RECENT WETLAND LOSSES AT THE GSU MARSH RESTORATION SITE, NECHES RIVER VALLEY

Final Report

by

William A. White, Robert A. Morton, and Thomas A. Tremblay

Principal Investigators

Robert A. Morton and William A. White

**Prepared for the Texas Parks and Wildlife Department
under Interagency Contract No. 96-0079**

**Bureau of Economic Geology
Noel Tyler, Director
The University of Texas at Austin
Austin, Texas 78713-8924**

May 1996

CONTENTS

Figures

Table

INTRODUCTION

Texas Parks and Wildlife Department's (TPWD) plans to restore a marsh in the lower Neches River valley south of the Gulf States Utilities (GSU) power plant, an area of known historical marsh loss due partly to subsidence and faulting, emphasized the need to investigate potential long-term impacts of subsidence on the marsh site (fig. 1). Marsh restoration efforts could fail, however, if the area continues to subside at a rate that exceeds marsh vertical accretion. Determining whether the GSU area is subsiding at a rate higher than that of the surrounding landscape could be answered by benchmark releveling surveys across the area, but those surveys have been conducted only across regions more inland (Ratzlaff, 1980). Although site-specific releveling surveys would provide the most quantitative and reliable data regarding subsidence, lack of time and funding for establishing benchmarks and conducting releveling surveys over a sufficient period of time prevented such an approach. Consequently potential future marsh loss as a result of submergence had to be estimated by other means.

HISTORICAL CHANGES IN MARSHES

Delineation of wetlands on sequential aerial photographs allows researchers to document the magnitude and rate of marsh loss through time. By looking at rates of change, they can draw conclusions about the stability of the marsh system and expected future trends. Previous studies have indicated that subsidence and faulting are among factors contributing to the transformation of areas of emergent vegetation to open water (White and others, 1987; White and Tremblay, 1995; White and Morton, in press). Marsh losses documented by White and others (1987) covered the period from 1956 through 1978 (fig. 2). During that period, more than 9,400 acres of marsh loss occurred in the Neches River valley, mostly as a result of encroachment of open water into areas previously supporting emergent vegetation.

