TRENDS AND STATUS OF WETLAND AND AQUATIC HABITATS IN THE GALVESTON BAY SYSTEM, TEXAS

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EXECUTIVE SUMMARY

by
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INTRODUCTION

Wetland and aquatic habitats are essential biological components of the Galveston Bay Estuarine System. Understanding the spatial and temporal distribution of these habitats is critical if they are to be effectively protected and managed. This report presents results of an investigation sponsored by the Galveston Bay National Estuary Program (GBNEP) to determine the trends and status of wetlands and aquatic habitats in the Galveston Bay system through aerial photographic analysis supported by field surveys.

METHODS

Status and trends of wetlands in the Galveston Bay system were determined by analyzing the distribution of wetlands mapped on aerial photographs taken in the 1950's, 1979, and 1989. Wetlands for all maps were delineated on photographs through stereoscopic interpretation using procedures developed for the U.S. Fish and Wildlife Service (USFWS) National Wetlands Inventory program. Field reconnaissance was an integral part of the interpretation process. Wetlands were mapped in accordance with the classification by Cowardin and others (1979), in which wetlands were classified by system (marine, estuarine, riverine, palustrine, lacustrine), subsystem (reflective of hydrologic conditions), and class (descriptive of vegetation and substrate). Maps for 1979 and 1989 were additionally classified by subclass (subdivisions of vegetated classes only), water-regime, and special modifiers. Upland habitats were delineated on 1979 and 1989 maps using a modified Anderson and others (1976) land-use classification system.

More than 180 field sites were examined as part of the effort to characterize wetland plant communities and define wetland map units in the Galveston Bay system. Topographic surveys were conducted along several transects. County soil surveys were used to define and characterize soils at the various field check sites.

CURRENT STATUS: 1989

Wetlands and aquatic habitats are dominated by an estuarine system that encompasses approximately 507,500 acres (table I) in the 30 7.5-minute quadrangles that make up the Galveston Bay study area (fig. I). Major estuarine and palustrine habitats include salt, brackish, and fresh marshes, forested and scrub-shrub wetlands, subtidal aquatic beds, intertidal flats, and estuarine open water (table II). Vegetated wetlands (marshes, scrub-shrub, and forested

Table I. Areal extent of wetland systems and uplands.

Wetland System	**Acres**	**Percent of Study Area Coverage**
Estuarine	507,500	47.5
Palustrine	34,100	3.2
Lacustrine	21,600	2.0
Riverine	3,000	0.3
Marine	†2300	†0.2
Uplands	498,900	46.7

†Excludes marine open water.

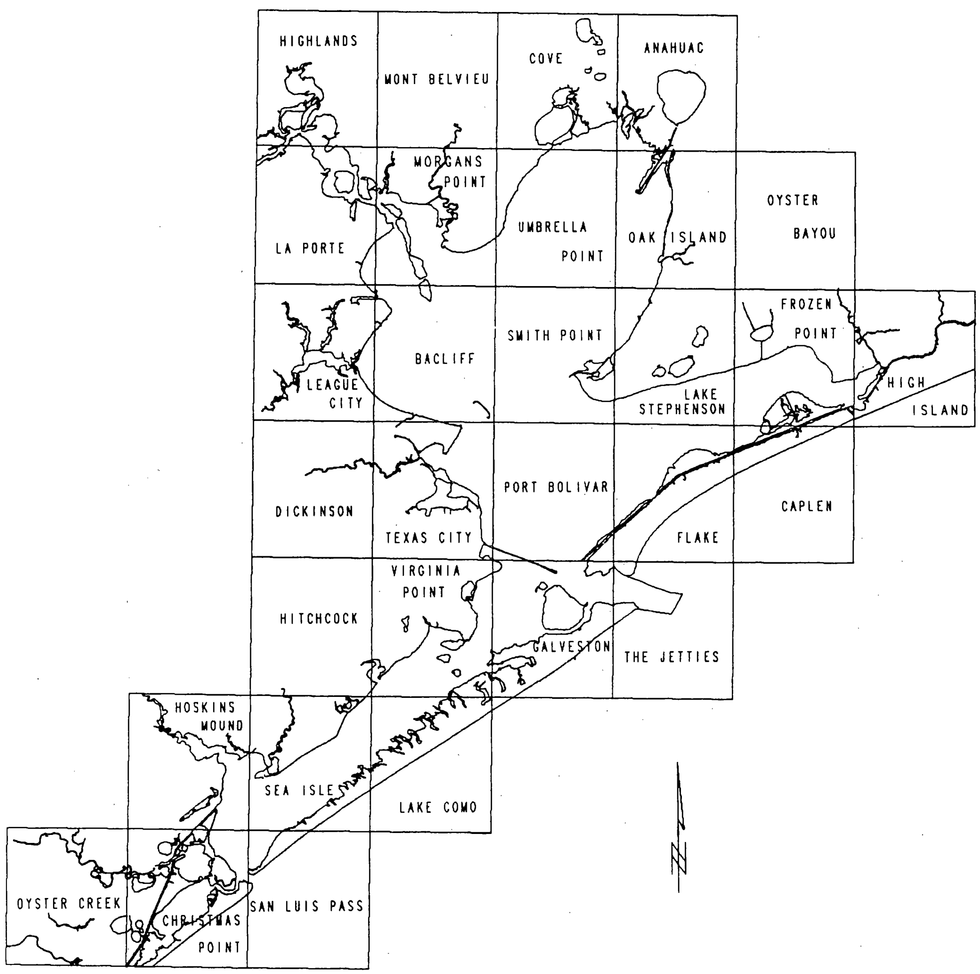

Figure I. Study area defined by 30 USGS 7.5-minute quads.

Table II. Current status (1989) of major estuarine and palustrine habitats.

ESTUARINE SYSTEM

Estuarine Intertidal Emergent Wetlands (Salt and Brackish Marshes)

Most extensive wetland habitat in the study area
108,200 acres of salt and brackish marshes
Composes 75% of vegetated wetlands* and 83% of the marsh habitats (emergent wetlands)

Estuarine Intertidal Unconsolidated Shores

Intertidal flats and beaches
17,800 acres in Galveston Bay system
Extremely low tides when photographs were taken caused many areas that would normally have been submerged to be mapped as flats instead of open water

Estuarine Intertidal Scrub/Shrub Wetlands

550 acres total with most quads having less than 50 acres
Morgans Point and Virginia Point each have about 100 acres

Estuarine Aquatic Beds

700 acres of submerged vascular vegetation in Galveston Bay system proper (excluding smaller inland water bodies and misinterpreted areas)
Largest area (386 acres) in Christmas Bay; remainder along margins of upper Trinity Bay

Estuarine Subtidal Unconsolidated Bottom

378,200 acres of open water (65% of study area)
Includes Galveston, Trinity, East, West, Christmas, and Chocolate Bays, etc.

PALUSTRINE SYSTEM

Palustrine Emergent Wetlands (Fresh, or Interior, Marshes)

22,200 acres (16% of vegetated wetlands and 17% of marsh habitat)
Most extensive distribution is along the Trinity River alluvial valley and inland of Christmas, West, and East Bays

Palustrine Scrub/Shrub Wetlands

2,000 acres (1.4% of vegetated wetlands)
Largest acreages (> 300 acres each) occur in Dickinson and Highlands quads
Most quads have less than 100 acres

Palustrine Forested Wetlands

5,648 acres (4% of vegetated wetlands)
Most abundant in Trinity River valley; other notable quads include Oyster Creek, Highlands, and Hitchcock

*Vegetated wetlands as used in this table do not include aquatic beds wetlands) have a total area of about 138,600 acres, or 13 percent of all habitats (fig. II). Marshes, or estuarine and palustrine emergent wetlands, cover approximately 130,400 acres, representing about 94 percent of vegetated wetlands. Estuarine emergent wetlands (salt and brackish marshes) are the most extensive wetlands in the study area (fig. III). The most extensive upland habitat is rangeland (fig. IV).

TRENDS: 1950'S TO 1979 TO 1989

There were gains and losses in wetlands from the 1950's to 1989, but the net trend was one of wetland loss. This downward trend is illustrated by acreages of 171,000 in the 1950's, 146,000 in 1979, and 138,600 in 1989 (table III and fig. V). The rate of loss, however, decreased over time from about 1,000 acres per year between 1953 and 1979, to about 700 acres per year between 1979 and 1989. The rate of loss for the period 1979 to 1989 would be lower (<500 acres/yr) if inaccuracies in wetland interpretation on the 1979 photographs are taken into account. In general, scrub-shrub habitats decreased in area from the 1950's to 1979 and 1989 while forested wetlands increased (table III).

OVERALL TRENDS AND THEIR PROBABLE CAUSES: 1950–1989

In analyzing trends, emphasis was placed on wetland classes and not on water regimes and special modifiers. This approach was taken because habitats were mapped only down to class on 1950's photographs and because the 1979 photographs were taken during a period of high tides and the 1989 photographs during a period of low tides. It should also be noted that there are a number of possible photointerpretation shortcomings—not the least of which is the involvement of different photointerpreters at different times.

Emphasis is placed on net losses in wetlands. Losses in wetland vegetation resulted from conversion of the wetlands to (1) open water and flats, (2) uplands, and (3) other wetland classes. From the 1950's to 1989, there was a net loss in vegetated wetlands of 32,400 acres, which amounts to 19 percent of the vegetated wetland system that existed in the 1950's. The actual loss in wetlands is somewhat less, perhaps closer to 17 percent, because delineations of wetlands in some areas on the 1950's-vintage black-and-white aerial photographs included peripheral upland areas, which inflated the 1950's wetland acreages.

Estuarine and Palustrine Emergent Wetlands

The area of mapped emergent wetlands (marshes) decreased from about 165,500 acres in the 1950's to about 130,400 acres in 1989, producing a total net marsh loss of approximately 35,100 acres, or 21 percent of the 1950's resource. As in the case of vegetated wetlands, this amount of loss in emergent wetlands is thought to be on the high side; the actual loss is probably below 19 percent.

Net losses in vegetation occurred in 25 of the 30 quadrangles (quads) studied. The most substantial losses occurred in the southwest part of the study area and include Virginia Point, Hitchcock, Hoskins Mound, Texas City, and Sea Isle (fig. I). Approximately 55 percent of the total losses of emergent vegetation in the Galveston Bay System occurred in these areas. The most extensive net loss, exceeding 5,000 acres, occurred in the Virginia Point quad on the inland margin of West Bay.

The causes of wetland loss include both natural and artificial processes. Among them are humanly induced subsidence and relative sea-level rise, and draining and filling of wetlands for agricultural, transportational, industrial, residential, and commercial purposes (table IV). Major losses in estuarine emergent wetlands (salt and brackish marshes) occurred as they were converted to open water and barren flats. Major losses in palustrine emergent wetlands (interior, or fresh marshes) resulted from their conversion to uplands.

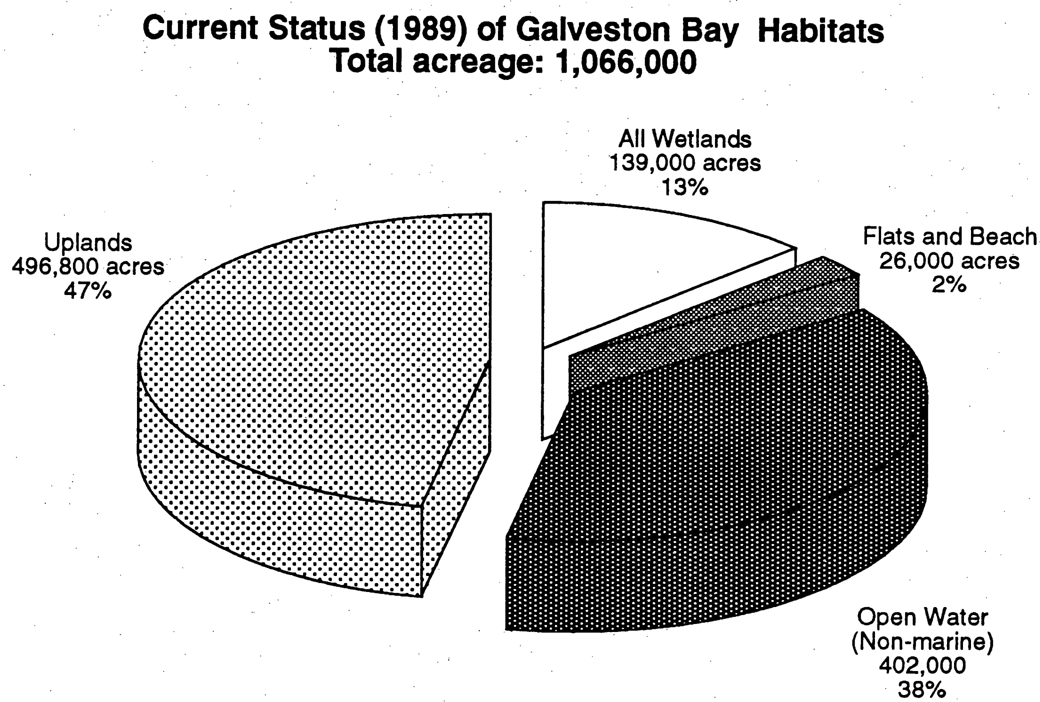

Figure II. Current status of Galveston Bay habitats.

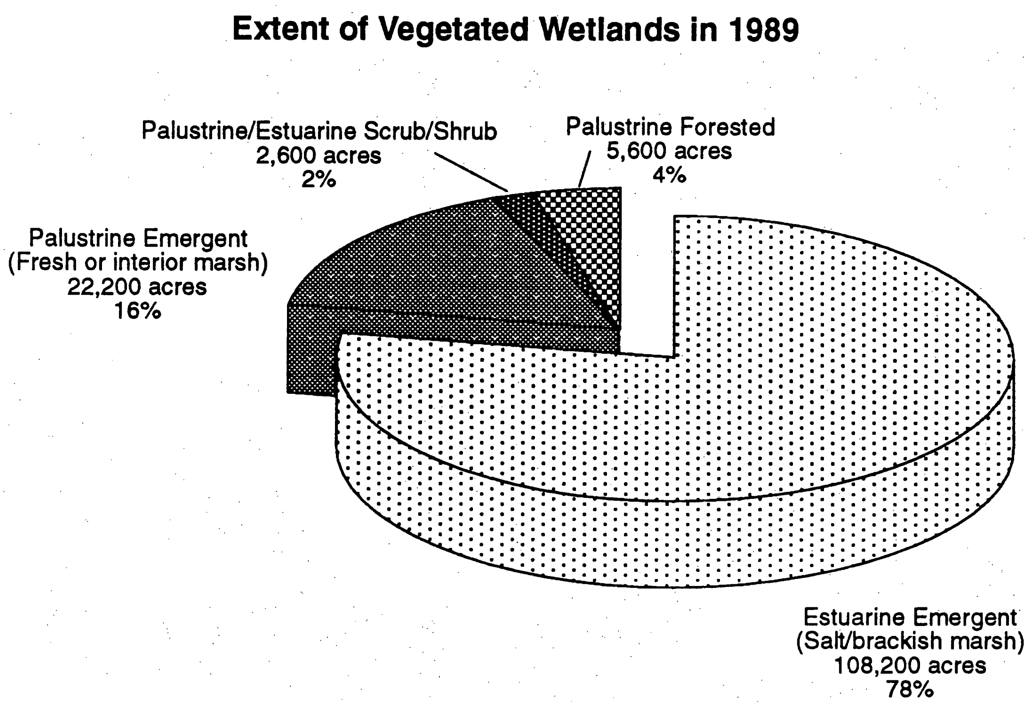

Figure III. Areal extent of vegetated wetlands in 1989.

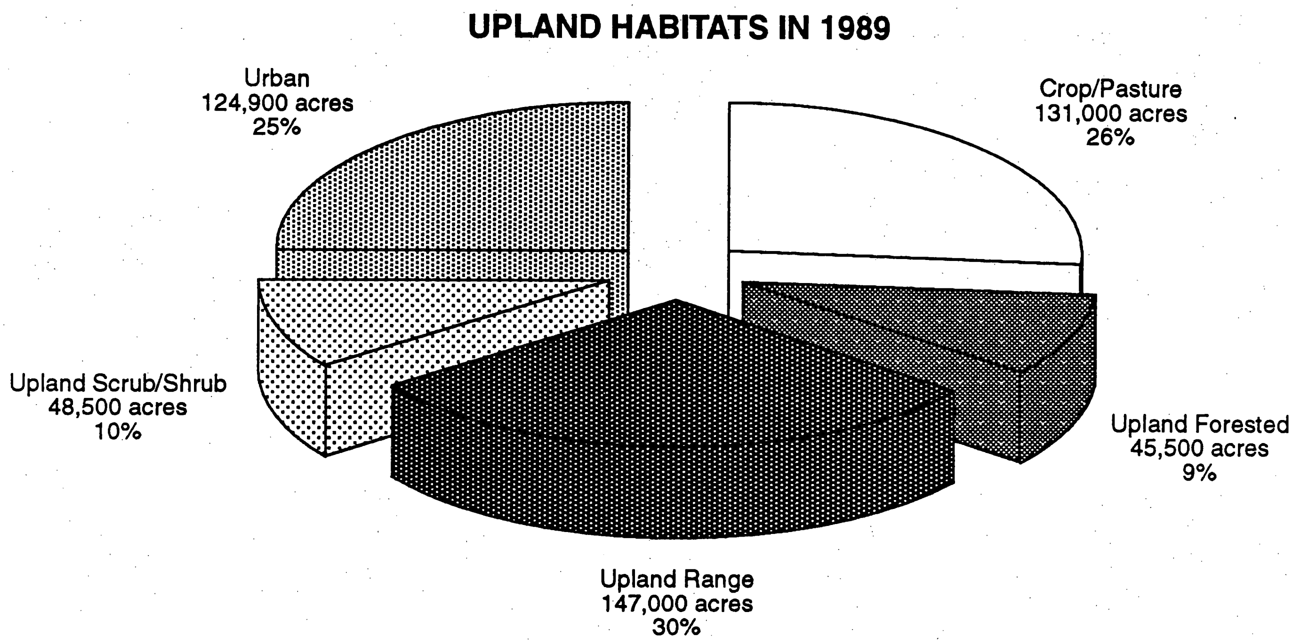

Figure IV. Areal extent of upland habitats in 1989.

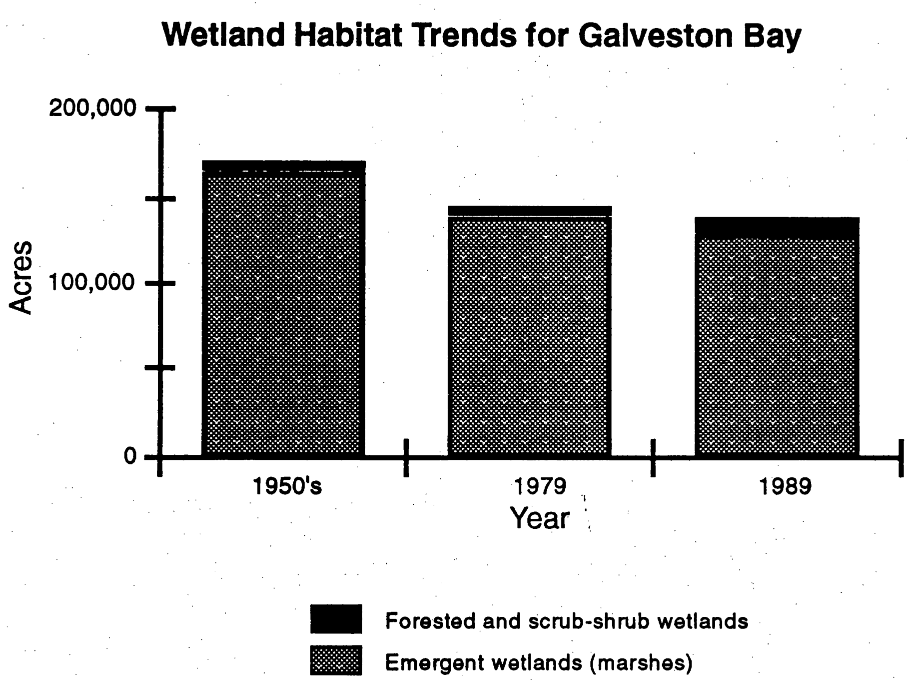

Figure V. Trends in marshes and forested and scrub-shrub wetlands in the Galveston Bay system.

Table III. Areal extent of vegetated wetlands and aquatic beds in the 1950's, 1979, and 1989.

Wetland Type	Area (acres)		
	1950's	1979	1989
Estuarine and Palustrine Emergents (marshes)	165,500	138,130	130,370
Scrub/Shrub	3,430	2,300	2,570
Forested	2,040	5,580	5,650
Total	170,970	146,010	138,590
Estuarine Subtidal Aquatic Beds	2,500	N/A	700

Table IV. Major causes of wetland losses from the 1950's to 1989.

Cause of Emergent Wetland (Marsh) Loss	Acres Lost
Conversion to open water and flat principally due to subsidence and relative sea-level rise	26,450
Conversion to Uplands	
Upland Range	25,000
Upland Urban	*5,700
Upland Agriculture	3,600
Upland Spoil	1,500
Total Conversion to Uplands	**35,800

*Incudes 800 Acres of Upland Oil and Gas

**Changes (apparent losses) are in part due to photointerpretation

Although the net loss in emergent wetlands (marshes) from the 1950's to 1989 encompassed about 35,000 acres, the gross loss, exclusive of offsetting gains in other areas, was considerably larger—approximately 88,500 acres. Conversion of emergent wetlands to open water and flats exceeded 26,400 acres, accounting for about 30 percent of the total gross loss. There is evidence that humanly induced subsidence and associated relative sea-level rise was the major factor contributing to the conversion of marshes to open water and barren flats (table IV). Subsidence along active surface faults contributed to marsh loss in some areas.

Major losses in interior, or fresh, marshes occurred as large areas of palustrine emergent wetlands were transformed to uplands. The magnitude of this change is approximately 35,600 acres from the 1950's to 1989, and accounts for about 40 percent of the total gross loss in palustrine and estuarine emergent wetlands. The change from emergent wetlands in the 1950's to upland rangeland in 1989 encompassed 25,400 acres. Conversion of wetlands to urban upland areas amounted to 5,700 acres, and to cropland and pastureland, 3,600 acres (table IV). It appears that some changes are related to natural conditions, such as annual (and seasonal) changes in moisture levels, which affected photointerpretation, but a substantial amount of the change appears to be due to draining of wetlands. This has been a common practice, especially from the 1950's to 1970's. Approximately 33 percent of the gross loss in emergent wetlands is attributed to the conversion of marshes to upland rangeland and cropland.

Losses in emergent wetlands in some areas were partly offset by gains in emergent wetlands in other areas. Conversion of uplands to emergent wetlands accounted for an increase of about 21,000 acres. Regionally, these changes were most pronounced inland from East, West, and Christmas Bays. The conversion of uplands to wetlands generally took place in transitional areas peripheral to existing wetlands, and appears to be related to subsidence and associated relative sea-level rise in some areas. Additional increases in emergent wetlands resulted from the spread of emergent vegetation across intertidal flats. However, the replacement of vegetated areas by flats was a much more significant process.

Although vegetated wetland expansion may have partially offset wetland losses in terms of acreage, this offset does not necessarily apply in terms of overall functional value. There is evidence that newly created wetlands are not functionally equivalent to older, long-established wetlands.

Scrub-Shrub and Forested Wetlands

The general trend in scrub-shrub wetlands for the 1950's to 1989 period was one of net loss. However, this trend was countered by forested wetlands, which had a significant net gain. Scrub-shrub wetlands decreased by approximately 850 acres, representing a loss of about 25 percent of the 1950's resource. Forested wetlands, on the other hand, increased in area by approximately 3,600 acres, an increase of about 1.8 times the 1950's area. Much of this gain in forested wetlands was due to (1) taller growth of shrubs and trees in areas previously mapped as scrub-shrub wetlands and (2) inconsistent delineation of forested wetlands on the different sets of photographs. Locally, losses in forested wetlands were due to alterations in hydrology.

Estuarine Aquatic Beds

Submerged vascular vegetation decreased from about 2,500 acres in the 1950's to approximately 700 acres in 1989, reflecting a decline in submerged vegetation of 1,800 acres, or more than 70 percent of the 1950's habitat. There is evidence from another study that submerged vegetation in the mid-1950's may have been as extensive as 5,000 acres, reflecting a decline of 86 percent of this resource by 1989. Loss of submerged vegetation has been attributed to subsidence and Hurricane Carla in parts of Galveston Bay, and to human activities including development, wastewater discharges, chemical spills, boat traffic, and dredging activities in West Bay (Pulich and White, 1991).

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INTRODUCTION

Wetland and aquatic habitats are essential biological components of the Galveston Bay Estuarine System. Understanding the spatial and temporal distribution of these habitats is critical if they are to be effectively protected and managed. This report presents results of an investigation to determine the trends and status of wetland and aquatic habitats in the Galveston Bay system. The investigation, sponsored by the Galveston Bay National Estuary Program (GBNEP) and funded by the U.S. Environmental Protection Agency, is a cooperative effort between the Bureau of Economic Geology and the National Wetlands Research Center and National Wetlands Inventory (NWI) program of the U.S. Fish and Wildlife Service (USFWS).

Objectives

Primary among the objectives of this investigation was to determine the trends and status of wetlands in the Galveston Bay system (fig. 1) using aerial-photographic analysis supported by field surveys. Associated objectives included characterization of wetland plant communities in the Galveston Bay system (White and Paine, 1992) and determination of the probable causes of documented wetland trends (changes).

Wetland Classification and Definition

For the purposes of this investigation, wetlands were classified in two ways: (1) in accordance with *The Classification for Wetlands and Deepwater Habitats of the United States* by Cowardin and others (1979) and (2) in more classical terms—for example, salt, brackish, and fresh marshes, and swamps. The classification by Cowardin and others (1979), which is the classification used by the USFWS for the NWI, was used in delineating wetlands on aerial photographs and in ground-truthing delineations during field surveys. The more classical definitions were used in defining wetland plant communities (White and Paine, 1992) as specified in contract requirements. The classical terms were used because salinity regimes were not mapped using the Cowardin and others system, and subdivision of estuarine emergent wetlands into salt- and brackish-water marshes provides additional information about the distribution of plant communities. The general relationships between the two classifications are presented through numerous examples in this report.

The definitions of wetlands and deepwater habitats according to Cowardin and others (1979) are as follows:

> Wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. For purposes of this classification wetlands must have one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes[1]; (2) the substrate is predominantly undrained hydric soil[2]; and (3) the substrate is nonsoil and is saturated

[1]The USFWS has prepared a list of hydrophytes and other plants occurring in wetlands of the United States.

[2]The U.S. Soil Conservation Service has prepared a list of hydric soils for use in this classification system.

