals were cut through the CWU prior to construction of the MRGO. These canals led to alterations in the hydrology and aided the intrusion of more saline water into the study area.

Logging is another process that impacted the swamp prior to the MRGO. The swamp was exploited as a close source of timber. In a study of St. Bernard Parish, Coastal Environments Inc. (1972) noted traces of access canals and logging activity from the late 1800's and early 1900's. Figure 8 is a map compilation of a 1932 photograph showing logging access canals in the CWU. Figure 9 is a scene from 2005 photography showing a dense network of pullboat logging scars radiating from man-made canals, also in the CWU. Evidence of the logging activity shown on the 2005 photography is also on the Tobin 1958 photography of the same area, but is difficult to discern due to the photo quality and remaining canopy. Most of the old-growth baldcypress swamp was likely logged out in the early 1900's and only remnants of the virgin swamp and second-growth baldcypress remained.

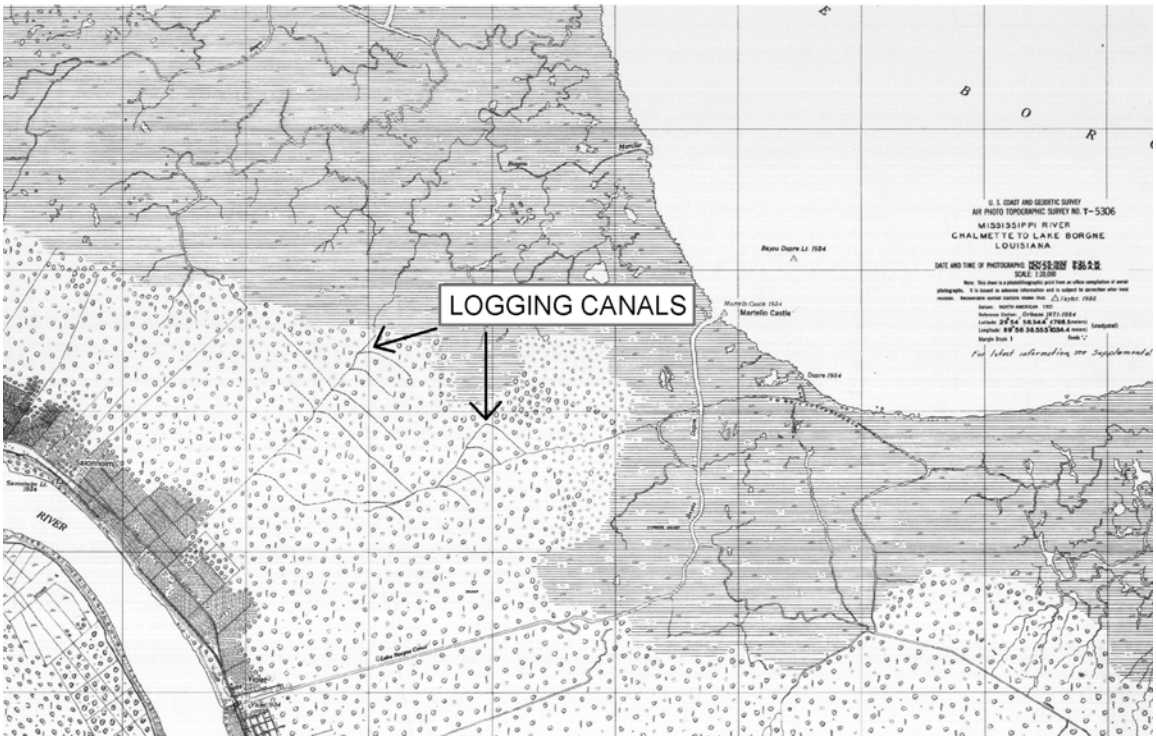


Figure 8. Excerpt from 1932 U.S. Coast and Geodetic Survey Sheet, Chalmette to Lake Borgne showing branching canals indicative of logging activity in the CWU.

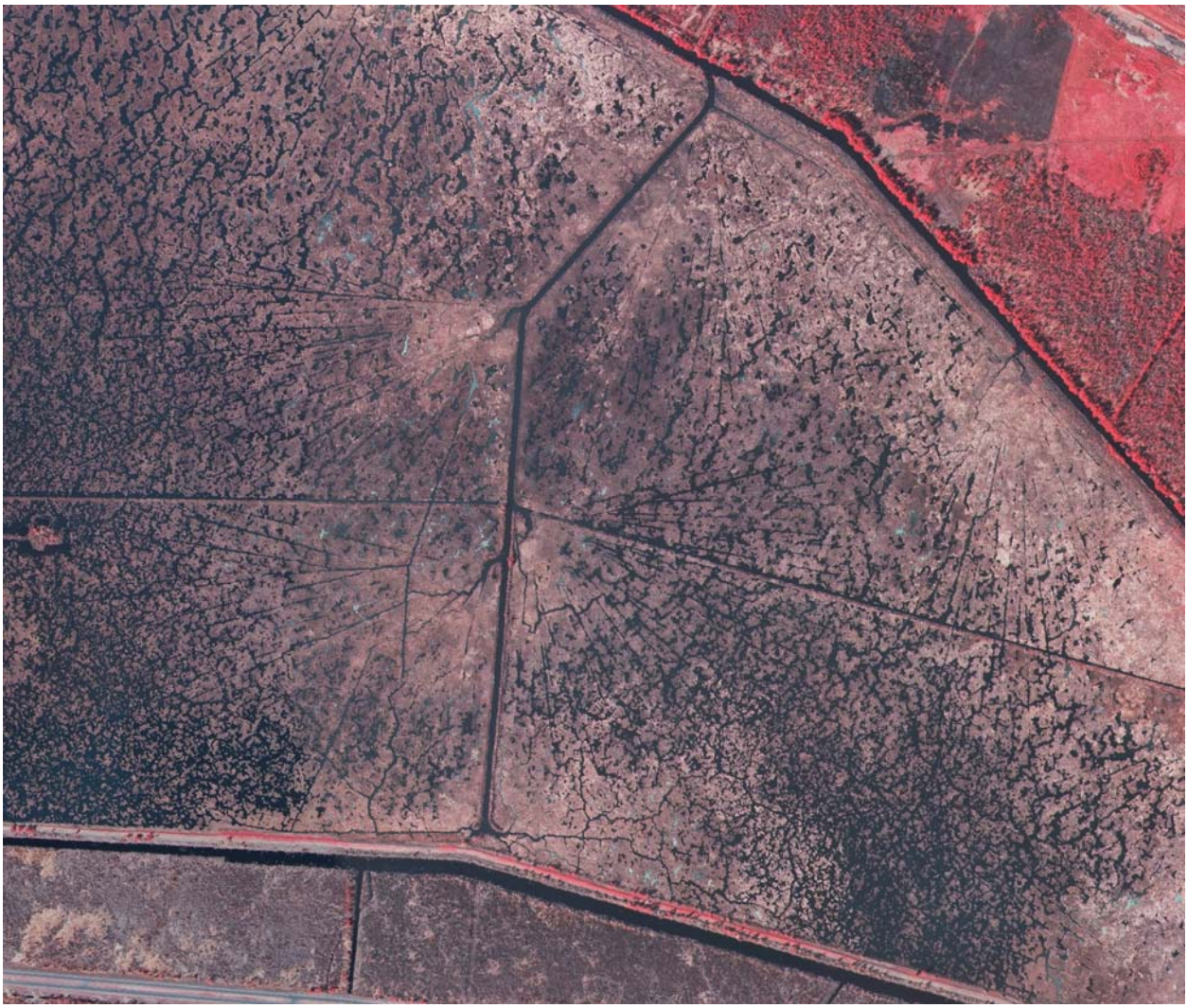


Figure 9. Scene from 2005 color IR photography showing pattern of scars from logging activity radiating from access canals in the central portion of the CWU.

