The purpose of this appendix is to collect discussion of the causes of Louisiana wetlands loss from the major policy documents of state and federal government in one place. This will enable users of our study to read the entire sections in these sources and judge for themselves the importance placed by these regulatory and policy making agencies on wetlands damage from OCS activities as opposed to other causes.

CONTENTS:

1) LACOAST - LOUISIANA COASTAL RESTORATION WEB SITE www.lacoast.gov

This site is funded by Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA) and is maintained by the USGS National Wetlands Research Center.
Louisiana Coastal Wetlands Conservation and Restoration Task Force
[Governor of Louisiana, Administrator of EPA, Secretary of the Interior, Secretary of Agriculture, Secretary of Commerce, Secretary of the Army]
Publishers of WaterMarks

Story
Louisiana is blessed with an abundance of natural resources. Approximately 40 percent of the coastal wetlands of the lower 48 states is located here. This fragile environment is disappearing at an alarming rate. Louisiana has lost up to 40 square miles of marsh a year for several decades - that's 80 percent of the nation's annual coastal wetland loss. If the current rate of loss is not slowed, by the year 2040 an additional 800,000 acres of wetlands will disappear, and the Louisiana shoreline will advance inland as much as 33 miles in some areas. This prompted Congress to pass the Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA) in 1990. It funds wetland enhancement projects nationwide, designating approximately $35 million annually for work in Louisiana.

Justification for Action
www.lacoast.gov/Programs/CWPPRA/Overview/CWPPRAintro/JustificationforAction.htm

Louisiana's 3.5 million acres of coastal wetlands represent about 40 percent of all of the coastal wetlands in the continental United States. These wetlands are extremely valuable to all citizens, not only because of their commercial, recreational and cultural values, but also because of the biological and physical process benefits they provide to coastal communities, the state and the nation. Important coastal wetland functions include:

- Buffering against hurricanes and storms
- Holding excess floodwaters during high rainfall or high tides
- Recharging groundwater aquifers used for drinking and irrigation
- Cleaning water by filtering pollutants and taking up nutrients

Coastal wetland habitats in Louisiana serve as the foundation for a $1 billion seafood industry, a $200 million sport hunting industry, a $14 million alligator industry, valuable fur resources, wild crawfish resources, hardwood timber and commercial livestock rangelands that equate to thousands of jobs crucial to the economies of many coastal communities. Numerous species of nonharvested fish and wildlife resources also depend directly on healthy coastal wetland ecosystems.

State oil and gas severance tax collections, in large part generated from exploration and production activities conducted in Louisiana's coastal wetlands, exceed $500 million annually. These tax revenues help the state provide vital community services such as roads, education and public health needs.

Because of the alteration of several important coastal wetland processes over the past 75-80 years, Louisiana has lost more than 600,000 acres of coastal vegetated wetlands and is now losing coastal wetlands at an average annual rate of 25-35 square miles per year (20,000-25,000 acres per year).

Processes that have had the most significant impact include:

- Leveeing of the Mississippi and Atchafalaya rivers (stopped natural flow of sediment and fresh water into coastal marshes)
- Construction of large water control structures on the Mississippi and Atchafalaya rivers (stopped natural river flow and new delta formation)
- Construction of the Gulf Intracoastal Waterway (altered natural flow of fresh water from the uplands to the coastal marshes south)
- Ship channel construction (changed shallow, normally slow-moving, meandering river/bayou systems into straight, deep channels that connect directly to more saline Gulf of Mexico waters)
- Access canal construction (increased saltwater intrusion and altered natural water flow/hydrology)

PUBLISHERS OF WATERMARKS - Louisiana Coastal Wetlands Planning, Protection and Restoration News. Published quarterly by the Louisiana Coastal Wetlands Conservation and Restoration Task Force to communicate news and issues of interest related to the Coastal Wetlands Planning, Protection and Restoration Act of 1990. This legislation funds wetlands enhancement projects nationwide, designating approximately $35 million annually for work in Louisiana. The state contributes 15 percent of the cost of project construction. Please address all questions, comments, suggestions to: James D. Addison, WaterMarks Editor, New Orleans District, U. S. Army Corps of Engineers, P. O. Box 60267, New Orleans, LA 70160-0267 (504) 862-2201

All issues published (1995 to date) were read by Ray Kreig as part of this study.

WaterMarks (Winter 2000) - “The reasons for the [wetlands] losses vary. Storm damage, sea-level rise, subsidence, and floods, combined with human alterations such as oil and gas exploration, navigation canals, flood control levees, and urban and agricultural expansion, constantly challenge the survival of coastal wetlands. Moreover, the individual response of each wetland area to these events varies greatly, depending on location and the timing of such events. This makes understanding wetland systems even more difficult."

2) THE 1997 EVALUATION REPORT TO THE U.S. CONGRESS ON THE EFFECTIVENESS OF LOUISIANA COASTAL WETLAND RESTORATION PROJECTS

Submitted by the Louisiana Coastal Wetlands Conservation and Restoration Task Force, which consists of the Secretary of the Army, Honorable Togo D. West, who serves as chairman; the Administrator of the Environmental Protection Agency, Carol M. Browner; the Governor of Louisiana, M.J. "Mike" Foster, Jr.; the Secretary of the Interior, Bruce Babbitt; the Secretary of Agriculture, Dan Glickman; and the Secretary of Commerce, William M. Daley. In accordance with THE COASTAL WETLANDS PLANNING, PROTECTION AND RESTORATION ACT PUBLIC LAW 101-646, TITLE III OR "BREAUX ACT"

www.lacoast.gov/Programs/CWPPRA/Reports/EvaluationReport1997/Title.htm

Wetland Loss In Louisiana (page 8-10)

History of Wetland Loss

Over the last 200 years, wetlands in the United States have been drained, dredged, filled, leveled and flooded for urban, agricultural, and residential development (Mitsch and Gosselink 1993). Because of these activities, 22 states have lost 50% or more of their original wetlands. The problem in Louisiana is somewhat different-wetland growth and deterioration have been naturally occurring here for thousands of years.

Over the past 10,000 years, the Mississippi River has built southeast Louisiana as a series of overlapping delta lobes (Kolb and van Lopik 1958). With the transition from one delta lobe to another, marsh sediments compact and sink under their own weight. Vegetation becomes increasingly flooded, gradually loses vigor, and dies. The marsh slowly breaks up, until it is replaced by open water, and the stage is set for a repetition of the cycle and the building of new land. The chenier plain in western Louisiana also developed in association with the river switching from one delta location to another. When sediment was discharged in the western part of the deltaic plain, longshore currents led to the accumulation of vast mud deposits to the west. When the river switched to a more easterly location, these deposits were eroded and reworked, forming cheniers as the coarser sediment was pushed landward. This cycle was repeated, leading to a sequence of cheniers, parallel to the shore, separated by wetlands.