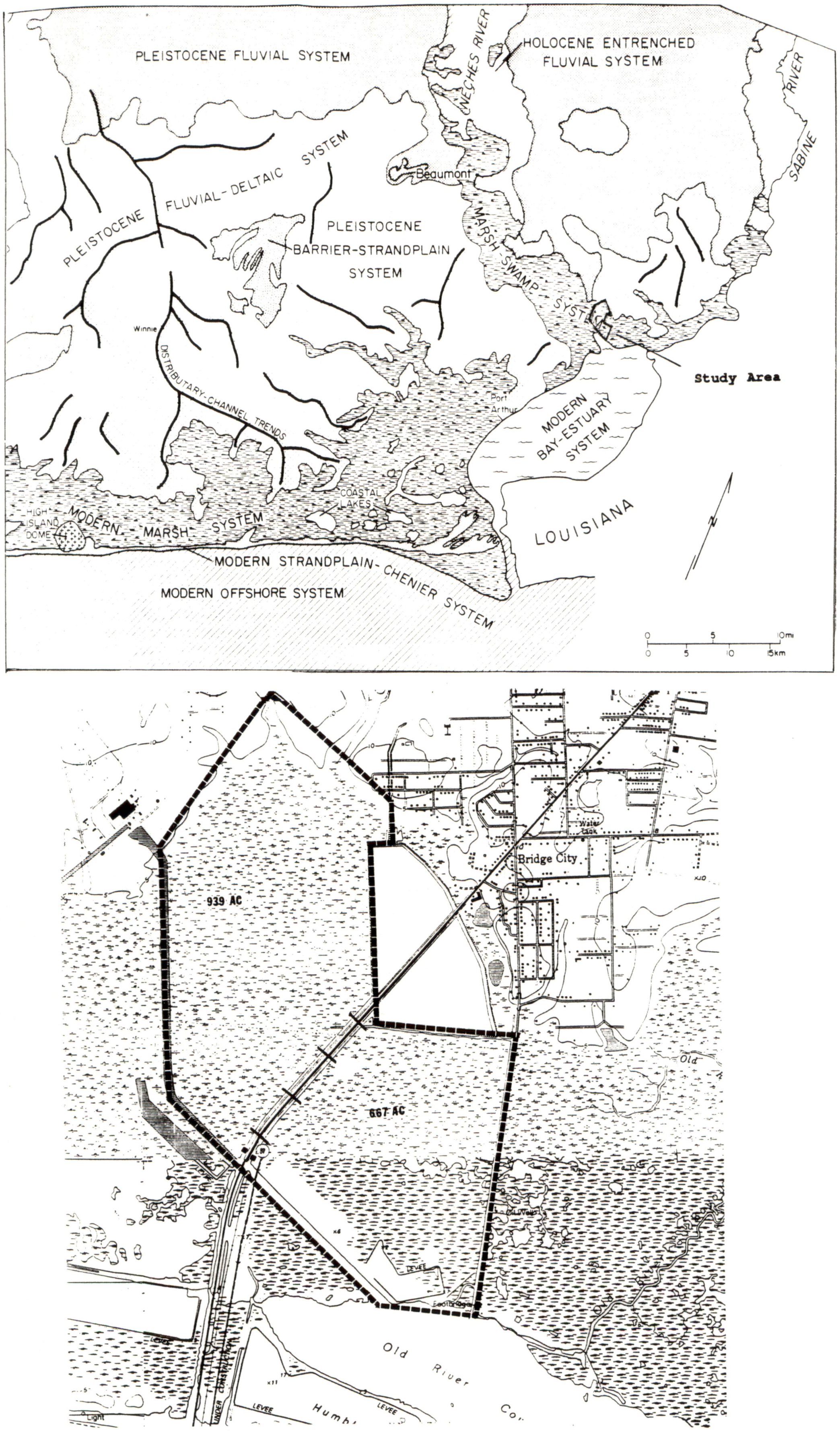
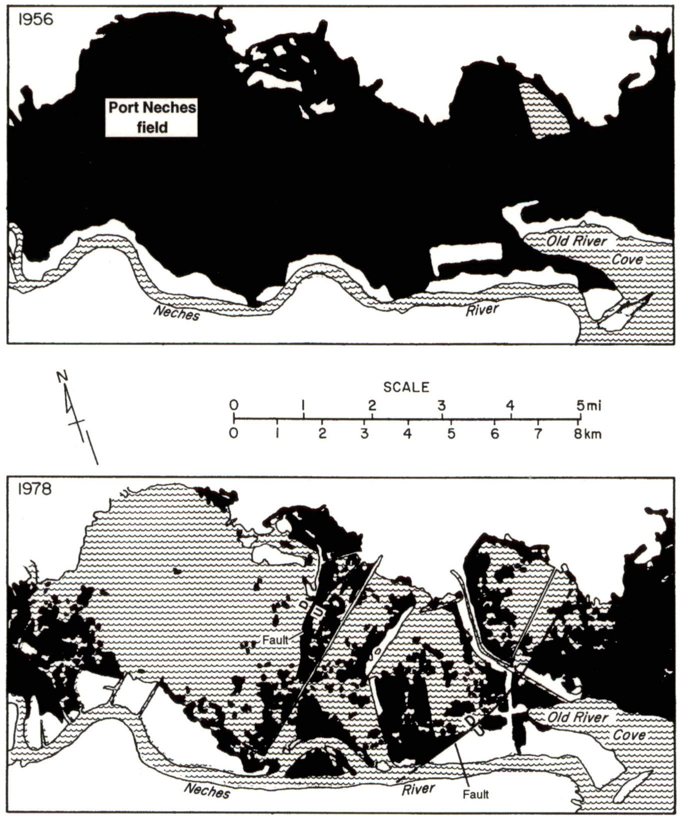


Figure 1. Index map showing location of study area. Map at top shows location of study area with respect to natural systems in the Beaumont–Port Arthur area (from Fisher and others, 1973); map at bottom shows study area in more detail (from E. J. Taylor, Texas Parks and Wildlife Department, personal communication, 1996).



Map Unit	1956		1978		Net Change*	
	Acres	Hectares	Acres	Hectares	Acres	Hectares
Water	2,560	1,037	11,070	4,483	+8,510	+3,446
Marsh	15,740	6,375	6,330	2,564	−9,410	−3,811

* Loss of additional 900 acres (365 hectares) of marsh primarily due to spoil disposal.

QA3384c

Figure 2. Changes in the distribution of wetlands between 1956 and 1978 in the Neches River valley at the head of Sabine Lake. Differential subsidence along the faults crossing the valley has contributed to conversion of emergent vegetation to open water. D = downthrown side, U = upthrown side. From White and Morton (in press) as modified from White and others (1987).

