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Scientific Assessment of Coastal Wetland Loss, Restoration and Management in Louisiana

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EXECUTIVE SUMMARY

From the 1930s to 1990, the coastal zone of Louisiana lost an estimated 3,950 square kilometers, or 1,526 square miles, of wetlands (i.e., periodically flooded land containing emergent vegetation. This loss of wetlands resulted, for the most part, from inundation or erosion of wetlands rather than from the draining or filling characteristic of many wetland losses elsewhere. In addition, large areas of brackish and freshwater wetlands have become progressively more saline as salt water has increasingly invaded the deteriorating coastal zone. Because 40% of U.S. coastal wetlands are found in Louisiana, this loss constitutes about 80% of the total national coastal wetland loss. Louisiana coastal wetlands are exceptionally valuable in terms of coastal fisheries and migratory waterfowl, protection of low-lying population centers from hurricanes and other storms, and oil and gas production. Furthermore, the greatly accelerated rates of coastal wetland loss appear to be the unintended result of massive human disturbances of these wetlands and intervention (for purposes of flood protection, water supply, maritime commerce, energy production, and wildlife management) in the processes that sustain coastal wetlands.

Growing awareness of rapid coastal wetland loss has resulted in extensive studies to quantify the problem, understand its underlying causes, and assess possible solutions. Advocacy groups have been formed for wetland protection and restoration, and state and federal statutes have been enacted that authorize and finance coastal restoration on a large scale. Federal and state outlays for the coastal restoration effort now exceed $40 million per year, and some major projects under consideration may cost more than a billion dollars. But controversies remain as to whether wetland deterioration is due primarily to natural or human causes; the human activities most responsible; the effectiveness of approaches such as barrier island restoration and water-level control in tidal wetlands; and whether anything could really be done to reverse the powerful processes of wetland destruction.

Mindful of the seriousness of loss of Louisiana coastal wetlands, the magnitude of public investments being made and under consideration, and the importance of a sound technical basis for wetland restoration and management, the W. Alton Jones Foundation sponsored this scientific assessment of coastal wetland loss, restoration, and management in Louisiana. This assessment by a panel of environmental scientists with expertise in the science and engineering of coastal wetlands, who are not actively involved in research or management activities underway in Louisiana, is intended to provide guidance to those entrusted with the stewardship of this nationally important ecosystem. Specifically, the Panel addressed a charge to:

- Examine space and time scales over which the fundamental processes of wetland loss operate and on which appropriate restoration strategies should be based.

- Identify issues on which there is scientific consensus or controversy.

- Determine actions that will assure the long-term (decades to centuries) continuance of extensive wetlands in coastal Louisiana.

- Propose scientific and technical needs for research, modeling, and monitoring, including criteria for assessing the effectiveness of wetland restoration and creation.

Louisiana Coastal Wetlands

The coastal zone of Louisiana consists of the Mississippi Deltaic Plain to the east and the Chenier Plain to the west. The wetlands of both of these coastal provinces are products of the interaction of the Mississippi River with the sea. The lower Mississippi has changed its course several times over the last 7,000 years; hence, the Deltaic Plain was formed as a composite of several delta lobes with intervening basins. Over the last millennium, the Mississippi has distributed its flow primarily through the "birdfoot"-shaped distributary system of the Modern delta in extreme southeastern Louisiana. During this century, a new delta has been emerging at the mouth of the Atchafalaya River, which now carries 30% (as regulated by a flow-control structure) of the flow of the Mississippi system to the Gulf of Mexico. The Pontchartrain, Breton Sound, Barataria, Terrebonne, Atchafalaya, and Teche/Vermilion basins lie between these major deltas, or where the older deltas have subsided below sea level. These basins function as hydrological units of tidal exchange and drainage.

The Chenier Plain is also a product of the Mississippi, but was built by sediments that escaped the delta over the past 3,000 years and were deposited along the coast and periodically eroded as the river shifted its mouth. Eroded deposits are evident as intermittent shell ridges, called "cheniers" because of the live oaks that grow on them. The Mermentau and Calcasieu/Sabine basins comprise the hydrological units of the Chenier Plain.