Another probable cause of swamp loss was saltwater intrusion into these predominantly freshwater environments during hurricanes. Penfound and Hatthaway (1938) describe numerous ghost forests (forests killed by saltwater) in the Lake Pontchartrain-Lake Borgne region. They state that all available evidence points to saltwater brought inland by a hurricane in 1915 as the cause for the destruction. Their paper clearly indicates that large areas of ghost forests existed in the study area prior to 1938 and that saltwater intrusion was a likely cause of swamp loss well before the construction of the MRGO. Another hurricane in 1947 impacted the study area and likely brought in saltwater to the swamp area causing more swamp loss. This is in direct contrast to the notion that the CWU was characterized by tens of thousands of acres of healthy baldcypress-water tupelo swamps prior to construction of the MRGO, as described in the expert report by Day and Shaffer. Figure 10 is a 1959 photograph taken during dredging of the MRGO access channel. Large areas of marsh loss are visible north and south of the channel. This loss

likely resulted from erosion during the 1947 hurricane and is unrelated to construction of the MRGO.



Fig. 10. Areas of marsh loss adjacent to MRGO access channel. This loss is likely related to erosion during the 1947 hurricane which impacted the study area.

Breton Island Impact

Geomorphic and migration data presented by FitzGerald and others in their expert report (Figures 3.5 to 3.8) indicates that the erosion and migration patterns of the Chandeleur Islands chain, including Breton Island at the southernmost end, are the same now as they were in the late 1800's. The Island area was decreasing and migrating landward since 1885, prior to construction of the MRGO. Recurved spits at the ends of Grand Gosier and Breton Islands prior to construction of the MRGO indicate that the tidal inlet between these islands was influencing island morphology and limiting sediment transport to Breton Island from the northeast. Spit

growth on Breton Island since at least 1885 indicates that sand transport on the northern half of the island is actually northeast, towards the MRGO. The impact to the islands from the MRGO, if any, is difficult to quantify with any degree of certainty because the erosion and migration patterns in place since the late 1800's were still operating in 2005, with no obvious change after construction of the MRGO.

Conclusions

The study area contained approximately 113,643 acres of land in 1958 based on data from the Corps Land Loss Study. Of this total, approximately 23,519 acres of land loss occurred in the study area between 1958 and 2001. Land loss in the study area is generally due to direct removal, erosion, and submergence. Dredging of the MRGO and subsequent bankline erosion accounted for 7,086 acres of the total. The remaining loss is due mainly to shoreline erosion of Lake Borgne, bays, and ponds, and submergence due to altered hydrology from a combination of canal and channel dredging, levee and road construction, and natural subsidence.

The study area is part of an abandoned Mississippi River delta in which natural subsidence, land loss, and saltwater intrusion are part of the natural delta cycle. These destructive processes were active for hundreds of years prior to the construction of the MRGO. Man's activities such as levee, road, and canal construction, logging, and construction of the MRGO have contributed to and in some cases accelerated these natural processes. The design of the MRGO channel led to the dissection of the Bayou LaLoutre natural levees which altered the hydrology in the study area accelerating the process of saltwater intrusion and contributing to land loss. Therefore, to the extent the MRGO caused an increase of salinity into the study area and the CWU, it was a direct result of the design of the channel and the altered hydrology resulting from the dissection of these natural levees.

Like land loss, loss of swamp is caused by a number of man-made and natural processes. Many of the processes responsible for loss and degradation of swamp habitat were active in the study area prior to 1958; especially subsidence, levee construction, dredging of canals, logging, and saltwater intrusion related to hurricanes.

Data presented in this report supports the conclusion that the MRGO is only one of numerous factors and processes which have led to the observed changes in land area and habitats within the study area, many of which were active prior to MRGO construction.

I intend to use photography and other materials cited in my report and listed below, or included in plaintiffs' expert reports or that they use at trial, to support my testimony at trial or to testify regarding discrepancies in the plaintiffs' reports or trial testimony. I have read the expert reports by Day and Shaffer (2008) and Fitzgerald and others (2008), but the plaintiffs' experts have not yet been deposed on their reports, and I may also use their deposition testimony as a basis for my testimony at trial.

References

Barras, J. A., Bourgeois, P. E., and Handley, L. R. 1994. "Land Loss in Coastal Louisiana, 1956-1990," National Biological Survey, National Wetlands Research Center Open File Report 94-01, Lafayette, Louisiana.

Boesch, D. F., Josselyn, M. N., Mehta, A. J., Morris, J. T., Nuttle, W. K., Simenstad, C. A., and Swift, D. J. 1994. Scientific Assessment of Coastal Wetland Loss, Restoration, and Management in Louisiana, Journal of Coastal Research, Special Issue No. 20.

Britsch, L. D., and Kemp, E. B. 1990. "Land Loss Rates: Mississippi River Deltaic Plain," Technical report GL-90-2, Report 1 of a Series, USAE Waterways Experiment Station, Vicksburg, MS.

Britsch, L. D., and Dunbar, J. B. 2006. "Land Loss in Coastal Louisiana: 1930's to 2001", Technical Report TR-05-13, Engineer Research and Development Center, Vicksburg, MS.

Coastal Environments, Inc. 1972. "Environmental Baseline Study: St. Bernard Parish, Louisiana," Baton Rouge, LA.

Coleman, J. M. and Gagliano, S. M. 1964. "Cyclic Sedimentation in the Mississippi River Deltaic Plain", Gulf Coast Association of Geological Societies, Transactions, v. 14, p. 67-80.

Dunbar, J. D., Britsch, L. D., and Kemp E. B. 1992. "Land Loss Rates, report 3, Louisiana coastal Plain," Technical report GL-90-2, USAE Waterways Experiment Station, Vicksburg, MS.

Dunbar, J. B., Blaes, M., Dueitt, S. and Stroud, K. 1994. "Geological Investigation of the Mississippi River Deltaic Plain, Report 2 of a Series," Technical Report GL-84-15, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Dunbar, J. B., Blaes, M., Dueitt, S. and May, J. 1994. "Geological Investigation of the Mississippi River Deltaic Plain, Report 3 of a Series," Technical Report GL-84-15, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Fisk, H. N. 1944. "Geological Investigation of the Alluvial Valley of the Lower Mississippi River", Mississippi River Commission, Vicksburg, MS.

Fisk, H. N., and McFarlon, E. 1955. "Late Quaternary Deposits of the Mississippi River," Crust of the Earth. Special Paper No. 62. Geological Society of America, Boulder, CO., p. 279-302.

Fisk, H. N. 1960. "Recent Mississippi River sedimentation and peat accumulation, 4th International Congress Carboniferous Stratigraphy and Geology, Heerlen, Holland, 1958, Compte. Rendu. P. 187-199.

Frazier, D. E. 1967. "Recent Deltaic Deposits of the Mississippi River: Their Development and

Chronology," Transactions Gulf Coast Association Geological Society, Vol. XVII, p. 287-315.

Gagliano, S. M., Meyer-Arendt, K. J., and Wicker, K. M. 1981. "Land Loss in the Mississippi River deltaic Plain," Transactions of the Gulf Coast Association of Geological Societies, Vol. 31, p. 295-300.

Kesel, R. H. 1988. "The Decline in Suspended Load of the Lower Mississippi River and its Influence on Adjacent Wetlands, Environmental Geology and Water Sciences, 11, p. 271-281.

Kolb, C. R., and Van Lopik, J. R. 1958. "Geology of the Mississippi River Deltaic Plain, Southeastern Louisiana." Technical Report 3-483, US Army Engineers Waterways Experiment Station, Vicksburg, MS.