The marsh system in the Neches River valley is intersected by two high-angle normal faults that are downthrown toward the Port Neches oil and gas field (Bessie Heights field) (White and Tremblay, 1995; White and Morton, in press). One of the faults that intersects the GSU marsh can be traced on aerial photographs for a distance of 5.5 km. Marsh loss in the GSU area is more extensive on the downthrown side of the fault. Documentation of wetland losses from 1978 through the 1990's provides more recent, indirect evidence about fault movement and associated subsidence in the GSU area. If marshes are continuing to be lost during more recent periods, one possible conclusion is that relative sea-level rise, the principal component of which is subsidence, is continuing at a rate that exceeds marsh sediment accumulation rates.

METHODS

The most recent available aerial photographs were obtained for analysis of marsh distribution and areal extent. Two sets of photographs were used: TPWD CIR stereoscopic photographs (scale 1:9,600) taken on July 11, 1995, and USFWS CIR stereoscopic photographs (scale 1:65,000) taken March 3, 1993. The TPWD photographs cover approximately 60 percent of the study area (south portion), and the USFWS photographs cover the entire area.

Areas of emergent vegetation, open water, and barren flat were interpreted and delineated optically at a common scale (approximately 1:22,500) for all photographs. Using a Zoom-Transfer-Scope, we transferred delineations to enlarged (10-percent enlargement) USGS 7.5-minute base maps. We checked marsh interpretations using a fixed mirror stereoscope that had 6× magnification. We then digitized wetlands and areas of open water and entered the data into the geographic information system (GIS) ARC/INFO. We followed these same procedures using NASA CIR stereoscopic photographs taken October 9, 1978 (scale enlarged to 1:21,800; original scale 1:65,000). We also delineated areas of open water and digitized them on black and white aerial photographic mosaics taken in September 1956 (scale 1:24,000).

The GIS data sets consist of digital overlays corresponding to mapped marsh and open water areas for 1978 and 1993–95 and open water for 1956. We plotted draft maps of each period at a scale of 1:12,000 and checked them against aerial photographs for consistency and accuracy of delineations and to verify observed changes. We manipulated the final data sets as information overlays, from which we analyzed detailed spatial and temporal patterns to determine trends in habitat losses or gains. To develop trends, we compared the most recent data with habitat changes during earlier periods.

Because the major objective of the study was to determine the magnitude, location, and rate of marsh transformation to open water, we used fixed outer boundaries of the study area so that the total acreage would be equal for each year. Also, because some changes in marsh area were due to construction of the new State Highway 87 and disposal of dredged spoil from channels, we used the highway and dredged material areas as they were mapped on 1990 photographs for both time periods.

RESULTS

Analyses of marsh and open-water habitats on sequential aerial photographs show a net transformation of marsh to open water through time (table 1). In 1956, marsh/land covered an area of 1,496 ac and water, 70 ac. By 1978 (fig. 3), 892 ac of marsh/land and 674 ac of open water existed, and by 1993–95 (fig. 4), 815 ac of marsh/land and 751 ac of water.

Marsh loss has been continuous but not constant (fig. 5). In 1956, open water was 4 percent of the map area, by 1978, 43 percent, and by 1993–95, 48 percent of the area. The highest rate of change occurred during the period from 1956 through 1978, when 604 ac of marsh was converted to open water. The average rate of loss of marsh habitat during this 22-yr period was 27.5 ac/yr, and about 40 percent of the marsh was lost. The rate of marsh loss decreased from 1978 through 1993–95 (1994 was used to calculate rates), to 4.8 ac/yr—a reduction in rate of loss of about 5.7 times. During this period, 9 percent of the existing marsh was lost.

To go back farther in time, we reviewed vertical aerial photographs taken in 1938. Because open water was an insignificant part of the map area in 1938, we assumed that the study area consisted of all marsh/land habitat, or 1,566 ac. According to this figure, the amount of marsh loss

Table 1. Acreage of marsh and open water in the GSU map area, 1938 through 1993–95.

Year of aerial photograph	Area of marsh/land (ac)	Area of water (ac)
1938	1,566	0*
1956	1,496	70
1978	892	674
1993–95	815	751

*See text.