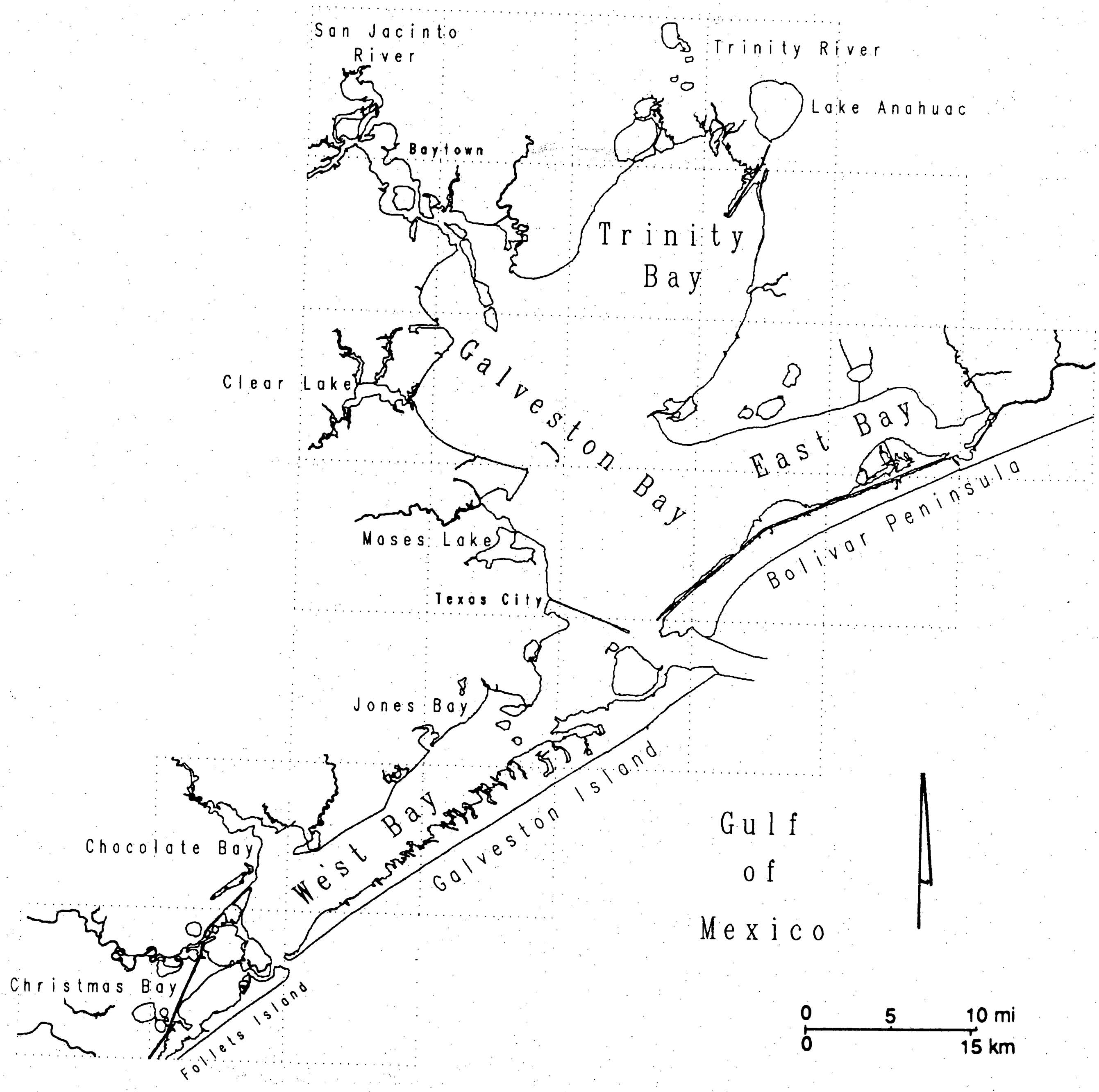


Figure 1. Index map of the Galveston Bay system.

with water or covered by shallow water at some time during the growing season of each year.

Deepwater habitats are permanently flooded lands lying below the deepwater boundary of wetlands. Deepwater habitats include environments where surface water is permanent and often deep, so that water, rather than air, is the principal medium within which the dominant organisms live, whether or not they are attached to the substrate. As in wetlands, the dominant plants are hydrophytes; however, the substrates are considered nonsoil because the water is too deep to support emergent vegetation (U.S. Soil Conservation Service, Soil Survey Staff, 1975).

Because the fundamental objective of the GBNEP project was to determine the trends and status of wetlands in the Galveston Bay system using aerial photographs, classification and definition of wetlands are integrally connected to the photographs and the interpretation of wetland signatures. Wetlands were not defined nor mapped in accordance with the *Federal Manual for Identifying and Delineating Jurisdictional Wetlands*, which is currently being revised.

METHODS

Mapping and Analyzing Status and Trends

The Galveston Bay project area is defined by 30 U.S. Geological Survey (USGS) 7.5-minute quadrangles (quads) (fig. 2). Status and trends of wetlands in the Galveston Bay system were determined by analyzing the distribution of wetlands mapped on aerial photographs taken in the 1950's, 1979, and late 1980's. Only the late-1980's wetlands maps were completed as part of this project. Maps of the 1950's and 1979 were prepared as part of the USFWS-sponsored Texas Barrier Island Ecological Characterization study (Shew and others, 1981) by Texas A&M University and the National Coastal Ecosystems Team of the USFWS. Final maps of the 1979 series were prepared under the National Wetlands Inventory program. Maps of the 1950's and 1979 series were digitized and initially analyzed in 1983 (USFWS, 1983).

Interpretation of Wetlands

Wetlands for all maps (1950's, 1979, and 1980's) were delineated on aerial photographs through stereoscopic interpretation using procedures developed for the USFWS National Wetlands Inventory program. Field reconnaissance is an integral part of the interpretation process. Photographic signatures were compared to the appearance of wetlands in the field by observing vegetation, soil, hydrology, and topography. This information is weighted for seasonality and conditions existing at the time of photography and ground truthing. Extensive field surveys of wetlands were conducted as part of this study in support of the 1980's delineations (see discussions on field investigations and wetland plant communities). Still, field-surveyed sites represent only a small percentage of the thousands of areas (polygons) delineated. Most areas are delineated on the basis of photointerpretation alone, and mis-classifications may occur.

The following explanation is printed on all wetland maps that were used in this project to determine the trends and status of wetlands in the Galveston Bay system:

> This document (map) was prepared primarily by stereoscopic analysis of high-altitude aerial photographs. Wetlands were identified on the photographs based on vegetation, visible hydrology, and geography in accordance with "Classification of Wetlands and Deepwater Habitats of the United States" (FWS/OBS–79/31 December 1979). The aerial photographs typically reflect conditions during the specific year and season when they were taken. In addition, there is a margin of error inherent in the use of the aerial photographs. Thus, a detailed on the ground and historical analysis of a single site may result in a revision of the

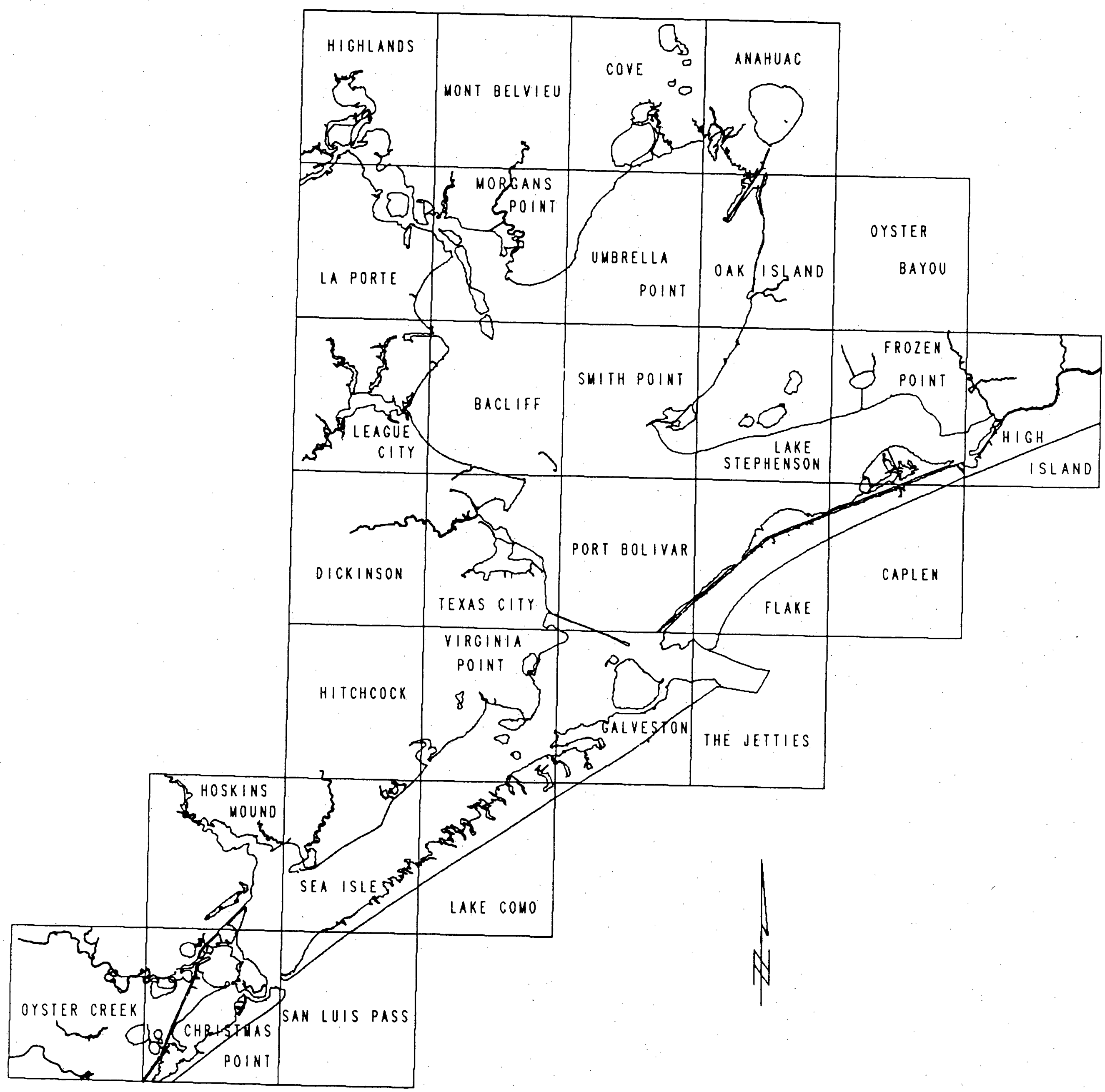


Figure 2. Study area defined by 30 USGS 7.5-minute quads. Map scale is same as figure 1.

wetland boundaries established through photographic interpretation. In addition, some small wetlands and those obscured by dense forest cover may not be included on this document.

Federal, State, and local regulatory agencies with jurisdiction over wetlands may define and describe wetlands in a different manner than that used in this inventory. There is no attempt in either the design or products of this inventory to define the limits of proprietary jurisdiction of any Federal, State or local government or to establish the geographical scope of the regulatory programs of government agencies. . .

Photographs

The 1950's photographs are black-and-white stereo-pair, scale 1:24,000, from the U.S. Department of Agriculture; most were taken in 1952 and 1953, but a few were taken in 1957. The 1979 photographs are NASA color-infrared stereo-pair, scale 1:62,500, taken in November. Late-1980's photographs are NASA color-infrared stereo-pair, scale 1:62,500. Most of the late-1980's photographs used for mapping wetlands were taken in December 1989, but a few that were used in this project were taken in November 1987 and 1988. For simplification in this report, the year 1989 is used when referring to the late-1980's photographs and maps.

Photographs taken in 1979 and 1989 are of high quality, overall. Tidal conditions, however, varied widely. Higher than normal tides were "captured" in 1979, and lower than normal in 1989 (1987 photographs reflected higher tides than in 1989). In addition, abnormally high precipitation in 1979 raised water levels in wetlands. These differences affected certain habitats and their interpreted, or mapped, water regimes. For example, photointerpreted regularly flooded marshes are, in general, more extensive on the 1979 maps than the 1989 maps. Also, many areas mapped as intertidal flats on 1989 photographs were submerged in 1979 and mapped as open water. These flats can be identified on 1989 maps by the water-regime modifier assigned to them.

Although the 1950's photographs are black and white, they are at a large scale (1:24,000), which aids in the photointerpretation and delineation process. The influence of the severe drought that characterized the mid-1950's in Texas (Riggio and others, 1987) apparently had not influenced the Upper Texas Coast in 1952 and 1953 (Dallas Morning News, 1981), the years when most of the 1950's photographs were taken. In fact, a review of some of the 1952 photographs of the Hoskins Mound area indicate abnormally high water levels in some fresh marsh systems. These higher water levels affected the interpretation of wetland habitats, and some peripheral upland areas were mapped as wetlands. In some areas, uplands were misinterpreted and mapped as wetlands. Accordingly, 1950's wetland (marsh) acreages for some areas reflect a larger inland wetland system than actually existed. Problems in photointerpretation are discussed more thoroughly in the section titled "Trends in Wetland Habitats."

Maps

From the photointerpretations, draft maps were prepared, distributed for review, and field checked. Final maps were prepared by transferring lines delineated on aerial photographs to USGS 7.5-minute quadrangle base maps, scale 1:24,000, using Zoom-Transfer Scopes. As in the photointerpretation process (discussed more thoroughly in a following section of photointerpretation errors), there is a margin of error involved in the transfer process. Transfers to maps were completed by a different contractor for the 1950's photographs than for the 1979 and 1989 photographs. Accordingly, a higher degree of standardization and consistency was achieved in the 1979 and 1989 map series.

On 1979 and 1989 maps, wetlands are classified by system, subsystem, class, subclass (for vegetated classes), water-regime, and special modifier in accordance with Cowardin and others (1979) (figs. 3–5). For the 1950's maps, wetlands are classified by system, subsystem, and class. On the 1979 and 1989 maps, upland areas were also mapped and classified by upland habitats using a modified Anderson and others (1976) land-use classification system (fig. 5). Flats and beach/bar classes designated separately on 1950's and 1979 maps were combined into a single class, unconsolidated shore, on 1989 maps (fig. 5).

Thirty 7.5-minute quads make up the Galveston Bay Project area (fig. 2). Delineations for the 1989 maps were digitized and entered into the geographic information system (GIS) ARC/INFO for analysis on a quad by quad basis. GIS data files previously digitized and maintained by the USFWS for the 1950's, and 1979 photographs were obtained and translated to digital line graph (DLG) format in a form readable by ARC/INFO.

The digitizing process is a means of data capture of the lines, points, and polygons displayed on hard-copy maps. Data are captured with a digitizing tablet using a software package called the Analytical Mapping System (AMS). The AMS is a menu-driven geographically referenced digitizing system that contains predefined, sequential data-entry procedures, including: map preparation and georeferencing; digitizing and editing; polygon verification/formation; and data base construction and transfer. The base map to be digitized is registered to a geographic referencing system with AMS by establishing the longitude and latitude registration marks (maximum 16, minimum 8) of the map as points within the digitizing tablet grid and the latitude/longitude registration points of the map. These values are either accepted or declined by the digitizer in compliance with national map-accuracy standards. The data are digitized and stored in an arc-mode format. AMS provides internal verification of polygon closure, island formation, and edge matching. Quality control is performed within AMS to identify errors in attribute assignment, open polygons, crossing line segments, unattached edge modes, or misassigned islands. Additional quality control is done by the digitizer who produces a plot of the digitized data and compares it to the original map. This provides a check for errant lines, missed polygons, missing lines, or lines that diverge from the original in location, direction, or directness. Following editing and verification, the digital map data are transferred to a permanent AMS data base and can be exported to the Map Overlay and Statistical Subsystem (MOSS) or to ARC/INFO for analysis of the data.

Results include GIS data sets consisting of electronic-information overlays corresponding to mapped habitat features for the 1950's, 1979, and 1980's. The data can be manipulated as information overlays, whereby scaling and selection features allow portions of the estuary to be electronically selected for specific analysis.

Among the objectives of the geographic information system are: (1) to allow direct historical comparisons of habitat types to gauge historical trends and status of estuarine habitat, (2) to allow novel comparisons of feature overlays to suggest probable causes of wetland changes, (3) to make information on wetlands directly available to managers in a convenient and readily assimilated form, and (4) to allow overlays to be combined from both this and future studies on other topics in a single system that integrates disparate environmental features for purposes of creating a Comprehensive Conservation and Management Plan (CCMP). The GIS is expected to become a flexible and valuable management tool for future use by resource agencies.

Field Investigations

Field investigations were conducted for two related purposes: (1) to characterize wetland plant communities through representative field surveys and (2) to compare various wetland plant communities in the field with corresponding "signatures" on aerial photographs used to define wetland classes, including water regimes, for mapping purposes. All field work was done with reference to aerial photographs (1979 or 1989). Characterization of prevalent plant associations

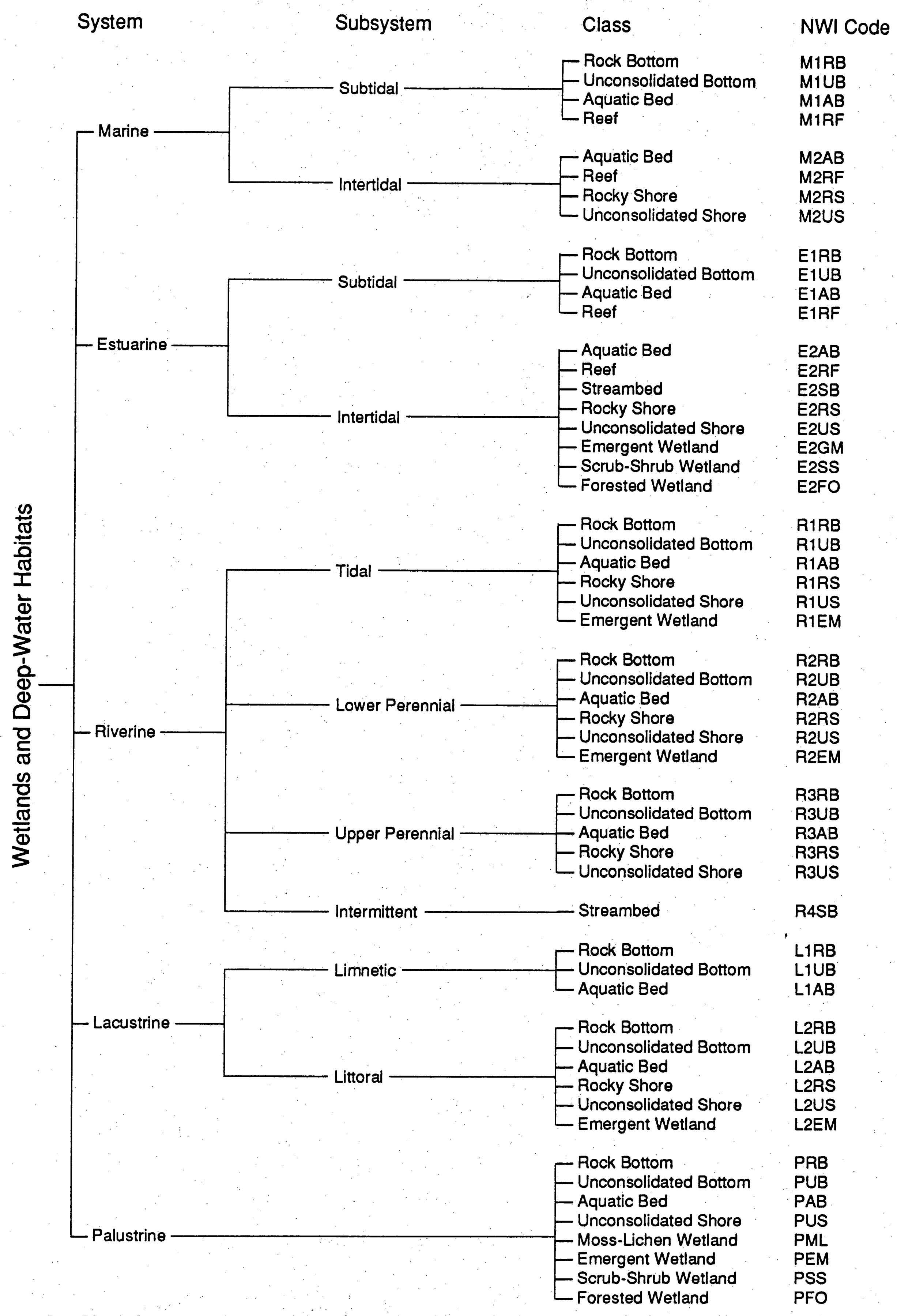


Figure 3. Classification hierarchy of wetlands and deepwater habitats showing systems, subsystems, and classes. From Cowardin and others (1979).

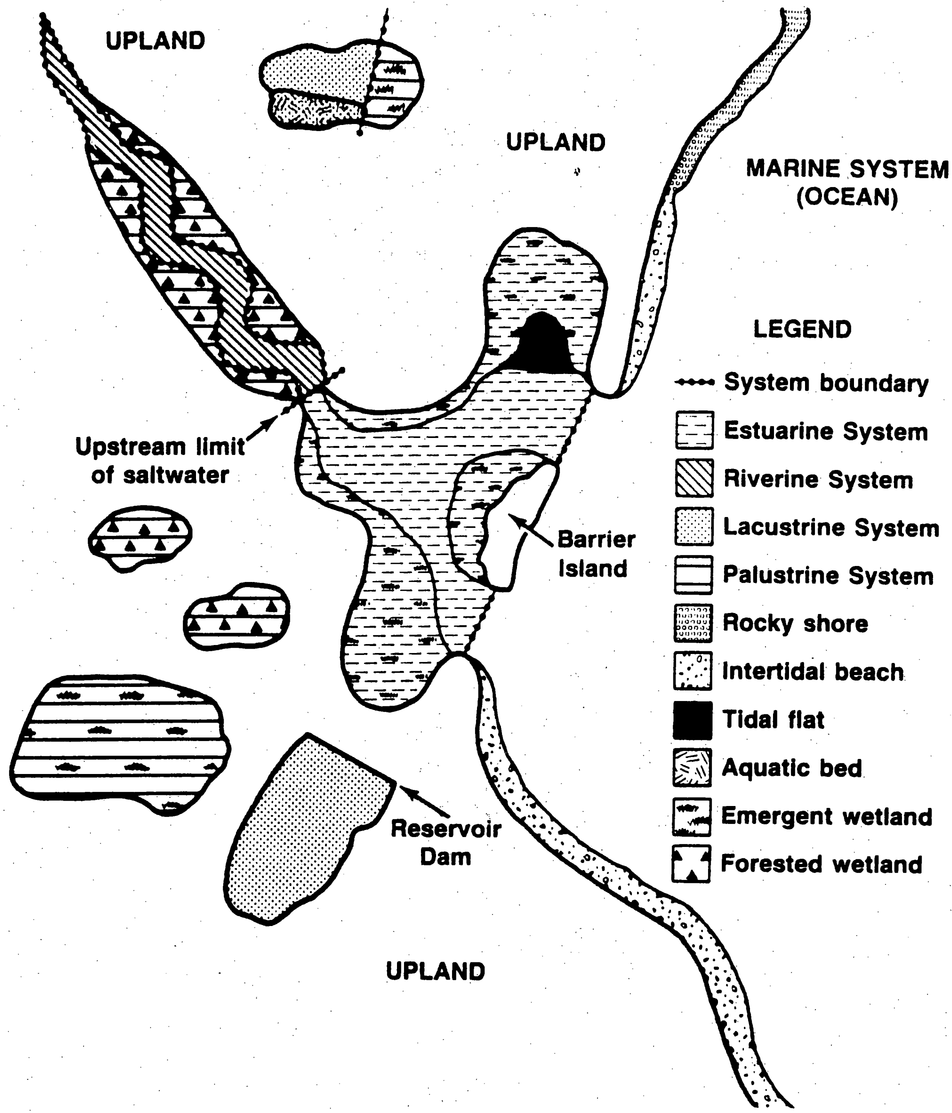
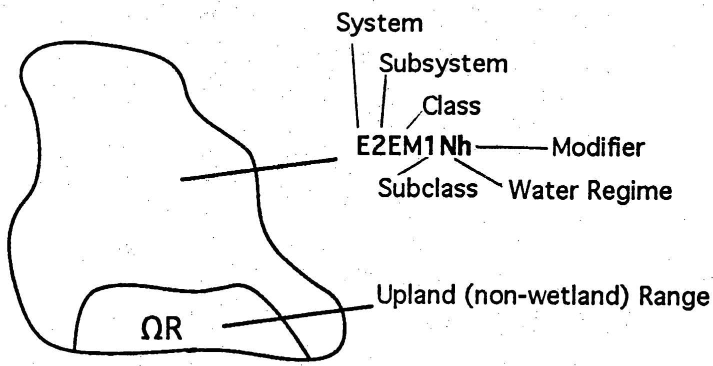


Figure 4. Schematic diagram showing major wetland and deepwater habitat systems. From Tiner (1984).

Symbology example



Upland Legend

Upland Classes	Modifying Terms
U-Urban or Developed	o-oil and/or gas
A-Agricultural	r-rice field
F-Forest	6-deciduous 7-evergreen
SS-Scrub/Shrub	8-mixed
R-Range	s-spoil d-dune
B-Barren	t-transportation

Changes in Class Symbols

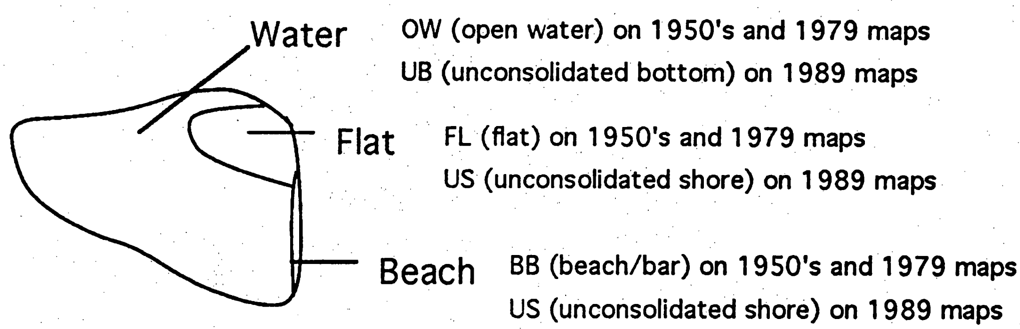


Figure 5. Example of symbology used to define wetland and upland habitats on National Wetland Inventory maps.

(White and Paine, 1992) provided vital plant community information for defining mapped wetland classes in terms of typical vegetation associations.

During field surveys, prevalent plant species associations were characterized "within the constraints imposed by the resolution of the photos" (as stated in the Project Scope of Work, 1990). More than 180 sites were examined in the Galveston Bay system. Many more sites were surveyed in less detail during the process of ground-truthing delineations on photographs and draft maps. Only the most recent aerial photographs were "ground truthed." Ancillary information used in the field and in photointerpretation included topographic maps, soil surveys, lists of hydrophytes and hydric soils, and consultation with field experts about wetland communities, water management practices, impoundments, and rice cultivation.

Survey sites included the Brazoria and Anahuac National Wildlife Refuge, Armand Bayou Nature Center, Follets and Galveston Islands, Bolivar Peninsula, Smith Point, High Island area, Trinity River delta, and other areas. Plant communities were surveyed during the months of June, July, and November, 1990, and May and September, 1991. Personnel, other than the authors, involved in one or more field surveys included Warren Hagenbuck and Curtis Carley (USFWS–National Wetlands Inventory), Todd Mecklenborg (Geonex Martel, Inc.), Melvin Fuhrmann (USFWS–National Wetlands Research Center), Jeff Paine (Bureau of Economic Geology), and Warren Pulich (Texas Parks and Wildlife Department). In addition, Ron Bisbee (Refuge Manager), Richard Antonette, and Mike Lange of the Brazoria National Wildlife Refuge, and Jim Neaville and Ed Jackson of the Anahuac National Wildlife Refuge accompanied field parties to their respective areas.