Louisiana Coastal Wetlands Conservation and Restoration Task Force and the Wetlands Conservation and Restoration Authority. 1999. "Coast 2050: Toward a Sustainable Coastal Louisiana, The Appendices," Appendix C-Region 1 Supplemental Information, Louisiana Department of Natural Resources, Baton Rouge, LA.

May, J. R., Britsch, L. D., Dunbar, J. B., Rodriguez J. P., and Wlosinski L. B. 1984. "Geological Investigation of the Mississippi River Deltaic Plain," Technical Report GL-84-15, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Myers, R. S., Shaffer, G. P., and Llewellyn, D. W., 1995. "Baldcypress Restoration in Southeast Louisiana: The Relative Effects of Herbivory, Flooding, Competition, and Macronutrients," Wetlands, Vol. 15, No. 2, p. 141-148.

Penfound, W. T. and Hathaway, E. S. 1938. Plant Communities in the Marshlands of Southeastern Louisiana, Ecological Monographs 8(1):1-56.

Penland, S., Wayne, L., Britsch, L. D., Williams, S. J., Beall, A. D., and Butterworth, V. C., 2001. "Process Classification of Coastal Land Loss Between 1932 and 1990 in the Mississippi River Deltaic Plain, Southeastern Louisiana," USGS Open File Report 00-418.

Penland, S., Wayne, L., Britsch, L. D., Williams, S. J., Beall, A. D., and Butterworth, V. C., 2001. "Geomorphic Classification of Coastal Land Loss Between 1932 and 1990 in the Mississippi River Deltaic Plain, Southeastern Louisiana," USGS Open File Report 00-417.

Roberts, H. H. 1997. "Dynamic Change of the Holocene Mississippi River Deltaic Plain: The Delta Cycle," Journal of Coastal Research, 13(3): p. 605-627.

Saucier, R. T. 1963. "Recent Geomorphic History of the Pontchartrain Basin, Louisiana State University," Coastal Studies Series no. 9, Baton Rouge, LA.

Saucier, R. T. 1974. "Quaternary Geology of the Lower Mississippi Valley," Arkansas Archeological Survey, Research Series No. 6, Fayetteville, Ark.

Saucier, R. T. 1994. “Geomorphology and Quaternary Geologic History of the Lower Mississippi Valley,” US Army Engineer Waterways Experiment Station, Vol.1, Vicksburg, Ms.

Scruton, P. C. 1960. "Delta Building and Deltaic Sequence," In F.P. Shepard et al., Eds. Recent Sediments, Northwest Gulf of Mexico, pp 827-TO2. American Association of Petroleum Geologists, Tulsa, OK.

Turner, R. E. and Cahoon, D. R. (eds.). 1987. “Causes of Wetland Loss in the Coastal Central Gulf of Mexico,” Volume II: Technical Narrative, Minerals Management Service, New Orleans, LA, OCS Study/MMS 87-0120.

U. S. Army Corps of Engineers. 1999. For the Environmental Subcommittee of the Technical Committee Convened by EPA in Response to the St. Bernard Parish Council Resolution 12-98, 1999. Habitat impacts of the construction of the MRGO, 83 pp.

Zganjar, C., Westphal, K., McCarty, P., Bridges, S., Penland, S., 2001. Shoreline change rates of Lake Borgne, in S. Penland, A. Beall and J. Waters (editors), Environmental Atlas of the Lake Pontchartrain Basin. Lake Pontchartrain Basin Foundation, New Orleans, LA, p. 140.

Publications

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. Revised 2004. “Historic and Projected Coastal Louisiana Land Changes: 1978 – 2050, U.S. Geological Survey Open-File Report 03-334, 40 p.

Britsch, L. D., and Dunbar, J. B. 1990. “Geomorphic Investigation of Davis Pond, Louisiana,” Technical Report GL-90-12, USAE Waterways Experiment Station, Vicksburg, MS.

Britsch, L. D., and Dunbar, J. B. 1993. “Land Loss Rates: Louisiana Coastal Plain,” Journal of Coastal Research, Vol. 9, no. 2.

Britsch, L. D., and Kemp, E. B. 1990. “Land Loss Rates: Mississippi River Deltaic Plain,” Technical report GL-90-2, Report 1 of a Series, USAE Waterways Experiment Station, Vicksburg, MS.

Britsch, L. D., Dillon, D. L., and Markewich, H. W. 1998. “Geologic and Hydrologic Setting,” *in* Markewich, H.W. (ed.), “Carbon Storage and Late Holocene Chronostratigraphy of a Mississippi River Deltaic Marsh, St. Bernard Parish, Louisiana,” U.S. Geological Survey Open-File Report 98-36, 31 p.

Britsch, L. D., and Dunbar, J. B. 2006. “Land Loss in Coastal Louisiana: 1930’s to 2001”, Technical Report TR-05-13, Engineer Research and Development Center, Vicksburg, MS.

Day, J., Shaffer, G., Britsch, L., Reed, D., Hawes, S., and Cahoon, D. 2000. "Pattern and Process of Land Loss in the Mississippi Delta: A Spatial and Temporal Analysis of Wetland Habitat Change," Estuaries, 23: 425-438.

Dunbar, J. B., Britsch, L. D., and Kemp, E. B. 1990. "Land Loss Rates, Report 2, Louisiana Chenier Plain", Technical Report GL-90-2, USAE Waterways Experiment Station, Vicksburg, MS.

Dunbar, J. B., Britsch, L. D., and Kemp, E. B. 1992a. "Louisiana Coastal Plain Land Loss Maps," Maps 1 through 7, scale 1:125,000, Technical Report GL-90-2, USAE Waterways Experiment Station, Vicksburg, MS.

Dunbar, J. B., Britsch, L. D., and Kemp, E. B. 1992b. "Land Loss Rates, Report 3, Louisiana Coastal Plain," Technical report GL-90-2, USAE Waterways Experiment Station, Vicksburg, MS.

Dunbar, J. B. and, Britsch, L. D. In press. "The Geology of the New Orleans Area and the Canal Levee Failures", Journal of Geotechnical and Geoenvironmental Engineering.

Kindinger, J., Flocks, J., Kulp, M., Penland, S. and Britsch, L. 2001. "Sand Resources, Regional Geology, and Coastal processes for the Restoration of the Barataria Barrier Shoreline, U. S. Geological Survey Open File Report 01-384.

Markewich, H. W., Buell, G. R., Britsch, L. D., McGeehin, J. P., Robbins, J. A., Wrenn, J. H., Dillon, D. L., Fries, T. L., and Morehead, N. R. 2007. "Organic-Carbon Sequestration in Soil/Sediment of the Mississippi River Deltaic Plain-Data; Landscape Distribution, Storage, and Inventory; Accumulation Rates; and Recent Loss, Including a Post-Katrina Preliminary Analysis," U. S. Geological Survey Professional Paper 1686-B, U. S. Geological Survey.

May, J. R., Britsch, L. D., Dunbar, J. B., Rodriguez J. P., and Wlosinski L. B. 1984. "Geological Investigation of the Mississippi River Deltaic Plain," Technical Report GL-84-15, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

May, J. R. and Britsch, L. D. 1987. "Geological Investigation of the Mississippi River Deltaic Plain: Land Loss and Land Accretion," Technical Report GL-87-13, USAE Waterways Experiment Station, Vicksburg, MS.

Patterson, L. J., Muhammad, Z., Bentley, S. J., Britsch, L. D., and Dillon, D. L. 2003. "^{210}Pb and ^{137}Cs Geochronology of the Lake Fausse Pointe Region of the Lower Atchafalaya Basin," Gulf Coast Association of Geological Societies Transactions, Vol. 53.