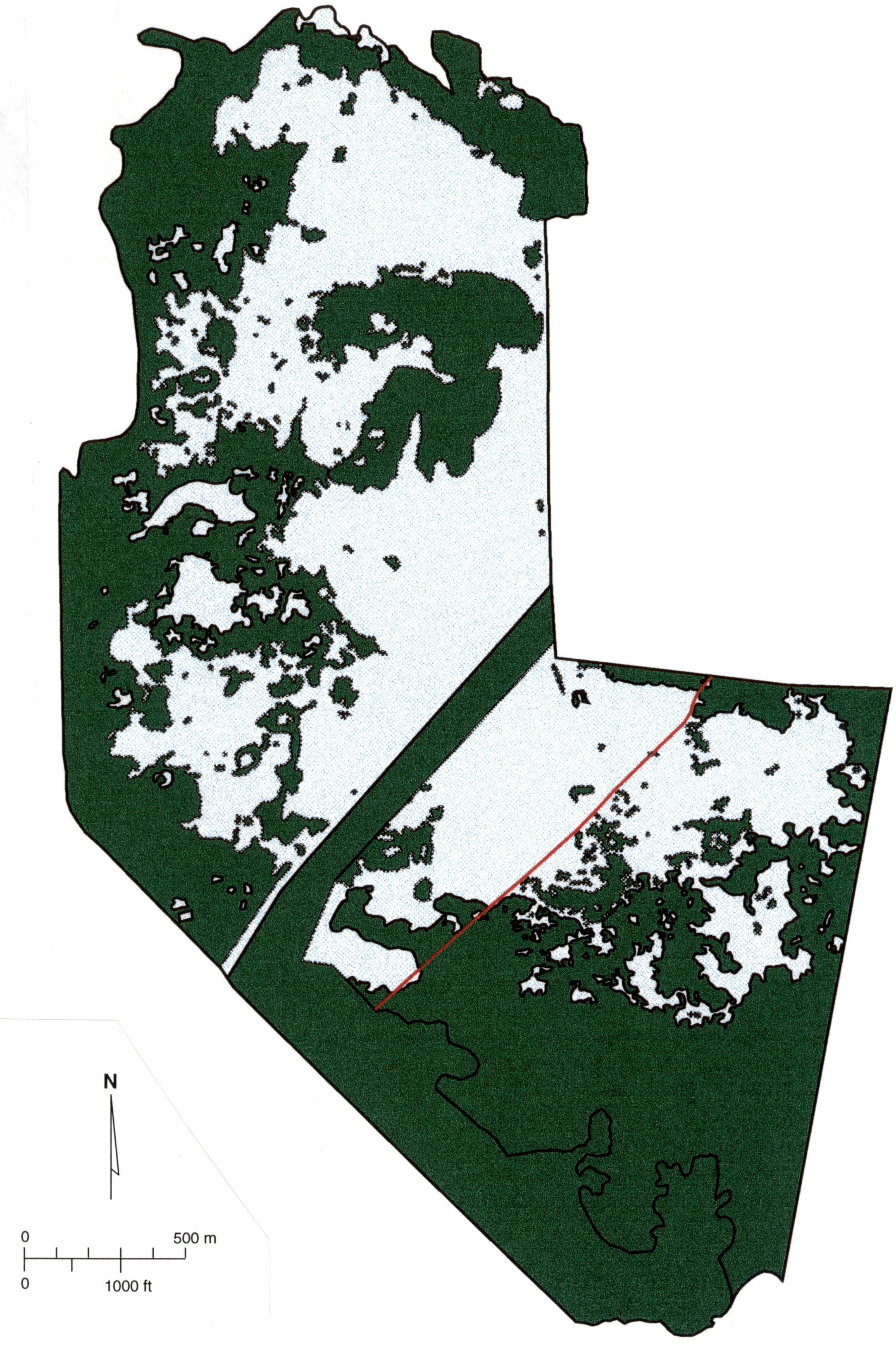


Figure 3. Distribution of marsh/land and open water in the study area in 1978. Green or black represents marsh/land areas and blue or white, open water. The red or black line in the south part of the study area represents trace of the easternmost fault shown in figure 2.