During the initial field investigations, methods were developed to characterize prevalent species associations. The primary method was one in which wetland plants were identified at selected field survey sites, principally along transects aligned perpendicular to the hydrologic gradient so that plant assemblages from the water's edge to upland areas were intercepted. A second approach was to conduct a topographic survey along selected transects that crossed representative plant communities to identify relative elevations at which various plant species occur. This is helpful in defining water regimes and in differentiating between high and low marsh communities. The boundaries between some plant assemblages are controlled in part by elevation, so elevation measurements focus on such boundaries. Plant species that were difficult to identify in the field were collected for identification in the laboratory or with reference to the plant collection at The University of Texas Herbarium. References used in plant identification were Correll and Correll, 1975; Correll and Johnston, 1970; Texas Forest Service, 1963; Gould, 1975; and Fleetwood, no date, among others.

Topography surveys were conducted along several transects. Measurements of elevation, distance, and plant community composition were made along the survey lines, which crossed salt marshes (Smith Point, Follets Island, and mainland margin of West Bay) and brackish to fresh marshes (Anahuac National Wildlife Refuge, Brazoria National Wildlife Refuge, and Trinity River delta). Elevations were measured to the nearest 0.5 cm and distances were measured to the nearest meter. Compass bearings of the transects were also recorded.

County soil surveys (Brazoria County, Crenwelge and others, 1981; Chambers County, Crout, 1976; Galveston County, Crenwelge and others, 1988; and Harris County, Wheeler and others, 1976) were used to define and characterize soils at the various field check sites. Information obtained from the soil surveys included soil type, salinity, drainage, frequency of flooding, position of water table, and prevalent vegetation.

The locations of field survey sites were plotted on aerial photographs, and later accurately transferred to USGS 7.5-minute quadrangle topographic maps using a Zoom Transfer Scope where necessary. Universal Transverse Mercator (UTM) coordinates were determined for each site and these data were entered into computer data management systems, including the GIS, ARC/INFO.

STATUS (DESCRIPTION AND DISTRIBUTION) OF WETLAND HABITATS

General Setting of the Galveston Bay System

The geologic framework of the Galveston Bay area consists of Modern-Holocene and Pleistocene systems including the modern wetland, or marsh and marsh-swamp systems (fig. 6). The geomorphic features on which the various types of coastal wetlands have developed are the result of numerous interacting processes. Physical processes that influence wetlands include rainfall, runoff, fluctuations in the water table, streamflow, evapotranspiration, waves and longshore currents, astronomical and wind tides, storms and hurricanes, deposition and erosion, subsidence, faulting, and sea-level rise (table 1). These processes have contributed to the development of a gradational array of permanently inundated to infrequently inundated environments ranging in elevation from the submerged lands of the estuarine system through the topographically higher wetland system, which grades upward from the astronomical-tidal zone through the wind-tidal zone to the storm-tidal zone.

Exchange of marine waters with bay-estuary-lagoon waters in the Galveston Bay system occurs primarily through two major tidal inlets, Bolivar Roads at the north end of Galveston Island, and San Luis Pass at its south end (fig. 6). Additional exchange occurs at Rollover Pass, a narrow dredged channel at the east end of Bolivar Peninsula. The predominant sources of fresh-water inflow are the Trinity and San Jacinto Rivers (fig. 6). Salinities in the Galveston Bay system are generally highest in West and Christmas Bays where mean salinities are typically above 20 ppt and may range into the 30's (Pulich and White, 1991; Orlando and others, 1991). These salinities are in marked contrast to Trinity Bay, where Trinity River fresh-water inflows have a moderating influence; mean monthly salinities in Trinity Bay are usually less than 15 ppt and occasionally are below 5 ppt (Pulich and White, 1991).

These numerous interacting processes in the Galveston Bay system have a major bearing on the location and composition of wetland plant communities.

Description of Mapped Wetlands in the Galveston Bay System

Wetland and Deepwater Habitats

Cowardin and others (1979) defined five major systems in their classification of wetlands and deepwater habitats: Marine, Estuarine, Riverine, Lacustrine, and Palustrine (fig. 3). All include wetlands and deepwater habitats except for the Palustrine System, which includes only wetland habitats. Systems are subdivided into subsystems, which reflect hydrologic conditions, such as intertidal and subtidal for the marine and estuarine systems. Subsystems are further subdivided into class, which describes the appearance of the wetland in terms of vegetation or substrate. Classes are subdivided into subclasses. Only vegetated classes were subdivided into subclasses for this project, and only for the years 1979 and 1989. In addition, water-regime modifiers (table 2) and special modifiers were used for these years.

The USFWS National Wetlands Inventory program established criteria for mapping wetlands using the Cowardin and others (1979) classification. Alphanumeric abbreviations are used to denote the systems, subsystems, classes, subclasses, water regimes, and special modifiers (table 3, fig. 5). Symbols for certain habitats changed after 1979; these changes are shown in figure 5 and are noted in the section on trends in wetland and aquatic habitats. Examples of alphanumeric abbreviations used in this section on status of wetlands apply only to the 1989 maps.

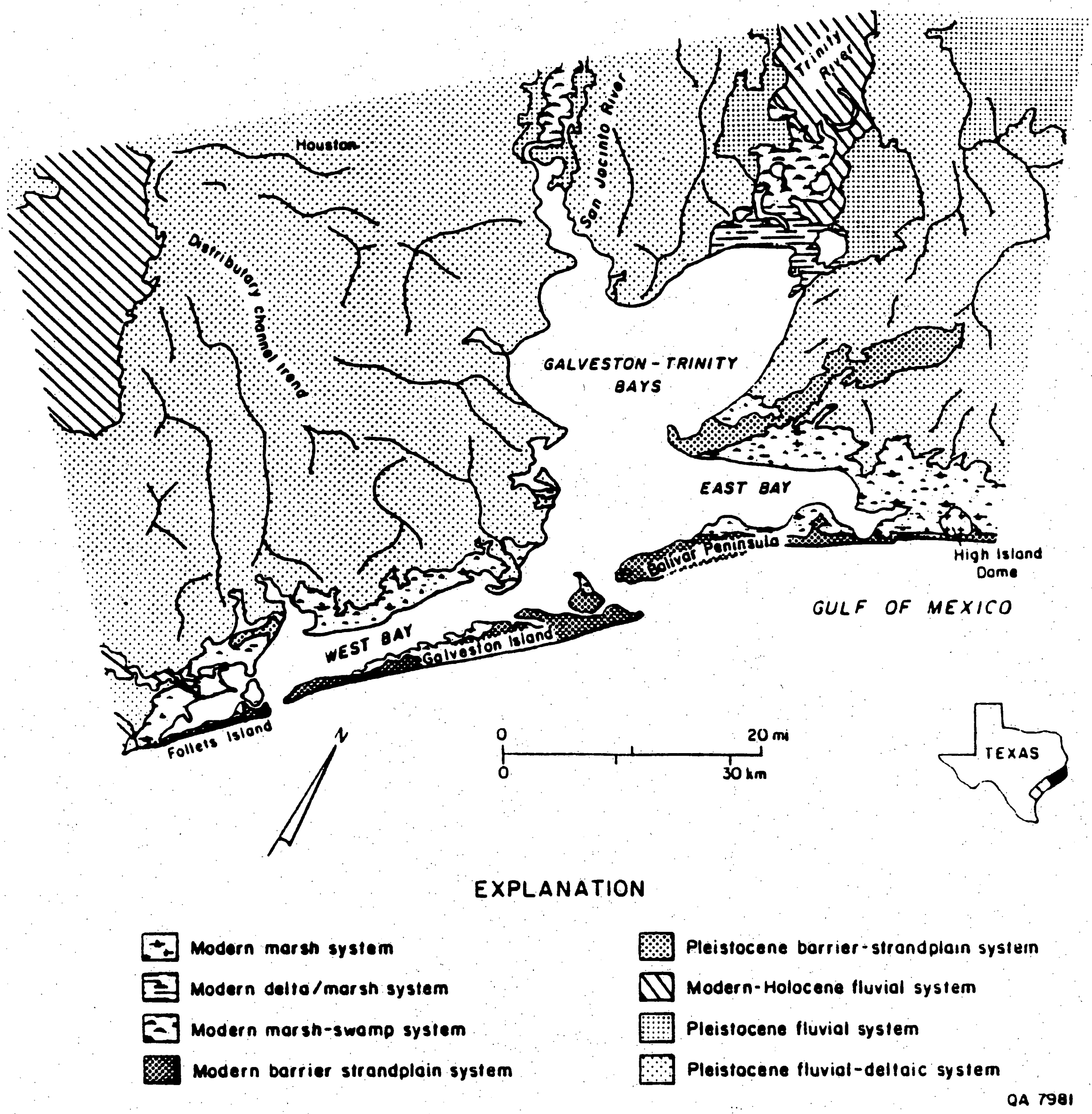


Figure 6. Natural systems in the Galveston Bay area. From Fisher and others (1972, 1973).

Table 1. Generalized characteristics of active coastal processes and conditions in the Galveston Bay area. From White and others (1985).

Climatic zone:	Humid *(Thornthwaite, 1948)*
Average annual precipitation:	41.8 to 51.5 inches/yr (106.2 to 130.8 cm/yr) *(Fisher and others, 1972)*
Dominant wind directions:	Southeasterly, northerly *(Fisher and others, 1972)*
Average wind speed (in 1978 at Texas City):	6.8 knots (12.6 km/hr) *(Shew and others, 1981)*
Astronomical tidal range: Gulf shoreline (Galveston Pleasure Pier) Mean diurnal: Bay shoreline (mean):	 2.1 ft (0.6 m) *(U.S. Department of Commerce, 1978)* 0.5 to 1.4 ft (0.2 to 0.4 m) *(Diener, 1975)*
Tidal current velocities: Bolivar Roads Average maximum flood: Average maximum ebb:	 3.3 knots (1.7 m/sec) *(Bernard and others, 1959)* 4.3 knots (2.2 m/sec) *(Bernard and others, 1959)*
Wave height (Gulf): (Caplan, Texas) Onshore wave height:	 Between 2.5 and 3.5 ft (0.8 and 1.1 m) about 65% of the time, *(U.S. Army Corps of Engineers, 1956)*
Direction of net longshore sediment transport:	Southwesterly *(Fisher and others, 1972)*
Maximum hurricane surge height on open coast:	12.7 ft (3.9 m) above MSL *(Bodine, 1969)*
Hurricane frequency:	12% in any one year *(Simpson and Lawrence, 1971)*
Gulf shoreline change, Bolivar Roads to San Luis Pass from 1850-52 to 1973-74:	Total gain from accretion of 1,074 acres and loss from erosion of 1,183 acres; net loss of 109 acres *(Morton, 1977)*
Subsidence: Pasadena - Houston Ship Channel area:	 8.5 to 9 ft (2.6 to 2.7 m) during 1906-1973 *(Ratzlaff, 1980)*
Faulting: Houston metropolitan area:	 Offset by at least 160 faults *(Verbeek and Clanton, 1981)*

Table 2. Water regime descriptions for wetlands used in the Cowardin and others (1979) classification system.

Nontidal

(A) Temporarily flooded—Surface water present for brief periods during the growing season, but water table usually lies below soil surface. Plants that grow both in uplands and wetlands are characteristic of this water regime.

(C) Seasonally flooded—Surface water is present for extended periods, especially early in the growing season, but is absent by the end of the growing season in most years. The water table is extremely variable after flooding ceases, extending from saturated to well below the ground surface.

(F) Semipermanently flooded—surface water persists throughout the growing season in most years. When surface water is absent, the water table is usually at or near the land's surface.

(H) Permanently flooded—Water covers land surface throughout the year in all years.

Tidal

(L) Subtidal—The substrate is permanently flooded with tidal water.

(M) Irregularly exposed—The land surface is exposed by tides less often than daily.

(N) Regularly flooded—Tidal water alternately floods and exposes the land surface at least once daily.

(P) Irregularly flooded—Tidal water floods the land surface less often than daily.

(S)* Temporarily flooded—Tidal

(R)* Seasonally flooded—Tidal

(T)* Semipermanently flooded—Tidal

(V)* Permanently flooded—Tidal

*These water regimes are only used in tidally influenced, freshwater systems.

Table 3. Wetland codes and descriptions from Cowardin and others (1979).

NWI CODE (WATER REGIME)	NWI DESCRIPTION	COMMON DESCRIPTION	CHARACTERISTIC VEGETATION
M1UB (L)	Marine, subtidal unconsolidated bottom	Gulf of Mexico	Unconsolidated bottom
M2US (P,N,M)	Marine, intertidal unconsolidated bottom	Marine beaches, barrier islands	Unconsolidated shores
M2RS (P)	Marine, intertidal rocky shore	Marine breakers, beach stabilizers	Jetties
E1UBL (L)	Estuarine, subtidal unconsolidated bottom	Estuarine bays, Estuarine rivers	Unconsolidated bottom
E1AB (L)	Estuarine, subtidal aquatic bed	Estuarine bays	*Ruppia maritima* *Halodule wrightii*
E2US (P,N,M)	Estuarine, intertitdal unconsolidated shore	Estuarine bay, tidal flats, beaches	Unconsolidated shore
E2EM (P,N)	Estuarine, intertidal emergent	Estuarine bay marshes, salt and brackish water	*Spartina alterniflora* *Spartina patens* *Distichlis spicata*
E2SS (P)	Estuarine, intertidal scrub/shrub	Estuarine shrubs	*Iva frutescens* *Baccharis halimifolia*
R1UB (V)	Riverine, tidal, unconsolidated bottom	Rivers	Unconsolidated bottom
R1SB (T)	Riverine, tidal, streambed	Rivers	Unconsolidated bottom
R2UB (H)	Riverine, lower perennial, unconsolidated bottom	Rivers	Unconsolidated bottom
R4SB (C,F)	Riverine, intermittent streambed	Streams, creeks	Unconsolidated bottom
L1UB (H,V)	Lacustrine, limnetic, unconsolidated bottom	Lakes	Unconsolidated bottom
L2UB (H,V)	Lacustrine, littoral, unconsolidated bottom	Lakes	Unconsolidated bottom
L2AB (H,V)	Lacustrine, littoral, aquatic bed	Lake aquatic vegetation and marshes	*Nelumbo lutea* *Ruppia maritima*
PUB (F,H)	Palustrine, aquatic bed	Pond, aquatic vegetation and marshes	*Nelumbo lutea*
PEM (A,C,F,S,R,T)	Palustrine emergent	Fresh-water marshes, meadows, depressions, or drainage areas	*Scirpus californicus* *Typha spp.* *Alternanthera philoxeriodes*
PSS (A,C,F,S,R,T)	Palustrine scrub/shrub	Willow thicket, river banks	*Salix nigra* *Sesbania drummondii*
PFO (A,C,F,S,R,T)	Palustrine forested	Swamps, woodlands in floodplains depressions, meadow rims	*Taxodium distichum* *Liquidambar styraciflua*

Marine System

Marine areas include unconsolidated bottom (open water), unconsolidated shore (beaches), and rocky shore (jetties). The mean range in Gulf tides is approximately 0.6 m (2.1 ft) (table 1). Nonvegetated open water overlying the Texas Continental Shelf is classified as marine subtidal unconsolidated bottom (M1UBL) (table 3). Unconsolidated shore is mostly irregularly flooded shore or beach (M2USP) with a narrow zone of regularly flooded shore (M2USN). The composition of these areas is primarily sand and shell. Granite jetties along the coast in the marine system are classified as rocky shore irregularly flooded artificial substrate (M2RSPr).

Estuarine System

The estuarine system consists of many types of wetland habitats. Estuarine subtidal unconsolidated bottom (E1UBL), or open water, occurs in the numerous bays and in adjacent salt and brackish marshes. Unconsolidated shore (E2US) includes intertidal sand and mud flats and estuarine beaches and bars. Water regimes for this habitat range from irregularly exposed (E2USM), regularly flooded (E2USN), to irregularly flooded (E2USP).

Aquatic beds observed in this system are predominantly submerged rooted vascular plants (E1AB3L) that include, in the Christmas Bay area (fig. 1), *Halodule wrightii*, *Ruppia maritima*, *Halophila engelmanni*, and *Thalassia testudinum* (Pulich and White, 1991). Some areas that were delineated on 1989 photographs (which reflected extremely low tidal conditions) were classified as unknown aquatic bed (E1AB5L)—possibly algae and other organic material.

Emergent areas closest to estuarine waters consist of regularly flooded (E2EM1N) salt-tolerant grasses (low salt and brackish marshes). These communities are mainly composed of *Spartina alterniflora, Distichlis spicata, Salicornia* spp., *Batis maritima, Juncus roemerianus*, and *Scirpus maritimus* in more saline areas (fig. 7). In brackish areas such as in the Trinity River delta at the head of Trinity Bay, species composition changes toward a brackish to fresh-water assemblage. At slightly higher elevations the irregularly flooded estuarine emergent wetlands (E2EM1P) (high salt and brackish marshes) include *Spartina patens, Distichlis spicata, Spartina spartinae, Scirpus maritimus, Borrichia frutescens, Aster* spp., and many others (fig. 8).

Estuarine scrub-shrub wetlands (E2SS) are much less extensive than estuarine emergent wetlands. Representative plant species, which generally occur in irregularly flooded zones (E2SS1P) between emergent wetland communities and upland habitats, include *Iva frutescens, Baccharis halimifolia, Sesbania drummondii*, and *Tamarix gallica*.

Mapping criteria allow classes to be mixed in complex areas where individual classes cannot be separated. The most commonly used combinations include the estuarine emergent class (E2EM) and unconsolidated shore (E2US), for example, E2EM1P/USP. In such combinations, each class must compose at least 30 percent of the mapped area (polygon); the dominant classes were listed first on maps prepared from 1989 photographs. The estuarine emergent and unconsolidated shore combination was most frequently used on Galveston and Follets Islands where intertidal sand flats were juxtaposed with patches of salt-marsh vegetation. Vegetation commonly found in these areas includes *Monanthochloe littoralis, Salicornia* spp., *Batis maritima*, and *Suaeda linearis*.

The estuarine system extends upstream or landward to the point where ocean-derived salts are less than 0.5 parts per thousand (during average annual low flow) (Cowardin and others, 1979). Mapping of these boundaries is subjective in the absence of detailed long-term salinity data characterizing water and marsh features. Vegetation types, proximity and connection to estuarine water bodies, salinities of water bodies, and location of artificial levees and dikes are frequently used as evidence to determine the boundary between estuarine and adjacent fresh-water systems.

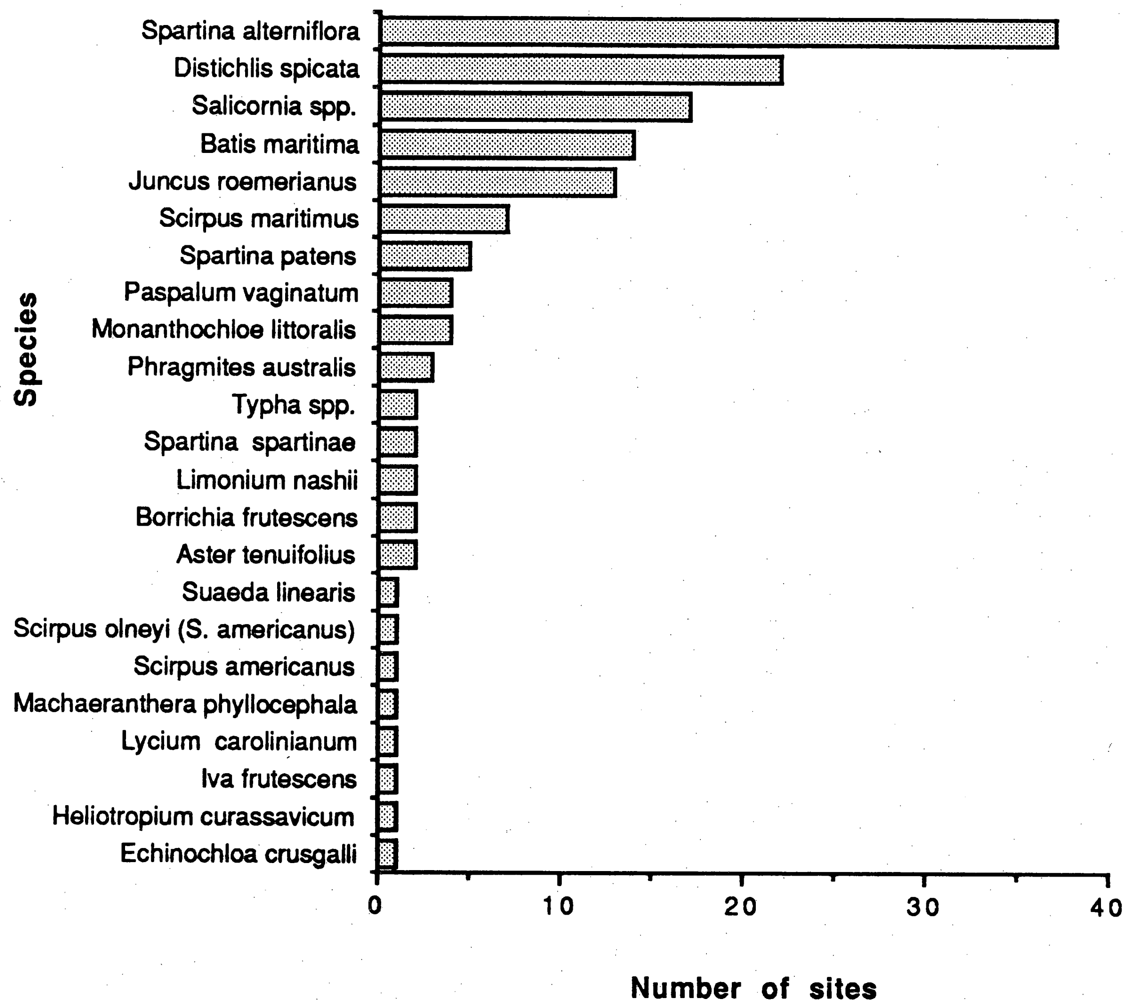


Figure 7. Plant species characterizing areas mapped as regularly flooded estuarine intertidal wetlands (E2EM1N), or low salt- and brackish-water marshes.

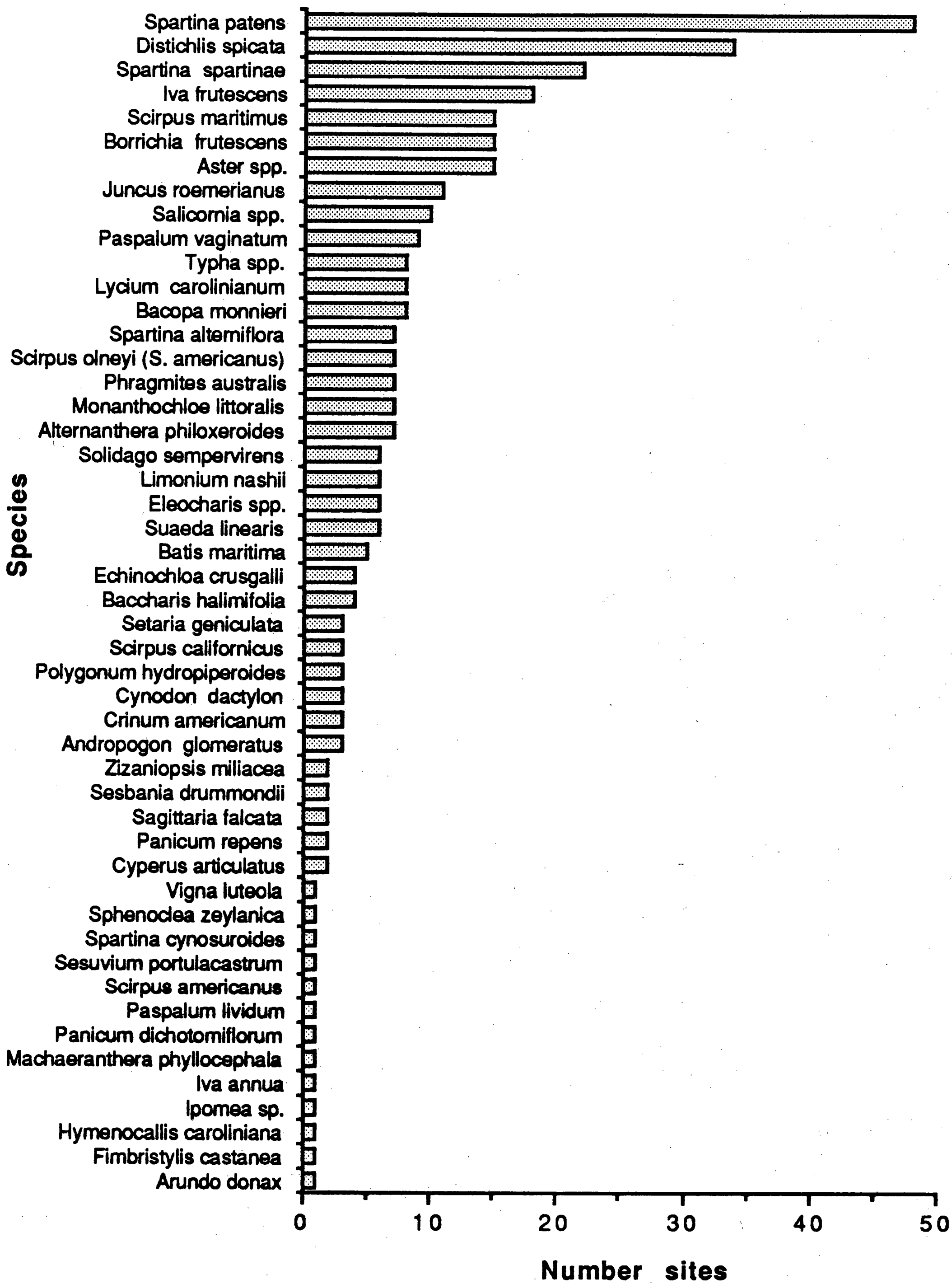


Figure 8. Plant species characterizing areas mapped as irregularly flooded estuarine intertidal wetlands (E2EM1P), or high salt- and brackish-water marshes.

Lacustrine System

Water bodies greater than 20 acres are included in this system with both limnetic and littoral subsystems represented. Numerous lakes and reservoirs exist within the study area. Major bodies of water include Lake Anahuac (Anahuac quad), Lake Charlotte (Cove quad), and Highlands Reservoir (Highlands quad).

Nonvegetated water bodies are labeled limnetic or littoral unconsolidated bottom (L1UB or L2UB) depending on water depth. Bodies of water with vegetation are classified with the subclass of rooted (L1AB3 and L2AB3) or floating (L1AB4 and L2AB4) aquatic bed. The impounded modifier (h) is used on bodies of water impounded by locks or artificial means. The artificially flooded modifier (k) is used in situations where water is controlled by pumps and siphons.

Riverine System

Three riverine subsystems occur in the project area: tidal (R1), lower perennial (R2), and intermittent (R4). The major rivers discharging into the bay are the Trinity and San Jacinto Rivers (fig. 6). Ditches large enough to be delineated were identified with the (x) modifier (for example, R2UBHx or R4SBFx).

Palustrine System

Palustrine areas include the following classes: unconsolidated bottom (open water), unconsolidated shore (including flats), aquatic bed, emergent (fresh or inland marsh), scrub-shrub, and forested. Naturally occurring ponds are identified as unconsolidated bottom permanently or semipermanently flooded (PUBH or PUBF). Excavated or impounded ponds and borrow pits are labeled with their respective modifiers (PUBHx or PUBHh).

