LAND LOSS IN THE MISSISSIPPI RIVER DELTAIC PLAIN

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ABSTRACT

Systematic measurements and comparisons of maps, black-and-white aerial photographs, and color infrared imagery taken at five periods within the interval from 1890-1978 have been used to document land loss and habitat change within the Mississippi River Deltaic Plain. The studies show that the long-term trend of net progradation, which persisted through most of the past 5000 years, was reversed during the late nineteenth century, and that during the twentieth century land-loss rates have accelerated geometrically. Within the 11,500 mi² study area, land-loss rates have progressed from approximately 6.7 mi²/year in 1913 to a projected 39.4 mi²/year in 1980. The greatest loss has occurred in the wetlands, but barrier islands and natural levee ridges are also disappearing at a very high rate.

The data can be used not only to document past change, but also to project future conditions. The findings have great significance to fish and wildlife resources, flood-protection planning, and land ownership.

Apparent causes of the high rates of land loss include the harnessing of the Mississippi River by levees and control structures which reduce tendencies toward natural diversion and funnel valuable sediments to deep, offshore waters. Additional factors include canal dredging and accelerated subsidence related to mineral extraction, both of which are often associated with saltwater intrusion. The net effect is a rapidly accelerating man-induced transgression of a major coastal system.

INTRODUCTION

The vast deltaic plain of coastal Louisiana is a product of 5000 years of Mississippi River delta building. Land was built as a result of sediment deposition in the vicinity of active outlets of the Mississippi River during an interval of sea-level stability. Through periodic upstream diversions the river has been able to construct a complex deltaic plain. Each diversion has initiated a cyclic episode of delta growth and coastal environmental change, including an interval of growth followed by an interval of breakup and decline with waxing and waning of river outflow and sediment deposition. The net result has been a gradual progradation of the deltaic plain.

These processes have resulted in an extensive coastal lowland characterized by a skeleton of alluvial natural levee ridges along active and abandoned distributaries, an outer fringe of sandy barrier islands and Gulf beaches, and vast areas of interdistributary swamps, marshes, lakes and bays (Fig. 1).

The extent and character of the deltaic coast, as well as the cyclic habit of delta building and the environmental succession which it drives, have resulted in a bounty of renewable resources. The magnitude and importance of these values, related primarily to fish, wildlife, and recreational resources, have been well documented (Chabreck, 1973; Day et al., 1979; Fruge and Ruelle, 1980; Lindall et al., 1972; Perret et al., 1971; U.S. Fish and Wildlife Service [FWS] 1981), and need not be repeated here, though it is noteworthy that they do represent a resource of national importance.

Two aspects of deltaic processes are vital to maintenance of the system and its high level of productivity. The first is its ability to build new land through sediment deposition in the vicinity of active distributary outlets. The second is its ability to continue to build up the land mass through overbank sedimentation and through accumulation of organic sediments such as peat and shell deposits. The former processes can be thought of as outbuilding, the latter as upbuilding or maintenance. Upbuilding is necessary to offset deterioration and erosion related to marine processes and subsidence.

Wetlands in the deltaic plain are truly “living surfaces.” That is, the marsh and swamp plant communities usually become established initially on a substrate of clastic sediment derived from the river (subaqueous natural levees, bars, mudflats, natural levee back slopes, etc.). Early colonizers hold newly deposited sediment together and trap additional sediment. Because of high, natural-subsidence rates (typically 0.7 ft/century, but up to 4 ft/century), the initial substrate may gradually sink to a level well below that of the sea. The root zone of wetland plants maintains its position near sea level by gradually building up organic litter (peats) and trapping clays at a rate equal to, or faster than, that of subsidence. Radiocarbon dates from the base of thick sections of peat indicate that in many instances these living surfaces have persisted for 3000 years or more. In other instances, especially in fresher interior marshes,
the rate of sinking may exceed that of sediment accumulation, but the living surface is maintained through development of floating vegetation mats (flotant). If the floating mat is fragmented or fails to develop and subsidence exceeds the rate of sediment accumulation, the vegetated wetland reverts to open water.

The distribution of wetlands vegetation in the deltaic plain is controlled by such factors as elevation, drainage, soil type, hydroperiod, and salinity. However, it is well recognized that salinity is a critical factor. Marsh plants, for example, are mapped as vegetative types whose zonation is based primarily on average salinity conditions (Fig. 2). In general, there is a broad landward-to-seaward zonation from fresh through intermediate and brackish to saline marshes. The main exception is an "island" of fresh and intermediate marsh in the active birdfoot delta area where conditions are predominately fresh throughout the year.