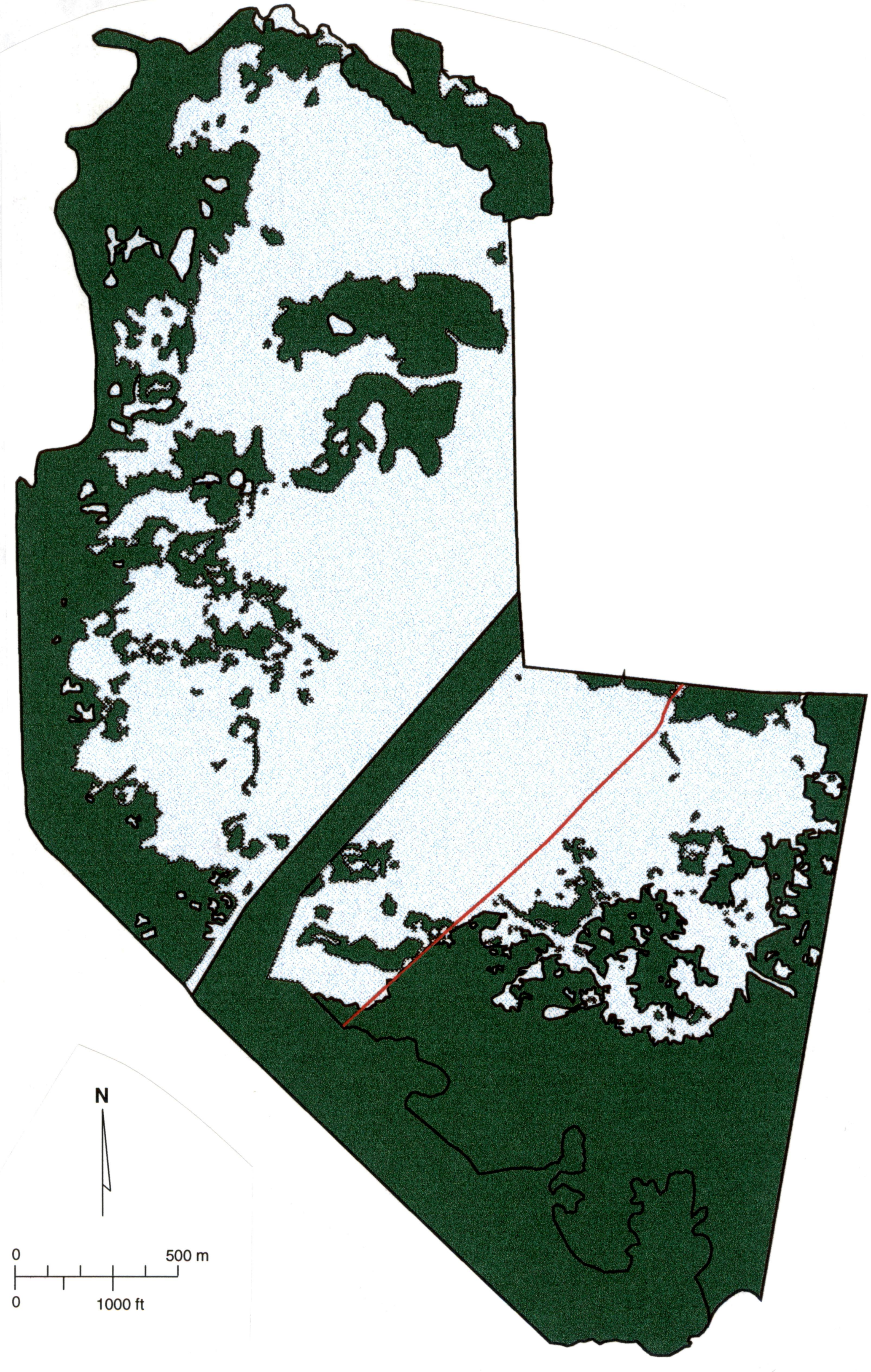


Figure 4. Distribution of marsh/land and open water in the study area in 1993–95. Green or black represents marsh/land areas and blue or white, open water. The red or black line in the south part of the study area represents trace of the easternmost fault shown in figure 2.