Palustrine emergent wetlands are generally equivalent to fresh, or inland marshes. Semipermanently flooded emergent wetlands (PEM1F) are low fresh marshes; seasonally flooded (PEM1C) and temporarily flooded (PEM1A) palustrine emergent wetlands are high fresh marshes. Emergent areas bordering estuarine vegetation and estuarine-influenced rivers are typically affected by tides. For these tidally influenced fresh-water systems, special water-regime modifiers are applied for semipermanently (PEM1T), seasonally (PEM1R), and temporarily (PEM1S) flooded areas.

Vegetation communities typically characterizing areas mapped as low emergent wetlands (PEM1F and PEM1T) include *Scirpus californicus, Typha* spp., *Alternanthera philoxeroides, Cyperus articulatus, Spartina patens* (in higher areas), *Scirpus americanus, Polygonum hydropiperoides, Bacopa monnieri, Phragmites australis, Eleocharis* spp., *Zizaniopsis miliacea*, and others (fig. 9). Areas mapped as topographically higher and less frequently flooded emergent wetlands (PEM1C and PEM1A) include *Cyperus* spp., *Scirpus americanus, Eleocharis spp., Sesbania drummondii* (more typical in areas mapped as scrub-shrub), *Typha* spp., *Spartina patens*, and *Polygonum hydropiperoides*, to mention a few (fig. 10).

It should be noted that in many areas, field observations revealed the existence of small depressions or mounds with plant communities and moisture regimes that varied from that which could be resolved on the photographs. Thus, some plant species that may typify a low regularly flooded marsh, for example, may be included in a high marsh map unit (see figs. 9 and 10, for instance). Differentiation of high and low marsh communities was better achieved through field transects, some of which include elevation measurements.

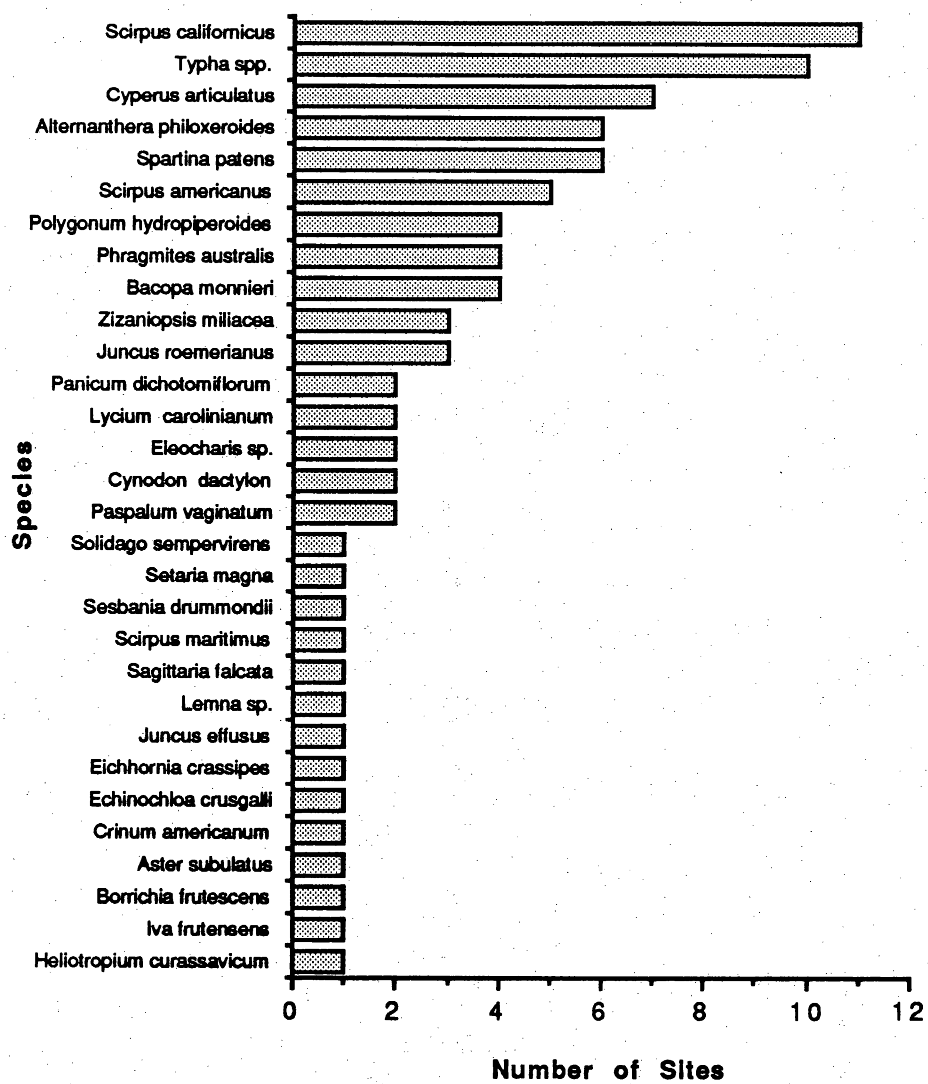


Figure 9. Plant species characterizing areas mapped as semipermanently flooded palustrine emergent wetlands (PEM1F and PEM1T), or low fresh-water marshes.

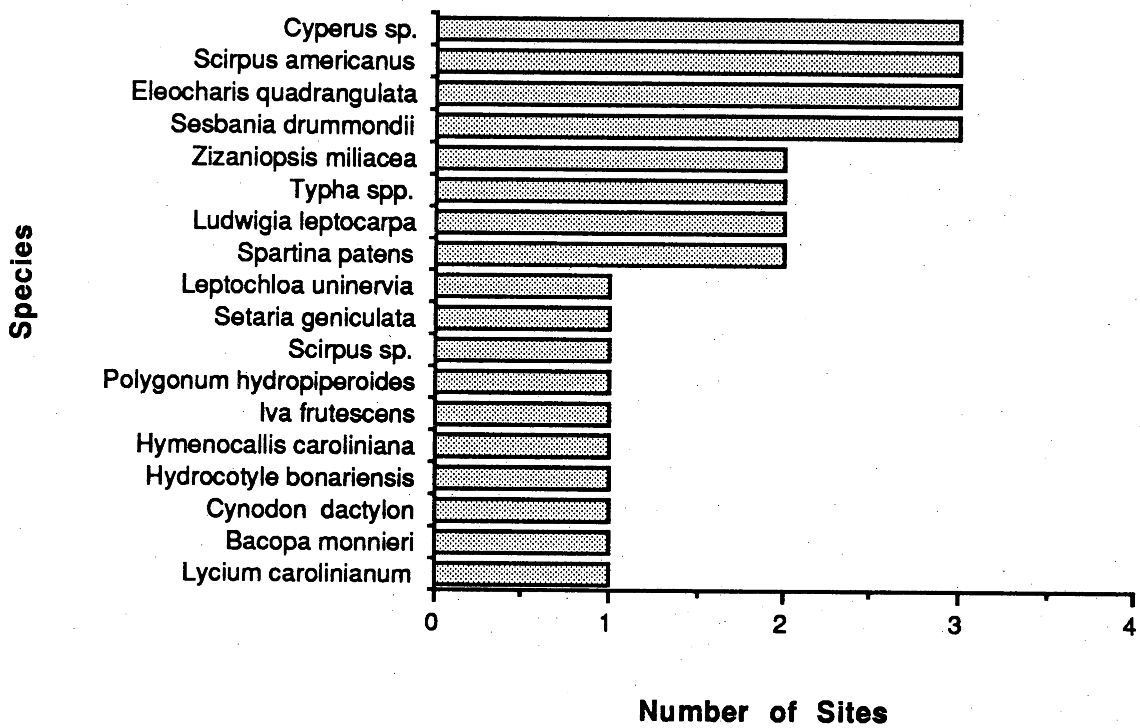


Figure 10. Plant species characterizing areas mapped as seasonally to temporarily flooded palustrine emergent wetlands (PEM1C AND PEM1A), or high fresh-water marshes.

Palustrine scrub-shrub wetlands that were mapped are typically seasonally flooded (PSS1C) and dominated by *Salix nigra, Sapium sebiferum,* and *Sesbania drummondii.* Temporarily and semipermanently flooded scrub-shrub habitat also occur with similar species. Water regimes include both tidally and nontidally influenced areas. *Tamarix gallica* is labeled PSS2A or PSS2C depending on the water conditions present (table 2).

Palustrine forested areas, semipermanently flooded (PFO2F), are represented by *Taxodium distichum.* Temporarily (PFO1A) and seasonally (PFO1C) flooded forested areas incorporate a large mixture of tree species including *Fraxinus pennsylvanica, Celtis laevigata, Salix nigra, Liquidambar styraciflua, Gleditsia aquatica, Planera aquatica, Sapium sebiferum, Cephalanthus occidentalis, Acer rubrum, Betula nigra,* and others. A split subclass was used when both needle-leaved and broad-leaved deciduous species are present (PFO2/1 or PFO1/2), with more than 30 percent coverage of each. The first subclass modifier is more abundant in canopy.

Species Composition of Wetland Plant Communities

To collect information on plant composition, wetland communities were surveyed at more than 180 sites around the Galveston Bay system; 135+ sites are shown in figure 11, and are listed in appendices A and B. The Galveston Bay project area is defined by 30 USGS 7.5-minute quadrangle maps, but one additional map (Freeport) was included for the field surveys. The maps were assigned numbers from 1 to 31 to simplify numerical designations of the surveyed sites (fig. 12). Species composition at the various sites along with very brief descriptive notes on the relationship of the identified plant communities to topography (e.g., high versus low zones) and local geographic features (such as roads or streams) are presented in appendix B. The relationships between plant species and relative elevations were determined along some transects (appendix C).

Wetland plant communities in the Galveston Bay system include high and low categories of salt, brackish, and fresh marshes, and forested wetlands. Other environments include mud and sand flats, beaches and bars, submerged vascular vegetation, disturbed areas, and open water.

The most widely distributed wetland habitats in the Galveston Bay system are marshes, the most extensive of which are brackish. Brackish marshes, as mapped by White and others (1985), compose roughly 65 to 70 percent of the marsh system in the Galveston Bay project area. Salt marshes are a distant second, composing roughly 25 to 30 percent. Fresh marshes make up the remaining 5 to 10 percent of the marsh system. Because many species can tolerate varying salinity regimes as well as water regimes, there is considerable overlap in the species composition of these marsh systems. The divergent plant communities in the project area are exemplified by the fresh marshes and swamps along the Trinity River, which contrast sharply with the salt marshes that fringe Christmas Bay.

Because of the predominance of brackish and salt marshes in the project area, more than 60 percent of the field surveys were located in these marshes. Surveys of other environments ranged from approximately 8 percent in forested wetlands to about 5 percent in transitional areas. With reference to all sites visited, the 15 most frequently encountered species were headed by *Spartina patens* and *Distichlis spicata* (fig. 13).

Each of the species in figure 13 was observed at more than 10 sites, *Spartina patens* and *Distichlis spicata* occurred at more than 55 sites, and *Spartina alterniflora* at more than 40 sites. Other species listed as among the top 25 reported include *Solidago* spp., *Limonium nashii, Phragmites australis, Lycium carolinianum, Paspalum vaginatum,* and *Suaeda linearis.* These species are typical of the brackish and salt marsh systems.

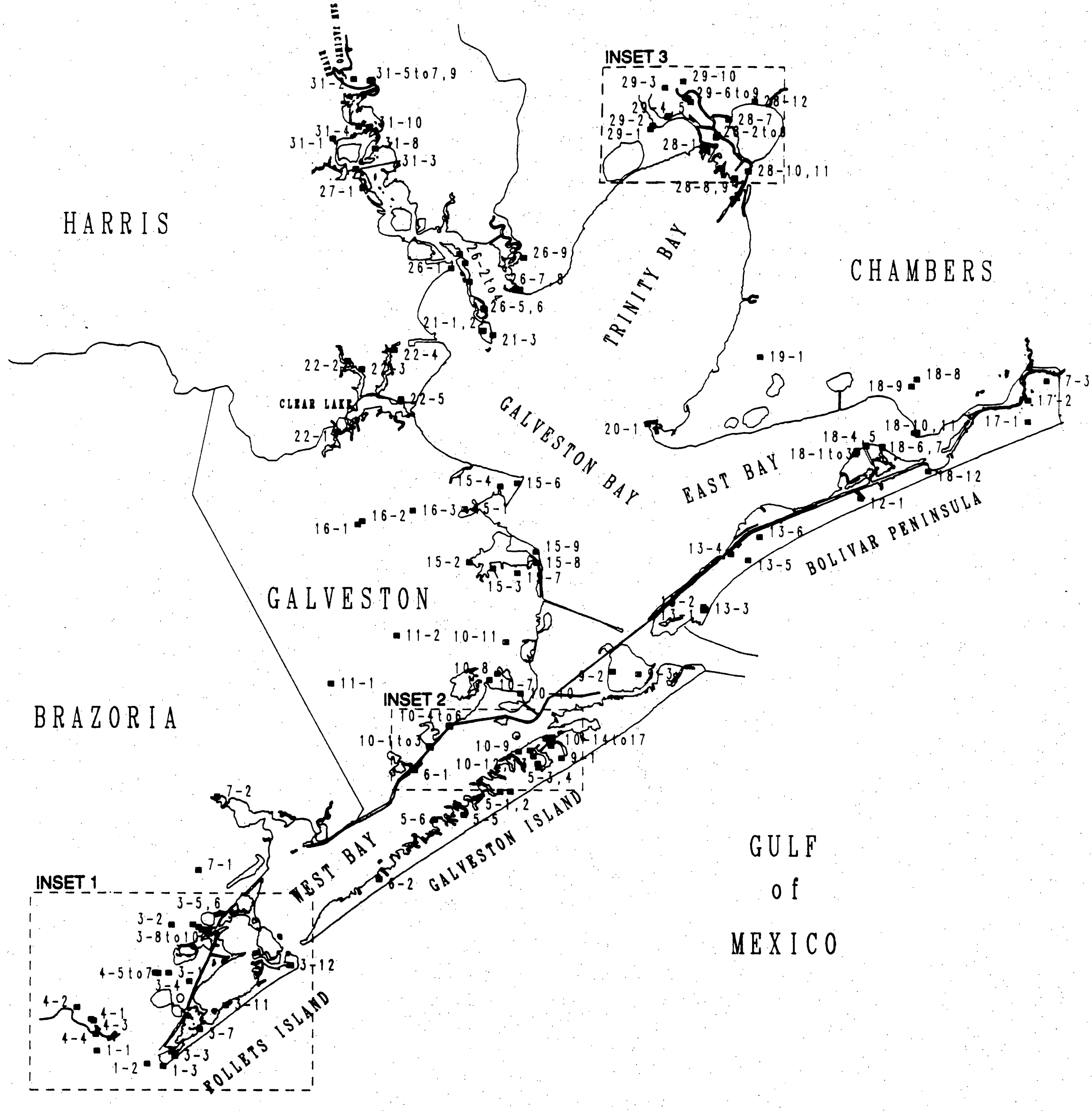


Figure 11. Location map of field survey sites. Inset maps are not shown. From White and Paine (1992).

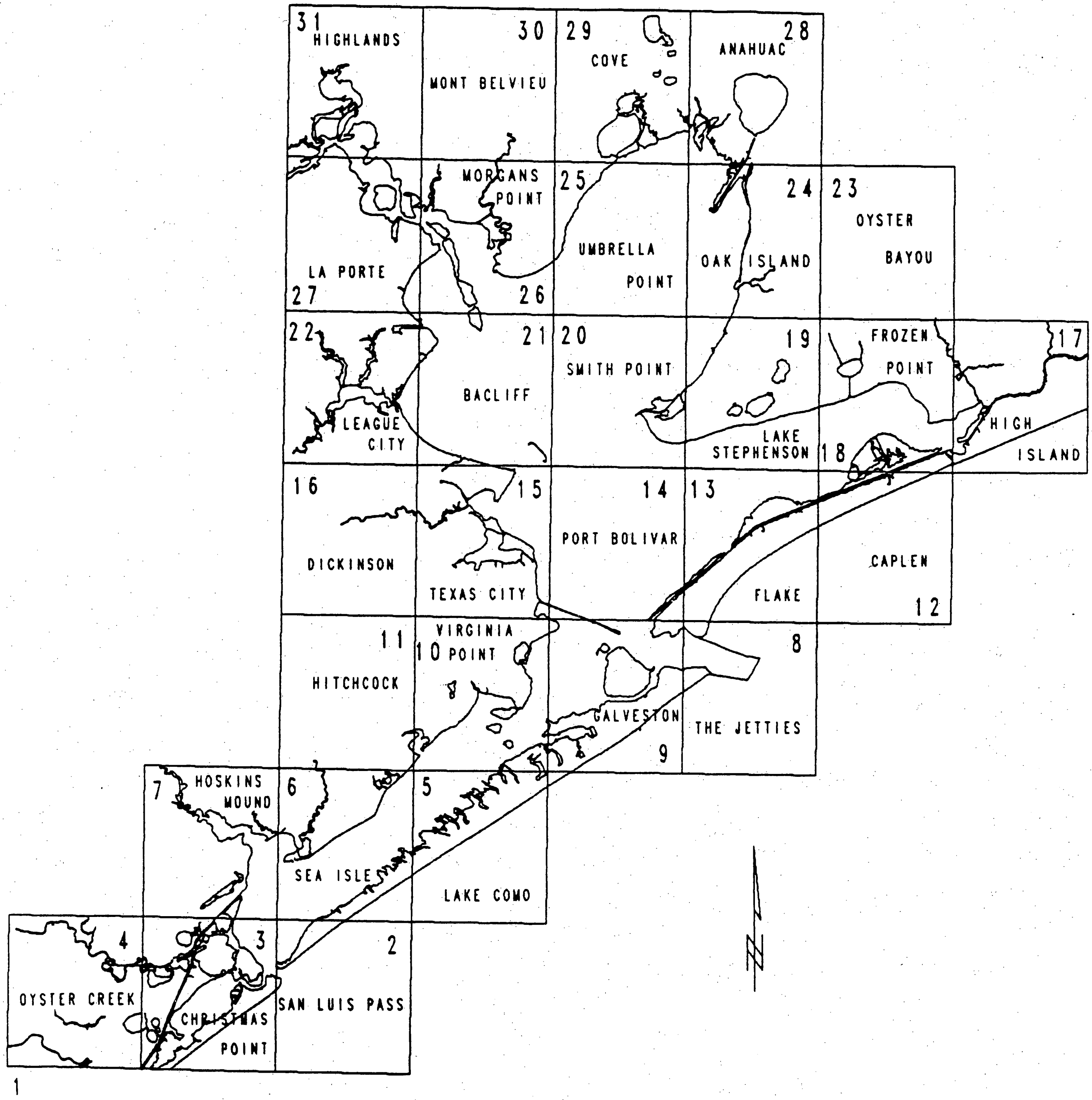


Figure 12. Index map of quadrangles and identifying numbers defining the Galveston Bay study area. The numbers are used in identifying field sites (see fig. 11).

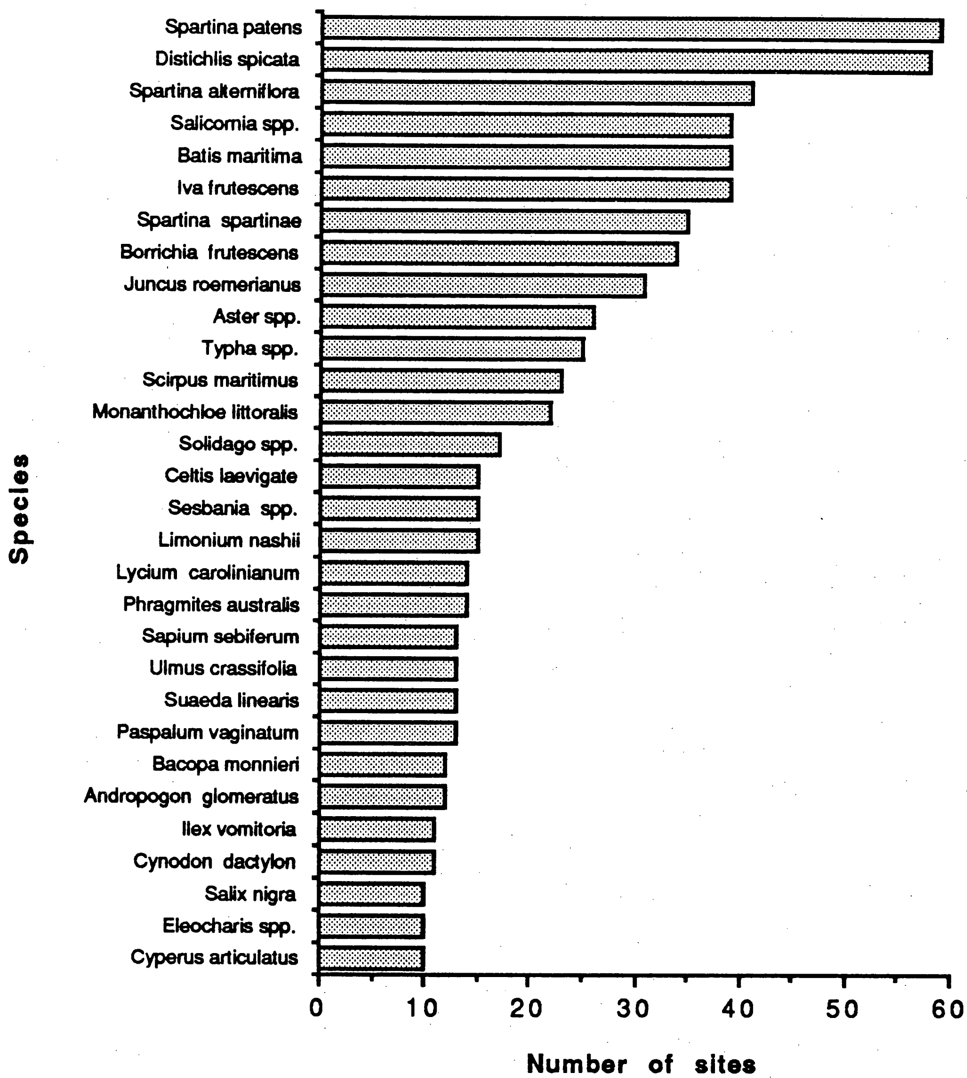


Figure 13. Dominant wetland species determined from field surveys in the Galveston Bay area.

Wetland Indicator Status of Prevalent Plants at Survey Sites

The scientific and common names of plant species identified at field survey sites are presented in table 4. Each species is classified in terms of its wetland indicator status for Region 6, which includes Texas, and for the Nation. The indicator status is based on the "National List of Plant Species That Occur in Wetlands: 1988, Texas" (Reed, 1988). In addition, the habit for each species as defined in the list (Reed, 1988) is presented in table 4.

Of the species identified at the survey sites (fig. 11), about 34 percent are classified as obligate (OBL) wetland plants, which means that under natural conditions these plants occur in wetlands with an estimated probability of 99 percent. Among the species are those typically found in wetter conditions, e.g., those characterizing topographically low salt, brackish, and fresh marshes (figs. 7 and 9). Such species include *Spartina alterniflora, Juncus roemerianus, Batis maritima, Scirpus californicus, Scirpus olneyi, Eleocharis* spp., *Bacopa monnieri, Typha* spp., *Alternanthera philoxeroides,* and *Sagittaria* spp., among others.

Approximately 37 percent of the species listed (table 4) are classified as Facultative Wetland plants (FACW, FACW+, FACW–). These species usually occur in wetlands, or have an estimated probability of 67 to 99 percent of occurring in wetlands; but occasionally they occur in nonwetland areas. Included species are those that typically define topographically higher marshes such as *Borrichia frutescens, Spartina patens, Distichlis spicata* (also common in topographically low marshes) *Spartina spartinae, Phragmites australis, Echinochloa crusgalli, Hydrocotyle bonariensis, Heliotropium curassuvicum,* and *Aster spinosus*, for example. Some Facultative Wetland plants may also occur in wetter, typically low marshes, for instance, *Paspalum vaginatum.*

About 19 percent of the listed species are classified as Facultative (FAC). These species are equally likely to occur in wetlands or nonwetlands (estimated probability 34–66 percent). Such species include grasses like *Setaria geniculata, Paspalum urvillei,* and *Panicum repens.* Many trees such as *Carya illinoensis, Celtis laevigata, Pinus taeda,* and *Ulmus crassifolia* also are listed as Facultative plants.

Only 7 percent of the plants listed are classified as Facultative Upland (FACU). These species are usually not found in wetlands; their estimated probability of occurring in wetlands is 1 to 33 percent. Such species include the grasses *Cynodon dactylon, Andropogon virginicus*, and *Eragrostis spectabilis*.

Wetland Plant Communities and Prevalent Species

In the following discussion of coastal wetland communities in the Galveston Bay system (extracted from White and Paine, 1992), marshes are subdivided into salt, brackish, and fresh communities to assist in the discussions of vegetation composition. A lack of long-term field data precludes the establishment of definite salinity values for these units. Because some plant species can tolerate a relatively large range in salinities (Penfound and Hathaway, 1938; Chabreck, 1972), species tend to overlap between the fresh-marsh and the brackish-marsh communities, and the brackish-marsh and the salt-marsh communities. In addition, wide variation can occur between surface water salinities and pore or ground water salinities, which can affect plant distribution (Webb, 1983). Overlap between communities also occurs between topographically high and low marshes. Some species can tolerate a range in water regimes, or frequencies of inundation, and therefore may occur in wet, low areas as well as in high, dryer areas.

Mapping of wetlands and aquatic habitats follows the classification by Cowardin and others, 1979. As mentioned previously, in general terms, emergent vegetation in the Estuarine system corresponds to salt and brackish marshes, and emergent vegetation in the Palustrine system

Table 4. Wetland indicator status and common names of plants identified in field surveys. Indicator status from Reed (1988). Abbreviations and symbols given at end of table. From White and Paine (1992)

Emergent spp. Scientific name	Emergent spp. Common name	Status, Reg. 6	Status, Nat.	Habit
Acer rubrum	Red maple	FAC	FAC	NT
Acacia angustissima	Fern acacia	not listed		
Alternanthera philoxeroides	Alligator weed	OBL	OBL	PIEF
Ambrosia psilostachya	Western ragweed	FAC-	FACU-, FAC	PNF
Ambosia trifida	Giant ragweed	FAC	FAC,FACW	ANF
Andropogon glomeratus	Bushy bluestem	FACW+	FACW,OBL	PNG
Andropogon virginicus	Broom-sedge	FACU+	FACU,FAC	PNG
Aristida sp.	Three-awn	FACW-to FACU		
Arundo donax	Giant reed	FAC+	FACU-,FACW	PIG
Aster spinosus	Spiny aster	FACW-	FAC, FACW	PNF
Aster subulatus	Annual saltmarsh aster	OBL	FACW,OBL	ANF
Aster tenuifolius	Perennial saltmarsh aster	OBL	OBL	PNF
Baccharis halimifolia	Eastern B., Sea-myrtle	FACW-	FAC,FACW	NS
Bacopa monnieri	Coastal waterhyssop	OBL	OBL	PNF
Batis maritima	Saltwort	OBL	OBL	N$S
Betula nigra	River birch	FACW	FACW,OBL	NT
Borrichia frutescens	Sea oxeye	FACW+	FACW+,OBL	NS
Cardiospermum halicacabum	Balloon vine	FAC	FACU,FAC	AIF
Carya aquatica	Water hickory	OBL	OBL	NT
Carya illinoensis	Pecan hickory	FAC+	FACU,FACW	NT
Celtis laevigata	Sugar-berry	FAC	UPL,FACW	NT
Celtis occidentalis	Common hacberry	FAC	FACU,FAC	NTS
Cephalanthus occidentalis	Common buttonbush	OBL	OBL	NT
Crinum americanum	Swamp lily	OBL	OBL	PNF
Cynodon dactylon	Bermuda grass	FACU+	FACU,FAC	PIG
Cyperus articulatus	Jointed flatsedge	OBL	OBL	PNGL
Cyperus elegans	Sticky flatsedge	FACW-	FACW-,FACW	PNGL
Cyperus oxylepis	Sharp-scale flatsedge	FACW	FACW	PNEGL
Cyperus virens	Green flatsedge	FACW	FACW	PNEGL
Dichromena colorata	Starrush whitetop	FACW	FACW	PNGL
Distichlis spicata	Seashore saltgrass	FACW+	FAC+,FACW+	PNG
Desmodium canadense	Tickclover	FAC	FACU, FAC	PNF
Echinochloa crusgalli	Barnyard grass, water millet	FACW-	FACU,FACW	AIG
Eichhornia crassipes	Common water-hyacinth	OBL	OBL	PNE/F (I-Ck.Lst.)
Eleocharis parvula	Dwarf spikesedge	OBL	OBL	PNGL
Eleocharis cellulosa	Gulf Coast spikesedge	OBL	OBL	PNGL
Eleocharis microcarpa	Small-fruit spikerush	OBL	OBL	ANEGL
Eleocharis quadrangulata	Squarestem spikesedge	OBL	OGL	PNEGL
Eleocharis lanceolata ?	Lanceleaf spikesedge	OBL	OBL	PNGL
Eleocharis sp.	Spikesedge	OBL?	OBL?	PIG?
Eragrostis spectabilis	Purple lovegrass	FACU-	UPL,FACU	PNG
Eustachys petraea	Pinewoods finger grass	FAC-	FACU-, FAC	NG
Fimbristylis castanea	Marsh fimbry	OBL	OBL	PNEGL
Forestiera acuminata	Swamp privet	OBL	OBL	NST
Fraxinus caroliniana	Carolina ash	OBL	OBL	NETS
Fraxinus pennsylvanica	Green ash	FACW-	FAC,FACW	NT
Gleditsia aquatica	Water locus	OBL	OBL	NET
Halodule wrightii	Shoalgrass	OBL	OBL	PNZF
Heliotropium curassavicum	Seaside heliotrope	FACW	FACW,OBL	API$F
Hydrocotyle bonariensis	Coastal plain penny-wort	FACW	FACW	PNF
Hymenocallis caroliniana	Carolina spider lily	FACW	FACW	PNF

Table 4 (cont.)

