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Wetland Loss in the Northern Gulf of Mexico: Multiple Working Hypotheses

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ABSTRACT: I examined four hypotheses about causes for the dramatically high coastal wetland losses (0.86% yr^{-1}) in the northern Gulf of Mexico: an extensive dredged canal and spoil bank network, a decline in sediments in the Mississippi River during the 1950s, Mississippi River navigation and flood protection levees, and salinity changes. Natural factors contributing to these habitat changes include eustatic sea-level rise and geological compaction, which appear to have remained relatively constant this century, although variation does occur. These four hypotheses were tested using data on land-to-water changes in 15-min quadrangle maps inventoried for four intervals between the 1930s and 1990. Land loss rates were directly proportional to changes in wetland hydrology in time and space. A linear regression of the direct losses due to dredging versus the losses due to all other factors (indirect losses) had a zero intercept and a slope that increased with time. The ratio indirect:direct land loss was highest nearest the estuarine entrance. The coastwide patterns of land loss do not appear to be affected by riverine sediment reductions over the last 60 yr. The effects of changes in wetland hydrology from dredging human-made channels and forming dredged spoil banks appear to be the most efficacious hypothesis explaining these dramatic losses. The effects of extensive human-induced changes on this coast have apparently overwhelmed the causal linkages identified in the historical re-constructionist view of deltaic gain and loss that emphasizes the role of mineral sediments. A paradigm shift is therefore proposed that emphasizes a broad ecological view as contrasted to a mostly physical view emphasizing the role of sediment supply in wetland maintenance. In this view, plants are not an ancillary consequence of strictly geological dynamics such as sediment supply but are dominant agents controlling factors relevant to coastal restoration and management efforts.

Introduction

The most dramatic coastal wetland losses in the United States are in the northern Gulf of Mexico (Turner 1990), which has 41% of the national inventory of coastal wetlands (Turner and Gosselink 1975) and 80% of the nation's total wetland losses (Dahl 1990). The annual wetland losses were 12,700 ha from 1955 to 1978 (0.86% yr^{-1}; Baumann and Turner 1990). At this rate, land equivalent to the area of Rhode Island was converted to open water within 21 yr. The loss rate subsequently declined between 1983 and 1990 (Britsch and Dunbar 1993).

The initial habitat conversions from human activities, or "direct impacts," are well documented and represent about 12% of the total land losses (Britsch and Dunbar 1993; note: on this coast wetland loss and land loss are essentially equal, e.g., Baumann and Turner 1990). The remaining 88% of the losses are the result of other causes. These "indirect impacts" are the secondary or subsequent changes resulting from, for example, reductions in sediment supply or from dredging, from subsurface fluid withdrawal, or from hydrologic alterations. The ratio of direct: indirect impacts resulting from human activities may vary under influences such as global sea-level rise, climate changes, soil type, geologic setting, or management.

The causes of these indirect coastal wetland losses have rarely been explicitly stated as hypotheses or quantified in the scientific literature. A recent scientific review by coastal experts (Boesch et al. 1994) included dredged canals as a major factor, but management documents give a different view. For example, a report by the Science Advisory Panel to the Governor of Louisiana included canals within a discussion of "marine tidal invasion," one of six categories of causes (Gagliano 1994). This report suggested that a vigorous management program (presently $147 million from 1992 to 1996; Anonymous 1995a) could achieve a balance of no coastal land loss within 50 yr. A recent Louisiana State Government "White Paper" unequivocally concluded that a decrease in the sediment supply was the one cause of coastal wetland losses: "alterations to the river system, resulting in a long term sediment deficit in a subsiding coast, is the major overall problem" (Anonymous 1995b, p. 4).

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The State of Louisiana has clearly adopted the perspective that landloss is a consequence of sediment starvation and that restoration is therefore dependent on sediment management.

The general absence of clearly stated hypotheses that allow for testing, quantification, and prediction hinders development of clear management choices with known consequences, for example, area conserved and/or restored and resources allocated. I agree with Slobodkin who commented (1988, p. 342) on the role of science in public resource management: "Practical questions of environmental management in the absence of ecology are likely to receive misleading and even dangerous answers."