Therefore, while wetland loss has occurred for thousands of years in Louisiana, it has, until recently, been balanced by various natural wetland building processes. During the twentieth century, with the help of detailed aerial imagery, we have discovered that land is being lost at a far greater rate than it is being replaced; that loss is threatening the sustainability of the entire ecosystem (figure 8). Varying degrees of land loss are occurring among the state's nine hydrologic basins, ranging from 0.1 square miles (64 acres) per year in the Atchafalaya Basin to 11.1 square miles (7,104 acres) per year in the Barataria Basin (figure 9).

Causes of Wetland Loss in Louisiana

The causes of Louisiana's wetland loss have been researched extensively, and are well documented as being the result of cumulative natural and human-induced impacts (Boesch 1982, Mendelssohn et al. 1983, Titus 1986, Turner and Cahoon 1987, Day and Templet 1989, Duffy and Clark 1989, LCWCRTF 1993, Nyman et al. 1993, Touchet 1994, Penland et al. 1996). An important implication of the delta lobe cycle for coastal Louisiana is the associated subsidence. Subsidence is variable from one part of the coast to another, but regardless of the specific rate, this natural process cannot be controlled by human intervention.

More within human control are the processes that build wetlands vertically and maintain marsh vegetation at an intertidal elevation where it can survive. In some areas, fresh vegetative growth has been able to compensate for subsidence and maintain marsh elevation with more fragile organic material. Sediment deposition and organic accumulation have been occurring naturally (in concert with subsidence) for thousands of years (Touchet 1994, Nyman et al. 1992). However, with construction of extensive levee systems along the Mississippi River to maintain navigation and reduce flooding of adjacent homes and businesses, the Mississippi River has been confined to a small portion of its original flood plain. The levees have prevented coastal wetlands from receiving the regular nourishment of riverine water, nutrients and sediment that are critical to coastal wetland survival. In addition, the declining sediment load in the Mississippi River, due to upstream dams on the river and its tributaries, results in less sediment available for coastal marsh nourishment to compensate for subsidence (Kesel 1988). The amount of sediment currently being carried by the Mississippi River is only 50% of that carried during historic delta building conditions (Kesel 1988, Kesel 1989, Kesel et al. 1992, Mossa 1996).

These regional impacts are exacerbated by the hydrologic alterations that have modified the movement of freshwater, suspended sediment, and saltwater through the system. Canals, dredged for navigation or in support of mineral extraction, have allowed saltwater to penetrate into previously fresh marshes. The placement of straight canals in areas previously drained by sinuous natural channels has increased the speed of tidal movements through the coastal marshes. High canal banks formed from placement of dredged material can restrict both the drainage of water from the marsh and the input of suspended sediment necessary to maintain marshes. Most of these canals were dredged from the 1950s to the 1970s. The current regulatory climate, along with improved exploration technologies, prevents similar impacts today. However, this damage to the coastal ecosystem continues to make local areas less able to combat subsidence and more susceptible to saltwater intrusion.

Implications of Wetland Loss

If the current land loss rates continue unabated, by the year 2040 Louisiana will have lost more than one million acres of coastal wetlands, an area larger than the state of Rhode Island (Watzin and Gosselink 1992). In addition, the Gulf of Mexico will continue to advance inland as much as 33 miles during this period, transforming previously productive wetlands into open water and leaving major towns and cities, such as New Orleans and Houma, exposed to open marine forces of the Gulf of Mexico (figure 10). By the year 2040, the commercial and recreational fisheries harvest could decline by 30%, and nearly 50,000 jobs directly related to fishing, processing and wholesaling activities would be at risk. Production of numerous food staples and basic minerals, such as sugar, rice, salt, sulphur and lime will be reduced and have an impact on national markets. Not only will the use values associated with aquaculture, fur trapping, hunting enterprises, recreational fishing, cattle grazing, alligator egg sales and alligator hunting decrease, but the taxable income based on these revenues will also suffer (Roberts et al. 1996). Oil and gas production and supply to the nation will be severely impacted (LCWCRTF 1993). Existing transportation infrastructures will suffer as highways and rail systems are lost and costs of channel and river maintenance increase. Treatment costs of drinking water will increase. In addition, populations of migratory birds and other wildlife directly dependent on the marshes and swamps will decrease dramatically, which might, for some species, result in impacts felt in much of North America (LCWCRTF 1993). Since many of these benefits are of national interest, the entire country, not just Louisiana, stands to lose economic resources.

3) COASTAL LOUISIANA - THE UNIFIED VISION

June 1996 State report on saving Louisiana's coast. Prepared by the Governor's Office of Coastal Activities and the Louisiana Department of Natural Resources.

http://www.lacoast.gov/Programs/CWPPRA/Reports/vision.htm

HOW WE GET THERE

Achieving our vision requires a big picture approach. In the past, our coastal restoration efforts have been small scale; money was spent on projects that produced valuable but limited results. At the time this was the best we could do. Now we must develop a new plan of action based on what we have learned.

Common sense indicates that we must work with nature if we are to preserve and rebuild our wetlands. Before Louisiana's extensive network of levees was built, the Mississippi River's annual floods spread fresh water and sediment across the deltaic plain and provided the raw material for coastal wetlands. Although we cannot allow the floods to return, we can mimic this natural process while protecting Louisiana communities.

In fact, not only can we stop further erosion of coastal wetlands and barrier islands, we can actually add new land to what we have already. Impossible? Our coastal scientists and engineers don't think so. They have designed a three-point plan for systematically rebuilding coastal Louisiana using methods that take advantage of natural wetlands building processes.

The three elements in this plan are all equally important. They must each be accomplished if we are to successfully restore our coast.

Restore functions of Louisiana's barrier islands, cheniers, and other shorelines. Barrier islands and shorelines are Louisiana's boundary against the sea and our first line of defense against storms. Without these protective buffers, inland areas and billions of dollars in public and private investments will be vulnerable to wave and wind damage. Barrier islands and shorelines also serve as vital habitat for important species such as migrating songbirds and the brown pelican, our state bird.

We have the technology to rebuild Louisiana's barrier islands by the year 2000. But even the most successfully rebuilt island can be damaged by a hurricane. As taxpayers we must understand that barrier islands will inevitably erode as they bear the brunt of storms. We must be prepared to repair barrier islands periodically so they can maintain their protective function.