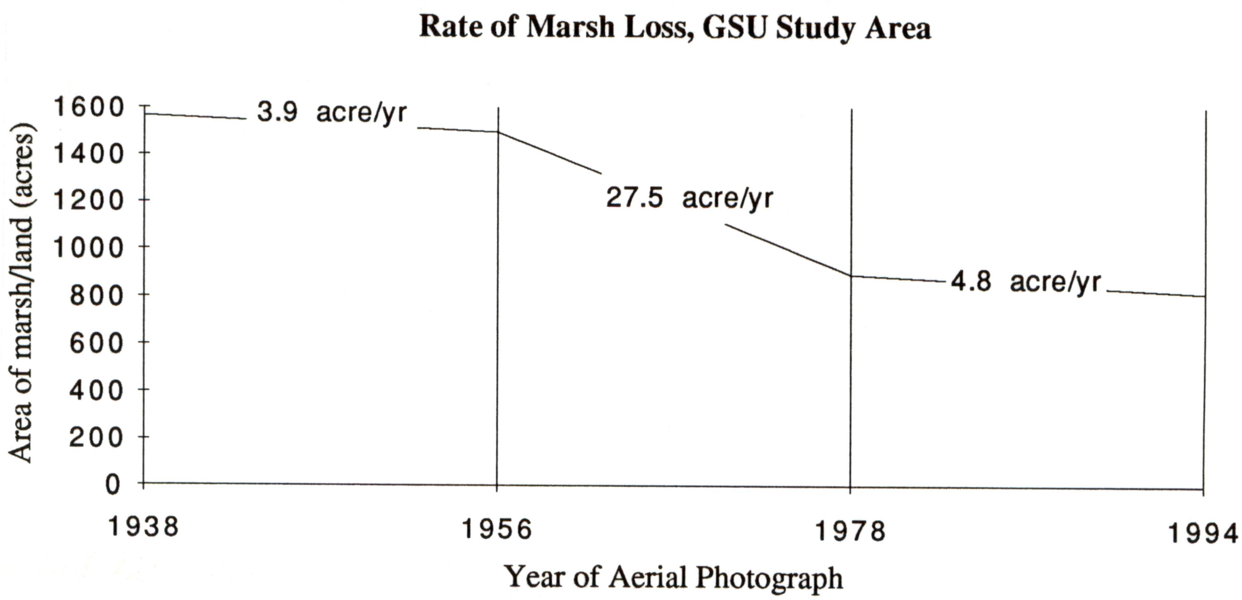


Figure 5. Approximate rates of marsh loss from 1938 through 1993–95.

between 1938 and 1956 was about 70 ac, yielding a rate of loss of 3.9 ac/yr for this 18-yr period, or slightly less than the rate of the most recent period, 1978 through 1993–95 (fig. 5). Approximately 4 percent of the marsh was lost during this early period. Interestingly the rate of loss for the midperiod (1956–1978) is about seven times higher than that of the early period.

Although marsh habitat was converted to open water throughout the map area, the conversion was more extensive on the downthrown side of the fault that crosses the study area (fig. 6). A net loss of emergent vegetation was on both sides of the fault, but local small gains occurred in emergent vegetation between 1978 and 1993–95. The most noticeable areas of increase were in the northwest corner of the map area and along the banks and on the flood-tidal delta of a tidal channel on the east edge of the map area.

The higher rate of marsh loss during the period of 1956 through 1978 correlates with the highest rate of gas production from the Port Neches oil and gas field (fig. 7), suggesting a cause-and-effect relationship (White and Morton, in press). Still, the analysis is complicated by the fact that human activities at the surface may also have affected marsh changes. For example, old Highway 87 through the center of the study area and a gravel road along the east margin of the study area were constructed before 1938. In addition, the GSU intake canal that borders the west side of the study area was dredged soon after 1956, and the GSU discharge canal was dredged southwest of the study area. Increases in aquatic habitat (open water) to the southwest were attributed to intrusion of water as a result of the canal being dredged through the marsh (Wiersema and others, 1973). Discharges are not made along the intake canal that borders the west side of the study area, however, and the impact of this canal on the marsh is different. The intake canal isolates or compartmentalizes the marsh and may have contributed to ponding of water as subsidence occurred. Transformation of the marsh to open water, however, had begun in 1956 before the canal was dredged. Other factors, such as disposal of dredged material and reductions in sediment supply, which may have contributed to marsh loss in the Neches River Valley, were reported by White and others, (1987).