I tested four hypotheses about the causes of wetland losses along this coast. A central concern is to identify the cause-and-effect relationships leading to land (and wetland) losses to reduce or even reverse the present and past regression through either active or passive management.

The Environmental Setting

The Louisiana coast formed after the Pleistocene as a series of overlapping riverine deltas extended onto the continental shelf. The Mississippi River, now partially captured by the Atchafalaya River, shifted 6 times over the last 6,000 yr seeking the lower hydrologic resistance of a shorter route to the sea (Fisk et al. 1954). This process of individual delta growth and abandonment continued until the position of the modern bird-foot (Balize) delta was reached about 200 yr ago and more than 1 million ha accumulated coastwide.

As the coastline progressed seaward, delta mud was overlain by silts and sands and topped by deltaic sediments, including organic deposits (Fisk et al. 1954). Smaller subdeltas may deposit sediments up to 14 m thick and the entire delta sequence may be 150 m deep. These fine-grained and highly organic sediments undergo consolidation, compaction, and oxidation resulting in subsidence. The highest subsidence rates occur in the upper 2 m of the marsh soils (Turner 1991).

The Chenier Plain, located in western Louisiana, is a series of sand and shell ridges (shore-parallel to shore-oblique) that are separated by progradational mudflats, wetlands, or open water. It is called a 'Chenier' in reference to the oak trees (*chene* in French) growing on the stranded beach ridges. Mudflats grow during periods of deltaic abandonment as reworked sediments move westward with littoral drift; subsequent sediment re-sorting builds ridges, which structure waterflow within the estuary between them.

The suspended sediment load from the Mississippi River drainage system declined in the mid-1950s following dam and reservoir construction on major tributaries (Meade and Parker 1984; Kesel 1988). It is not clear how the present suspended sediment load compares to that before Europeans colonized the Mississippi River watershed. Increased habitation and deforestation within the Mississippi River basin probably led to increased suspended sediment concentrations prior to dam constructions, as happened elsewhere. For example, Brush (1984) documented a twofold increase in sediment delivery to coastal systems following deforestation and farming in Chesapeake Bay tributaries. Sediment loading in the 1950s may therefore be an inappropriate baseline measure of long-term (centuries) averages to compare with present sediment loadings.

Reducing the direct introduction of riverine sediment into wetlands (via either natural breaks in the river levee or overbank flooding in the 1930s before flood protection levees on the lower Mississippi River were completed) undoubtedly influenced sedimentation supply rates to the coastal zone. About 3% of the suspended mineral matter presently confined within the Mississippi River levees would be delivered directly to the wetlands through overbank flooding and crevasses (levee breeches) if the levees did not prevent it (Kesel 1988). However, our knowledge of sediment storage in rivers, continental shelves, and coastal wetlands is too incomplete to predict how much less land would be built, or even if there would be a net loss, with such changes in suspended sediment supply.

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Fig. 1. Aerial views of Louisiana coastal wetlands. An approximate scale in each is the width of an individual canal (normally 30 m). A. A false-color image of the Big Mar, a former agriculture reclamation site (circa 1915) located to the southeast of New Orleans. B. A former logging site near Lake Maurepas, Louisiana. The star-shape lines in the center by the canal are where cypress logs were dragged out around the beginning of this century. C. A network of canals in the Leeville oilfield at Leeville, Louisiana, located along Bayou Lafourche and near Catfish lake. D. A network of canals and spoil banks. The terminus of each dredged 'keyhole' is a drilling location. E. A dredged canal and spoil bank crossing a natural saltmarsh bayou. The nearby artificial channel is probably a drainage ditch. Note the interruption in natural channel network by the spoil bank. F. Wetlands on the northwest shore of Lake Pontchartrain. Note the drastic vegetation differences on either side of the spoil bank. G. A ground view of a canal and spoil bank built ca. 30 yr ago in a salt marsh near Cocodrie, Louisiana. H. A dredged canal and spoil bank crossing a natural saltmarsh bayou in the Barataria Bay estuary. A natural channel is blocked on the southern side of the dredged channel, and eroded on the northern side.