This zonation of marshes reflects a gradual dilution of inland freshwater runoff by saline gulf tidal inflow. Freshwater is presently derived largely from local precipitation and runoff, but, under natural conditions, was supplemented by overbank floodwaters from the Mississippi River. Freshwater moved seaward through an intricate network of tidally influenced, backswamp, drainage streams. Marine water was introduced to marsh systems through relatively shallow-tidal streams and inlets between barrier islands.

In modern years, hydrologic conditions in the deltaic plain have changed greatly, and in most areas there has been accelerated saltwater intrusion via an extensive, deep, Gulf-to-interior-canal network. This has caused major changes in the distribution of wetland vegetation. In general, there has been a landward shift in marsh zones, i.e., saline marshes displacing brackish marshes and brackish marshes displacing intermediate marshes. However, even slight salinity increases will kill freshwater swamps and marshes, and in many places these habitat types have reverted to barren mudflats or open water.

LAND LOSS MEASUREMENTS

While patterns of marsh deterioration and land loss along the lower Mississippi River were documented as early as the 1930's (Russell, 1936), initial attempts at quantifying areal extent of water bodies within the coastal zone did not begin until the late 1960's. Methodologies consisted of planimetering watersurface features from U.S. Geological Survey (USGS) topographic quadrangles (Barrett, 1970) and multiplying percentage frequency of water-occupied sampling stations by the area of coverage (Chabreck, 1971). The first systematic analysis of land-water ratio changes over three successive periods of topographic-map coverage employed a grid-sampling technique (Gagliano and van Beek, 1970). Center points of each grid, spaced at 0.50-mi intervals, were differentiated as to land or water. Point estimates of the distribution were then used to

Figure 2. Zonation of marsh types in the Mississippi River Deltaic Plain in 1978. (From Chabreck and Linscombe, 1978.)
evaluate changes in land-water ratios. For a study area covering 20,480 mi², a land loss rate of 16.5 mi²/yr was derived (Gagliano and van Beek, 1970).

Aerial black-and-white and color infrared imagery was first used in land-loss analyses of Barataria Basin during the late 1970's (Adams et al., 1976; Craig et al., 1979). Surface coverage of land and water was electronically digitized for the periods of study. A more comprehensive examination of habitat change in the Mississippi River Deltaic Plain, conducted for the FWS, employed large-scale, black-and-white, 1955-56 air photos and 1978 NASA color infrared photos (Wicker, 1980). Habitat types were interpreted within a 1:24,000 USGS topographic quadrangle framework for both periods (Wicker et al., 1980a). Resultant overlay maps were manually planimetered with an electronic digitizer, and the data subsequently transferred to computer tape for analysis (Wicker, 1980: App. 9).

Comparative measurements from five mapping intervals are now available from an 11,500 mi² study area of southeastern and south central Louisiana (Fig. 3). Characteristics of these data sets and the primary references describing the measurement techniques are as follows:

P₁-1890-1914. USGS topographic maps. Based on field surveys before the advent of aerial photography. 15 minute quadrangle format. Point count measurement technique. Maps available for only 7300 mi² of total study area (Gagliano and van Beek, 1970).

P₂-1930-1950. USGS planimetric and topographic maps. Aerial photo controlled with field verification. 15 and 7¾ minute quadrangle format. Point count measurement technique (Gagliano and van Beek, 1970).

P₃-1942-1967. USGS topographic maps. Aerial photo controlled with field verification. 15 and 7¾ minute quadrangle format. Point count measurement technique (Gagliano and van Beek, 1970).


RESULTS OF THE STUDY

Since the reversal of the long-term trend of land-building in the late nineteenth century, land loss has increased steadily and geometrically. Data from the 1970 study show a land loss rate of 6.7 mi²/yr from 1913 and a rate of 15.8 mi²/yr for 1946 (Gagliano and van Beek, 1970). The 1955 to 1978 period (P₄-P₅) showed a
The severity of the land loss is perhaps best shown in cartographic form (Fig. 5). By assigning to the center points of each topographic quadrangle within the study area the respective value of average annual land acreage loss\(^3\) for the 1955-1978 period (based on unpublished data generated for the FWS), a contouring of "iso-loss" lines is made possible.