Restore natural waterflow. Fifty years ago, we did not understand the importance of natural waterflow in the chenier and deltaic plains. Projects begun in the 1930s to change the region's plumbing have created expensive problems in the 1990s. To correct this, we must design projects that imitate nature but do not flood communities, endanger existing infrastructure, or disrupt navigation. Reconnecting waterways and modifying man-made channels will allow us to manage flow and maximize the controlled use of fresh water and sediment to improve wetlands.

Divert fresh water and sediment into coastal wetlands. We must divert fresh water and sediment into coastal wetlands using reconnected waterways. The diversion projects will only operate in late winter and spring during high water stages. The project will use excess water from the Mississippi River and other coastal waterways that now goes into the Gulf; water needed for navigation and drinking supplies will not be affected. Diversion projects will be accomplished without flooding communities or damaging infrastructure.

Rebuilding barrier islands and shorelines, reconnecting natural waterways, and diverting fresh water and sediment will cost billions of dollars. The investment required will be on the same scale as a single B2 Bomber, ($2.1 billion); the Denver Airport, ($4.5 billion); or the Red River Waterway, ($2 billion). We refuse to believe that our coastal resources and communities are worth any less.

Our choice is clear. We can pay the price to restore our coast now, or we can pay later when we lose billions in infrastructure and economic and cultural assets. Fortunately, if Louisiana citizens agree that our coastal wetlands, communities, and economic opportunities are worth saving, we can more easily persuade the nation to help us get the job done.

4) RESTORATION PLAN [no given date, printed from website on 7/9/00]
Formulation of a comprehensive wetlands restoration plan for coastal Louisiana.

http://www.lacoast.gov/Programs/CWPPRA/Reports/RestorationPlan/contents.htm

THE PROBLEM: LOSS OF COASTAL WETLANDS

INTRODUCTION

Recognizing that extremely valuable resources are at risk, it is important to determine what the problems impacting the resources are and to what extent they are human induced. The primary causes of wetland loss in coastal Louisiana have been understood for some time; they include subsidence, global sea level rise, sediment deprivation, and hydrologic alteration (Boesch 1982; Mendelssohn et al. 1983, Titus

1986, Turner and Cahoon 1987, Day and Templet 1989, Duffy and Clark 1989). Subsidence and global sea level rise have combined to subject wetland plant communities to relative sea level rise (RSLR) rates that exceed half an inch per year in parts of the Louisiana coast (Hatton et al. 1983, Baumann et al. 1984). Rapid submergence and local penetration of marine processes into the freshwater interior of Louisiana's coastal estuaries are secondary effects, resulting from the interplay of these factors, that impose stresses on these wetland plant communities (Mendelssohn and McKee 1989, Nyman et al. 1993).

These stresses reduce plant productivity and compromise the inherent ability of most wetland vegetation to withstand submergence by adding sufficient organic matter to the substrate to maintain surface elevation within the intertidal or intermittently flooded zone (Mitsch and Gosselink 1986). A variety of more local impacts, associated with canal dredging, faulting, ponding, hurricanes, herbivory, and erosion by waves and currents, affect stressed marshes--far more severely than healthy ones--and can act as the "last straw" that gives rise to dramatic "hot spots" of loss (Leibowitz and Hill 1987).

Coastal Louisiana has been extensively altered by human activity. Each of the primary causes of land loss has a natural and man-induced component. Subsidence, for example, occurs naturally in the wetlands built by the Mississippi River as a consequence of geologic downwarping and compaction of a sediment column with a high component of water, gas, and organic materials (Kolb and van Lopik 1958, McGinnis et al. 1991). However, subsidence also may be significantly affected by local drainage efforts that reduce the water content of the upper few feet of the soil profile (Harrison and Kollmorgen 1947), by placement of levees and other structures that load the surface (Kolb and van Lopik 1958), or by removal of minerals (e.g., oil, gas, or sulphur) from near-surface deposits.

Similarly, sediment deprivation in a marsh can be a natural consequence of the switching and change in dominance of the various distributaries of the Mississippi River (Coleman and Gagliano 1964), but it also is affected by development of continuous river levee systems that prevent overbank flooding and crevasse development (Kesel 1989) or promote loss of sediment into deep waters overlying the continental slope (Viosca 1928). Finally, hydrologic alterations can occur as a natural consequence of the breakup of barrier island systems at the mouths of estuaries (Penland and Boyd 1981), abandonment of distributary channels, or the development of tidal drainage networks (Tye and Costers 1986). However, the viability of coastal wetlands also is affected by thousands of miles of dredged channels and associated levees that alter hydrology, sedimentation, and salinity regimes (Scaife et al. 1983, Swenson and Turner 1987).

The basin plans included in the appendices of this report provide an overview of the complexity of this system. The remainder of this section is devoted to a review of the research findings critical to the restoration process.

HISTORICAL PERSPECTIVE

More than 4 million acres of the coastal wetlands built by the Mississippi River survived into the 20th Century. Nearly one million of these acres have been converted to open water in the last 60 years alone (Dunbar et al. 1992). It is critical to clearly identify the processes that have caused the most damage in the past to determine whether they are still causing destruction and to prioritize restoration efforts to stop or offset the most serious loss-producing processes.

Much coastal wetland loss in Louisiana, as in other maritime states, accompanied canal, railroad, and highway building, and development of drainage systems for agricultural, industrial, and residential purposes. In the first two decades of the 20th century over 200,000 acres were leveed and put under pump to create agricultural and suburban lands (Harrison and Kollmorgen 1947). Pumping of the organic soils caused rapid subsidence within the leveed areas and many areas, with the exception of some suburban districts adjacent to New Orleans, underwent conversion to open water once the pumps stopped or storms breached the levees.

Unique to Louisiana is the connection between current land loss and the evolution of a comprehensive levee system along the Mississippi River and the damming of distributaries like the Atchafalaya River, Bayou Plaquemine, Bayou Manchac, Bayou Lafourche, and several others south of New Orleans. The confining of the Mississippi River to a small part of its original flood plain and to a single course was initiated to provide flood control in the last century. Efforts to improve navigation resulted in the extension and stabilization of the mouth as a jettied channel to the edge of the continental shelf (Humphreys and Abbot 1861). Sediment supply to river flanking marshes was decreased, but continued to occur through crevasses or high-water levee breaks (Millis 1894).