Emergent spp. Scientific name	**Emergent spp. Common name**	**Status, Reg. 6**	**Status, Nat.**	**Habit**
Ilex vomitoria	Yaupon	FAC-	FAC-,FAC	NST
Ipomea sp.	Morning glory	FAC?	FAC?	?
Iva annua	Annual sumpweed, marsh-elder	FAC	FAC	AIF
Iva angustifolia	Narrowleaf sumpweed	Not listed		
Iva frutescens	Big-leaf sumpweed	FACW	FACW,FACW+	PNH$F
Juncus effusus	Soft rush	OBL	FACW+,OBL	PNEGL
Juncus roemerianus	Needlegrass rush	OBL	OBL	PNGL
Lemna sp.	Duckweed	OBL	OBL	PN/F
Leptochloa uninervia	Mexican Spangle-Top	FACW	FACW-,FACW	ANG
Limonium nashii	Sea-lavender	NA*	OBL	PNF
Liquidambar styraciflua	Sweet gum	FAC	FAC,FACW	NT
Lolium perenne	Perennial ryegrass	FACU	FACU-, FAC	PIG
Ludwigia leptocarpa	River seedbox	OBL	OBL	PNEF
Lycium carolinianum	Carolina wolf-berry	FACW	VACW	NS
Machaeranthera phyllocephala	Camphor daisy	FACW	FACU,FACW	ANF
Medicago minima	Small medic	Not listed		
Monanthochloe littoralis	Shoregrass	OBL	OBL	PNEG
Nelumbo lutea	American lotus	OBL	OBL	PNZ/F
Nothoscordum bivalve	False garlic	FACU	FACU	PNF
Panicum dichotomiflorum	Fall panic grass	FACW	FAC,FACW	ANG
Panicum hians	Gaping panicum	FACW-	FACW-,OBL	PNG
Panicum virgatum	Switchgrass	FACW	FAC,FACW	PNG
Panicum repens	Torpedograss	FAC+	FAC+, FACW-	PIG
Parkinsonia aculeata	Retama	FACW-	FAC-,FACW	NT
Paspalum floridanum	Florida paspalum	FACW-	FACW-,FACW	PNG
Paspalum lividum	Longtom	OBL*	OBL	PNEG
Paspalum monostachyum	Gulfdune paspalum	FACW+	FACW,FACW+	PNG
Paspalum urvillei	Vasey grass	FAC	FAC	PIG
Paspalum vaginatum	Seashore paspalum	FACW+	FACW,OBL	PNG
Phragmites australis	Common reed	FACW	FACW,FACW+	PNEG
Phyla lanceolata	Lance leaf frog fruit	FACW	FACW,OBL	PNF
Physostegia intermedia	Intermediate Lionsheart	OBL	FACW-, OBL	PNF
Pinus taeda	Loblolly pine	FAC-	UPL,FAC	NT
Planera aquatica	Water elm	OBL	OBL	NET
Platanus occidentalis	American sycamore	FAC+	FAC,FACW	NT
Pluchea purpurascens	Saltmarsh camphor-weed	OBL	FACW+,OBL	AIEF
Pologonum hydropiperoides	Swamp smartweed	OBL	OBL	PNEF
Polygonum ramosissimum	Bushy knotweed	FACW	FACU-,FACW	ANF
Populus deltoides	Eastern cotton-wood	FAC	FAC,FACW	NT
Quercus phellos	Willow oak	FACW	FAC+,FACW	NT
Quercus falcata	Southern red oak	FACU	FACU-,FACU	NT
Quercus nigra	Water oak	FAC+	FAC,FACW	NT
Quercus virginiana	Live oak	FACU+	FACU,FACU+	NT
Ruppia maritima	Widgeon-grass	OBL	OBL	PNZF
Sabal minor	Dwarf palmetto	FACW	FACW	NST
Sabatia campestris	Prairie rose-gentian	FACU	FACU	ANF
Sagittaria falcata	Coastal arrow-head	OBL	OBL	PNEF
Sagittaria lancifolia	Bull-tongue arrow-head	OBL	OBL	PNEF
Salicornia bigelovii	Annual glasswort	0BL*	OBL	ANE$F
Salicornia virginica	Perennial glasswort	OBL*	OBL	PNE$F
Salix nigra	Black willow	FACW+	UPL, OBL	NT
Sapium sebiferum	Chinese tallow	FACU+	FACU+,FAC	IT
Scirpus americanus	Olney's (American) bulrush	OBL	OBL	PNEGL
Scirpus californicus	California bulbush	OBL	OBL	PNEGL
Scirpus maritimus	Saltmarsh bulrush	NI	OBL	PNEGL
Scirpus olneyi (S. americanus)	Olney's bulrush	OBL	OBL	PNEGL
Sesbania drummondii	Drummond's rattle-bush	FACW	FACW	NSH
Sesuvium portulacastrum	Sea-purslane	FACW	FACW	PN$F
Setaria geniculata	Knotroot bristlegrass	FAC	FAC	PNG
Setaria magna	Giant bristlegrass	FACW	FACW,FACW+	ANEG
Sisyrichium exile	Yellow blue-eyed grass	FACW	FAC, FACW-	AIF

Emergent spp. Scientific name	Emergent spp. Common name	Status, Reg. 6	Status, Nat.	Habit
Solidago altissima	Tall goldenrod	FACU	FACU-, FACU+	PNF
Solidago sempervirens	Seaside golden-rod	FACW-	FACW-,FACW	PN$F
Spartina spartinae	Gulf cordgrass	FACW+	FACW+,OBL	PNG
Spartina alterniflora	Smooth cordgrass	OBL	OBL	PNEG
Spartina cynosuroides	Big cordgrass	OBL	OBL	PNEG
Spartina patens	Saltmeadow (marshhay) cordgrass	FACW	FACW,OBL	PNG
Spartina pectinata	Prairie cordgrass	FACW+	FACW,OBL	PNG
Spiranthes ovalis	October ladiestresses	FAC*	FAC	PNF
Sporobolus virginicus	Seashore dropseed	FACW+	FACW+	PNG
Sphenoclea zeylanica	Chicken-spike (piefruit)			
Suaeda linearis	Annual seepweed	OBL	OBL	ANEF
Tamarix gallica	Salt cedar	FACW	FAC, FACW	IT
Taxodium distichum	Bald cypress	OBL	OBL	NET
Thalassia testudinum	Turtle-grass	OBL	OBL	PNZF
Teucrium cubense	Small coast germander	FAC+	UPL, FACW	APNF
Typha spp.	Cattail	OBL	OBL	PNEF
Ulmus americana	American elm	FAC	FAC,FACW	NT
Ulmus crassifolia	Cedar elm	FAC	FAC	NT
Vigna luteola	Cowpea	FACW-	FACW-,FACW	PNVF
Zizaniopsis miliacea	Marsh millet, giant cutgrass	OBL	OBL	PNG

Habitat symbols	Characteristic or life form
A =	Annual
E =	Emergent
F =	Forb
/ =	Floating
G =	grass
GL =	Grass like
H =	Partly woody
HS =	Half shrub
I =	Introduced
N =	Native
P =	Perennial
S =	Shrub
Z =	Submerged
$ =	Succulent
T =	Tree
V =	Herbaceous vine
WV =	Woody vine
NA =	No agreement by regional panel
* =	Tentative assignment based on limited information
"+"=	More frequently found in wetland
"-"=	Less frequently found in wetland

ABBREVIATION	INDICATOR CATEGORY	DESCRIPTION
OBL	Obligate wetland	Occur almost always (est. prob. >99%) under natural conditions in wetlands.
FACW	Facultative wetland	Usually occur in wetlands (est. prob. 76-99%), but occasionally found in nonwetlands.
FAC	Facultative	Equally likely to occur in wetlands or nonwetlands (est. prob. 34-66%).
FACU	Facultative upland	Usually occur in nonwetlnads (est. prob. 67-99%), but occasionally found in wetlands (e.p. 1-33%).
UPL	Obligate upland	Occur in wetlands in another region, but occur almost always (e.p. >99%) under natural conditions in nonwetlands

corresponds to fresh marshes (table 3). Water regimes used as modifiers in classifying and mapping wetlands help define high and low wetlands (table 2).

Salt-Marsh Community (Estuarine Intertidal Emergent Wetlands)

Salt marshes were examined principally on Follets and Galveston Islands, and Bolivar Peninsula, along the inland margin of West Bay, near Texas City, and at Houston and Smith Points (White and Paine, 1992). Prevalent species in the salt-marsh community include *Spartina alterniflora* (smooth cordgrass), *Batis maritima* (saltwort), *Distichlis spicata* (saltgrass), *Salicornia virginica* and *S. bigelovii* (glasswort), *Borrichia frutescens* (sea-oxeye), *Monanthochloe littoralis* (shoregrass), *Juncus roemerianus* (needlegrass rush or blackrush), *Suaeda linearis* (seepweed), *Scirpus maritimus* (salt-marsh bulrush), *Limonium nashii* (sea-lavender), *Aster tenuifolius* (perennial saltmarsh aster) and *Lycium carolinianum* (Carolina wolfberry). Many of these species, such as smooth cordgrass, saltwort, saltgrass, and glasswort, are common in areas mapped as regularly-flooded estuarine intertidal areas (E2EM1N, fig. 7). At higher elevations, *Spartina patens* (marshhay cordgrass) and *Spartina spartinae* (Gulf cordgrass) occur, although these species are more common in brackish marshes. *Iva frutescens* (big-leaf sumpweed) is locally abundant at higher elevations such as along natural levees. These species—marshhay cordgrass, Gulf cordgrass, and big-leaf sumpweed—are among those that characterize irregularly flooded estuarine emergent wetlands (fig. 8).

The low salt-marsh community is dominated by *Spartina alterniflora*, which lives in the intertidal zone (fig. 14). Species intermixed most frequently with *Spartina alterniflora* along the upper part of the intertidal zone include *Batis maritima* (fig. 15), *Distichlis spicata, Scirpus maritimus, Juncus roemerianus*, and *Salicornia virginica*.

Wind-tidal sand flats are common features in some areas, especially on the barrier islands. Although algal mats are abundant in these areas, the flats are generally barren of emergent vegetation because of intermittent salt-water flooding and subsequent evaporation—a process that concentrates salts and inhibits the growth of most plants. Soil salinities on the flats can reach concentrations high enough to kill *Spartina alterniflora* and *Spartina patens* (Webb, 1983). The flats may locally have scattered salt-marsh vegetation. Common plant species are *Salicornia virginica, Salicornia bigelovii, Monanthochloe littoralis*, and *Batis maritima*. Zonation of some salt-marsh species is well defined by elevation transects at Smith Point, in the Brazoria National Wildlife Refuge, and other locations (see section on "Examples of Wetland Profiles Developed from Topographic Surveys" and appendix C).

The salt-marsh community corresponds in general terms to salt marshes (and locally, salt flats) defined by Shaw and Fredine (1956), Fisher and others (1972, 1973), Gosselink and others (1979), and White and others (1985), and to saline wetland species identified by Lazarine (n.d.). In accordance with the classification of wetlands by Cowardin and others (1979), this community is designated (down to class) as estuarine, intertidal, emergent wetland (E2EM). The water regime modifier, "regularly flooded" (N), is used most frequently to identify low-salt marshes; the modifier, "irregularly flooded" (P), is used to define higher marshes (table 2). (The classification by Cowardin and others has provisions for going beyond the class level and designating species dominance type, water chemistry, and human modifications; examples of the classification given here, however, will be only down to class and water regime.)

Brackish-Marsh Community (Estuarine Intertidal Emergent Wetlands)

The brackish-marsh community is transitional between salt marshes and fresh marshes. These areas are affected both by storm-tidal flooding from bay-estuary-lagoon and Gulf waters and by fresh-water inundation from rivers, precipitation and runoff, or ground water. Because the brackish-marsh community encompasses a range in salinities from near fresh to near saline, the

Figure 14. Low salt-marsh community (E2EM1N) of *Spartina alterniflora*, and open water on the inland margins of Jones Bay (east end of West Bay). Site No. 10-7 (fig. 11), Virginia Point quad. View is toward Galveston Island.

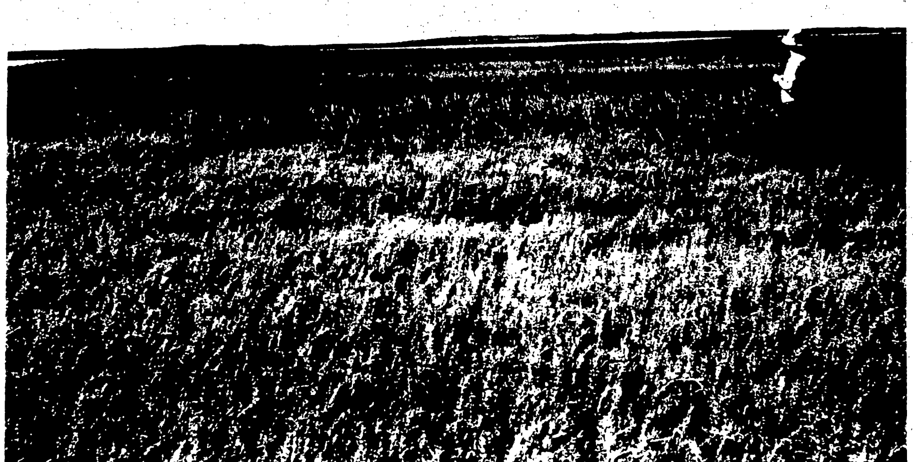


Figure 15. Salt-marsh community (E2EM) on Follets Island. *Batis maritima* in foreground, intergrades with *Spartina alterniflora* in background. Site No. 3-3 (fig. 11), Christmas Point quad. View is landward. See survey line at this site in appendix C.

vegetation types cover a broad spectrum. Species range from those typical of saline marshes to those that occur in fresh marshes.

Areas in which brackish-marsh surveys were conducted included the Brazoria National Wildlife Refuge (figs. 16 and 17), Anahuac National Wildlife Refuge and near High Island, Galveston, and Follets Islands, and Trinity River delta. Among the dominant species in topographically higher areas of this community are *Spartina patens* (salt meadow cordgrass), *Spartina spartinae* (gulf cordgrass), *Borrichia frutescens* (sea oxeye), *Phragmites australis* (common reed), *Solidago sempervirens* (seaside goldenrod), *Panicum virgatum* (switchgrass) and *Spartina cynosuroides* (big cordgrass). Other prevalent species, most of which occur in lower, wetter areas (relative to the cordgrasses) include *Scirpus maritimus* (salt marsh bullrush), *Scirpus olneyi* (*olney bulrush*), *Juncus roemerianus* (needlegrass rush), *Typha* spp. (cattail), *Paspalum vaginatum* (seashore paspalum), *Scirpus californicus* (California bulrush), *Scirpus americanus* (three-square bulrush), *Alternanthera philoxeroides* (alligatorweed), *Eleocharis* sp. (spikesedge), *Bacopa monnieri* (coastal waterhyssop), *Echinochloa crusgalli* (barnyard grass or water millet), and *Aster tenuifolius* and *A. subulatus* (saline and saltmarsh aster), among others. *Spartina alterniflora* (smooth cordgrass) also occurs locally in the brackish-marsh community (fig. 16). Zonation of various species with respect to elevation are illustrated by marsh profiles on the Trinity River delta and in the Brazoria and Anahuac National Wildlife Refuges (appendix C). There are considerable differences in brackish marsh composition in the Brazoria and Anahuac National Wildlife Refuges compared to brackish marshes in the Trinity River delta. In general, the Trinity River delta, which has extensive areas of *Alternanthera philoxeroides* and other species occurring in fresher areas, is toward the fresh end of the brackish salinity spectrum.

The brackish-marsh community corresponds, generally, with the coastal salt meadows (grading into fresh marshes) defined by Shaw and Fredine (1956), the brackish (closed) and brackish- to fresh-water marsh by Fisher and others (1972, 1973), the brackish and intermediate marsh by Gosselink and others (1979), and the brackish marsh by Harcombe and Neaville (1977) and White and others (1985). In the classification system of Cowardin and others (1979) this community is generally designated (down to class) as estuarine, intertidal, emergent wetland (E2EM). Water regimes are generally the same as for the salt marshes—regularly flooded (N) (low marshes) and irregularly flooded (P) (high marshes).

Spartina spartinae is a common species in brackish marshes (fig. 17). Because of its tendency to occur mostly in topographically higher areas, it has been placed in the marsh, transitional (occurring between wetlands and uplands), and prairie communities by various researchers. It occurs in many areas in conjunction with *Spartina patens*, becoming more predominant and extensive (relative to *Spartina patens*) south of the Galveston Bay area along the Texas coast. Tharp (1926) listed *Spartina spartinae* as a dominant species in the coastal marsh community, but also included it as part of a coastal prairie-marsh transition community. McAtee (1976) noted that *Spartina spartinae* flourishes at an elevation between lowland marshes and higher uplands, and apparently requires periodic inundation. The U.S. Army Corps of Engineers, which has jurisdictional responsibilities for wetlands, considers it to be a transitional species (Lazarine, n.d.). Many classifications place it in wetlands, transitional areas, and prairie grasslands (Fisher and others, 1972, 1973; Correll and Correll, 1975; White and others, 1985), presumably depending on associated plants and soil-moisture conditions reflecting inundation frequency. In the list of wetland plants of Texas (Reed, 1988), *Spartina spartinae* is categorized as usually found in wetlands, but occasionally found in nonwetlands. Harcombe and Neaville (1977) place it in their cordgrass prairie unit, but also list it in a checklist of marsh species and note that it probably once was more extensive (in Chambers County) as an intermediate type between upland prairie and brackish marsh. Fleetwood (n.d.) reported that *Spartina spartinae* was the predominant species in his salty prairie community.

Brackish marshes dominate the coastal marsh community between High Island and Trinity Bay (fig. 6). They are also widely distributed along the lower reaches of the Trinity bay-head delta below Interstate Highway 10, inland from parts of West Bay and the Intracoastal Waterway in the Christmas Bay area. They occur in swales and intergrade with salt marshes and sand flats on Galveston Island and Bolivar Peninsula.

Figure 16. Brackish-marsh community (E2EM1P and E2EM1N) in the Brazoria National Wildlife Refuge southwest of Hoskins Mound. Although dominant species are *Spartina patens* and *Distichlis spicata*, *Spartina alterniflora* occurs along the tidal channel. *Ruppia maritima* (widgeongrass) occurs in the channel. Site No. 3-2 (fig. 11), Christmas Point and Oyster Creek quads. View is landward. This site is on the Oyster Creek quad. at the west end of the survey line at this site. See survey line in appendix C.

Figure 17. Brackish-marsh community (E2EM1P) in the Brazoria National Wildlife Refuge east of Hoskins Mound. *Spartina spartinae* is dominant in the foreground, and *Juncus roemerianus* in the background. Site No. 7-1 (fig. 11), Hoskins Mound quad. Several elevation surveys were conducted in this area (appendix C).

Fresh-Marsh Community (Palustrine Emergent Wetlands)

Surveys of fresh to intermediate marshes were conducted along the Trinity (figs. 18 and 19) and San Jacinto Rivers and at other inland sites. Environments in which fresh marshes occur are generally beyond the limits of salt-water flooding except perhaps locally during hurricanes. The fresh-water influence from rivers, precipitation, runoff, and ground water is sufficient to maintain a fresher water vegetation community (although many species also occur in brackish marshes) consisting of species such as *Typha* spp., *Phragmites australis*, *Zizaniopsis miliacea* (marsh millet or giant cutgrass), *Sagittaria falcata* (coastal arrow-head), *Scirpus californicus*, *Eleocharis quadrangulata* (squarestem spikesedge) and other species of *Eleocharis*, *Cyperus* spp. (flatsedge), *Bacopa monnieri*, *Alternanthera philoxeroides*, *Paspalum lividum* (longtom), and *Eichhornia crassipes* (water hyacinth) in lower, wetter areas. Topographically higher areas generally include such species as *Phragmites australis*, *Paspalum* spp., *Polygonum* sp. (smartweed), *Panicum* spp. (panic grass), *Rhynchospora* spp. (beakrush), and *Aster spinosus* (spiney aster). Riverine and tidally influenced fresh-water marshes, along the lower reaches of the Trinity and San Jacinto Rivers for example, are functionally different from interior nontidal-influenced fresh-water marsh areas. Tidally influenced fresh-water systems were designated on maps with special water-regime modifiers (table 2). Shrubs such as *Sesbania drummondii* (rattlebush) are scattered around the margins of some fresh marshes and are locally abundant. Some species that are more common in brackish marshes such as *Spartina spartinae* may also occur in fresh marshes. Harcombe and Neaville (1977) used *Spartina patens* as an indicator of brackish conditions in differentiating brackish from fresh marshes.

The fresh-marsh community corresponds to the deep fresh and shallow fresh marshes of Shaw and Fredine (1956), inland fresh-water marsh and, locally, brackish- to fresh-water marsh of Fisher and others (1972, 1973), and fresh marsh of Fleetwood (n.d.), Harcombe and Neaville (1977), Gosselink and others (1979), and White and others (1985). Following the classification by Cowardin and others (1979) this community could be designated (down to class) as palustrine, emergent wetland (PEM) in areas where persistent emergent vegetation such as *Typha* spp. is present, and palustrine aquatic bed (PAB), where floating vascular plants such as *Eichhornia crassipes* occur. A variety of water regimes can be applied under the Cowardin system. Low fresh marshes are usually characterized by the "semipermanently flooded" (F) or "seasonally flooded" (C) water regimes, and higher marshes by the "temporarily flooded" (A) regime, and occasionally the "seasonally flooded" regime. Fresh-water marshes in tidally influenced areas, have a different set of modifiers ranging from "semipermanently flooded—tidal" (T) to "temporarily flooded—tidal" (S) (table 2). These regimes are applicable along river systems, for example, and have been applied to some fresh marshes in the Trinity River delta.

Fresh marshes occur inland along river or fluvial systems and in upland basins and depressions on the mainland and locally on the barrier islands. Upstream along the river valleys of the Trinity and San Jacinto Rivers, salinities decrease and fresh marshes intergrade with and replace brackish marshes (fig. 18). Fresh marshes also occur locally in swales on the modern barrier islands, on the Pleistocene barrier strandplain, and in abandoned channels and courses of the Pleistocene fluvial-deltaic systems (fig. 6).

Forested Wetland Communities (Swamps) (Palustrine Forested Wetlands)

Forested wetlands as defined by Cowardin and others (1979) include swamps as well as forested areas less frequently inundated. Swamps, as defined most commonly, are woodlands or forested areas that contain saturated soils or are inundated by water during much of the year. This community is located almost entirely in the alluvial valley of the Trinity River. The swamp community is composed principally of *Taxodium distichum* (bald cypress) (fig. 20). Associated species may include *Cephalanthus occidentalis* (buttonbush), *Planera aquatica* (water elm), and *Carya aquatic* (water hickory) (Harcombe and Neaville, 1977).

Figure 18. Fresh-marsh community (PEM1T) in the Trinity River valley north of Interstate Highway 10. Species include *Cyperus articulatus*, *Sagittaria falcata*, *Scirpus californicus*, *Zizaniopsis miliacea*, and *Alternanthera philoxeroides*. Site No. 29-3 (fig. 11), Cove quad. View is westward.

Figure 19. Fresh- to brackish-marsh community (included in area mapped as E2EM1P) on the Trinity River delta near Old River Lake. Species include *Zizaniopsis miliacea*, *Sagittaria falcata*, and *Alternanthera philoxeroides*. Site No. 29-2 (fig. 11), Cove. View is northwest.

Figure 20. Swamp community, or forested wetlands (PFO2T), dominated by *Taxodium distichum* along the Trinity River north of Interstate Highway 10. Northeast of site 29-10 (fig. 11), Anahuac quad.

Areas along the floodplains of streams (excluding swamps) support assemblages of water-tolerant trees and shrubs that are inundated less frequently than swamps. Trees and shrubs occurring in these areas include *Planera aquatica* (water elm), *Quercus phellos* (willow oak), *Quercus nigra* (water oak), *Fraxinus pennsylvanica* (green ash), *Fraxinus caroliniana* (Carolina ash), *Salix nigra* (black willow), *Ulmus* spp. (elm), *Celtis laevigata* (sugar-berry), *Carya illinoensis* (pecan hickory), *Carya aquatica* (water hickory), *Cephalanthus occidentalis* (button bush), *Ilex vomitoria* (yaupon), *Liquidambar styraciflua* (sweet gum), *Sapium sebiferum* (Chinese tallow), *Parkinsonia aculeata* (retama), *Gleditsia aquatica* (water locus), and *Sabal minor* (dwarf palmetto). Occurring with hardwoods in some topographically higher areas is *Pinus taeda* (loblolly pine).

Submerged Vegetation Community (Estuarine Subtidal Aquatic Bed)

Submerged vegetation has a limited distribution in the Galveston Bay system. It occurs principally in patches along the margins of the Trinity River delta, upper Trinity Bay, and Christmas Bay (Pulich and White, 1991). Plant species occurring in the comparatively fresh area of the Trinity River delta include *Ruppia maritima* (widgeongrass), *Vallisneria americana* (wild celery), *Potamogeton pusillus* (pondweed), and *Najas quadalupensis* (water nymph) (Pulich and others, 1991). The dominant submerged vegetation along the north and eastern shores of upper Trinity Bay is *Ruppia maritima* (Pulich and White, 1991). In the Christmas Bay area, near Follets island, several true seagrasses occur including *Halodule wrightii* (shoalgrass), the dominant species, *Halophila engelmannii* (clovergrass), and *Thalassia testudinum* (turtlegrass) (Pulich and White, 1991). *Ruppia maritima* is abundant in many inland water bodies and tidal creeks (fig. 16).