Penland, S., Mendelssohn, I., Wayne, L., and Britsch, D. 1996. "Natural and Human Causes of Coastal Land Loss in Louisiana," Coastal Studies Institute and Wetland Biogeochemistry Institute, Louisiana State University, Baton Rouge, Louisiana.

Penland, S., Wayne, L., Britsch, L. D., Williams, S. J., Beall, A. D., and Butterworth, V. C., 2001. "Process Classification of Coastal Land Loss Between 1932 and 1990 in the Mississippi River Deltaic Plain, Southeastern Louisiana," USGS Open File Report 00-418.

Penland, S., Wayne, L., Britsch, L. D., Williams, S. J., Beall, A. D., and Butterworth, V. C., 2001. "Geomorphic Classification of Coastal Land Loss Between 1932 and 1990 in the Mississippi River Deltaic Plain, Southeastern Louisiana," USGS Open File Report 00-417.

Smith, L. M., Dunbar, J. B., and Britsch, L. D. 1986. "Geomorphological Investigation of the Atchafalaya Basin, Area West, Atchafalaya Delta, and Terrebonne Marsh," Technical Report GL-86-3, Vol. 1, US Army Waterways Experiment Station, Vicksburg, MS.

Data Sources and Materials Reviewed

Penland, S., Beall, A., and Waters, J. (eds.), 2001. Environmental Atlas of Lake Pontchartrain. Lake Pontchartrain Basin Foundation, New Orleans, La., 185 pp.

Expert Reports of Day and Shaffer (2007;2008); FitzGerald, Penland, Milanes, Miner, and Westphal (2007;2008); and Kemp (2007;2008)

USACE Engineering Geology and Land Loss Mapping
http://lmvmapping.erdc.usace.army.mil/

Preliminary Report of Marsh Vegetation Study Mississippi River-Gulf Outlet Navigation Project Orleans and St. Bernard Parishes, Louisiana. U.S. Fish and Wildlife Service, Bureau of Sport Fisheries and Wildlife, Region 4, Atlanta, Georgia.

1932-33 U.S. Coast and Geodetic Survey Air Photo Compilation Sheets (T-sheets)
1956-58 Tobin Surveys black and white photo mosaics
1974 NASA color IR
1983 National High Altitude Program color IR
1990 NASA color IR
2001 NASA color IR.

MRGO construction photography (United States Production Volume KC989;NED275)

1943 and 1952 photography from the U.S. National Archives and Records Administration (NARA)

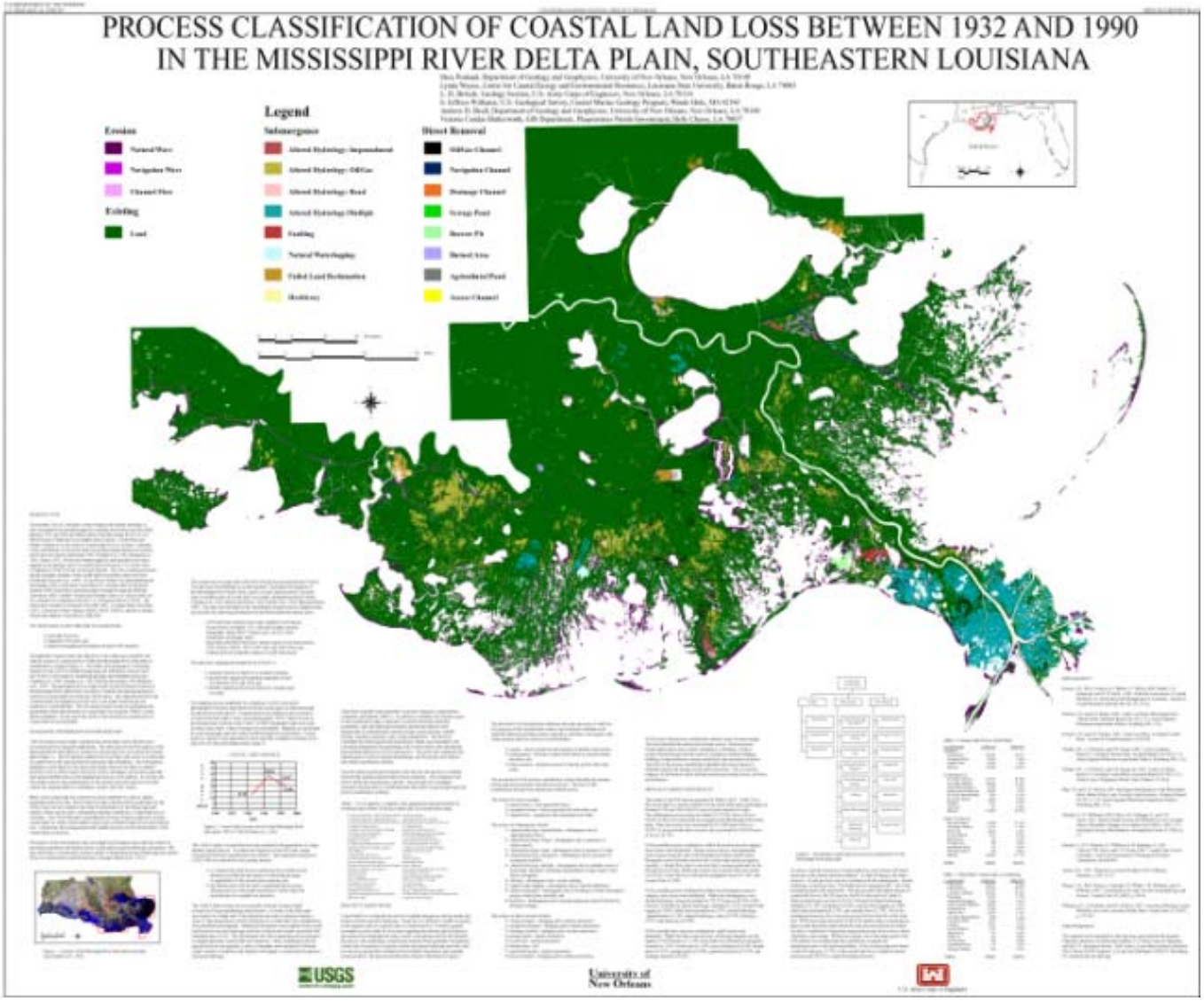
1945 photography from U.S.D.A. Forest Service

Wetland habitat data received from John Barras, USGS

MRGO and LPV Design Memoranda

CD received from DOJ including materials relied upon by Day and Shaffer and Fitzgerald et al.

Appendix A. Process classification of coastal land loss by Penland et al. (2001).


PROCESS CLASSIFICATION OF COASTAL LAND LOSS BETWEEN 1932 AND 1990
IN THE MISSISSIPPI RIVER DELTA PLAIN, SOUTHEASTERN LOUISIANA
Legend
Erosion
Natural Shore
Navigation Shore
Channel Shore
Existing
Land
Submergence
Altered Hydrology: Impoundment
Altered Hydrology: Oil/Gas
Altered Hydrology: Road
Altered Hydrology: Dieback
Canal/Ditch
Natural Waterbody
Filled Land Reclamation
Levee
Direct Removal
Oil/Gas Channel
Navigation Channel
Drainage Channel
Swamp Pond
Borrow Pit
Dredged Area
Agriculture/Pond
Levee Channel
USGS
University of New Orleans

Vitae

Louis D. Britsch III
U.S. Army Corps of Engineers
P.O. Box 60267
New Orleans, LA 70160
Ph. 504-862-1022
Email:louis.d.britsch@usace.army.mil

Education

Nicholls State University, B.S., Geology, May 1981
Tulane University, M.S., Geology, May 1984
University of New Orleans, Ph.D., Major: Coastal Geology, December 2007

Experience

1990 – Present: Geologist, U.S. Army Corps of Engineers, New Orleans District. Served in supervisory and senior geologist roles responsible for the planning and execution of geological investigations related to flood control, navigation, and coastal restoration projects.