The disastrous 1927 flood galvanized the Nation and provided impetus for a massive federal effort to raise and reinforce levees for comprehensive flood control (Elliott 1932). Crevassing was effectively stopped and control over the river tightened. Construction of the Old River Control Structure was completed in 1963 to stop the capture of the Mississippi by the Atchafalaya (Fisk 1952) and distribute the combined flows of the Red and Mississippi Rivers so that 70 percent flowed down the Mississippi and 30 percent flowed down the Atchafalaya. Revetments constructed along the Mississippi River and dams built on the Missouri and other large tributaries in the 1950's have affected the amount of sediment reaching the Gulf of Mexico (Meade and Parker 1985, Keown et al. 1986, Kesel 1987).

The suspended sediment load from the Mississippi River drainage system that helped build these wetlands apparently declined in the mid-1950's following a long-term drought and the construction mentioned above (Meade and Parker 1985). Measurements of bed materials also show a shift to finer grained sediment in the active delta during the 20th century (Keown et al. 1981). However, land clearing for agriculture and urban expansion has undoubtedly contributed to increased sediment loading in the river over the last 200 years. These changes, coupled with the elimination of direct input to the wetlands through crevasses, levee breaks, and delta lobe construction, have influenced sediment supply rates to the coastal wetlands.

Development of projects within the coastal basins themselves accelerated once river flooding was controlled. Large navigation channels were constructed and enlarged between 1920 and 1970. The Gulf Intracoastal Waterway joined and incorporated several smaller canals running parallel to, but considerably inland of, the coast. In addition, large channels perpendicular to the coast were built to connect inland ports located along the GIWW with the Gulf of Mexico. These connect the fresh interior marshes with the gulf and provide efficient conduits for freshwater drainage, and for sea water to move inland across natural subbasin boundaries (Wang 1987). Such channels have promoted the invasion of marine processes into freshwater areas previously isolated from them.

Pertinent information on the major navigation channels that transit the Louisiana coastal zone can be found in Exhibit 6 of this report. A high percentage of the banks of these waterways are unstable and were left unprotected during the construction process. As a result, bank erosion has caused many of the channels to grow far beyond the authorized width (Johnson and Gosselink 1982). The Mississippi River Gulf Outlet (MRGO), a channel completed east of New Orleans in 1968, is now as much as 2,000 feet wide, nearly three times its original width of 750 feet.

The dredging of smaller channels for drilling rig access and pipeline installation proliferated in the coastal wetlands of Louisiana during the oil and gas exploration and development boom of the 1950's, 1960's, and 1970's (Lindstedt et al. 1991). Where onshore fields were developed, the marsh was broken up by dense canal networks. Offshore fields also caused destruction as pipeline canals were dredged through the marshes and barrier islands to connect with onshore processing facilities. By 1978, more than six percent of Louisiana's coastal wetlands had been directly converted to open water or spoil through canal dredging alone (Baumann and Turner 1990). Indirect losses are estimated to be considerably greater than this (Cowan and Turner 1987).

Pursuant to the Coastal Zone Management Act of 1972 and subsequent State legislation, a state-administered Coastal Zone Management Program (CZMP) became operational in Louisiana in 1980. This began a new era of public interest and involvement in the way coastal wetland areas were managed and developed. Data presented in Table 3 reflect federal permitting in coastal Louisiana, of which CZMP permits are a subset. Over the period of this record, the number of public notices advertising work proposed in coastal wetlands declined and the acreage of wetlands permitted for dredging and filling decreased by approximately 50 percent.

The decline in public notices and permitted dredge and fill acreage resulted, in part, from a general economic downturn and increased use of general permits. However, these decreases also reflect the heightened public concern and enhanced regulatory efforts through federal and state permitting programs. An important regulatory development has been the increased use of directional drilling by the petroleum industry. This allows exploration of new sites from existing canals or reduced canal excavation to reach drill sites. The increased cooperation between the oil and gas industry and regulatory agencies and the eventual development of a state Conservation Plan will help to ensure that wetlands restored at public expense will not be destroyed later by permitted activities.

Table 3 Acreage Permitted for Development (Hartman et al. 1993)

Year	Number of Public Notices	Area Permitted for Dredge and Fill (acres)
1982	1,645	1,476
1983	1,341	1,413
1984	1,517	962
1985	1,606	2,362
1986	1,138	925
1987	1,138	339
1988	974	402
1989	983	988
1990	1,271	721

The potential for restoration has inspired a great deal of applied scientific study directed at quantifying and categorizing land loss processes. Much new insight has emerged in the past five years, largely as a consequence of research sponsored by the agencies that now make up the CWPPRA Task Force; some of that research is ongoing. The results of this work, together with project monitoring findings, form a credible basis for continued improvement in the design of coastal restoration projects.

CHARACTERIZATION OF WETLANDS LOSS

REGIONAL LAND LOSS

The rates at which different parts of the coastal plain are sinking have been related to the thickness of sediment deposited during the last 8,000 years, which varies across the coastal zone. This sediment has the potential to lose volume by dewatering, degassing, and compaction (Penland et al. 1991). During the last glaciation, about 20,000 years ago, when sea level was about 400 feet lower than it is today, the ancestral Mississippi eroded a deep valley into the underlying Pleistocene surface across what is now the coastal zone. When sea level began to rise, the valley was gradually filled with sediment, until about 5,000 years ago when sedimentation spilled out of the valley across the deltaic plain. Consequently, some parts of the deltaic plain are underlain by a massive thickness of Holocene sediment of more than 400 feet. The Holocene layer gradually thickens seaward (Frazier 1967). Slow seaward growth of the chenier plain on the western end of the state has resulted in a much thinner wedge (generally less than 40 feet) of recent deposits over the Pleistocene (Gould and McFarlan 1959).

The rate of sinking and compaction of organic soils and the varied history of sediment deposition across the coastal zone means that RSLR also varies. RSLR estimates include 0.09 inches per year for regional sea level rise in the Gulf of Mexico (Gornitz et al. 1982), and in Louisiana range from a high of 0.51 inches per year in the Atchafalaya and Mississippi deltas to 0.24 inches per year in the chenier plain (Ramsey and Moslow 1987). However, other factors can affect RSLR in local areas. Basin sediment can move downward along fault lines. There are hundreds of "growth faults" in coastal Louisiana, some of which cause displacement at the land surface. The downthrown side of these faults is seaward, and unless sediment deposition counteracts this displacement, land loss rates may increase on this side of the fault, which is thought to be true in the Barataria basin south of Empire.