The submerged-vegetation community is classified under sounds and bays by Shaw and Fredine (1956); as grassflats by Fisher and others (1972, 1973) and White and others (1985); and as submerged vegetation by Diener (1975). Submerged-vegetation communities are designated as estuarine, subtidal, aquatic bed (E1AB) in the classification by Cowardin and others (1979); the water-regime modifier is "subtidal" (L) (table 2).

Soils and Wetland Community Relationships

At 135+ sites surveyed around the Galveston Bay system, approximately 40 soil types were identified from county soil surveys (appendix A). Several soils were encountered more frequently than others, and can be considered the dominant soils corresponding to wetland communities. For example, the soil most frequently occurring at wetland survey sites was the Harris clay. This typically saline, poorly-drained soil is flooded by abnormally high tides, and supports a vegetation assemblage composed predominantly of *Spartina patens* and *Distichlis spicata*. These species were the most frequently encountered during field surveys.

To simplify the discussion of soil types and their relationships to wetland communities, Marsh Rangeland Sites defined by Crenwelge and others (1988) in the soil survey of Galveston County will be used for comparing soils with wetland communities described in this report. Marsh Rangeland Sites (Crenwelge and others, 1988) include the following 8 sites:

(1) The **Salt Marsh Range Site**, with elevations of 0.3 to 1.2 m (1 to 4 ft) above mean sea level, occurs in relatively level coastal marsh areas and in flood plains. It is composed of the Harris clay (Ha and 19), Placedo clay (Pd), and Veston loam, strongly saline (Vx). Almost 40 sites, or about 30 percent of all the sites surveyed, corresponded to the Salt Marsh Range Site complex as defined by Crenwelge and others (1988). Based on field survey locations, the wetland communities that were typically found on these soils are brackish-water and salt-water marshes (as mapped by White and others, 1985 [see White and Paine, 1992]). These communities make up 70 percent of the survey sites within the Salt Marsh Range. High brackish-water marshes

represent 30 percent of the sites. Among the dominant species in high brackish- and high salt-water marshes are *Spartina patens* and *Distichlis Spicata* (fig. 8).

(2) The **Tidal Flat Range Site** corresponds to broad coastal tidal marshes at elevations slightly below mean sea level to about 0.3 m (1 ft) above mean sea level. It consists of the Follet clay loam (Fo), Tatlum clay loam (Ta), and the Tracosa soil in the Caplen-Tracosa complex (Ct), the Tracosa mucky clay (Tm), and the Tracosa mucky clay-clay, low complex (Tx). Approximately 15 percent of the field survey sites are located within the Tidal Flat Range Site. The predominant wetland communities (as defined and mapped by White and others, 1985) are proximal salt-water marshes, which represent about 70 percent of the field survey sites located in the Tidal Flat Range Site. The predominant vegetation is *Spartina alterniflora;* other species may include *Batis maritima, Distichlis spicata, Salicornia* spp., *Scirpus maritimus,* and *Juncus roemerianus.*

(3) The **Salt Flat Range Site** occurs in nearly level coastal marshes with elevations slightly above to about 1 m (3 ft) above mean sea level. Soils of this range site are strongly saline Mustang fine sand (Ms) and very strongly saline Veston loam (Vx). Sixteen survey sites were located within these soils, or slightly more than 10 percent of all sites surveyed. Wetland communities represented on the Salt Flat Range site are predominantly salt-water marshes, but some include transitional areas and mixtures of marshes and sand flats. Vegetation includes *Batis maritima, Monanthochloe littoralis, Salicornia* spp., *Borrichia frutescens, Distichlis spicata, Limonium nashii, Lycium carolinianum* and others.

(4) The **Low Coastal Range Site** consists of level to gently sloping coastal sands that roughly parallel the Gulf shoreline; elevations are less than 3 m (10 ft) above mean sea level. Soils in this range site are the Galveston soil in the Galveston-Nass complex (Gc) and Nass-Galveston complex (Nx), and Mustang soils in Mustang fine sand (Mn), Mustang-Nass complex (Mt), and Mustang fine sand, slightly saline (Ms). The Galveston and Mustang soils are at elevations generally too high for marsh development, and therefore, correspond most frequently to uplands (U) and possibly transitional areas. Wetlands occur in the Nass soils of the Gc and Nx complexes (see Coastal Swale Range Site).

(5) The **Coastal Swale Range Site** occurs in swales between beach ridges and in shallow depressions on nearly level coastal flats. Soils in this range site are principally in the Nass soil of the Galveston-Nass complex (Gc), the Mustang-Nass complex (Mt), and the Nass-Galveston complex, shell substratum (Nx). Vegetation communities were surveyed at nine sites corresponding to soils in the Coastal Swale Range Site. The areas surveyed were mostly located on Galveston Island, much of which is characterized by relict beach ridge and swale topography. Vegetation communities are predominantly defined by brackish- and salt-water marshes, both low and high marshes (White and others, 1985). Vegetation includes *Spartina patens, Distichlis spicata, Paspalum vaginatum, Paspalum monostachyum, Monanthochloe littoralis, Spartina spartinae, Juncus roemerianus, Salicornia* spp., and *Borrichia frutescens.*

(6) The **Deep Marsh Range Site** commonly corresponds with marshes near bays and bayous where tidal-water salinities are lower because of saltwater and freshwater mixing. Elevations range from mean sea level to 0.3 m (1 ft) above. Soils include the Caplen mucky silty clay loam (Ca), and the Caplen soil in the Caplen-Tracosa complex (Ct). Dominant vegetation is *Spartina patens* and *Distichlis spicata. Spartina cynosuroides* has been a dominant species on this range site in the past, but has been replaced principally by *Spartina patens* (Crenwelge and others, 1988). Depending on water depth and salinities, *Sagittaria* and bulrushes may also occur in this marsh range site. Only two survey sites (high, or distal, salt-water marshes) occur within this range site.

(7) The **Salty Prairie Range Site** occurs on broad, relatively level coastal flats and marshes, where elevations range from 0.6 to 2.4 m (2 to 8 ft) above mean sea level. Among the soils characterizing this range site is the Ijam soil in the Ijam clay, 0- to 2-percent slopes (ImA), and 2- to 8-percent slopes (ImB), Narta fine sandy loam (Na), Sievers loam (SeB), and slightly saline Veston loam (Vx). Most of the survey sites in this range site correspond to the Ijam soils, which might be considered a disturbed soil complex. Ijam soils are formed in saline, clayey, marine,

and alluvial sediment deposits that were dredged to construct and maintain canals or waterways. Plant communities on these soils vary widely because of the variations in salinities and elevations that characterize this range site. Plant communities may include brackish- and salt-water marshes, flats, transitional areas, and uplands. The dominant vegetation in many topographically higher areas is *Spartina spartinae*. Other species may include *Borrichia frutescens*, *Panicum virgatum*, *Spartina patens*, *Phragmites australis*, and *Setaria geniculata*.

(8) The **Coastal Sand Range Site** is composed of nearly level to undulating coastal ridges that parallel the Gulf shoreline. Elevations, which are as much as 3.7 m (12 ft) above mean sea level, preclude marsh development on this range site.

Examples of Wetland Profiles Developed from Topographic Survey Transects

Topographic surveys of marsh communities were conducted at selected sites around the Galveston Bay system. These data are presented in appendix C. Descriptions of the zonation of plant species along two transects are presented here.

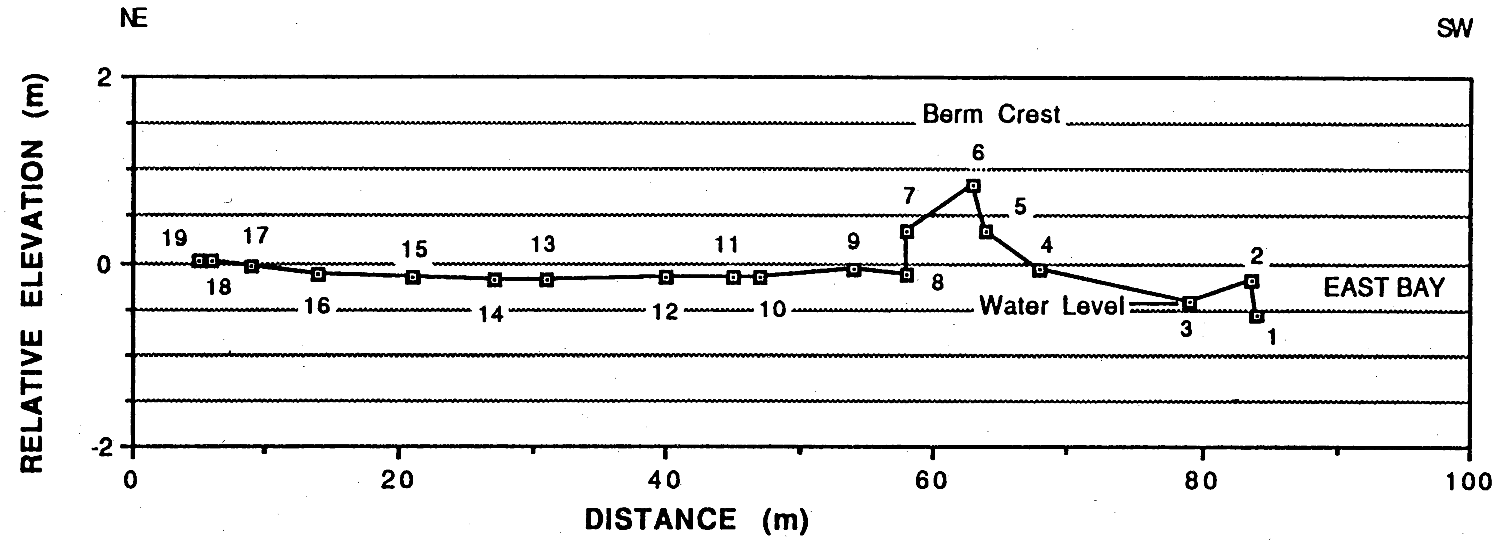
Smith Point Transect

The elevation survey of the Smith Point marsh is shown in figure 21. The transect has a bearing of south 45 degrees west (S45°W) and is approximately 85 m (~279 ft) long. The southwest end of the transect intersects the shoreline of East Galveston Bay. The total range in elevation of the transect is approximately 1.5 m (~5 ft), which is the vertical distance from station 1 (just below the water line) to station 6, the crest of the shell berm. Marsh plants, which are absent on the shell berm, have a much lower range in elevation, about 45 cm (~1.5 ft) (fig. 21). This salt marsh community, which is classified as an estuarine intertidal emergent community (E2EM) as defined by Cowardin, and others (1979), is made up of about eight different species. *Spartina alterniflora* (smooth cordgrass), as expected, occurs at the lowest elevation (water line), and a community composed of *Spartina spartinae* (gulf cordgrass or sacahuista), *Spartina patens* (marshhay cordgrass), *Iva frutescens* (big-leaf sumpweed or marshelder), and *Borrichia frutescens* (sea oxeye) occurs at the highest elevation (stations 18–19, fig. 21). The profile exemplifies how small changes in elevation along the microtidal Texas coast can affect plant distribution. Occurring at elevations between the water line and the highest marsh plants on the profile are several species (fig. 21) including, at lower elevations, *Scirpus maritimus* (saltmarsh bulrush) and *Juncus roemerianus* (needlegrass rush); at slightly higher elevations *Distichlis spicata* (seashore saltgrass) occurs. *Spartina patens* and *Borrichia* also occur at intermediate elevations, but are still higher than *Spartina alterniflora*, *Scirpus*, *Juncus*, and *Distichlis*. The range in elevation for *Spartina alterniflora* is about 25 cm (~0.8 ft) along this transect, so it occurs mixed with other species locally.

A close look at the profile (fig. 21) shows that very small changes in elevation can apparently increase the regularity of flooding and enable species like *Spartina alterniflora* to become established. Stations 10 and 14 have *Spartina alterniflora* mixed with *Distichlis*. At slightly higher elevations toward station 12, only *Distichlis* is present.

This particular survey shows that, in general, the species occurring at lowest (and therefore most frequently flooded) elevations are *Spartina alterniflora*, *Scirpus maritimus*, and *Juncus roemerianus*, with *Distichlis* mixing with these species locally. Occurring at higher elevations are *Spartina patens*, *Borrichia*, *Spartina spartinae*, and *Iva frutescens*.

Wetland indicator plant species designations in *The National List of Plant Species that Occur in Wetlands: 1988 Texas*, by P. B. Reed, U.S. Fish and Wildlife Service, were used as a guide to help delineate species associations in some areas. Species identified along the Smith Point profile are



1	Base of erosional scarp
2 to 3	*Spartina alterniflora*
3 to 4	Erosional clay ramp
4 to 8	Shell berm
8 to 9	*Juncus roemerianus*
9 to 10	*Spartina patens*
10 to 11	*Spartina alterniflora-Distichlis spicata*
11 to 13	*Distichlis spicata*
13 to 15	*Spartina alterniflora-Distichlis spicata*
15 to 16	*Scirpus maritimus-S. alterniflora-Distichlis*
16 to 17	*Distichlis-S. alterniflora-Scirpus-Borrichia frutescens*
17 to 18	*Spartina spartinae*
18 to 19	*S. spartinae-Spartina patens-Iva frutescens-Borrichia*

Figure 21. Profile of salt marsh at Smith Point showing relative elevations of plant communities. Site No. 20-1.

all wetland species, but *Spartina alterniflora*, *Scirpus maritimus*, and *Juncus roemerianus* are classified as obligate (OBL) wetland plants, which means that under natural conditions they have an estimated probability of occurring in wetlands more than 99 percent of the time. The other species listed above (i.e., those occurring at slightly higher and drier elevations) are facultative wetland (FACW) plants, which means that they usually occur in wetlands (estimated probability of 67 to 99 percent), but occasionally are found in nonwetlands. As expected, the elevation measurements properly defined the species that can tolerate wetter conditions, and are therefore more frequently found in wetlands.

Brazoria National Wildlife Refuge Transect

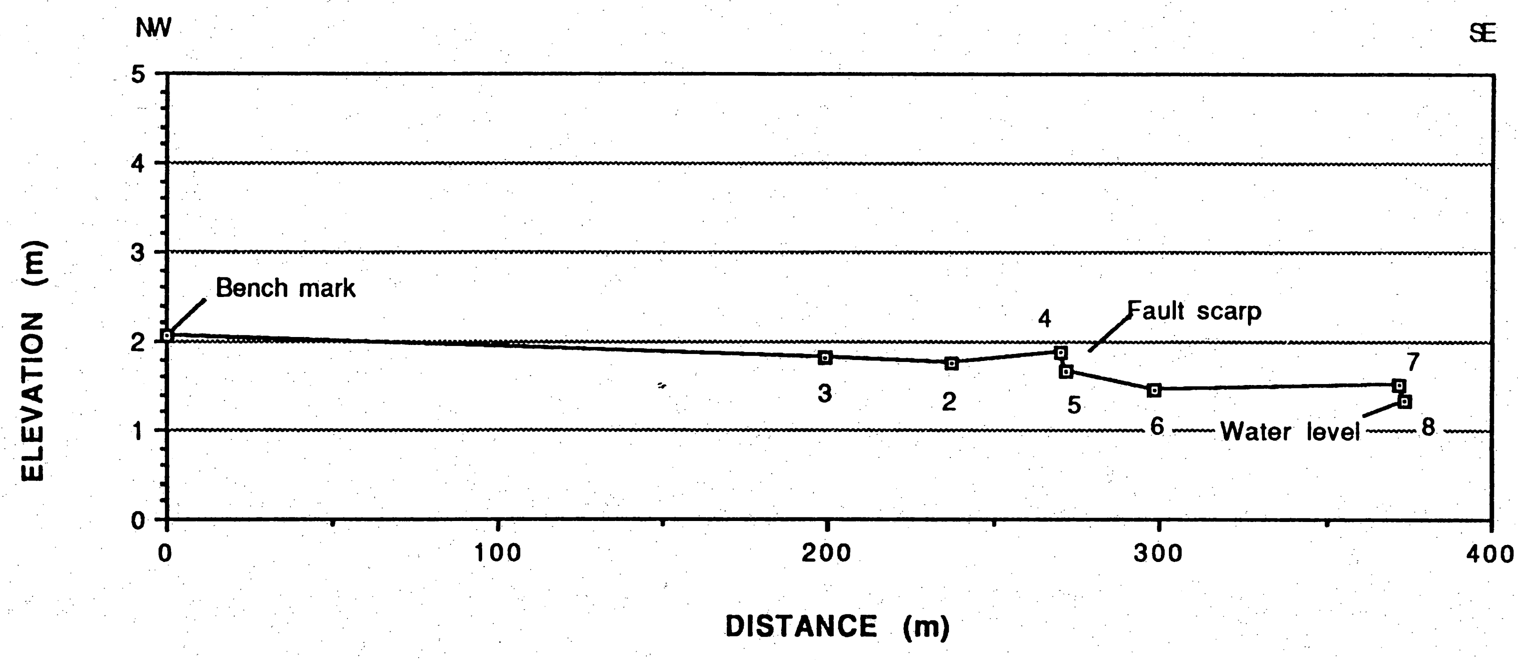
A second salt marsh transect along which elevations, distances, and bearings were measured was located in the Brazoria National Wildlife Refuge (fig. 22). The transect, which is approximately 375 m (1,230 ft) long, is oriented roughly perpendicular to the hydrologic gradient and was tied to a USGS bench mark with an elevation of 2.2 m (6.6 ft) at the northwest end of the transect. Lower elevations occur on the downthrown side of a fault (White and others, 1985; see following section on faulting and subsidence) located at stations 4 and 5 on the profile (fig. 22). The difference in elevations on each side of the fault line produces a dramatic effect in the vegetation communities. Between the bench mark and station 4 at the edge of the fault (this segment of the transect marks the upthrown side of the fault) the plant community is dominated by *Spartina spartinae*, with scattered species including *Setaria geniculata* (knotroot bristlegrass), *Iva annua* (seacoast sumpweed), and *Aster* sp. Additional species reported in this area in the Brazoria County Soil Survey include *Nothoscordum bivalve* (false garlic) and *Sabatia campestris* (prairie rose-gentian). The dominant species *Spartina spartinae* is classified as a faculative wetland (FACW), but other species, except for *Aster* (OBL), are found much less frequently in wetlands. *Iva annua* and *Setaria* are classified as facultative (FAC), and are, therefore, equally likely to occur in nonwetlands as wetlands. *Sabatia* and *Nothoscordum* are classified as facultative upland species (FACU), which means the probability of their occurring in a wetland is only 1 to 33 percent.

On the downthrown side of the fault a definite wetland community occurs. The drop in elevation from the top of the fault scarp to the wetland community is more than 30 cm (>1 ft). Plant species between stations 5 and 6 (fig. 22) on the profile are composed of patches of *Monanthochloe*, *Salicornia*, and *Batis*, occurring within a sand/mud flat that is capped by an algal mat. At lower elevations, between stations 6 and 7, *Distichlis* composes about 90 percent of the community, with scattered *Salicornia* making up the remaining 10 percent. All of the species on the downthrown side of the fault, where wetter conditions characterize the lower elevations, are obligate wetland plants.

Distribution of Wetland and Aquatic Habitats (1989)

In the late 1980's, wetland and aquatic habitats covered an area of about 570,000 acres (excluding the marine open-water class) within the 30 7.5-minute quadrangles that define the Galveston Bay project area (fig. 2). This constitutes 53 percent of the total map area. Of the five wetland systems mapped (fig. 3; table 5), the estuarine system encompasses about 507,500 acres and represents approximately 48 percent of the total map area. The palustrine system is second at 3 percent (34,100 acres), followed by the lacustrine (2 percent), riverine (0.2 percent), and marine (0.2 percent, excluding open water) (table 5). Upland areas (nearly 497,000 acres) represent the remaining 47 percent of the total mapped area.

Vegetated wetlands (E2EM, E2SS, PEM, PFO, and PSS areas; excluding AB areas) cover about 138,600 acres, or 25 percent of the wetland and deep-water habitat system (again excluding the marine open water or M1UB class). The marsh system (E2EM, E2EM/US, E2US/EM, and PEM) (fig. 23) covers approximately 130,400 acres, representing about 94 percent of the total



PLANT COMMUNITIES AND GEOMORPHIC FEATURES ALONG PROFILE

BM to 2	*Spartina spartinae (80%), Setaria geniculata, Aster sp., Iva annua, others (20%)*
2 to 4	*Spartina spartinae (90%)*
4 to 5	Fault Scarp
5 to 6	Mixed flat and emergent vegetation *Monanthochloe-Salicornia-Batis*
6 to 7	*Distichlis spicata (90%), Salicornia sp. (10%)*

Figure 22. Profile of brackish marsh in the Brazoria National Wildlife Refuge showing relative elevations of plant communities. Site No. 3-1.

Table 5. Areal extent of mapped wetland and upland habitats in 1989.

NWI CODE	National Wetlands Inventory Description	ACRES
E2EM	Estuarine Intertidal Emergent Vegetation	103,533
E2EM/US	Estuarine Intertidal Emergent Vegetation/Unconsolidated Shore	2,905
E2US/EM	Estuarine Intertidal Unconsolidated Shore/Emergent Vegetation	1,723
E2SS	Estuarine Intertidal Scrub/Shrub Wetland	551
E1AB	Estuarine Subtidal Aquatic Bed	1,688
E2AB	Estuarine Intertidal Aquatic Bed	1,084
E1UB	Estuarine Subtidal Unconsolidated Bottom	378,202
E2US	Estuarine Intertidal Unconsolidated Shore	17,773
PEM	Palustine Emergent Vegetation	22,211
PSS	Palustrine Scrub/Shrub Wetland	2,014
PFO	Palustrine Forested Wetland	5,648
PAB	Palustrine Aquatic Bed	85
PUB	Palustrine Unconsolidated Bottom	3,580
PUS	Palustrine Unconsolidated Shore	577
L1AB	Lacustrine Limnetic Aquatic Bed	309
L2AB	Lacustrine Littoral Aquatic Bed	1,403
L1UB	Lacustrine Limnetic Unconsolidated Bottom	8,899
L2UB	Lacustrine Littoral Unconsolidated Bottom	6,287
L2US	Lacustrine Limnetic Unconsolidated Shore	4,674
R1UB	Riverine Tidal Unconsolidated Bottom	2,754
R2UB	Riverine Lower Perennial Unconsolidated Bottom	241
R1US	Riverine Tidal Unconsolidated Shore	14
M1UB	Marine Subtidal Unconsolidated Bottom	219,522
M2US	Marine Intertidal Unconsolidated Shore	1,955
M2AB	Marine Intertidal Aquatic Bed	376
UA	Upland Agriculture	131,024
UB	Upland Barren	1,925
UF	Upland Forested	45,516
UR	Upland Range	146,990
USS	Upland Scrub/Shrub	48,525
UU	Upland Urban	124,895

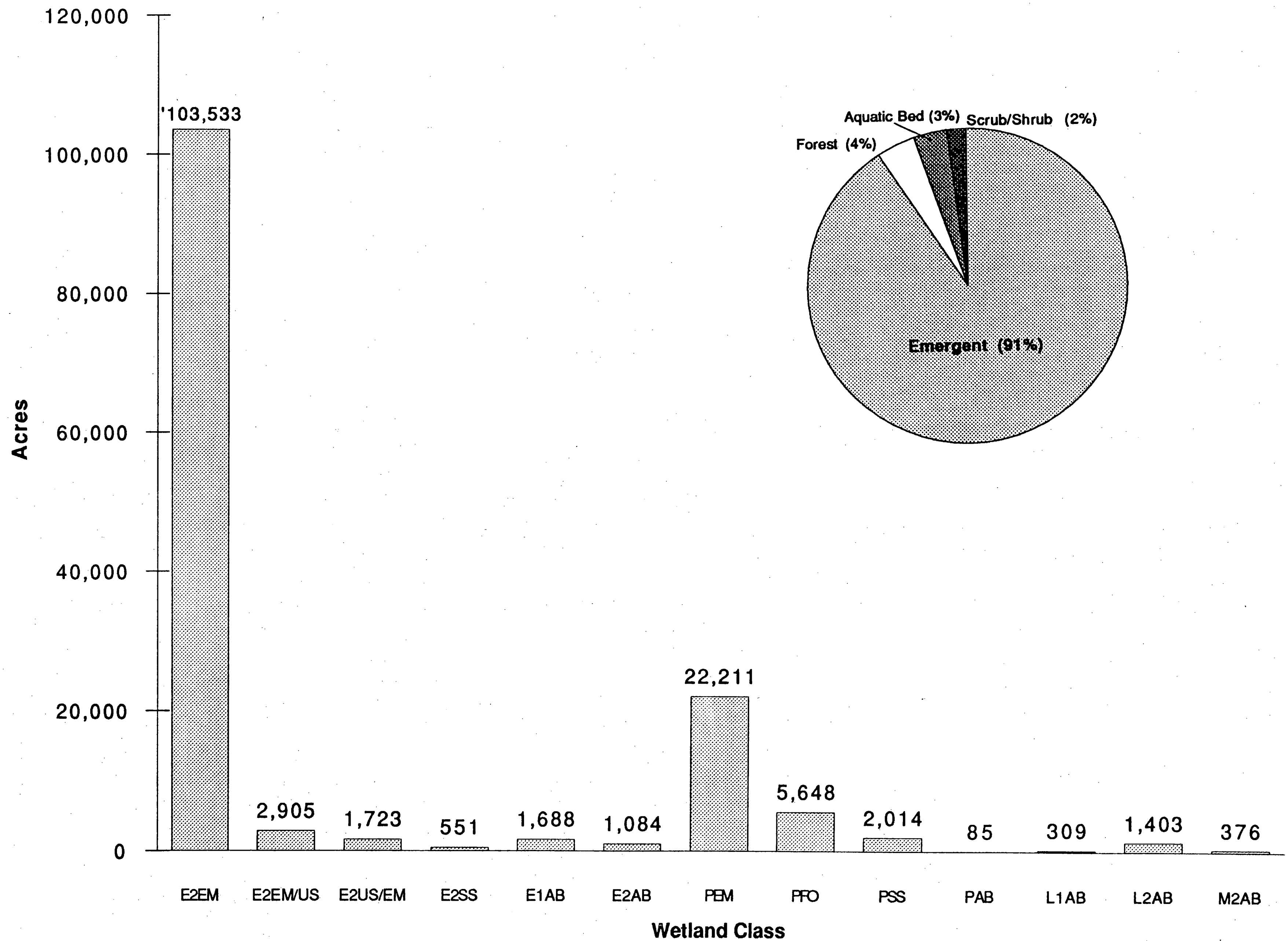


Figure 23. Bar graph showing total areal extent of vegetated wetland classes in 1989 in the Galveston Bay system. Refer to table 5 for wetland class descriptions.

vegetated wetlands. Estuarine open water and intertidal flats constitute almost 70 percent (~396,000 acres) of the total area of wetland and deep-water habitats (570,000). The extent (in acres) of all mapped wetlands, deep-water habitats, and uplands for each of the 30 quads are presented in appendix D.