Four parishes in particular appear to have very severe problems: Lafourche, St. Bernard, Terrebonne and Plaquemines. Based on a conservative arithmetic projection of the calculated 1980 loss rate, it can be shown that the land masses of these parishes will either be greatly reduced or will totally erode away within relatively short periods of time as follows:

<table>
<thead>
<tr>
<th>Parish</th>
<th>Remaining Land (in acres)</th>
<th>1980 Projected Loss Rate (in acres)</th>
<th>Life Expectancy (in years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lafourche</td>
<td>650,541</td>
<td>3,179</td>
<td>205</td>
</tr>
<tr>
<td>St. Bernard</td>
<td>257,816</td>
<td>1,695</td>
<td>152</td>
</tr>
<tr>
<td>Terrebonne</td>
<td>699,782</td>
<td>6,851</td>
<td>102</td>
</tr>
<tr>
<td>Plaquemines</td>
<td>457,523</td>
<td>8,831</td>
<td>52</td>
</tr>
</tbody>
</table>

\(^3\)Land-water ratios for each topographic quadrangle of the three study periods were multiplied by USGS stable base areas for the respective map quadrangles to derive land and water acreages from which overall loss could be calculated. A mean year was derived for study periods P\(_1\), P\(_2\), and P\(_3\), and the average land loss rates for periods P\(_1\)-P\(_2\) and P\(_2\)-P\(_3\) were plotted at the respective chronological mid-points.

The above figures may be regarded as slightly misleading, as the average land loss rates were used. It should be emphasized that while most of the acreage lost has been in wetland areas, the natural-levée ridgeland along the Mississippi River and its former distributaries (which constitute most of the habitable lands of coastal Louisiana) are sinking very rapidly (Fig. 6). Resistant, coarser-grained barrier islands and beaches are also losing acreage as a result of subsidence and marine forces. A study recently completed by CEI for the Terrebonne Parish Police Jury indicates that between 1955 and 1978 the Terrebonne barrier islands decreased in size by 44 percent (Wicker et al., 1980b) (Fig. 7). At this rate of erosion, the life expectancy of these islands is less than 30 years.

### RECOMMENDATIONS

As long as the Mississippi River is confined to its present channel by means of protection levees and control structures, valuable land-building sediments will be funneled out through the major distributaries of the active delta and onto the slopes of the Outer Continental Shelf. Historic natural riverine processes of overbank flooding, crevassing, and upstream diversion were responsible for extensive sedimentation and deltaic plain progradation. Virtual elimination of these processes, coupled with extensive canalization and hydrocarbon extraction, has led to the serious land loss problem we now face.

The senior author and associates have recognized the problem of wetland deterioration for well over a decade. Numerous publications have dealt with the need for a comprehensive wetland management plan, one that utilizes the method of controlled subdelta growth and sediment input through man-made crevasses (Gagliano et al., 1970; Gagliano et al., 1973; Gagliano and van Beek, 1973; Gagliano and van Beek, 1975; Gagliano and van Beek, 1976). The damaging effects of saltwater intrusion and overall high land loss rates can be retarded by the controlled diversion and input of fresh river water and also by the introduction of sediments into a deteriorating marsh or shallow water. The positive potential benefits of such measures have recently been specifically identified by the FWS (Frugé and Ruelle, 1980).

Upstream diversion, the process by which an increasingly efficient distributary captures Mississippi River flow and redirects the locus of active sedimentation, is presently underway as the Atchafalaya River is attempting to divert the Mississippi River near Simmesport. The effectiveness of the U.S. Army Corps of Engineers (USCE) in being able to maintain a 50 percent diversion into the Atchafalaya River by means of control structures is being questioned (Kazmann and Johnson, 1980), and some feel that the future of coastal Louisiana might be better served if diversion did occur (Kolb, 1980). The potential value of the emerging Atchafalaya Delta in restoring deteriorating marsh, retarding shoreline erosion, and creating additional wetlands has been recognized (van Beek and Meyer-Arendt, 1980).

### SUMMARY

A great natural catastrophe is occurring in the deltaic plain of coastal Louisiana. During 1980, approximately 25,000 ac of resource-rich coastal lowlands eroded away and the loss will be even higher in succeeding years. In the last 80 years, over 800,000 ac of land have been lost; approximately 58 percent of this occurring in the last 25 years. This trend will probably never reverse itself, but measures, such as freshwater diversion and controlled subdelta growth, can be taken to at least slow down the accelerating land loss rates coastal Louisiana is experiencing at present.
Figure 5. Variation in land loss rates within the Mississippi River Deltaic Plain.

Figure 6. Map showing projected loss of land along the lower reaches of the Mississippi River in Plaquemines Parish, Louisiana. Values based on present land area of each 7.5 minute quadrangle divided by 1955-1978 loss rate. Contours plotted on values at quadrangle center points.

Figure 7. Changes in position and size of the Isle Dernieres, Terrebonne Parish, Louisiana, 1955-1978.
ACKNOWLEDGMENTS

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SELECTED REFERENCES