The gulf shoreline of Louisiana retreats an average of 13.8 feet per year (U.S. Geological Survey 1988). However, some sections prograde as much as 11.2 feet per year on average, while other sections retreat at mean rates that are as high as 50.2 feet per year. Shoreline movement is not a steady process; accelerated erosion occurs during and after the passage of major cold fronts, tropical storms, and hurricanes (Dingler and Reiss 1991). Field measurements have documented 65 to 100 feet of coastal erosion during a single 3- to 4-day storm. These major storms produce a low-relief barrier landscape (Penland et al. 1988, 1990). Erosion along gulf and bay shorelines has resulted in a 55 percent decrease in the total area of Louisiana's barrier islands, and a great deal of lateral and inland migration, between 1880 and 1988. Isles Dernieres, in the Terrebonne basin, has the highest rate of coastal erosion of any Louisiana barrier system. Over the last 100 years the gulf shoreline of these islands has retreated northward a distance of 5,390 feet

Hurricane Andrew struck the Terrebonne and Barataria barrier islands in 1992, causing extensive erosion and breaching. Beaches were eroded more than 130 feet in two days, and some islands were reduced in area by 30 percent (Stone et al. 1993, van Heerden et al. 1993). The destabilized condition of the barrier islands, combined with the winter storms of 1992-1993, further accelerated the erosion problem (U.S. Geological Survey 1992).

Patterns of land loss between the 1930's and 1983 have been mapped coast wide (Britsch and May 1987), and these maps provide a clear indication that many other "hot spots" of loss exist. For most of these sites the cause of loss is so compounded that it defies any simple explanation (Leibowitz and Hill 1987). While land has been lost along gulf and bay shorelines, far more has disappeared in interior marshes many miles inland of the coast (Turner and Rao 1987), as ponds have formed, expanded, and coalesced into larger water bodies (Fisk et al. 1936, Reed 1991).

WETLAND LOSS AS A FUNCTION OF PLANT MORTALITY

It is important to identify the actual mechanisms through which processes such as submergence and the invasion of marine influences affect different plant communities. Effective measures to reverse coastal land loss must affect plant communities, in their root zone, in such a way as to promote healthy growth and reproduction, plant succession, or revegetation of denuded surfaces.

Sedimentation and the Accretion Deficit.

A positive difference between RSLR (Penland and Ramsey 1991) and the rate of marsh accretion (DeLaune et al. 1978, Baumann et al. 1984, Ritchie and McHenry 1990) implies that sedimentation is not keeping pace with submergence. Accretion deficits in excess of 0.1 inch per year result over time in a lowering of the elevation of affected wetland surfaces relative to a fixed datum (Baumann et al. 1984, Nyman et al. 1993). Even a minute accretion deficit could quickly influence flooding duration in Louisiana coastal marshes, which are seldom more than 1 foot above mean sea level (Chabreck 1970). Marsh water-level data from a deteriorating salt marsh near Cocodrie in the Terrebonne basin, for example, show that while high and low tides occurred daily, the marsh surface drained infrequently and for short periods such that it remained flooded for over 90 percent of an 11-day period of record (Cahoon 1992).

Vertical accretion of wetland soils depends on soil formation from sedimentary material of two types: mineral sand, silts, and clays brought in by flood waters or winds; and living and dead organic matter produced locally by the plants. In Louisiana (Nyman et al. 1990, 1991), organic matter accumulation is frequently more important than mineral sediment input to vertical accretion, except during initial phases of delta lobe building (van Heerden and Roberts 1988). Increased rates of root production, as opposed to above-ground shoot production, appear to be an adaptation to increased flooding in salt marsh cordgrass (Spartina alterniflora) and wiregrass (S. patens) that can increase the organic component of soil formation (Good et al. 1982). Another unique but poorly understood adaptation occurs when the living root mat of some fresh marshes actually detaches from the more mineral substrate and persists for long periods in a floating condition (Russell 1942). However, such adaptations can only occur if conditions are favorable for continued plant growth.

Pezeshki et al. (1992) showed that plants from all Louisiana coastal marsh types respond positively to experimental additions of mineral sediment and suggests that a certain minimal level of mineral sediment input may be required to maintain productivity. The minimal amount of mineral matter required each year by fresh marsh communities is about half of that necessary for brackish species and less than 20 percent of that needed by the salt marsh community (Nyman and DeLaune 1992). Because overbank flooding from the Mississippi has been eliminated, most of this material is derived from the limited return of Mississippi River discharge back into coastal estuaries via tidal passes, from the Atchafalaya sediment plume, and from bay bottom sediment reworked and distributed by tidal currents. Although the mineral matter may contribute from 50 to 90 percent of the dry weight of a Louisiana marsh soil, this denser material typically occupies from 2 to 7 percent of the soil volume, most of which is actually pore space within a matrix of living and dead plant roots (Nyman et al. 1990).

It is important to recognize that surface elevation in Louisiana marshes is controlled far more by soil volume than by its composition and that the formation of soil mass and structure is largely regulated in place by the plants themselves. Accretion deficits in Louisiana coastal marshes are caused primarily by inadequate organic matter accumulation (Nyman et al. 1993). The organic matter content of the soils supporting fresh, brackish, and salt marsh communities, in contrast to the mineral content, is similar. Inadequate organic matter accumulation results from a shift in the balance between plant production of organic mass, particularly below ground, that adds to the soil organic matter stock, and removal via conversion to carbon dioxide and other gases through decomposition. Any environmental change that lowers productivity or increases the rate of organic matter removal increases the vertical accretion deficit.

Decomposition is more vigorous in the fresh marsh than in the salt marsh and is slowest in the brackish marsh (Smith et al. 1983). As a result, to add enough organic matter to the marsh substrate to maintain position with respect to RSLR, fresh marsh plants must contribute about twice the amount of organic matter each year to the substrate than is true for brackish marshes, and the salt marshes fall in the middle (Nyman et al. 1990). Processes other than decomposition also can remove organic matter and may be locally important. These include lateral erosion of wetland margins due to waves and currents (Gagliano and Wicker 1989), deep burns of marshes during drought periods, and the direct consumption of below-ground root material by nutria, muskrats, and geese that can occur at times when population pressures are severe (O'Neill 1949).

An "eat-out" is a condition that occurs in the marsh when muskrats or nutria have populated an area to the extent of completely consuming the existing vegetation, including the root system which binds the organic soils (O'Neill 1949). Eatouts can be divided into 3 stages: initial, secondary, and final. Recovery of vegetation is dependent on the presence of other stressors, but is not well understood. During the 1970's and 1980's, much greater recognition of wetlands loss led some researchers to conclude that peak populations of muskrats during the 1940's and nutria during the 1960's likely played a major role in the breakup of some interior brackish marshes in coastal Louisiana.