1986 – 1990: Geologist, U. S. Army Engineer, Waterways Experiment Station, Geotechnical Laboratory, Vicksburg, MS. Principal investigator responsible for research studies related to land loss and deltaic development in coastal Louisiana.

1984 – 1986: Physical Scientist, U.S. Army Engineer, Waterways Experiment Station, Coastal Engineering Research Center, Vicksburg, MS. Developed models of deltaic evolution based on physical processes and subsurface information.

License

Professional Geologist, Indiana No. 769, 1988

Selected Publications

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. Revised 2004."Historic and Projected Coastal Louisiana Land Changes: 1978 – 2050, U.S. Geological Survey Open-File Report 03-334, 40 p.

Britsch, L. D., and Dunbar, J. B. 1990. "Geomorphic Investigation of Davis Pond, Louisiana," Technical Report GL-90-12, USAE Waterways Experiment Station, Vicksburg, MS.

Britsch, L. D., and Dunbar, J. B. 1993. "Land Loss Rates: Louisiana Coastal Plain," Journal of Coastal Research, Vol. 9, no. 2.

Britsch, L. D., and Kemp, E. B. 1990. "Land Loss Rates: Mississippi River Deltaic Plain," Technical report GL-90-2, Report 1 of a Series, USAE Waterways Experiment Station, Vicksburg, MS.

Britsch, L. D., and Dunbar, J. B. 2006. "Land Loss in Coastal Louisiana: 1930's to 2001", Technical Report TR-05-13, Engineer Research and Development Center, Vicksburg, MS.

Dunbar, J. B., Britsch, L. D., and Kemp, E. B. 1990. "Land Loss Rates, Report 2, Louisiana Chenier Plain", Technical Report GL-90-2, USAE Waterways Experiment Station, Vicksburg, MS.

Dunbar, J. B., Britsch, L. D., and Kemp, E. B. 1992a. "Louisiana Coastal Plain Land Loss Maps," Maps 1 through 7, scale 1:125,000, Technical Report GL-90-2, USAE Waterways Experiment Station, Vicksburg, MS.

Dunbar, J. B., Britsch, L. D., and Kemp, E. B. 1992b. "Land Loss Rates, Report 3, Louisiana Coastal Plain," Technical report GL-90-2, USAE Waterways Experiment Station, Vicksburg, MS.

Dunbar, J. B. and, Britsch, L. D. In press. "The Geology of the New Orleans Area and the Canal Levee Failures", Journal of Geotechnical and Geoenvironmental Engineering.

Day, J., Shaffer, G., Britsch, L., Reed, D., Hawes, S., and Cahoon, D. 2000. "Pattern and Process of Land Loss in the Mississippi Delta: A Spatial and Temporal Analysis of Wetland Habitat Change," Estuaries, 23: 425-438.

Britsch, L. D., Dillon, D. L., and Markewich, H. W. 1998. "Geologic and Hydrologic Setting," *in* Markewich, H.W. (ed.), "Carbon Storage and Late Holocene Chronostratigraphy of a Mississippi River Deltaic Marsh, St. Bernard Parish, Louisiana," U.S. Geological Survey Open-File Report 98-36, 31 p.

May, J. R., Britsch, L. D., Dunbar, J. B., Rodriguez J. P., and Wlosinski L. B. 1984. "Geological Investigation of the Mississippi River Deltaic Plain," Technical Report GL-84-15, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

May, J. R. and Britsch, L. D. 1987. "Geological Investigation of the Mississippi River Deltaic Plain: Land Loss and Land Accretion," Technical Report GL-87-13, USAE Waterways Experiment Station, Vicksburg, MS.

Markewich, H. W., Buell, G. R., Britsch, L. D., McGeehin, J. P., Robbins, J. A., Wrenn, J. H., Dillon, D. L., Fries, T. L., and Morehead, N. R. 2007. "Organic-Carbon Sequestration in Soil/Sediment of the Mississippi River Deltaic Plain-Data; landscape Distribution, Storage, and Inventory; Accumulation Rates; and Recent Loss, Including a Post-Katrina Preliminary Analysis," U. S. Geological Survey Professional Paper 1686-B, U. S. Geological Survey.

Patterson, L. J., Muhammad, Z., Bentley, S. J., Britsch, L. D., and Dillon, D. L. 2003. "^{210}Pb and ^{137}Cs Geochronology of the Lake Fausse Pointe Region of the Lower Atchafalaya Basin," Gulf Coast Association of Geological Societies Transactions, Vol. 53.

Penland, S., Mendelssohn, I., Wayne, L., and Britsch, D. 1996. "Natural and Human Causes of Coastal Land Loss in Louisiana," Coastal Studies Institute and Wetland Biogeochemistry Institute, Louisiana State University, Baton Rouge, Louisiana.

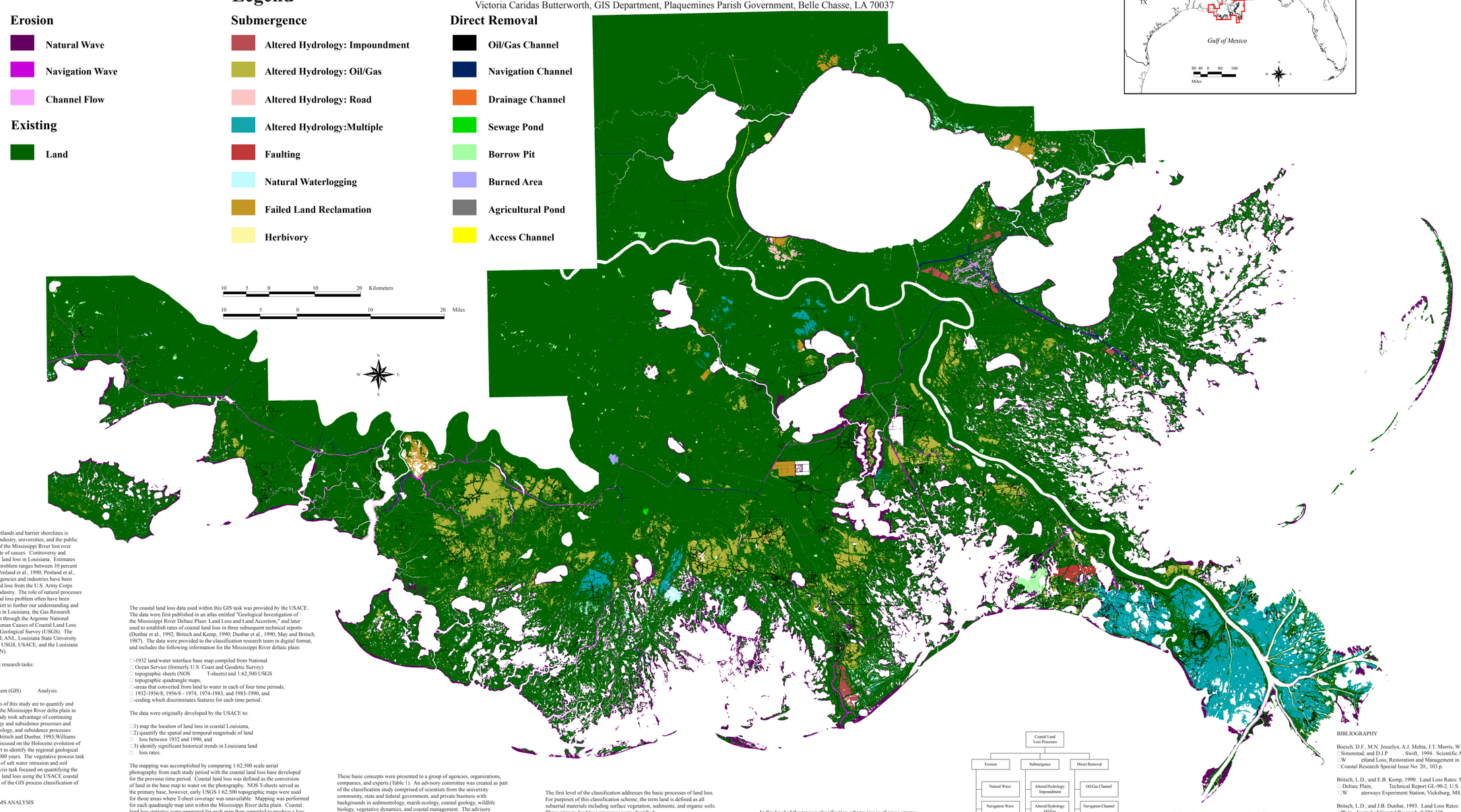
Penland, S., Wayne, L., Britsch, L. D., Williams, S. J., Beall, A. D., and Butterworth, V. C., 2001. "Process Classification of Coastal Land Loss Between 1932 and 1990 in the Mississippi River Deltaic Plain, Southeastern Louisiana," USGS Open File Report 00-418.