Overlying this geologic structure, zones of vegetation parallel the coast, representing a gradation from high salinity near the coast to freshwater conditions inland. Saltmarsh grades to brackish marsh, which grades to freshwater marshes and wooded swamps. Consequently, within the coastal landscape there are three distinct scales of wetland features and processes. At the largest scale, one can distinguish between two geologic provinces, the Mississippi Deltaic Plain and the Chenier Plain. At the smallest scale, the landscape can be characterized in terms of communities of wetland vegetation. At the intermediate scale, nine hydrologically distinct basins can be identified. Recognizing the possible link between scale and processes affecting both wetland loss and wetland creation, this assessment addresses wetland loss, restoration, and management in the context of the three spatial scales of Louisiana's coastal wetlands: province, hydrologic basin, and marsh.

This report examines in detail the causes and consequences of wetland loss; management options for protection and restoration; the comprehensive approach to management and restoration being pursued under the Coastal Wetlands Planning, Protection and Restoration Act of 1990; and the needs for ongoing scientific assessment, monitoring, and modeling. The findings and recommendations of the Panel's assessment are summarized below under the topics of Processes of Wetland Loss, Human Contributions to Wetland Loss, and Management and Restoration. For each topic, the broad conclusions are presented (in boxes); these are followed by the specific findings supporting these conclusions. We also identify issues on which there is broad consensus within the technical and scientific community, those on which there remains a clear lack of consensus, and opinions of the Panel.

Processes of Wetland Loss

Wetland loss in coastal Louisiana increased dramatically during the second half of the twentieth century and, although the rate of loss has slowed somewhat, approximately 65 km^2 of coastal wetlands continue to be lost each year. This loss poses a serious threat to the nation's coastal resources and Louisiana's citizens. The accelerated wetland loss is fundamentally much more a consequence of the sinking of the land, and deficiencies in the buildup of soil to offset this sinking, than erosion of its edges, filling, or draining.

Louisiana has a naturally highly dynamic coastal environment in which wetlands have dramatically grown or retreated over the centuries, depending on the position of the Mississippi River mouth and changes in sea level. At the beginning of the twentieth century, there was probably a small net rate of loss of wetlands along the coast. Aerial photographic evidence supports the consensus that the rate of net wetland loss increased dramatically from the 1940s to the 1980s, but that it declined somewhat during the 1980s and early 1990s. The various analyses of wetland loss that have been performed provide different estimates of the actual rates, but all agree in these trends. However, it should be understood that wetland loss rates and trends vary greatly among basins. In the Panel's opinion, the extrapolation of these historical curves of wetland loss rates to predicting future wetland conditions or loss rates into the next century, whether expressed on a coast-wide basis or by basin, is not scientifically justified.

Louisiana's coastal wetlands have also been changed in ways not fully reflected in wetland loss estimates, including changes in salinity and hydrological regimes that have significant consequences to the characteristics of these ecosystems and their long-term viability. There is consensus that, except in a few regions mainly around the Atchafalaya River mouth, there have been widespread changes in vegetation to more salt-tolerant species. In the Panel's opinion, such wetland habitat changes—as opposed to wetland loss—have not been well documented, either qualitatively or quantitatively, but must be taken into account when the consequences of long-term wetland changes in Louisiana are evaluated.

Several studies have confirmed that there has been a substantial reduction of sediment transported through the lower Mississippi River during the middle and late twentieth century. However, because levees prevent overbank flooding and little of the sediment load of the river is presently distributed to coastal wetlands (except at the mouths of the Mississippi and Atchafalaya rivers), the Panel believes that the reduction of riverine sediment load per se (as opposed to the interruption of the delivery of those sediments to the wetlands) has not been a major factor in twentieth century wetland loss. The reduced sediment load may, however, be a significant factor affecting future delta dynamics and restoration options.

There is a scientific consensus that natural subsidence is a major underlying factor in much wetland loss. Subsidence requires offsetting deposition of sediments and organic matter for soil accretion. It also increases flooding, wave attack, and, thus, erosion and salinity. Some have alleged that large withdrawals of oil and gas and associated formation waters have increased subsidence rates throughout coastal Louisiana. Others have argued that these withdrawals have been overwhelmingly from deep strata, and consequently the effects of these withdrawals on surface elevations should be minimal. Considering the evidence provided by geotechnical experts and the spatial patterns of wetland loss, the Panel concludes that the effects of withdrawal-influenced subsidence have been limited to localized wetland losses around shallow oil and gas fields, but can be significant in these locations.