At a Nutria and Muskrat Management Symposium held in October 1992, it was demonstrated that nutria and muskrat herbivory (particularly nutria) has produced substantial adverse economic and environmental impacts. Researchers with the Louisiana Department of Wildlife and Fisheries, United States Fish and Wildlife Service, and Louisiana State University (LSU) indicated that the impact of nutria herbivory is likely having a very significant detrimental effect on coastal vegetation (Conference Summary 1992. Proc. Nutria and Muskrat Management Symposium). These effects are thought to be particularly significant in marshes already stressed by submergence.

Submergence, Salinity, and Sulfide Effects on Plant Productivity.
While all wetland plants are adapted to grow in flooded soils, prolonged flooding negatively affects the productivity of many Louisiana swamp, brackish marsh, and salt marsh species to varying degrees. Plants must use more energy to obtain nutrients and respire toxins when the oxygen content of the soils drops because of prolonged flooding (Gosselink et al. 1977, DeLaune et al. 1979). Most existing information is available for salt (Spartina alterniflora) and brackish (S. patens) marsh species (Kirby and Gosselink 1976, Hopkinson et al. 1978, Mendelssohn et al. 1981, DeLaune et al. 1983, Mendelssohn and McKee 1988, Nyman et al. 1993) and swamp tree species (Kozlowski and Pallardy 1979, Pezeshki and Chambers 1985, 1986). Less information is available on fresh marsh species, but the negative response to flooding appears much less severe (Crawford and Tyler 1969, McKee and Mendelssohn 1989).

Sudden increases in salinity in waters flooding fresh marshes can result in vegetative die-back (Pezeshki et al. 1987). Brackish and salt marshes contain salt tolerant plant species with salt-excreting organs to make them better able to adjust to salinity increases (Mendelssohn and Marcellus 1976). Salt tolerant plant communities have encroached into historically fresh and intermediate marsh zones in many of the inland reaches of Louisiana's estuarine basins over the past 50 years (Chabreck and Linscombe 1982).

Increased salinity levels are often an important factor contributing to fresh marsh loss in areas adjacent to deep navigation channels or in impounded areas flooded by storm-driven seawater. It appears that sulfate, another constituent of seawater, may be at least as important as the salt itself in inducing toxicity in fresh marshes and reducing productivity in brackish and saline marshes when prolonged flooding results in oxygen-depleted soils. Such conditions can result in significant soil accumulation of free hydrogen sulfide (DeLaune et al. 1983) as well as root oxygen deficiencies (Mendelssohn et al. 1981). These factors can reduce nutrient uptake (Howes et al. 1986), growth, and productivity (Mendelssohn and McKee 1988). The iron associated with mineral sediment found in greater abundance in brackish and salt marsh soils can precipitate sulfides and reduce their concentrations below toxic levels for these marshes (Buresh et al. 1980).

When fresh marsh is killed by the toxic effects of salt or sulfide, it will be converted to open water if succession to salt marsh species is unsuccessful. This may happen if the soil surface elevation drops below the lower limit at which more salt- and sulfide-tolerant plants can live (Sasser 1977), if the mineral content of the soil is insufficient to support these species (Nyman and Delaune 1991), or if the soil is lost to erosion because of the lack of vegetation.

When the plants of any marsh type die, for any reason, the subsequent rapid decomposition of the root mass can result in a reduction in soil strength and a substantial collapse of the soil volume. Such collapses have been observed to result in a soil volume decrease that leads to a surface lowering of up to four inches. For marshes experiencing a RSLR about 0.5 inches per year, the amount of organic matter required to be returned to the soil each year just to maintain elevation begins to approach the limits for annual below-ground plant production (Nyman et al. 1993). Hydrologic changes by humans or nature that affect the sedimentation regime, freshwater supply or depth, and duration of flooding experienced by a marsh plant community influence its ability to flourish in a subsiding landscape (Stevenson et al. 1986, Reed 1991). Those effects may be manifested in the succession of one plant community to another or, alternatively, in the conversion of land to open water.

MAGNITUDE OF THE PROBLEM: LAND LOSS NUMBERS

Two parallel mapping efforts have been undertaken to characterize and quantify land loss on Louisiana's coastal plain by the USACE (Dunbar et al. 1992) and by the FWS and Louisiana Department of Natural Resources (FWS/LDNR). The USACE data set is complete for the entire coastal zone and provides land loss information for four time intervals (1931-33 to 1956-58, 1956-58 to 1974; 1974 to 1983; and 1983 to 1990). It is mapped at a resolution of 1:62,500, the scale of standard 15-minute topographic quadrangle maps. The results of this study are published in Dunbar et al. (1992). The FWS/LDNR effort has recently been completed, covering the time periods of 1956-1978 and 1978-1990. It provides habitat as well as land-to-water change information mapped at a resolution of 1:24,000, the scale of a standard 7.5-minute topographic quadrangle map. This mapping covers changes that have occurred since 1956, when the first comprehensive habitat map was prepared (Wicker et al. 1981).

The USACE data set is used for the following discussion because it has been published for the entire coastal zone, dates back to 1932, and recently has been aggregated by the nine basins used to analyze the Louisiana coast (Dunbar et al. 1992). The USACE researchers looked for land loss in 8,511 square miles (5,447,000 acres) of lands identified in an 18,000-square-mile coastal project area, much of which is open water. About 70 percent of this land lies in the delta plain, while the remainder constitutes the chenier plain. It should be noted that a significant portion of the area mapped is not actually wetland but includes developed levee ridges and areas ringed by levees within forced drainage districts. In addition, it is important to note that the USACE methodology measures gross land loss rather than net change in any interval. Open water that is converted to land, as in the Atchafalaya Delta, is not registered as a gain, for example.

The Dunbar et al. (1992) study deserves careful scrutiny because it dates back far enough to tell us much about man's role in accelerating land loss. The 1932 imagery provides a bench mark of conditions prior to most of the major local alterations that humans have made within the coastal plain. Mean annual loss rates, based on an average value over the time period of each data set, are shown in Figure 6 for the coastal plain as a whole, and for the delta plain and chenier plains separately.

These curves show that land loss increased for the coastal plain during the period between the early 1930's and mid-1970's, rising from 14.6 square miles per year (9,000 ac/yr), prior to the late 1950's, to an extreme value of about 42 square miles per year (27,000 ac/yr). Annual loss had dropped by 1990 to 25 square miles (16,000 ac/yr). Five square miles of loss occur each year in the chenier plain, while the delta plain loses about 20 square miles annually. Aggregate land loss for the entire coastal plain totalled nearly a million acres during the 60 years of record, at an average loss rate of about 27 square miles per year (17,000 ac/yr). Two important points emerge from these data. First, it is apparent that the land loss rate has dropped coastwide over the past two decades. Second, earlier projections of accelerating land loss have not been realized (Gagliano et al. 1981).