Estuarine System

Estuarine Intertidal Emergent Wetlands

The estuarine intertidal emergent wetland habitat (E2EM, E2EM/US, and E2US/EM) (marsh) is the most extensive wetland habitat in the Galveston Bay system (fig. 23; table 5). It consists of about 108,200 acres of salt and brackish marshes, which make up approximately 75 percent of the vegetated wetland habitats (including aquatic beds), and 83 percent of the marsh habitats (emergent wetlands) in the Galveston Bay system. The general distribution of estuarine emergent wetlands can be determined by comparing figure 24, which shows estuarine and palustrine emergent wetlands with figure 25, which shows only the palustrine system.

Extensive estuarine emergent wetlands occur around East and West Bays and at the head of Trinity Bay in the Trinity River delta (fig. 24). These areas are prominently defined by 12 quads where salt and brackish marshes cover broad areas (fig. 26). The High Island quad is the site of the most extensive marsh system; it contains more than 20,000 acres of estuarine emergent wetlands, consisting almost totally of brackish marshes (fig. 27). These brackish marshes continue westward into the adjacent quads of Frozen Point and Lake Stephenson. Together, marshes in these three quads situated along East Bay represent the most extensive marsh habitat system in the Galveston Bay study area. More than 45,000 acres of estuarine emergent wetlands were mapped in these three quads on the 1989 photographs. The Anahuac National Wildlife Refuge encompasses a portion of this extensive emergent wetland system.

Other quads containing more than 5,000 acres of estuarine emergent wetlands are located at the southwest end of West Bay and include Christmas Point (11,400 acres), Sea Isle (7,900 acres), Oyster Creek (6,700), Hoskins Mound (7,000 acres), and Virginia Point (5,600 acres) (fig. 27). Six additional quads contain at least 1,000 acres of estuarine emergent wetlands. Estuarine emergent wetlands consisting primarily of salt marshes characterize the bayward sides of the barriers—Bolivar Peninsula, Galveston Island, and Follets Island (figs. 6 and 24). The Trinity River delta is the site of relatively extensive brackish marshes that grade into fresh marshes northward up the river valley.

Estuarine Intertidal Unconsolidated Shores

Estuarine intertidal unconsolidated shores (E2US) include intertidal flats and beaches. Approximately 17,800 acres of E2US were mapped in the Galveston Bay system (table 5). This habitat represents about 9 percent of the wetland system (excluding subtidal habitats, the E1 and M1 map units). Because of extremely low tides during the time the 1989 aerial photographs were taken, this habitat includes many areas that are normally submerged. Map units were not corrected for the low tides, and therefore the extent of the intertidal flats mapped on 1989 photographs is an overestimate. These exposed areas were mapped using an "M" water-regime modifier (E2USM), which is used to define areas that are irregularly exposed (table 2). This water regime was rarely used on the 1979 aerial photographs because of high tides.

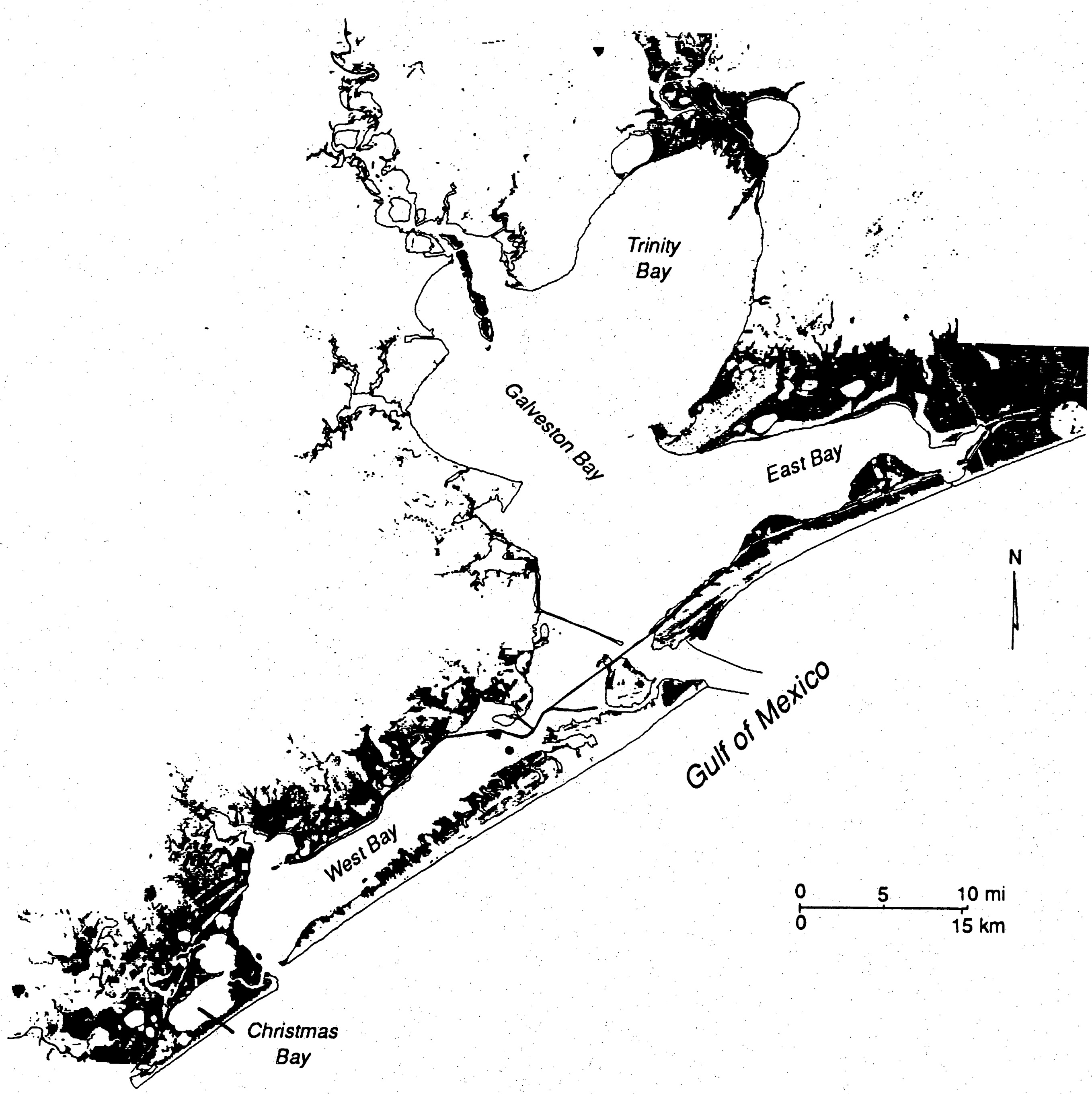


Figure 24. Distribution in 1989 of estuarine (E2EM, E2EM/US, and E2US/EM) and palustrine (PEM) emergent wetlands (marshes) in the Galveston Bay system. Compare with figure 25 to determine palustrine areas.

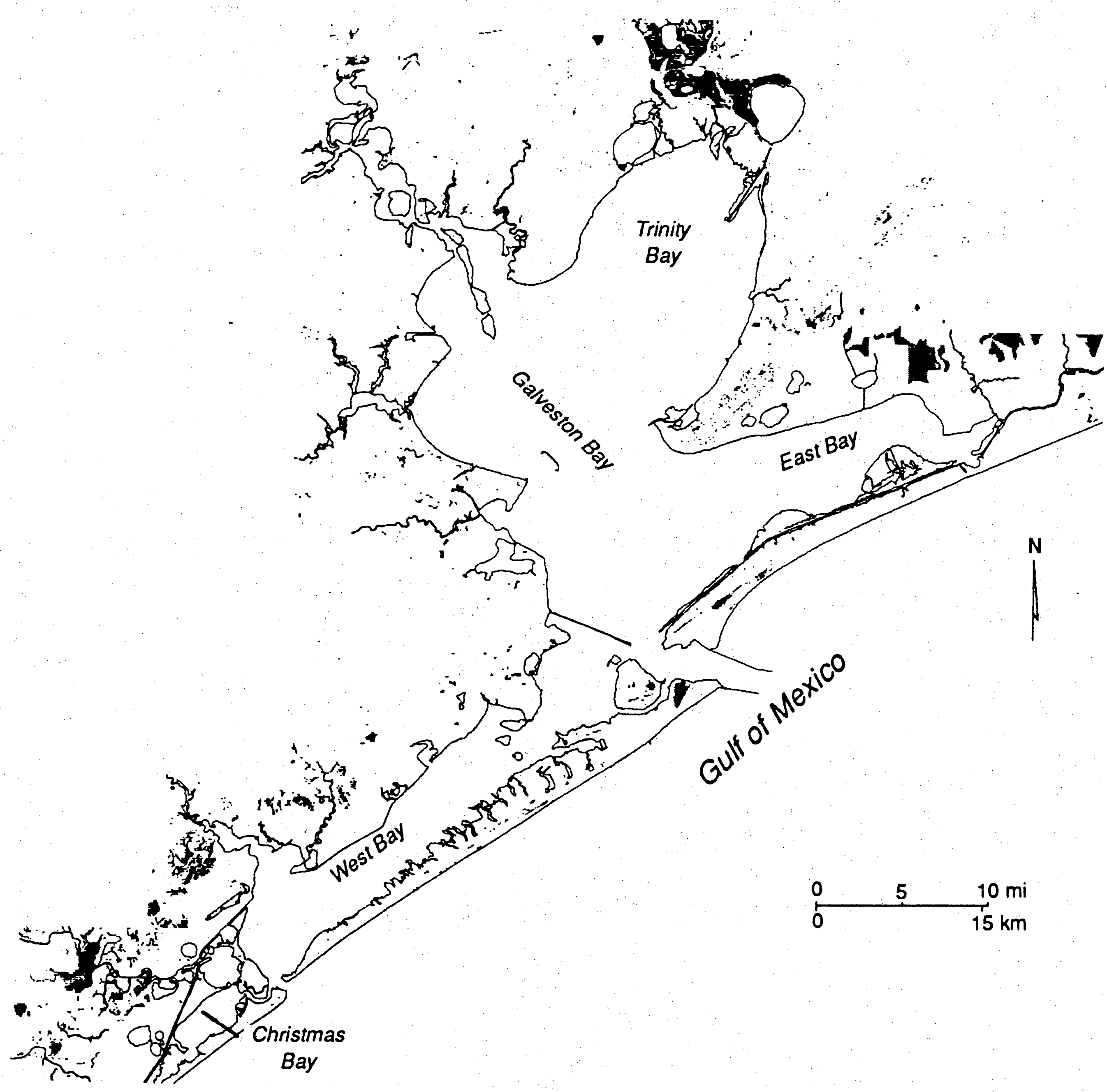


Figure 25. Distribution in 1989 of palustrine emergent wetlands (PEM) (fresh, or inland, marshes) in the Galveston Bay system.

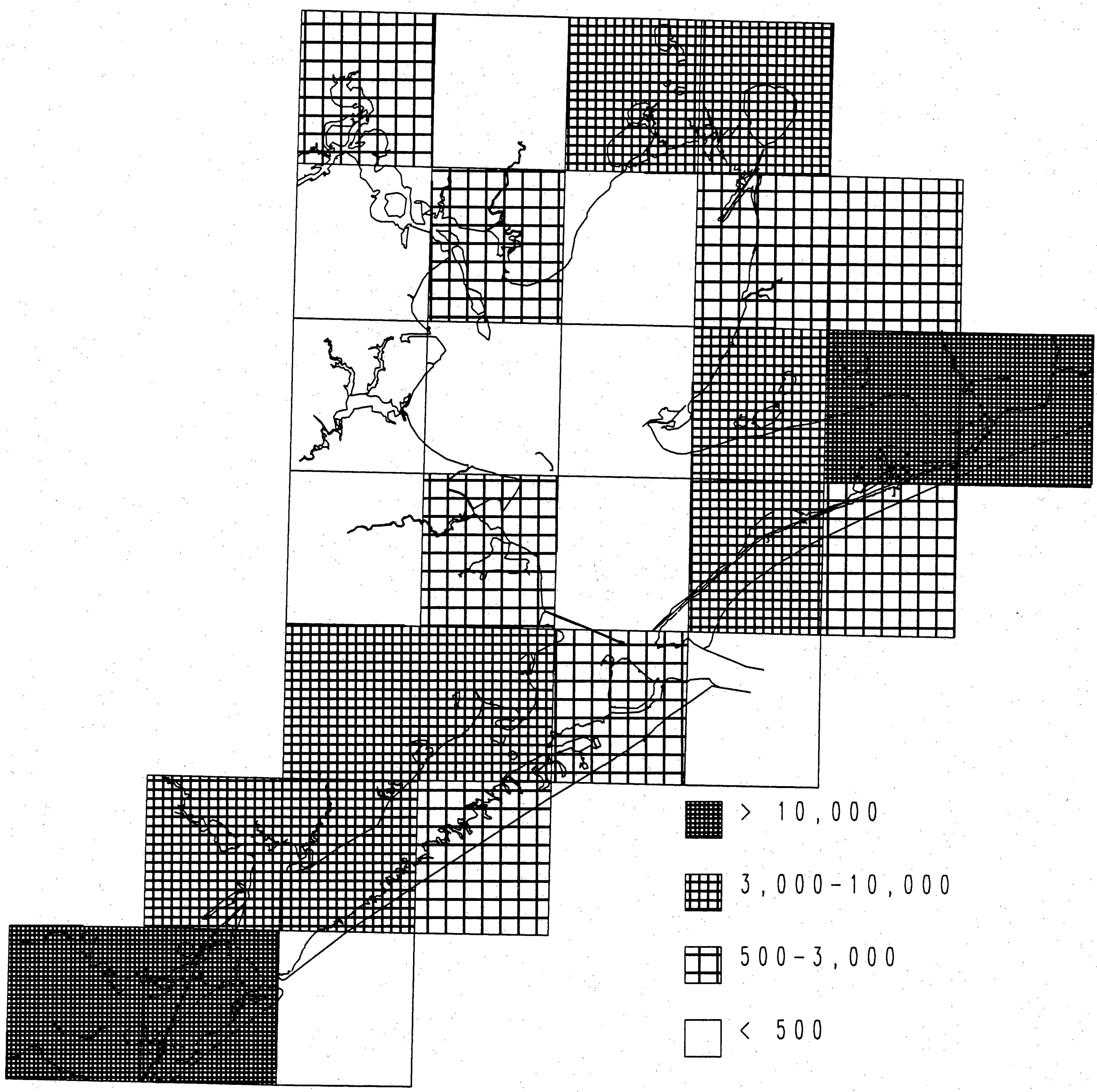


Figure 26. Map of 7.5-minute quads showing the distribution and extent (acres) of emergent wetlands (marshes) in 1989.

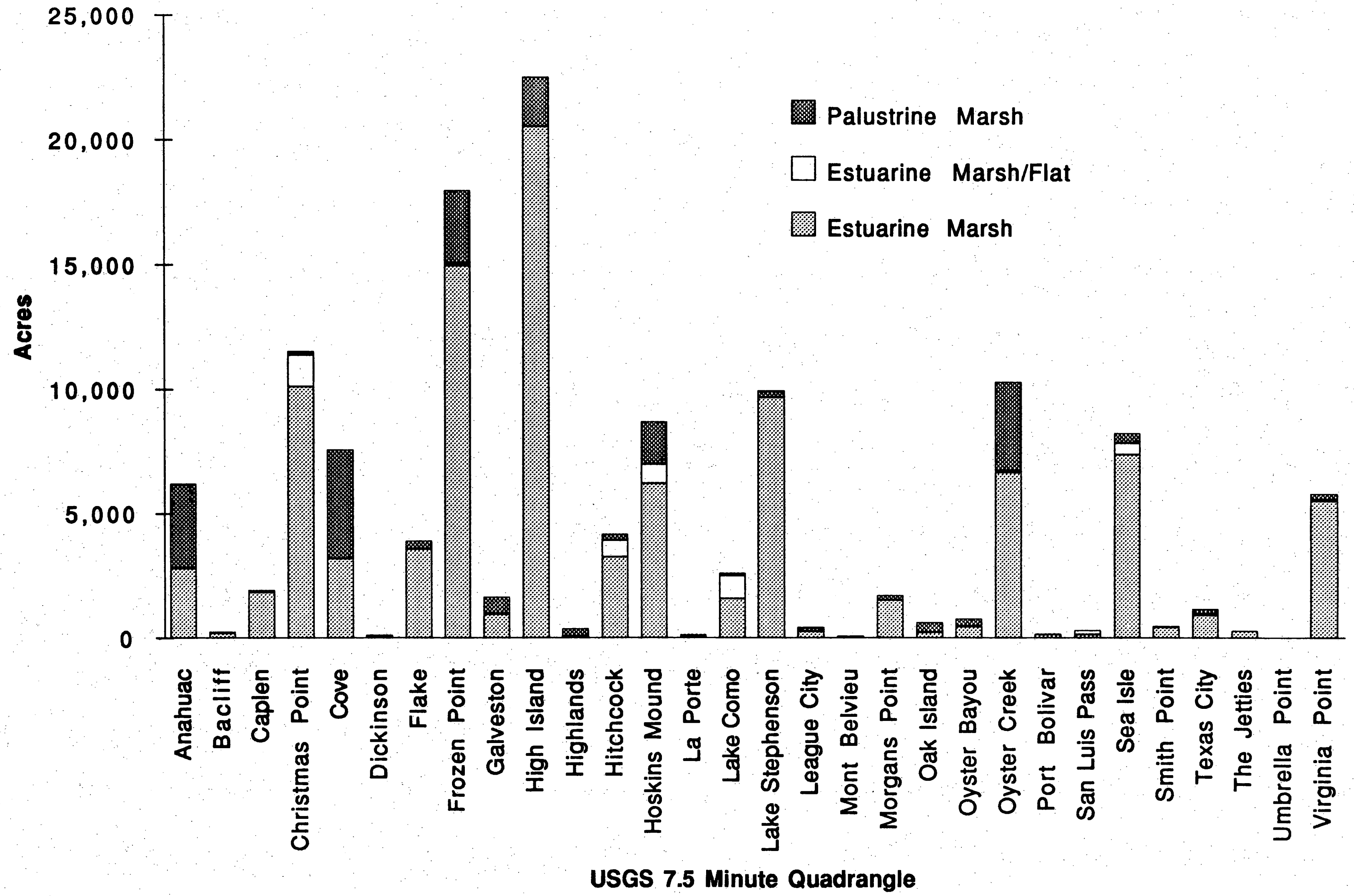


Figure 27. Bar graph of 7.5-minute quads showing the extent (acres) of emergent wetlands in 1989.

Estuarine Intertidal Scrub-Shrub Wetlands

The total area of mapped estuarine scrub-shrub wetlands (E2SS) on the 1989 data base is approximately 550 acres (fig. 23). This habitat was mapped in 21 of the 30 quads. The Virginia Point and Morgans Point quads have the largest amount of estuarine scrub-shrub, each with about 100 acres. Other quads, individually, contain fewer than 50 acres.

Estuarine Aquatic Beds

Estuarine subtidal rooted vascular aquatic beds (E1AB3L) represent areas of submerged vascular vegetation including marine grasses. Covering a total area of approximately 700 acres in the Galveston Bay project area in 1989, 386 acres were mapped in Christmas Bay, Christmas Point quad, where the largest distribution occurs. Other important areas include upper Trinity Bay along its eastern shore (Oak Island quad) and along the margins of the Trinity River delta (Anahuac and Cove quads). Submerged vascular vegetation has been previously reported and mapped in these areas (Benton and others, 1979; White and others, 1985; Pulich and others, 1991) (figs. 28 and 29).

In upper Trinity Bay along the margins of the Trinity River delta, submerged aquatics include such species as *Vallisneria* and *Ruppia* (Pulich and others, 1991). Because of the seasonal die-back in this area, coupled with the low tides occurring at the time of the November 1989 photo mission, the mapped aquatic beds do not reflect their true extent in the delta area. A general, simplified illustration showing areas in which aquatic beds have been known to occur along the margins of the delta is shown in figure 29.

Narrow bands (totaling 35 acres) mapped as unknown submerged aquatic beds (E1AB5L) along the eastern margins of Trinity Bay in the Lake Stephenson quad are also possibly rooted vascular plants (*Ruppia maritima*).

Other quads in which the E1AB3L habitat was mapped include Hoskins Mound, along the margins of Chocolate Bayou. Two areas (totaling 125 acres) on either side of the bayou show a dark, characteristic reflectance on the 1989 aerial photographs, but they were misidentified as aquatic beds. These areas, which are clearly visible on the aerial photographs as a result of the extremely low tides, are extensive oyster beds. Another area mapped as aquatic beds occurs in the Sea Isle quad in Carancahua Lake inland from West Bay. This 120-acre area is apparently a shallow subaquaeous organic-rich mud flat that has a photographic signature similar to submerged vegetation. Subtracting these two areas from the mapped bay total of 950 acres yields a submerged vegetation resource of nearly 700 acres. Additional unmapped areas in upper Trinity Bay along the margins of the Tinity River delta (fig. 29) suggest that the resource could be somewhat larger than 700 acres.

Estuarine Subtidal Unconsolidated Bottom

The estuarine subtidal unconsolidated bottom (open-water) habitat (E1UBL) is the heart of the estuarine system and consists principally of Galveston, Trinity, East, West, Christmas, and Chocolate Bays, and associated smaller satellite bays and tidal lakes (fig. 1). This habitat covers about 378,200 acres (table 5) and accounts for more than 65 percent of the wetland and deep-water habitat system (excluding M1UBL).

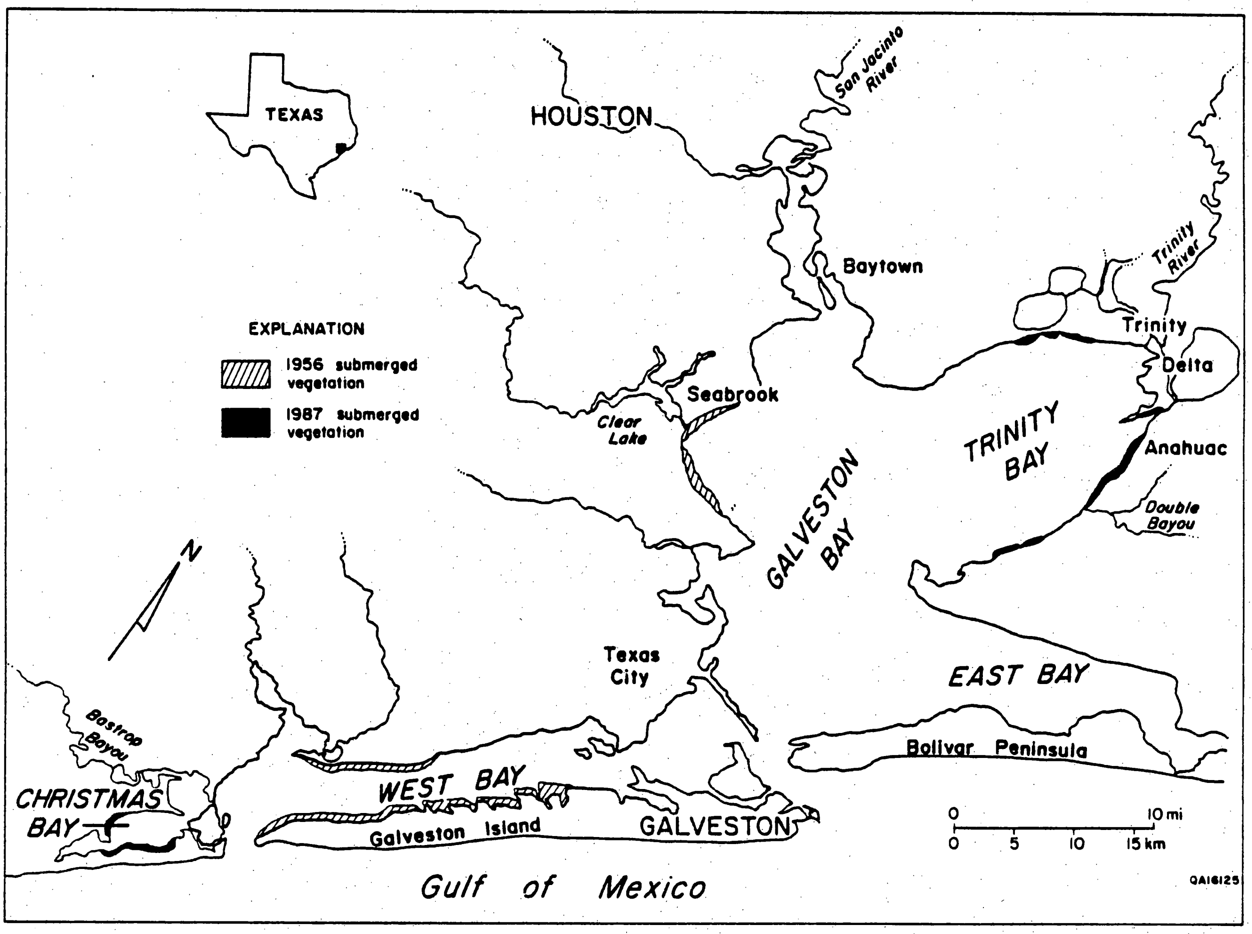


Figure 28. Generalized map showing the locations of submerged vegetation in 1956 and 1987 in the Galveston Bay system, excluding areas along the Trinity River delta. The 1956 distribution of submerged vegetation in Trinity and Christmas Bays is not shown. Modified from Pulich and White (1991).

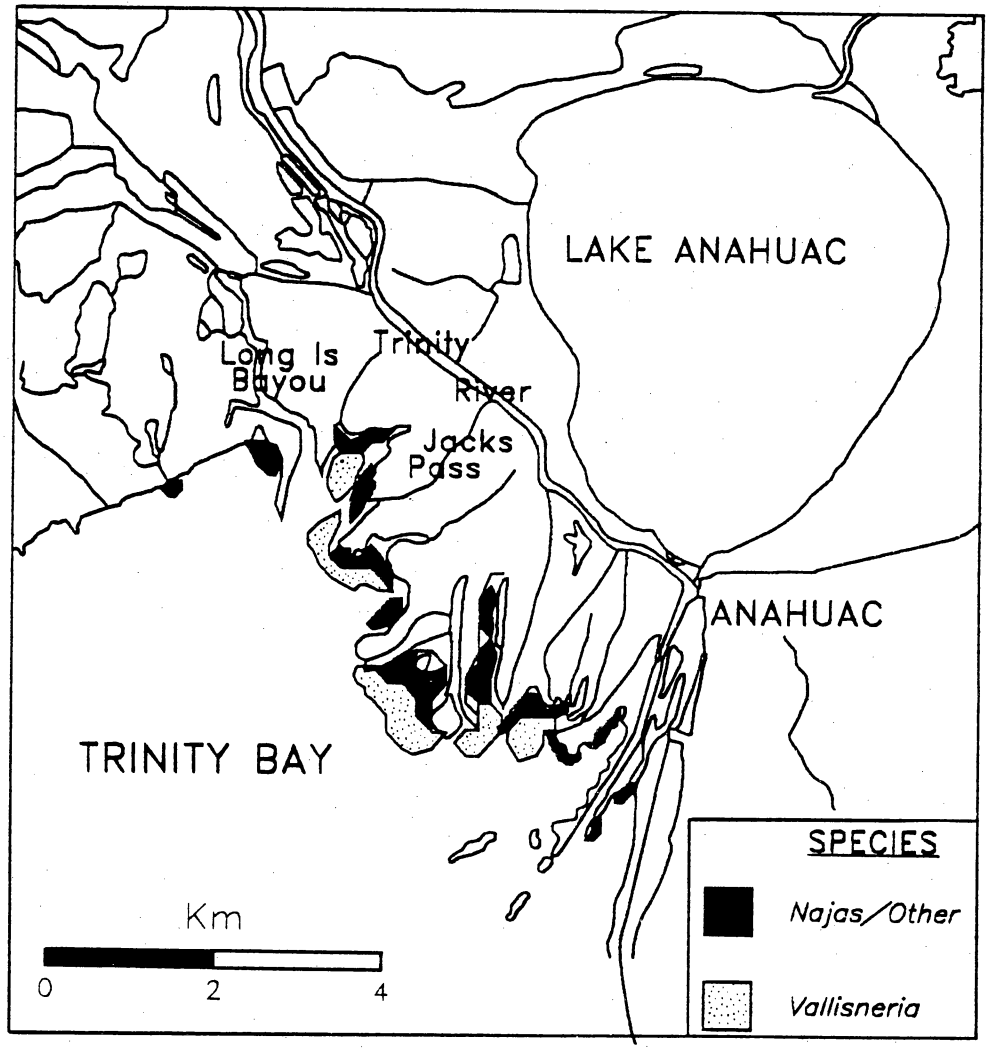


Figure 29. Generalized map showing the approximate locations of submerged vegetation along the margins of the Trinity River delta. From Pulich and others (1991).