Penland, S., Wayne, L., Britsch, L. D., Williams, S. J., Beall, A. D., and Butterworth, V. C., 2001. "Geomorphic Classification of Coastal Land Loss Between 1932 and 1990 in the Mississippi River Deltaic Plain, Southeastern Louisiana," USGS Open File Report 00-417.

Smith, L. M., Dunbar, J. B., and Britsch, L. D. 1986. "Geomorphological Investigation of the Atchafalaya Basin, Area West, Atchafalaya Delta, and Terrebonne Marsh," Technical Report GL-86-3, Vol. 1, US Army Waterways Experiment Station, Vicksburg, MS.

PROCESS CLASSIFICATION OF COASTAL LAND LOSS BETWEEN 1932 AND 1990 IN THE MISSISSIPPI RIVER DELTA PLAIN, SOUTHEASTERN LOUISIANA

Shea Penland, Department of Geology and Geophysics, University of New Orleans, New Orleans, LA 70148
Lynda Wayne, Center for Coastal Energy and Environmental Resources, Louisiana State University, Baton Rouge, LA 70803
L. D. Britsch, Geology Section, U.S. Army Corps of Engineers, New Orleans, LA 70116
S. Jeffress Williams, U.S. Geological Survey, Coastal Marine Geology Program, Woods Hole, MA 02543
Andrew D. Beall, Department of Geology and Geophysics, University of New Orleans, New Orleans, LA 70148
Victoria Caridas Butterworth, GIS Department, Plaquemines Parish Government, Belle Chasse, LA 70037



INTRODUCTION

The dramatic loss of Louisiana's coastal wetlands and barrier shorelines is well recognized by government agencies, industry, universities, and the public. Between 1932 and 1990, the deltaic plain of the Mississippi River lost over 680,000 acres of land due to a complex suite of causes. Controversy and debate continues as to the causes of coastal land loss in Louisiana. Estimates of the contribution of man to the land loss problem ranges between 10 percent and 90 percent (Britsch and Kemp, 1990; Penland et al., 1990; Penland et al., 1992; Turner, 1997). Several government agencies and industries have been targeted as the primary cause of coastal land loss from the U.S. Army Corps of Engineers (USACE) to the oil and gas industry. The role of natural processes and the multiple causality of the coastal land loss problem often have been overlooked (Boesch et al., 1994). In an effort to further our understanding and knowledge of the coastal land loss problem in Louisiana, the Gas Research Institute (GRI) sponsored a research project through the Argonne National Laboratory (ANL) entitled "Natural and Human Causes of Coastal Land Loss in Louisiana" in cooperation with the U.S. Geological Survey (USGS). The study team consisted of scientists from GRI, ANL, Louisiana State University (LSU), University of New Orleans (UNO), USGS, USACE, and the Louisiana Universities Marine Consortium (LUMCON).

This study focuses on three major land loss research tasks:

□1) Geologic Processes,
□2) Vegetative Processes, and
□3) Spatial Geographical Information System (GIS) Analysis.

Through these research tasks, the objectives of this study are to quantify and rank the causes of coastal land loss within the Mississippi River delta plain in southeastern Louisiana (Figure 1). This study took advantage of continuing research by the USGS in framework geology and subsidence processes and the USACE in GIS analysis, framework geology, and subsidence processes (Dunbar et al., 1990; Dunbar et al., 1992; Britsch and Dunbar, 1993;Williams et al., 1993). The geological process task focused on the Holocene evolution of the Mississippi River delta plain in an effort to identify the regional geological controls on coastal land loss of the last 18,000 years. The vegetative process task conducted field investigations into the role of salt water intrusion and soil inundation in plant dieback. The GIS analysis task focused on quantifying the geomorphic forms and processes of coastal land loss using the USACE coastal landloss database. In this report the results of the GIS process classification of coastal land loss are presented.

GEOGRAPHIC INFORMATION SYSTEMS ANALYSIS

The GIS analysis task sought to quantify the geomorphic forms and processes of coastal land loss using new digital data. The study area for the GIS analysis is the Mississippi River delta plain in southeast Louisiana and does not include the chenier plain (Figure 1). The GIS analysis captures the local types and causes of coastal land loss interwoven with regional land loss processes like subsidence. The GIS analysis highlights coastal land loss *Hot Spots* and change trends in the land loss pattern. Processes such as flood control, diversion control, subsidence, and eustacy generally lack spatial attributes that can be mapped and used in a GIS analysis. As a result, the GIS analysis allows the quantification of site specific processes and does not fully capture the regional effects of subsidence, eustacy, and river control.

Much of the coastal land loss controversy can be attributed to a lack of spatial quantitative land loss data. Recent land loss data collection efforts undertaken by the USACE have worked to address this need for information by providing maps and statistics which can be used to characterize baseline conditions of coastal land loss in Louisiana. The USGS National Coastal Marine Geology Program supports Louisiana coastal land loss studies which address issues such as barrier island erosion and wetland loss. Collectively, these programs provide needed resources for the development of this coastal land loss data set.

The purpose of the GIS analysis task is to expand upon baseline data collection efforts by providing quantitative information about coastal land loss geomorphology and process. We have developed a classification scheme capable of delineating the geomorphologically distinct forms of coastal land loss and the process of change (Wayne et al., 1993).

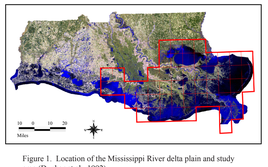


Figure 1. Location of the Mississippi River delta plain and study area (Dunbar et al., 1992).

The coastal land loss data used within this GIS task was provided by the USACE. The data were first published in an atlas entitled "Geological Investigation of the Mississippi River Deltaic Plain: Land Loss and Land Accretion," and later used to establish rates of coastal land loss in three subsequent technical reports (Dunbar et al., 1992; Britsch and Kemp, 1990; Dunbar et al., 1990; May and Britsch, 1987). The data were provided to the classification research team in digital format, and includes the following information for the Mississippi River deltaic plain:

□-1932 land/water interface base map compiled from National
□ Ocean Service (formerly U.S. Coast and Geodetic Survey)
□ topographic sheets (NOS T-sheets) and 1:62,500 USGS
□ topographic quadrangle maps,
□-areas that converted from land to water in each of four time periods,
□ 1932-1956;8, 1956;8 - 1974, 1974-1983, and 1983-1990, and
□-coding which discriminates features for each time period.

The data were originally developed by the USACE to:

□1) map the location of land loss in coastal Louisiana,
□2) quantify the spatial and temporal magnitude of land
□ loss between 1932 and 1990, and
□3) identify significant historical trends in Louisiana land
□ loss rates.