Global sea-level rise has not been a dominant factor in twentieth century wetland loss in Louisiana. But the rate of relative sea-level rise, resulting mainly from subsidence, has varied spatially from several millimeters to more than 2 cm/yr over the past century, and typically has been about 1 cm/yr along the coast. Sea-level rise was more rapid for short periods of this record, possibly as a result of climatic variations, which have influenced average as well as extreme water levels. The Panel concludes that these episodes of rapid relative sea-level rise could be a significant factor in accelerated wetland loss, but this hypothesis cannot be accepted with certainty and should be tested further.

Reduction in the area and length of barrier islands has been suggested by members of the public as well as scientists as a cause of increased wetland loss and a risk for future wetland losses. Recent observations and models strongly suggest that the protection afforded against waves is a significant factor in controlling the rate of erosion of wetland shorelines around the bays behind the barriers. However, in the opinion of the Panel, it is possible, but not yet demonstrated, that the presence of barriers also significantly reduces wetland loss by reducing tidal exchange and storm surge. It should be remembered, however, that barrier island deterioration is a process natural to deltas in the later stages of deterioration and that the preservation of deteriorating barrier islands will require a continuing effort.

The Modern Mississippi delta, which has been occupied since European settlement of the region, is a deep-water, "birdfoot" type through which much of its sediment load escapes the coastal system to deep water, unlike a classic broad delta, which retains and distributes sediment more effectively across the delta. This ejection of valuable sediments directly into the Gulf exacerbates the rapid coastal wetland loss throughout the Mississippi Deltaic Plain and poses constraints on effective restoration options. Human intervention through raising levees along the lower Mississippi, closing crevasses and the outlet to Bayou Lafourche, and preventing greater capture of flow by the Atchafalaya River has reduced the amount of sediments nourishing Deltaic Plain wetlands. Some people argue that this has been the major cause of wetland loss during the second half of the twentieth century. However, the dramatic and widespread increase in the wetland loss rate did not coincide with or follow major and widespread reduction in riverine sediment introduction. In the Panel's opinion, other human activities (as discussed below) were more responsible for this short-term increase in wetland loss, but the curtailment of riverine sediment supply to the wetlands presents the dominant long-range threat to their survival.

An unresolved issue is the degree to which wetlands in this subsiding environment depend on mineral sediment accretion and on organic soil formation. Some mineral sediment seems to be required by all sustainable wetland types.

Human Contributions to Wetland Loss

Net loss of coastal wetlands in Louisiana would probably be occurring without human intervention in this ecosystem because of the limited wetland-building potential of the delta presently occupied by the Mississippi River. However, a variety of human activities have caused wetland loss to accelerate greatly. These activities include construction of canals for transportation and oil and gas development and the hydrologic modifications that result from them; impoundments and failed land reclamation; and interference with floodwater flow across the natural levees of the river. Without mitigation or restoration, the modifications resulting from these activities will continue to cause high rates of wetland loss.

Direct wetland destruction by draining, dredging, spoil deposition, and subsequent widening of canals and navigation channels, according to some estimates, accounted for only 16% of the wetland loss that occurred in coastal Louisiana between 1955 and 1978. Potentially much more significant were the indirect effects of canals and navigation channels as a result of salinity intrusion, alterations of water flow, and interference with normal tidal flooding and drainage of the wetlands. Opinions of the magnitude of these indirect effects diverge widely. Although the indirect effects are incompletely understood and perhaps can never be quantified, the Panel considers to be reasonable the estimate by a team of Louisiana State University scientists that between 30% and 59% of the wetland losses between 1955 and 1978 were due to the direct and indirect effects of canals.

Impoundments of wetlands for agricultural development and control of wetland water level largely to promote waterfowl utilization have had significant local effects on wetland loss that are difficult or impossible to reverse. On the other hand, some would argue that impoundment and water-level control activities in some instances reduced wetland losses that would have occurred in their absence. Scientific evidence has not been conclusive on the effectiveness of structural water-level controls, generally referred to as "marsh management," for controlling wetland loss. In fact, many studies have demonstrated that undesirable impacts are common, such as loss of wetlands, reduction in sedimentation, and inhibition of access by migratory fish and crustaceans. The Panel recommends that the use of marsh management be reevaluated and the practice discouraged unless techniques are developed that assure long-term vegetative recovery within impounded areas.