Current land loss rates of approximately 25 square miles per year, though still very high, are far lower than earlier extrapolations projecting that annual losses would approach 60 square miles annually by the 1990's. This information challenges an earlier assumption implicit in those projections. That assumption is that land loss is self compounding and perpetuating. Rather, it can now be concluded that much land loss occurred relatively quickly in response to within-basin alterations occurring in the 1950's, 1960's, and 1970's, but the effect of these impacts has tapered off rather than grown over time.

The USACE data set has been broken out along the natural hydrologic basin boundaries used by the Task Force for planning. Time histories of annual land loss for each of the basins are shown in Figure 7. It is apparent that some of the loss curves are more peaked than others. This is most pronounced in the Calcasieu-Sabine basin, where the peak can be taken to represent very rapid loss associated with the compounding impacts of a major navigation project and a devastating hurricane occurring within this time step. In the Breton Sound and Teche-Vermilion basins, a flatter curve may indicate the more gradual effects of shoreline erosion, sediment deprivation, increased marine influences, and subsidence.
Figure 6. Louisiana Coastal Land Loss Rates by RegionFigure 7. Louisiana Coastal Land Loss Rates by BasinFrom the planning perspective, such comparisons can be useful in allocating restoration resources. They provide at least a qualitative basis for partitioning the recorded and, more importantly, ongoing land loss between local, within-basin alterations and those of a more regional nature, associated with the underlying geology, subsidence, and sediment supply.

BACKGROUND LOSS

One way to separate out various factors affecting land loss rates is to use the loss data from the first interval (1932-58) as recommended by Dunbar et al. (1992) to provide an estimate of "background" loss. It is important to recognize that this background differs significantly from "natural" loss because it includes the regional impacts of management of the lower Mississippi River and its distributaries. This management began long before the 1930's, but was systematized with the authorization of the Mississippi River and Tributaries project in 1928, and evolved rapidly through the 1940's and 1950's. Canal dredging and road building, however, did far less damage to the interior hydrology of the basins prior to 1958. About 40 percent of the canals present in 1978 were dredged prior to 1958 (Turner and Cahoon 1987). Conversely, most of the disastrous land loss, associated with the wave of failed agricultural reclamations, was already complete by 1932 (Harrison and Kollmorgen 1947).

Background land loss, within the subsiding Louisiana coastal plain largely cut off from its fluvial supply of mineral sediments, is expected to be at least loosely correlated with the initial land area of each basin. Coastal basins with large initial land areas have more to lose. Sediment to maintain existing wetlands must be derived from the erosion of other lands within the system or generated in place by wetland organic production. A plot of mean annual loss rates against basin land area during the background period (Figure 8) shows a positive correlation between basin land area and mean annual background land loss. This analysis is continued for two additional periods. The 1958-74 and 1974-83 data are considered together, and the 1983-90 interval is evaluated separately. The 1958-83 period brackets the time during which most internal basin alterations occurred.

Projecting cumulative background loss rates to the present for each of the basins and comparing these projections with the actual record provides an estimate of "excess" loss for each basin for the 58-year record. The Mississippi and Atchafalaya river mouth basins have experienced cumulative losses within 10 percent of the loss predicted from the 1932-58 background rates. Excess loss for the other basins ranges from a low of 31 percent for the Pontchartrain Basin to a high of 93 percent for the Calcasieu-Sabine Basin. The Terrebonne and Mermentau Basins each experienced cumulative excess loss of about 60 percent, while the remainder of the basins are in the 40-50 percent range. Coastwide, of the approximately 1 million acres that have been lost over the past 60 years, 51 percent falls into the "excess" category. The chenier plain has experienced proportionally more excess loss (70 percent) than has the delta plain (42 percent).

Despite a geological history of dynamic land building and land loss, the magnitude of current land loss in the coastal zone of Louisiana is a relatively recent phenomenon. These high rates of loss are primarily confined to the past 60 years--the period during which the lower Mississippi River was under human control and land building was brought to a halt. It also is a time during which the hydraulic Figure 8. Land Loss vs. Basin Area by Time Periodfunctioning of all basins has to a greater or lesser extent been modified by a variety of large and small development projects. The basins that have experienced the most loss within the chenier and delta plains are considered below. Additional detailed information, including habitat change data, is included in each of the basin plan appendixes.

CHENIER PLAIN

The Calcasieu-Sabine and Mermentau basins have experienced loss rates over the past 60 years that are out of proportion to basin land area, and can largely be attributed to basin-level alterations of hydrology. The 1983-90 data show that these two chenier plain basins appear to be returning to rates closer to background (Figure 8), but that this drop off in loss rates is far more dramatic in the Calcasieu-Sabine basin than in the Mermentau to the east.

The Calcasieu-Sabine and Mermentau basins have been dramatically affected by the dredging and enlargement of channels to the gulf. More than 82 percent of all documented loss in the Calcasieu-Sabine Basin, over 100,000 acres, occurred between 1955 and 1974. This destruction is believed to have been caused by the construction and expansion of the Calcasieu Ship Channel and Port Arthur Canal/Sabine Neches Waterway and accelerated by Hurricanes Audrey (1957) and

Carla (1961). These waterways were built in the 1940's, and were significantly enlarged in stages through the early 1970's.

Navigation channels have had less effect in the Mermentau basin. Projects were undertaken as early as 1913 to incorporate locks and water control structures to limit some of the most damaging impacts. By the early 1950's, the major means of saltwater access had been blocked. The USACE Mermentau River project controls saltwater intrusion into the system, maintaining a reliable source of fresh water for the irrigation of rice fields and crawfish ponds. The land loss picture in this basin is otherwise more complex than in the Calcasieu Basin, however, because it is characterized by long and unstable shorelines along the gulf on the south and adjacent to the large lakes in the areas north of the major beach ridge complexes. The gulf shoreline of this basin has historically experienced some of the most rapid retreat rates of any area in the nation. Along the eastern side of the basin this trend is changing, however, as land building associated with the increased influx of Atchafalaya River sediments acts to stabilize the coast from east to west (Huh et al. 1987).