The mapping was accomplished by comparing 1:62,500 scale aerial photography from each study period with the coastal land loss base developed for the previous time period. Coastal land loss was defined as the conversion of land in the base map to water on the photography. NOS T-sheets served as the primary base, however, early USGS 1:62,500 topographic maps were used for those areas where T-sheet coverage was unavailable. Mapping was performed for each quadrangle map unit within the Mississippi River delta plain. Coastal land loss statistics were generated for each map then compiled to produce a loss rate curve for the entire deltaic plain (Figure 2).

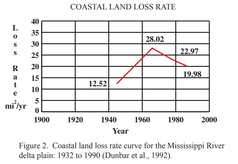


Figure 2. Coastal land loss rate curve for the Mississippi River delta plain: 1932 to 1990 (Dunbar et al., 1992).

The USACE study of coastal land loss rates resulted in the generation of a large, detailed, digital data set. To achieve the objectives of the GIS task a single time period of data for classification was utilized. The cumulative time period (1932-1990) was selected for two primary reasons:

□1) it contained the most diverse coastal land loss conditions and
□ therefore provided the best means of evaluating the range
□ of applicability of the classification schemes, and
□2) the interim data could be used to understand the processes
□ af fecting the loss, and enable researchers to better refine the
□ classification for complex loss scenarios.

The USACE land loss data set was carefully reviewed to derive initial concepts of loss geomorphology and processes. A mosaic of the fifty maps was created on a single wall of the laboratory and used as reference during a series of open discussions in which similarities in coastal land loss configurations were identified and evaluated. Additional information was compiled about coastal land loss processes and landscape activities (cultural and natural) associated with individual areas of loss. This information was used to generate process scenarios for highly expressive coastal land loss formations. Once a familiarity with the regional data set was acquired, a series of examples were extracted to illustrate rough concepts of similarity and disparity with regard to coastal land loss,process and geomorphology.

These basic concepts were presented to a group of agencies, organizations, companies, and experts (Table 1). An advisory committee was created as part of the classification study comprised of scientists from the university community, state and federal government, and private business with backgrounds in sedimentology, marsh ecology, coastal geology, wildlife biology, vegetative dynamics, and coastal management. The advisory committee provided regional and disciplinary insight, and responded to the conceptual presentation by generating a list of terms which more specifically characterized differences in form and process. The terms were organized into logical groupings of process and geomorphology, and the groups were refined into initial classification schemes.

Once the initial classification schemes were derived, the advisory committee reviewed the schemes and provided critical comments. The comments were used to refine the classification schemes. Several land loss committee meetings were held prior to establishing the final land loss geomorphology and process classification schemes.

Table 1. List of agencies, companies and organizations that participated in workshops and reviews of the gis coastal land loss classification maps.

Louisiana Department of Environmental Quality	Terrebonne Parish
Louisiana Department of Natural Resources	Southern Natural Gas Company
Louisiana Department of Wildlife and Fisheries	Natural Resources Conservation Services
Louisiana Governors Office	St. Charles Parish
Louisiana Land and Exploration Company	Argonne National Laboratory
U.S. Army Corps of Engineers	Coastal Wetlands Planning Advisory Committee
Louisiana State University	U.S. Fish and Wildlife Service
Southern University	National Marine Fisheries Service
Louisiana Universities Marine Consortium	Tulane Environmental Law Clinic
Coalition to Restore Coastal Louisiana	Louisiana Sea Grant College Program
Shell Offshore	Gulf Restoration Network
T. Baker Smith and Son, Inc.	Amoco
Texaco Exploration and Production Inc.	Times-Picayune
Environmental Protection Agency	Morning Advocate
Barataria-Terrebonne National Estuary Program	Exxon Company
Southern Lafourche Levee District	New Orleans City Planning Commission
Lafourche Parish	Southeastern University
BP Oil Company	Lake Pontchartrain Basin Foundation
Sierra Club Defense Fund	Women for a Better Louisiana
Coastal Environments Inc.	Loyola University
U.S. Geological Survey	Gas Research Institute
William W. Goodell Jr. P.L.C.	Bayou Lafourche Fresh Water District
Applied Technology Research Corporation	Louisiana Mid-Continent Oil and Gas Association
Jefferson Parish	University of New Orleans

PROCESS CLASSIFICATION

Coastal land loss is typically the result of complex interactions among natural and human activities upon the landscape. Therefore, it is difficult to isolate an activity as the singular cause of a specific area of coastal land loss. However, general assumptions can be made for most areas regarding the primary physical process that removed or submerged the land, as well as the primary actions that initiated the process. By employing a classification scheme which graduates from general coastal land loss process to specific cultural and natural landscape activities, each loss area was specifically classified as the available information and scientific consensus allow. The process classification scheme is illustrated in Figure 3.

The first level of the classification addresses the basic processes of land loss. For purposes of this classification scheme, the term land is defined as all subaerial materials including surface vegetation, sediments, and organic soils. Three primary land loss processes were identified:

□1) erosion - physical removal and transport of land by water action,
□2) submer gence - increase of water level relative to ground surface
□ elevation, and
□3) direct removal - physical removal of land by actions other than
□ water

The second level of the process classification scheme identifies the primary actions that are associated with each loss process. This level of the classification includes both natural and cultural actions.

The actions of erosion include:
□1) natural waves - wind generated waves,
□2) navigation waves - waves generated by boat wakes, and
□3) channel flow - suspension and conveyances by water

The actions of submergence include:
□1) altered hydrology: impoundment - submer gence due to
□ impoundment levees,
□2) altered hydrology: oil/gas - submer gence due to presence of
□ oil/gas canals,
□3) altered hydrology: roads - submer gence due to presence of roads,
□4) altered hydrology: navigation - submer gence due to presence of
□ navigation channels,
□5) altered hydrology: multiple - submer gence due to multiple causes of
□ hydrologic alteration; including impoundment, oil/gas canals, roads,
□ and/or navigation
□6) faulting - submer gence due to active faulting,
□7) natural water logging - submer gence due to natural subsidence,
□8) failed reclamation - submer gence due to flooding of former reclamation
□ projects which have subsided, and
□9) herbivory - submer gence due to animals eating the marsh followed by
□ substrate collapse.

The actions of direct removal include:
□1) oil/gas channels - dredging and/or surface excavation
□2) navigation channels - dredging and/or surface excavation
□3) drainage channels - dredging and/or surface excavation
□4) sewage ponds - surface excavation
□5) borrow pits - surface excavation
□6) burned areas - fire
□7) agricultural ponds - surface excavation
□8) access channels - dredging and/or surface excavation

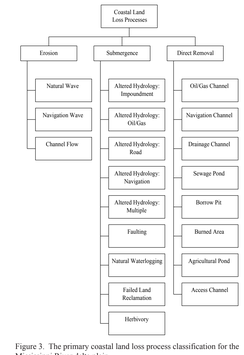


Figure 3. The primary coastal land loss process classification for the Mississippi River delta plain.

At this level of the process classification scheme issues of cause emerge. This level identifies the natural and cultural actions. Natural actions include phenomena such as wind, subsidence, or faulting. Cultural actions include human activities such as navigation, channel dredging, building of impoundments, resource extraction, and excavation of ponds. This level of the process classification identifies the factors known to stimulate natural and human coastal land loss actions. This is a diverse category of information which includes natural and cultural events, activities, and structures.

PROCESS CLASSIFICATION RESULTS

The results of the GIS task are presented in Tables 2 and 3. Table 2 lists the coastal land loss process statistics for the entire delta plain quadrangle set. Between 1932 and 1990, 690,931 acres of land converted to water. The submergence process class accounted for 375,612 acres of loss or 54.36% of the total coastal land loss mapped in the Mississippi River delta plain. Next, the erosion class accounted for 213,280 acres of loss or 30.87% of acres and the direct removal class accounted for 102,039 acres of loss or 14.77%.