Salinity increases have resulted in wetland change and loss, at least locally, and this seems to have particularly been the case in association with coast-normal navigation canals, which have greatly modified hydrology. Although the widespread shifts in vegetation types (inland expansion of saline marsh and contraction in fresh and brackish marsh) strongly suggest pervasive saltwater intrusion, analyses of long-term salinity records have yielded ambiguous results, and the changes in vegetation types are poorly documented.

Management and Restoration

Reduction in the intensity of new human intervention over the past decade or so has contributed to a reduction in wetland loss rate, but regulatory protection alone will be insufficient to reduce wetland losses to a level that avoids drastic consequences to resources and human habitation and enterprise in coastal Louisiana. Large-scale and comprehensive management and restoration will be required and are technically feasible. The Coastal Wetlands Planning, Protection and Restoration Act of 1990 provides an excellent mechanism and impetus for such a comprehensive effort. The planning activities conducted under this act are off to a good start but will have to more effectively: 1) integrate region-wide strategies with those developed locally (within hydrologic basins); 2) moderate the self-interests of performing parties (e.g., federal and state agencies) by objective technical and policy review; 3) balance private land rights with the greater public interest in the integrity of coastal wetlands; and 4) attain financing for the large-scale reintroductions of freshwater and sediments which must be the backbone of effective restoration in the Deltaic Plain.

There is broad consensus that reintroduction of water and sediments from the Mississippi and Atchafayala rivers into wetlands is essential for the long-term management and restoration of Louisiana coastal wetlands. Major questions remain for science and management related to how to introduce water and sediments most effectively, over what scales this introduction is feasible, and whether there is presently an adequate and available supply to meet the needs of region-wide wetland restoration.

Creation of significant new wetlands is needed to offset inevitable losses (even if maintenance efforts are successful). This objective can be accomplished only by increasing the expansion of new wetlands at the Mississippi River and Atchafalaya River mouths. For the active Mississippi River delta, this strategy will require creation of a new subdelta.

The effectiveness of water-level control for wetland preservation and restoration is questionable, and such measures, although they arguably may be able to protect existing wetlands, are unlikely to contribute to a long-term increase in wetlands. Water-level control approaches are the most controversial aspect of the restoration plan and are met with much skepticism within the scientific community. At a minimum, if such approaches are adopted, active control utilizing natural processes to promote sedimentation should always be used.

Wetlands can be created by use of dredged material, but this practice cannot restore large areas of wetlands and may not be feasible in most areas removed from dredging sites. Marsh creation from dredged material in the Modern delta proper has not been effective in restoring wetlands over the long term. Available dredged material should be used for strategic restoration in conjunction with other management practices.

The Coastal Wetlands Planning, Protection and Restoration Act of 1990 is a remarkable vehicle for developing and implementing a comprehensive approach to coastal wetland management and restoration. It provides a mechanism for consensus building, technical design, funding, and monitoring. The Panel believes that the Louisiana Coastal Wetlands Conservation and Restoration Task Force established under the Act has produced a plan that is a commendable first step but has not yet integrated the various strategies for restoration within each basin into a comprehensive strategy that addresses restoration across the entire region. Furthermore, the Panel has concerns regarding the methodology used by the Task Force to evaluate the costs and benefits of specific projects and the heavy reliance on approaches involving water-level control (such as marsh management and hydrologic restoration) among the projects selected for implementation during the first two years.

Large-scale, hydrologic basin-wide—i.e., for the whole Mississippi Deltaic Plain or Chenier Plain— projects are necessary if wetland loss is to be reduced significantly. However, these projects will require substantial and lengthy study and planning. The Panel concludes that, given the widespread human-induced changes that have diminished the capacity of this system to build and maintain wetlands such major coastal engineering approaches must be undertaken. The Task Force must fully engage its efforts to identify the most feasible large-scale projects as soon as possible.

Scientific research has served admirably as the basis for our understanding of the processes of coastal wetland loss in Louisiana. It cannot be ignored when contemplating approaches to restoring coastal wetlands and needs to be fully integrated into the planning and implementation process. Modeling and monitoring procedures need to more fully address "adaptive management" strategies to improve future restoration efforts.