Marshes in the southern part of the basin are separated from the freshwater lakes to the north by natural ridges, highway embankments, and control structures. The restricted exchange of flow between these subbasins presents a unique problem for each. Consistently high water levels in the gulf make drainage from the lakes difficult--USACE records based on hourly gauge readings show that for the period January 1987 to December 1990, gulf stages exceeded lake stages 74 percent of the time. These factors have resulted in periods of prolonged high water levels within the basin, causing submergence of marshes and wave erosion along the southern lake margins. The problem is exacerbated by upstream development and drainage projects, which have increased the volume and rate of runoff entering the basin.

In the lower subbasin the combination of structures, natural ridges, and highway embankments has limited the supply of fresh water to marshes south of the chenier ridges. The water management problem is only now beginning to be addressed, but a small, state-sponsored project to introduce fresh water from the lakes to marshes south of Pecan Island shows considerable promise and suggests that much loss abatement could be achieved through this approach. Similarly, state-sponsored construction of a series of detached breakwaters along the gulf shoreline of the western part of the chenier plain also may be effective in slowing coastal retreat in this area, which will not see the benefits of significant sedimentation from the Atchafalaya for perhaps another century.

DELTAIC PLAIN--ABANDONED DELTAS

The data for three of the four delta-plain basins, Terrebonne, Barataria, and Breton Sound, plot above the regression line for the 1983-90 interval (Figure 8). The Terrebonne basin has the distinction of having lost the most land of any coastal basin during the period 1932 to 1990, a total of over 200,000 acres, but the Barataria basin, at 190,000 acres, does not lag far behind. The Terrebonne and Pontchartrain basins show the 1960's peak and subsequent drop-off in annual loss rates (Figure 7) that characterize the coastal plain as a whole. Land loss in the Barataria Basin has shown a gradual increase through the early 1980's; Breton Sound Basin has shown a gradual increase through the period of record and continues at close to the historical high.

The Pontchartrain Basin experienced significant wetland loss associated initially with agricultural drainage and subsequently with suburban residential development adjacent to New Orleans through the 1970's. These conversions from wetland to fastland under forced drainage do not show up in the USACE data base, which documents only change from land to water. Despite the construction of the Mississippi River Gulf Outlet navigation channel (MRGO) in the late 1960's and a short segment of the Gulf Intracoastal Waterway in the early 1970's, the Pontchartrain basin has experienced relatively constant land loss rates throughout this period. Land loss today closely approximates the background rates measured during the 1932-58 period.

The Barataria and Breton Sound basins, adjacent to the course of the modern Mississippi, have been affected in places by the dredging of extensive oil field canal networks. Except in the vicinity of Shell Island (the easternmost of the islands on the west side of the river), the barrier islands of the Barataria basin have remained relatively intact. As discussed earlier, much of the wetland fragmentation south of Empire appears related to enhanced subsidence associated with faulting.

The gradual increase in loss rates over the past 60 years in the Breton Basin and continuing high rates in the Terrebonne and Barataria basins suggest that a process quite different from that observed on the chenier plain or even in the Pontchartrain Basin may be affecting these basins. With the exception of the Mississippi River mouth itself, the Breton and Barataria basins--because of their proximity to the river--should be more affected than all other basins by the change in river management that has occurred in the past 100 years. They once received the most sediment and fresh water from the river and its historically active distributaries. Now, they receive little more than any other basin in the coastal plain. It is to be expected that the impact of sediment deprivation should be more pronounced in these river-flanking basins than elsewhere.

The Terrebonne basin, lying more distant from the Mississippi's mouth but closer to that of the Atchafalaya, exhibits the most complex land loss pattern of any basin on the coast. The land loss rate curve (Figure 7) has a form and magnitude similar to that of the Calcasieu-Sabine basin for the early period, but it drops off much more gradually through subsequent time periods and remains currently at close to 4,000 acres per year. Numerous significant within-basin modifications, including the dredging of the Houma Navigation Canal, have contributed to loss of organic material and flotant marshes due to saltwater intrusion and rapid water level fluctuations in the central part of the basin. Breakup and removal of a once continuous barrier island chain appears to be a factor in much of the loss in the lower basin. These barrier islands, unlike the coastal plain as a whole, have experienced accelerating loss rates over time and, if not artificially nourished, are expected to be lost within a matter of a few decades (U.S. Geological Survey 1992).

The Dunbar et al. (1992) report provides additional evidence of the complexity of land loss in the Terrebonne basin. Loss rates during the 1958-74 period increased on the eastern side of Timbalier Bay and on the western side of the basin, closest to the Atchafalaya. High loss rates spread west across the marshes at the head of Timbalier Bay to those north of Terrebonne Bay during the 1974-83 period and remain extremely high. Loss rates on the western side of the basin adjacent to the Atchafalaya have returned, however, to a lower level. These data suggest that land loss on the bay margins has accompanied the dramatic storm-driven destruction of the barrier chain. It also shows the growing ameliorative effect of sediment entering from Atchafalaya Bay and Four League Bay on the west.

DELTAIC PLAIN--ACTIVE DELTAS

The Mississippi and Atchafalaya river mouth basins differ from all others in that current land loss rates are below the 1932-58 background level. Even so, land loss continues to exceed land building even in the immediate vicinity of the two modern mouths of the river. Despite the creation of nearly 25 square miles of land in the Wax Lake and Atchafalaya deltas since 1973, continued land loss in the basin as a whole offsets these gains. Current trends indicate that this trend will be reversed in the near future. In both cases, land building potential is restricted by the current mode of managing the associated navigation channel (van Heerden 1983).

The wetland systems associated with the river mouths differ in one important respect. The twin Atchafalaya deltas will continue to fill in the shallows of Atchafalaya Bay and eventually prograde into the shoal waters of a broad continental shelf. In contrast, the wetlands of the Mississippi River mouth are perched on the edge of the continental shelf on 400 feet of rapidly compacting recent deposits. Much of this area will disappear within thirty years if present trends continue. This is predicted despite a vigorous effort in the last decade to build land by using dredged materials and initiating artificial crevasse splays. A skeletal network of sandy natural and human-made levees and spits will continue to outline the channels and bays for some years after the marshes have been lost, but the habitat value of this delta will be reduced greatly.

PROJECTED LOSS BY THE YEAR 2040

Figure 2 of the Executive Summary illustrates the effect of the projected wetland loss on Louisiana's coastline. The illustration is based on projections of land loss derived from actual losses as demonstrated in aerial photographs and quad maps from 1956 to 1983. The line of demarcation is a 50/50 line; that is, the region south of the line is greater than 50 percent water, while the region north of the line is greater than 50 percent land. Projections of wetland loss used in this report are based on analysis of historical losses as presented in Dunbar, Britsch, and Kemp (1992).