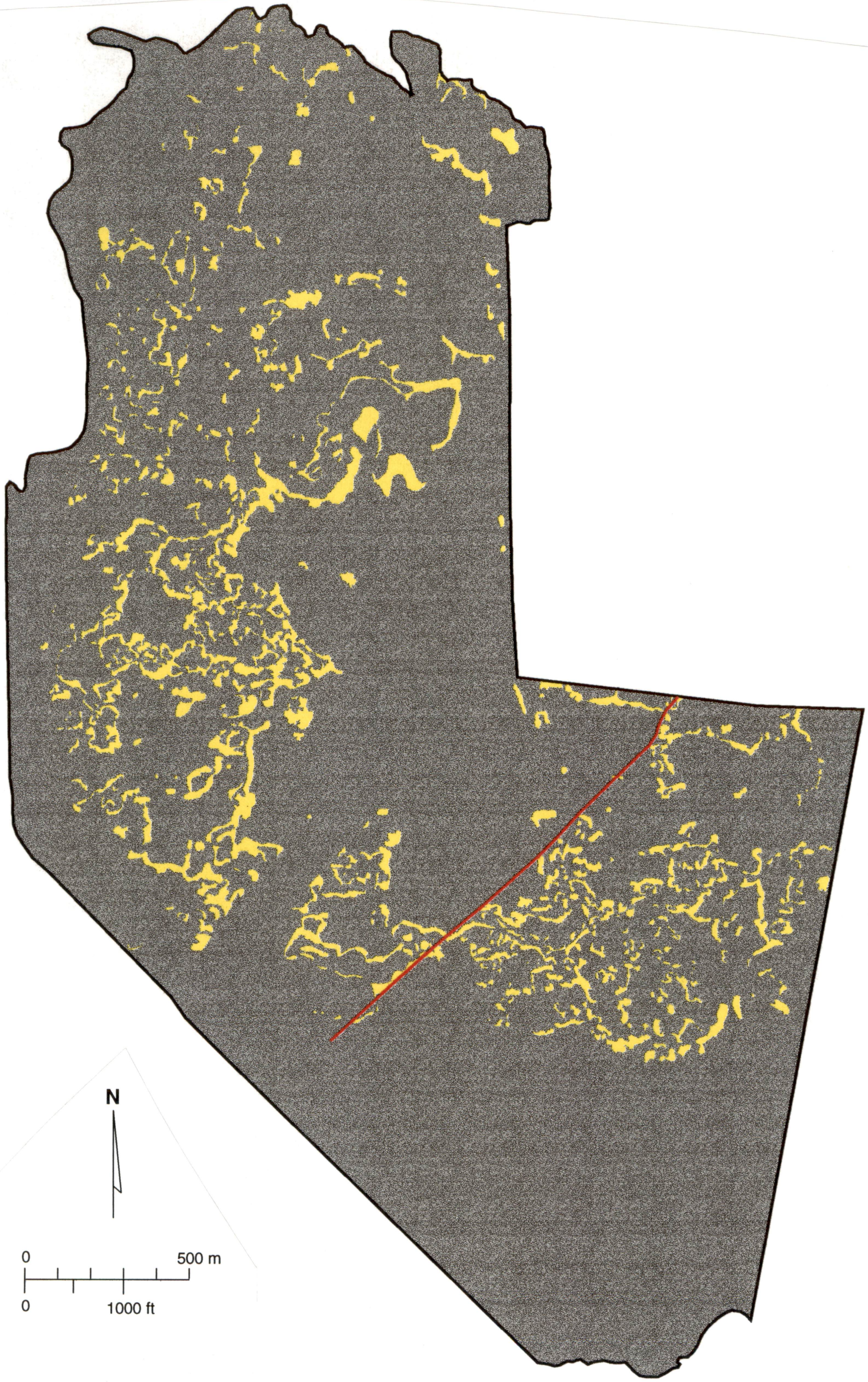


Figure 6. Distribution of marsh loss from 1978 through 1993–95. Lighter color represents areas of marsh that were converted to open water. The red or black line in the south part of the study area represents trace of the easternmost fault shown in figure 2. Note that losses were more extensive on the northwest, downthrown side of the fault.