Of the possible process combinations within the erosion process category, three classes were delineated. Natural waves refers to wind generated wave erosion along the outer Gulf shoreline and within inland waters. Navigation waves describes erosion due to boat wakes along navigation channels. Channel flow refers to erosion due to currents generated by the ebb and flood of tides. Within the erosion class natural waves accounted for 26.21% of the total loss, followed by navigation waves at 3.16%, and channel flow at 1.50%.

Of the possible process combinations within the submergence process category, nine classes were delineated. Within the submergence class, altered hydrology: oil/gas accounted for 172,174 acres or 24.92% of the total loss, followed by altered hydrology: multiple at 21.52%, natural water logging at 3.05%, failed land reclamation at 2.37%, altered hydrology: impoundment at 1.16%, altered hydrology: roads at 0.70%, faulting at 0.57%, and herbivory at 0.08%.

Of the possible direct removal combinations, eight classes were delineated. Within the direct removal class, oil and gas channels are the highest at 76,978 acres or 11.14% of the total loss, followed by navigation channels at 1.63%, borrow pits at 1.61%, access channels at 0.19%, burned areas at 0.11%, sewage ponds at 0.04%, agricultural ponds at 0.03%, and drainage channels at 0.02%.

In order to rank the processes of coastal land loss, some classes will stand alone and some classes must be combined. To rank oil and gas, the direct removal - oil and gas class must be combined with the submergence - altered hydrology: oil and gas class. This holds true for navigation also. All of the remaining classes will stand alone. Oil and gas ranks the highest process of coastal land loss at 249,152 acres or 36.06% of the total loss (Table 3). Next is natural wave erosion at 26.21% followed by altered hydrology - multiple at 21.52%, navigation at 4.97%, natural water logging at 3.05%, failed land reclamation at 2.37%, and channel flow at 2.27%. All of the remaining classes are 2% or less and account for less than 6% of the total loss. When discussing the results of the GIS analysis task it is important to keep in mind that these results describe local processes and do not reflect the direct contribution of important regional processes such as river control, subsidence, and eustacy. Within this context, one of the major goals of the GIS analysis was to determine the contribution of natural and human processes to the land loss problem. From a local perspective based on the GIS analysis, 31.33% of the coastal land loss is caused by natural processes and 68.67% is caused by human processes.

Table 2. Coastal Land Process- Delta Plain

CLASS NAME	ACREAGE	PERCENT
EROSION		
Natural Wave	181,090	26.21%
Navigation Wave	21,821	3.16%
Channel Flow	10,369	1.50%
Subtotal	213,280	30.87%
SUBMERGENCE		
Alt. Hydro Oil/Gas	172,174	24.92%
Alt. Hydro Multiple	148,666	21.52%
Natural Waterlogging	21,069	3.05%
Failed Land Reclamation	16,403	2.37%
Alt. Hydro Impoundment	7,992	1.16%
Alt. Hydro Roads	4,825	0.70%
Faulting	3,921	0.57%
Herbivory	561	0.08%
Subtotal	375,612	54.36%
DIRECT REMOVAL		
Oil/Gas Channel	76,978	11.14%
Navigation Channel	11,293	1.63%
Borrow Pit	11,130	1.61%
Access Channel	1,312	0.19%
Burned Area	729	0.11%
Sewage Pond	308	0.04%
Agricultural Pond	179	0.03%
Drainage Channel	109	0.02%
Subtotal	102,039	14.77%
TOTAL	**690,931**	**100.00%**

Table 3. Delta Plain Coastal Land Loss Ranking

CLASS NAME	ACREAGE	PERCENT
Oil and Gas	249,152	36.06%
Natural Waves	181,090	26.21%
Alt. Hydro Multiple	147,442	21.34%
Navigation	33,114	4.79%
Natural Waterlogging	21,069	3.05%
Failed Land Reclamation	16,403	2.37%
Channel Flow	15,668	2.27%
Borrow Pits	11,130	1.61%
Alt. Hydro Impoundment	7,992	1.16%
Alt. Hydro Road	4,825	0.70%
Faulting	3,921	0.57%
Access Channel	1,312	0.19%
Burned Area	729	0.11%
Herbivory	561	0.08%
Sewage Pond	308	0.04%
Agricultural Pond	179	0.03%
Drainage Channel	109	0.02%
TOTAL	**690,931**	**100.00%**

BIBLIOGRAPHY

Boesch, D.F., M.N. Josselyn, A.J. Mehta, J.T. Morris, W.K. Nuttle, C.A. □Simenstad, and D.J.P. Swift, 1994. Scientific Assessment of Coastal □W etland Loss, Restoration and Management in Louisiana. Journal of □Coastal Research Special Issue No. 20., 103 p.

Britsch, L.D., and E.B. Kemp, 1990. Land Loss Rates: Mississippi River □ Deltaic Plain, Technical Report GL-90-2, U.S. Army Engineer □W aterways Experiment Station, Vicksburg, MS., 25 p.

Britsch, L.D., and J.B. Dunbar, 1993. Land Loss Rates: Louisiana Coastal □Plain. Journal of Coastal Research, 9:324-338.

Dunbar, J.B., L.D. Britsch, and E.B. Kemp, 1990. Land Loss Rates: □Report 2, Louisiana Chenier Plain, Technical Report GL-90-2, U.S. □Army Engineer Waterways Experiment Station, Vicksburg, MS., 21 p.

Dunbar, J.B., L.D. Britsch, and E.B. Kemp, III, 1992. Land Loss Rates: □Report 3, Louisiana Coastal Plain, Technical Report GL-90-2, U.S. □Army Corps of Engineers District, New Orleans, LA, 28 p.

May, J.R. and L.D. Britsch, 1987. Geological Investigation of the Mississippi □River Deltaic Plain, Land Loss and Land Accretion. Technical Report □GL-87-13, U.S. Army Engineer Waterways Experiment Station, □V icksburg, MS., 51 p.

Penland, S., S.J. Williams, D.W. Davis, A.H. Sallenger Jr., and C.G. □Groat, 1992. Barrier Island Erosion and Wetland Loss in Louisiana. □Atlas of Shoreline Changes in Louisiana from 1985 to 1989. U.S. □Geological Survey , Miscellaneous Investigations Series I-1250A, p. □2-7.

Penland, S., H.H. Roberts, S.J. Williams, A.H. Sallenger, Jr., D.R. □Cahoon, D.W. Davis, and C.G. Groat, 1990. Coastal Land Loss in □Louisiana. Gulf Coast Association of Geological Societies □T ransactions, 40:685-699.

Turner, R.E., 1997. Wetland Loss in the Northern Gulf of Mexico. □Estuaries, v . 20(1):1-13.

Wayne, L.D., M.R. Byrnes, S. Penland, P.T. Wilkey, T.R. Williams, and S.J. □W illiams, 1993. Classification of Land Loss by Geomorphology and □Process. Coastal Zone '93, ASCE, p. 85-95.
□
Williams, S.J., S. Penland, and H.H. Roberts, 1993. Processes Affecting Coastal □W etland Loss in the Louisiana Deltaic Plain. Coastal Zone '93, ASCE, □p. 21 1-219.

Acknowledgements

The research results presented in this map were sponsored by the Argonne National Laboratory, Gas Research Institute, U.S. Army Corps of Engineers, and the U.S. Geological Survey. Paul Connor, Jr. provided technical assistance. Don Cahoon (USGS-Lafayette, LA) and Jack Kindinger (USGS-St. Petersburg, FL) reviewed the text and map.

USGS science for a changing world

University of New Orleans

U.S. Army Corps of Engineers