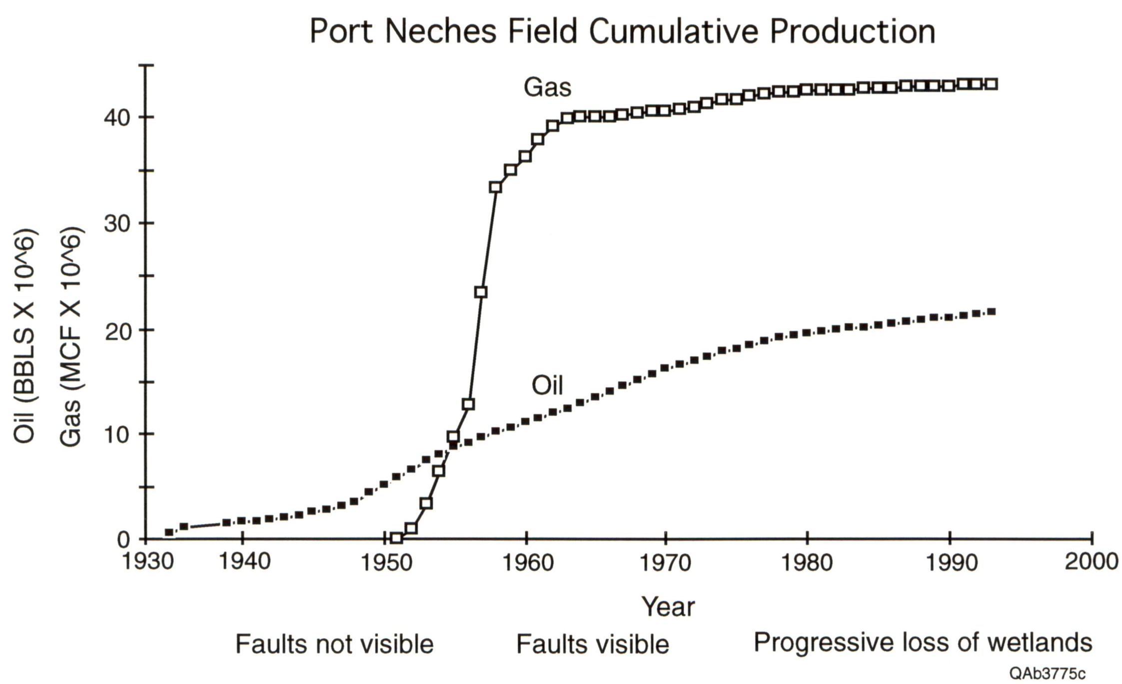


Figure 7. Cumulative production of oil and gas from Port Neches field in the Neches River valley. Surface faults (fig. 2) downthrown toward the field are not visible on aerial photographs taken in the mid-1950's but are visible by the mid-1960's after cumulative gas production had peaked. Production volumes from the Texas Railroad Commission. From White and Morton (in press).

CONCLUSIONS

Analysis of historical changes in marsh habitat provides indirect evidence that subsidence is contributing to loss of emergent vegetation. The more extensive losses of marsh have occurred on the downthrown side of a fault that crosses the marsh, a fact indicating that subsidence is occurring at a rate higher on the downthrown side than on the upthrown side. Similar observations have been made along other Gulf coast faults (White and Morton, in press).

The rate of marsh loss during the most recent period, from 1978 through 1993–95, was almost six times lower than the rate during the preceding period, 1956 through 1978. This decline in rate of marsh submergence appears to coincide with a 23-fold decrease in the rate of gas production in the Port Neches field. This lower rate of marsh loss suggests that the rate of subsidence (and fault movement) has declined.

Nevertheless, the conversion of marshes to open water has continued over the past 16 yr (although at a much slower rate) at about 4.8 ac/yr. If this rate continues, it will take approximately 170 yr for the 815 ac of marsh/land that existed in 1993–95 to be transformed to open water. Because part (185 ac) of the 815 ac includes upland areas, loss of existing marshes would occur over a somewhat shorter period.

Marsh restoration, if done properly, could reduce the rate of loss and extend the life of the marshes. Assuming that the principal cause of marsh loss is subsidence, which is a major factor contributing to a rise in relative sea-level, then trying to lower water levels and increase sediment deposition in marsh areas should help counter submergence of emergent vegetation and loss of marsh habitat.

ACKNOWLEDGMENTS

This investigation was funded by the Texas Parks and Wildlife Department. Susan Lloyd did word processing and pasteup. Lana Dieterich edited the report.

REFERENCES

Fisher, W. L., Brown, L. F., Jr., McGowen, J. H., and Groat, C. G., 1973. Environmental geologic atlas of the Texas Coastal Zone—Beaumont–Port Arthur area: The University of Texas at Austin, Bureau of Economic Geology, 93 p., 9 maps.

Ratzlaff, K. W., 1980, Land-surface subsidence in the Texas coastal region: U.S. Geological Survey Open File Report 80-969, 19 p.

White, W. A., Calnan, T. R., Morton, R. A., Kimble, R. S., Littleton, T. G., McGowen, J. H., and Nance, H. S., 1987, Submerged lands of Texas, Beaumont–Port Arthur area: sediments, geochemistry, benthic macroinvertebrates, and associated wetlands: The University of Texas at Austin, Bureau of Economic Geology, 138 p.

White, W. A., and Morton, R. A., in press, Wetland losses related to fault movement and hydrocarbon production, southeastern Texas Coast: Journal of Coastal Research.

White, W. A., and Tremblay, T. A., 1995, Submergence of wetlands as a result of human-induced subsidence and faulting along the upper Texas Gulf Coast: Journal of Coastal Research, v. 11, no. 3, p. 788–807.

Wiersema, J. M., Mitchell, R. P., and James, S. N., 1973, Sabine Power Station ecological program, v. 1, A. utilization of aquatic habitats in the GSU marsh; B. assessment of GSU thermal discharge on the biota of the Neches River: Austin, Texas, Tracor, Inc., document no. T73-AU-9507-U(R), submitted to Gulf States Utilities, 215 p.