Palustrine System

Palustrine Emergent Wetlands

Palustrine emergent wetlands (PEM), or "inland," "fresh-water" marshes, cover more than 22,000 acres (figs. 23 and 25), and represent approximately 16 percent of the vegetated wetland system (including aquatic beds), and 17 percent of the marsh (emergent wetland) system. The widest distribution of this habitat occurs in inland areas along the Trinity River alluvial valley in the Anahuac and Cove quads, inland of Christmas Bay and West Bay (Oyster Creek and Hoskins Mound quads), and inland of East Bay (Frozen Point and High Island quads) (figs. 2 and 25). Cove, Oyster Creek, and Anahuac have the largest areas of palustrine emergent wetlands, accounting for about 4,380, 3,600, and 3,360 acres, respectively (fig. 27). Frozen Point has almost 3,000 acres, and Hoskins Mound and High Island each contain more than 1,000 acres (fig. 27).

Palustrine Scrub-Shrub Wetlands

Palustrine scrub-shrub wetlands (PSS) total about 2,000 acres (fig. 23) (slightly >1 percent of vegetated wetlands); much of this acreage occurs in the Highlands (422 acres) and Dickinson quads (300 acres). All other quads each contain less than 140 acres of scrub-shrub wetlands. Most areas of scrub-shrub occur along rivers, bayous, and creeks, on the margins of reservoirs, and in relatively small depressions.

Palustrine Forested Wetlands

The total area of forested wetland habitat amounts to 5,648 acres (fig. 23), or about 4 percent of the vegetated wetland system (including aquatic beds). Forested wetlands (PFO) are most abundant in the Trinity River floodplain, defined by the Anahuac and Cove quads; these quads contain about 2,320 and 1,890 acres of forested wetlands, respectively. Other quads with notable acreages of PFO are Oyster Creek (675 acres), Highlands (441 acres), and Hitchcock (141 acres). The distribution of forested wetlands in other quads range from 55 to 0 acres.

TRENDS IN WETLAND HABITATS

Methods Used to Analyze Trends

Trends in wetland habitats were determined by analyzing habitat distribution as mapped on 1950's (fig. 30), 1979 (fig. 31), and 1987–1989 (fig. 24) aerial photographs. Most of the analyses focused on changes that occurred between the 1950's and late 1980's, the longest period of record. In analyzing trends, emphasis was placed on wetland classes (for example, E2EM and PEM), with less emphasis on water regimes and special modifiers. This approach was taken because habitats were mapped only down to class level on 1950's photographs and because water regimes can be influenced by local and short-term events such as tidal cycles. The 1979 photographs were taken during a period of high tides and the 1989 photographs during a period of low tides.

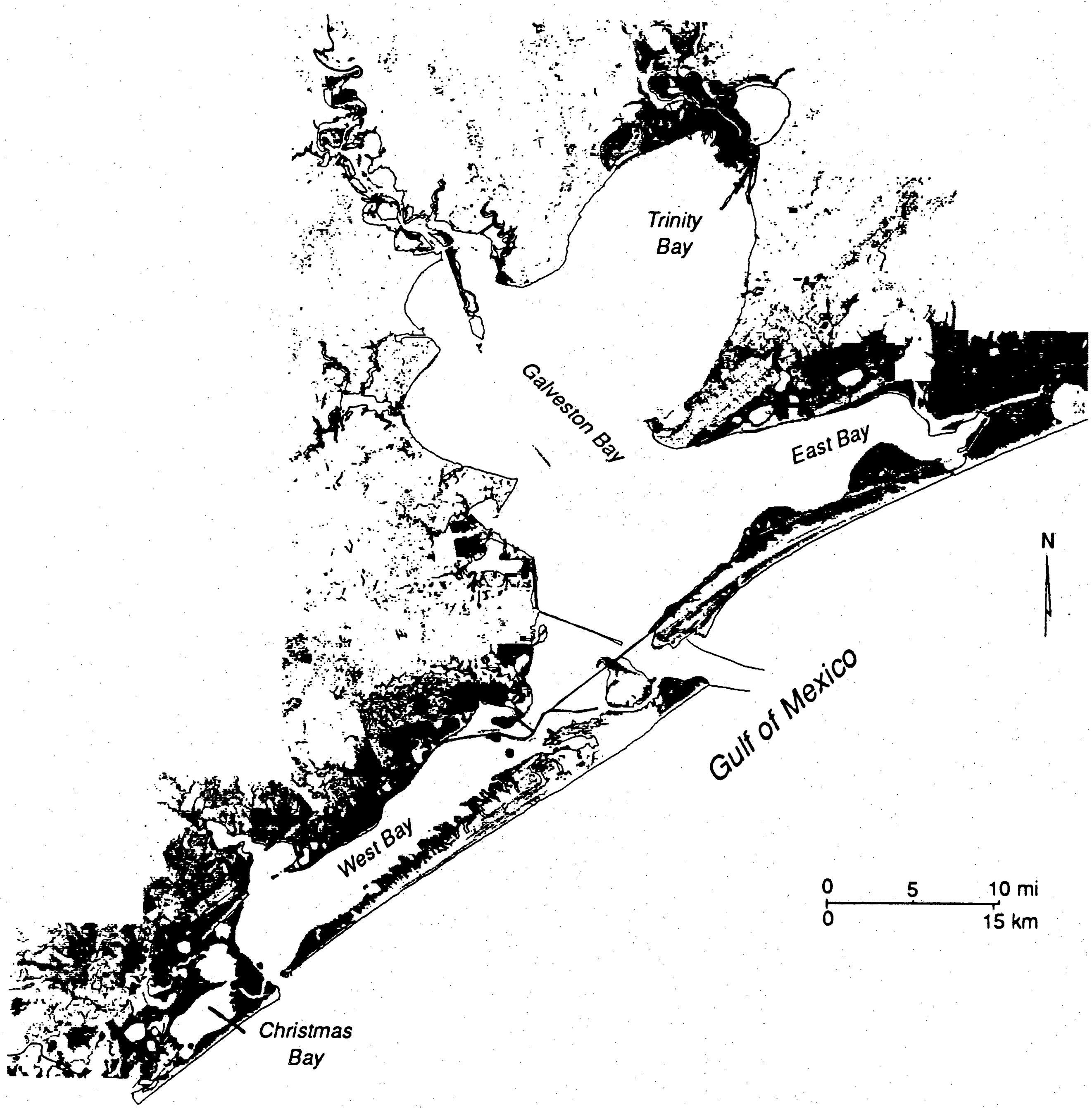


Figure 30. Distribution in the 1950's of estuarine (E2EM and E2EM/FL) and palustrine (PEM) emergent wetlands (marshes) in the Galveston Bay system.

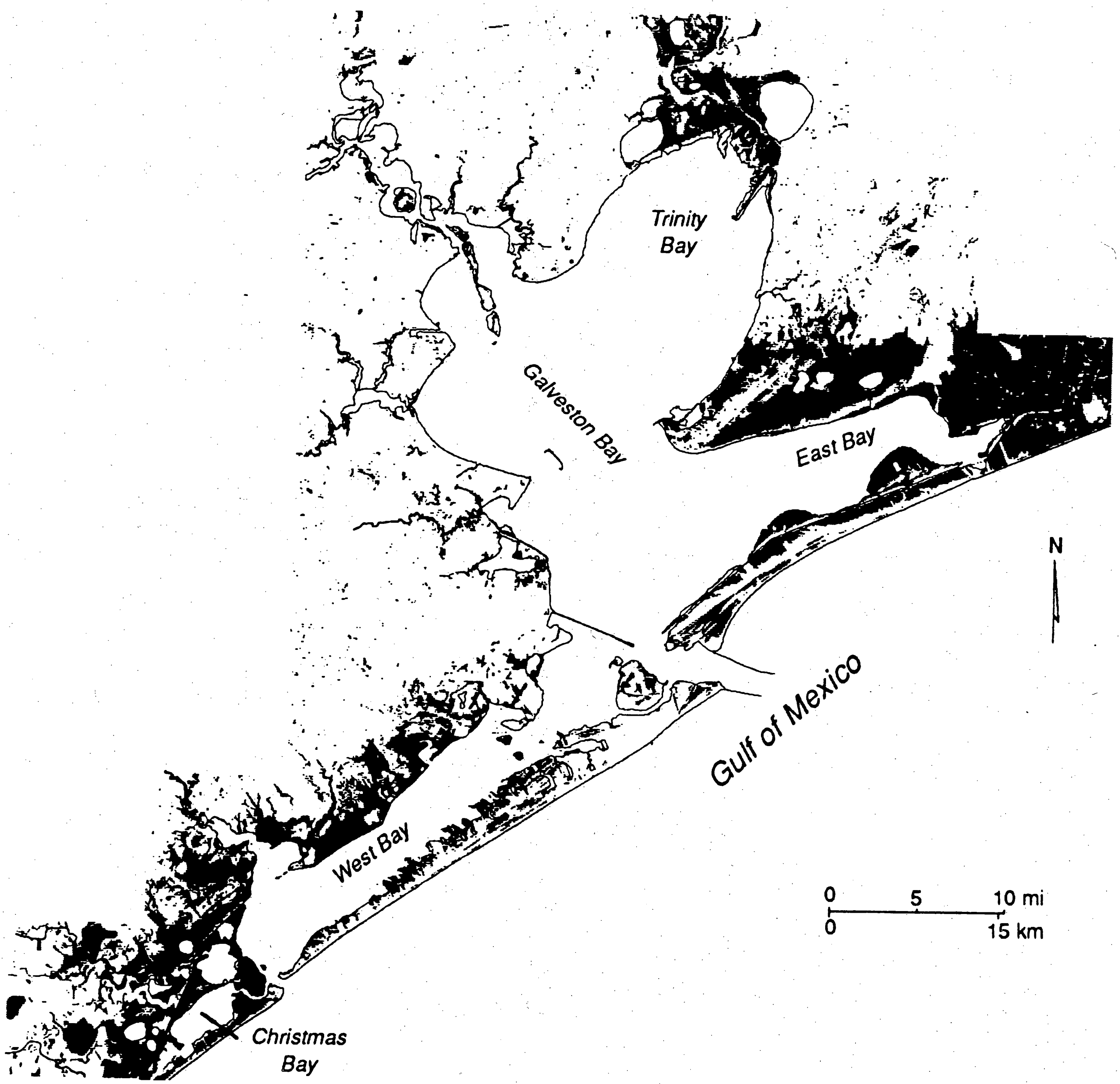


Figure 31. Distribution in 1979 of estuarine (E2EM and E2EM/FL) and palustrine (PEM) emergent wetlands (marshes) in the Galveston Bay system.

Geographic Information System

The geographic information system, ARC/INFO, was the primary tool used in analyzing trends. It allowed for direct comparison between years, generally on a quad by quad basis. Analyses included tabulation of losses and gains in wetland classes for each quad for selected periods. In addition, full-color, 1:24,000-scale maps showing basic wetland classes as mapped on 1989 photographs were prepared for each quad. These maps allowed relatively clear visual comparisons of changes to be made on a light table by overlaying them with the blue-line prints of the 1950's and 1979 map series. Supplementary to these maps were full-scale (1:24,000) colored maps showing vegetated-wetland losses and gains for the 1950's to 1989 period for each of the 30 quads. The GIS allowed cross classification of habitats in a given area as a means of determining changes and probable cause of such changes. Maps used in this report showing wetland distribution and changes were prepared from digital data using ARC/INFO.

Possible Photointerpretation Errors

Among the shortcomings of the photointerpretation process for this project (aside from the fact that different photointerpreters were involved for different time periods) is that wetlands were interpreted on each set of photographs without reference to the photographs taken during preceding or following years (this was particularly true for the 1950's and 1979 series). This procedure, in part unavoidable, prevented photointerpreters from selecting the most consistent (and accurate) wetland boundaries, especially along wetland-upland breaks, for the different time periods. As a result, some changes in the distribution of wetlands from one period to the next are not real but are relicts of the interpretation process.

The most striking example occurred in the Lake Stephenson quad inland from East Bay where an apparent gain of more than 3,500 acres of marshland between the 1950's and 1979, was offset by an almost equal loss (>3,000 acres) of marshland between 1979 and 1989. The apparent gain during the 1950's to 1979 period was caused by the inclusion of upland habitats within the irregularly flooded wetland habitat on the 1979 maps. The complexity of this particular area, characterized by upland "pimple mounds" that are surrounded by topographic lows marked by wetter conditions, complicated the interpretation process. Inconsistencies in interpretation seem to have occurred most frequently in transitional areas similar to this one where uplands and wetlands intergrade.

Some apparent wetland changes were due to the different scales of the aerial photographs. The 1950's aerial photographs were at a larger scale (1:24,000) than those taken in 1979 and 1989 (1:62,500), which affected the minimum mapping unit delineated on the photographs. Accordingly, more wetlands were mapped on the earlier, larger-scale photographs. This effectively produced a larger wetland loss (an apparent loss) between earlier and later periods than occurred. Such apparent losses were most pronounced in interior (palustrine) wetlands where complex distribution patterns were common, such as in the Hoskins Mound and Hitchcock quads.

The 1950's photographs were reviewed for three quads to estimate the extent of interpretation errors. Minor problems (excluding the scale problem mentioned above) in interpretation (consistency and accuracy) were found in the Lake Stephenson quad. In the Hoskins Mound area, some uplands that were peripheral to wetlands were misclassified as wetlands due to local high water at the time the photographs were taken. The third quad (Christmas Point) contained more extensive misclassifications. For example, some densely vegetated marshes (E2EM areas) were classified as mixtures of marshes and flats (E2EM/FL). A more significant misinterpretation in this quad, however, was the delineation of upland areas as estuarine emergent wetlands, which inflated the 1950's wetland totals. As a result, comparison of the 1950's totals with totals in later years reflects a larger loss in emergent wetlands than actually occurred. In fact, in this quad (Christmas Point) it appears that approximately 40 percent (almost 900 acres) of the reported losses in estuarine emergent wetlands for the period 1952–1953 to 1989 was due to interpretation errors rather than to real changes. In the Hoskins Mound quad it was estimated that about 40 percent of the wetland changes were also related to photointerpretation, in large part the result of photographic scale differences and very wet conditions in the early 1950's.

Based on the selected reviews of interpretations (supported by expected trends), it appears that the 1950's Christmas Point and Hoskins Mound examples and the 1979 Lake Stephenson example are extreme cases due to the complexities of the wetland distribution patterns in these quads. Considering the bay system as a whole, it is believed that the amount of change in wetland distribution attributable to misinterpretation is much lower than the above 40-percent examples; it should be less than 20 percent. Ideally, wetland habitats should be delineated with reference to all vintages of photographs to promote consistency and accuracy in the delineations. This could not be accomplished in this investigation without redoing the 1950's and 1979 maps.

In general, losses that seem to have been influenced most by photointerpretation problems are interior (palustrine) temporarily flooded wetlands with complex distribution patterns that appear to have been overestimated on the 1950's photographs and perhaps underestimated on the 1989 photographs for reasons noted in the above discussion. Acreages of losses in estuarine emergent wetlands are supported in many areas by previous studies and appear more reliable.

In the analysis of trends, wetland areas for the different time periods are compared without attempting to factor out misinterpretations and photo-to-map transfer errors. However, maps representing each period were visually compared for the 30 quads as part of the trend-analysis process and as part of the effort to identify potential problems in interpretation. Aerial photographs were spot checked as part of this review. Occasional comments in the text with respect to apparent changes are based on these comparisons, as well as on prior knowledge of wetland distribution in the Galveston Bay system (White and others, 1985). Still, users of the data should keep in mind that there is a margin of error inherent in photointerpretation and map preparation.

Trends in Wetland Distribution

In analyzing and discussing trends, emphasis is placed on net losses in wetlands. Typically within a quad there are spatial changes in the distribution of a given wetland class manifested by losses in one area that are partly or wholly offset by gains in other areas of the quad. Determining the difference between the losses and gains yields the net change.

In general terms, losses in vegetated wetlands may result from conversion of the wetlands to (1) open water and flats, (2) uplands, or (3) other wetland classes. Reasons for such transformations are analyzed and discussed in a later section on probable causes of wetland losses.

Trends: 1950's to 1989

Comparison of wetland distribution in the Galveston Bay system for the 1950's and 1989 indicates that there were gains and losses in wetlands over this period, but the net trend is one in which wetlands were lost (fig. 32). The area of vegetated wetlands (E2EM, E2SS, PEM, PSS, and PFO) decreased from approximately 171,000 acres in the 1950's to about 138,600 acres in 1989 (fig. 33). This loss of 32,400 acres amounts to 19 percent of the vegetated wetland system that existed in the 1950's. The actual loss in wetlands is somewhat less, perhaps closer to 17 percent, because delineations of wetlands in some areas on the 1950's-vintage black-and-

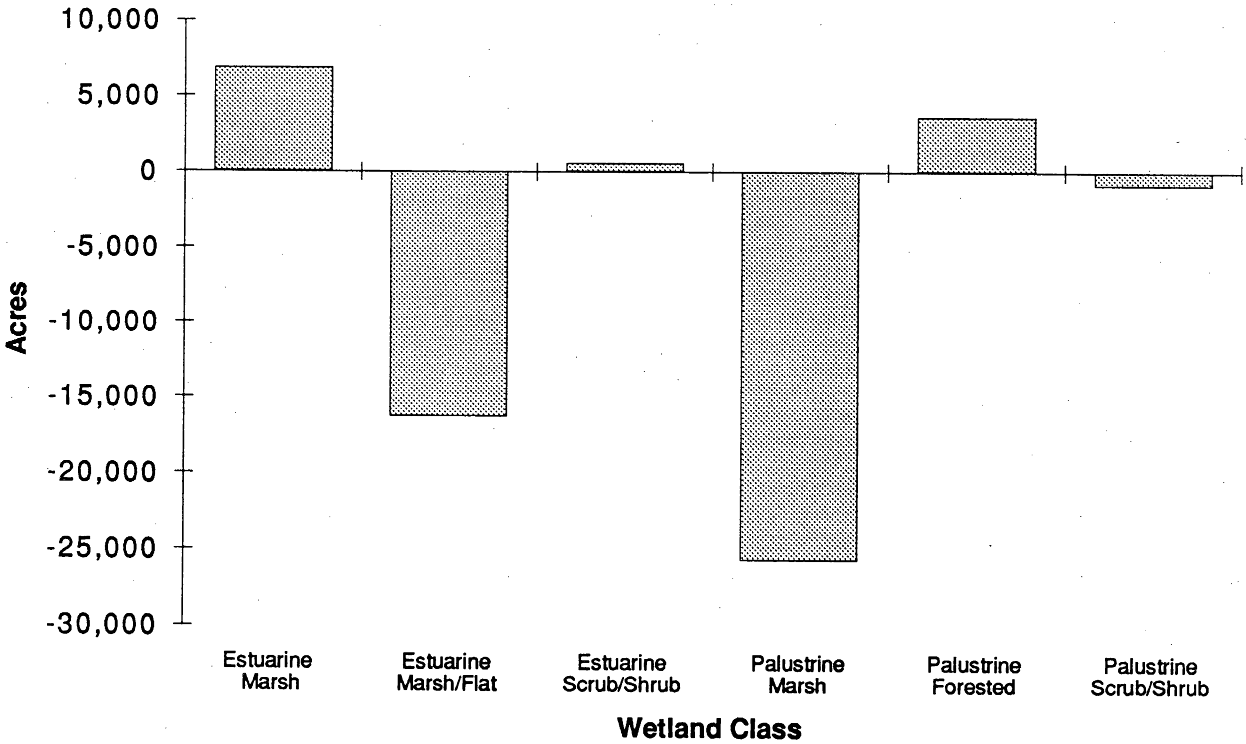


Figure 32. Net losses and gains in vegetated wetland classes (excluding aquatic beds) from the 1950's to 1989. The apparent increase in emergent wetlands (E2EM) is in large part due to reclassification of PEM and E2EM/FL (E2EM/US) areas in the 1950's to E2EM areas in 1989 (and 1979).

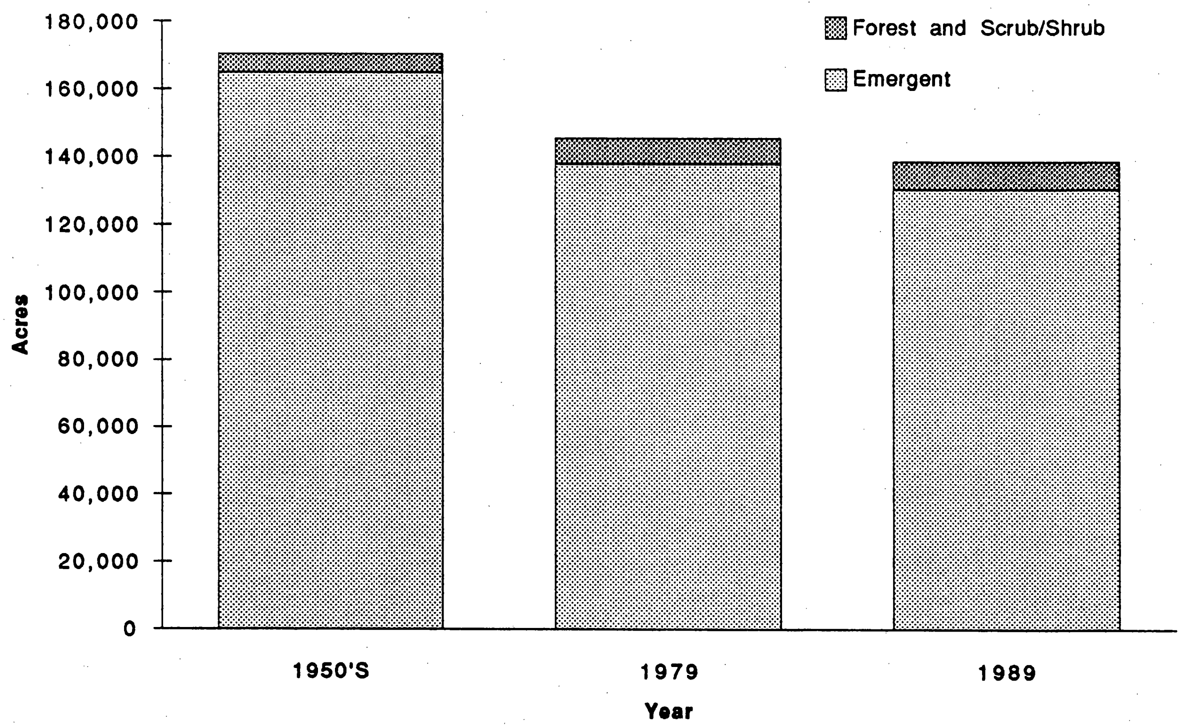


Figure 33. Bar graph comparing areas of emergent and forest/scrub-shrub wetlands for the 1950's, 1979, and 1989.

white aerial photographs included peripheral upland areas, which inflated the 1950's wetland acreages (see previous section on possible photointerpretation errors).

Estuarine and Palustrine Emergent Wetlands

Estuarine (E2EM) and palustrine (PEM) emergent wetlands, which are fundamentally equivalent to salt/brackish and fresh marshes, are considered together as a marsh system for analysis purposes. In addition, undifferentiated areas of emergent wetlands and tidal flats (mapped as E2EM/FL on 1950's and 1979 photographs and E2EM/US and E2US/EM on the 1980's photographs) are included with emergent wetland areas rather than with tidal-flat areas. These combinations are made because of inconsistencies in mapping of these areas for the different time periods.

The general trend in the distribution of emergent vegetation (marshes) from the 1950's to 1989 was one of net loss. The area of mapped emergent wetlands decreased from about 165,500 acres in the 1950's to about 130,400 acres in 1989, producing a total net loss across the Galveston Bay system of approximately 35,100 acres, or 21 percent of the 1950's resource. Again, as in the case of vegetated wetlands, this amount of loss in emergent wetlands is thought to be on the high side; the actual loss is probably below 19 percent.

Twenty-five of the 30 quads had apparent net losses in vegetation. Losses exceeded 3,000 acres in 5 quads, 1,000 to 3,000 acres in 10 quads, and 500 to 1,000 acres in 2 quads (fig. 34). The most substantial losses (>3,000 acres) are located in the southwestern part of the map area and include Virginia Point, Hitchcock, Hoskins Mound, Texas City, and Sea Isle (fig. 34). Changes in these five areas account for about 55 percent of the losses in emergent wetlands in Galveston Bay system. Areas with apparent losses of between 1,000 and 3,000 acres are scattered around the map area (fig. 34).

In all 30 quads, 26,450 acres of emergent wetlands were converted to open water and flats from the 1950's to 1989 (figs. 35 and 36). About 35,800 acres of emergent wetlands became uplands, either through natural or artificial processes. Additional losses in emergent vegetation were due to changes in wetland class such as from emergent vegetation to scrub-shrub vegetation. The total gross "loss" in emergent vegetation exceeded 88,500 acres.

The most extensive net loss occurred in the Virginia Point quad located on the inland margin of West Bay, where more than 5,000 acres of emergent wetlands disappeared by 1989. The gross loss in emergent wetlands exceeded 8,000 acres, but this amount was offset by increases of about 3,000 acres in other areas of the quad. About 3,600 acres of emergent wetland habitat was converted to open water (E1UBL) and tidal flats (E2US) (figs. 35 and 36). Most of the remainder of the decline was due to a change from emergent wetlands to uplands.

In other quads where net losses in emergent wetlands exceeded 3,000 acres, three (Hitchcock, Hoskins Mound, and Texas City) were characterized principally by conversion of marshes to uplands; replacement of marshes by open water and intertidal flats was of secondary importance. In the fourth (Sea Isle), decreases in emergent wetlands were about equally distributed between conversions to open water/flat and to uplands. In Cove, Highlands, and Anahuac, transformation of vegetated wetlands to open water and flats accounted for more than 80 percent of the loss in emergent wetlands in these quads. For the remaining quads, conversion of emergent wetlands to uplands accounted for between 40 and 95 percent of the change, while conversion to open water and flats accounted for most of the remainder.

Losses in emergent wetlands in some areas were partly offset by gains in emergent wetlands in other areas. Much of the increase in wetlands occurred in areas previously mapped as uplands; this type of conversion, from upland to wetland, accounted for an increase of about 21,000 acres (figs. 37–39). Regionally, these changes were most pronounced inland from East Bay, for example in the Lake Stephenson quad (fig. 40), on Galveston Island (fig. 41), and

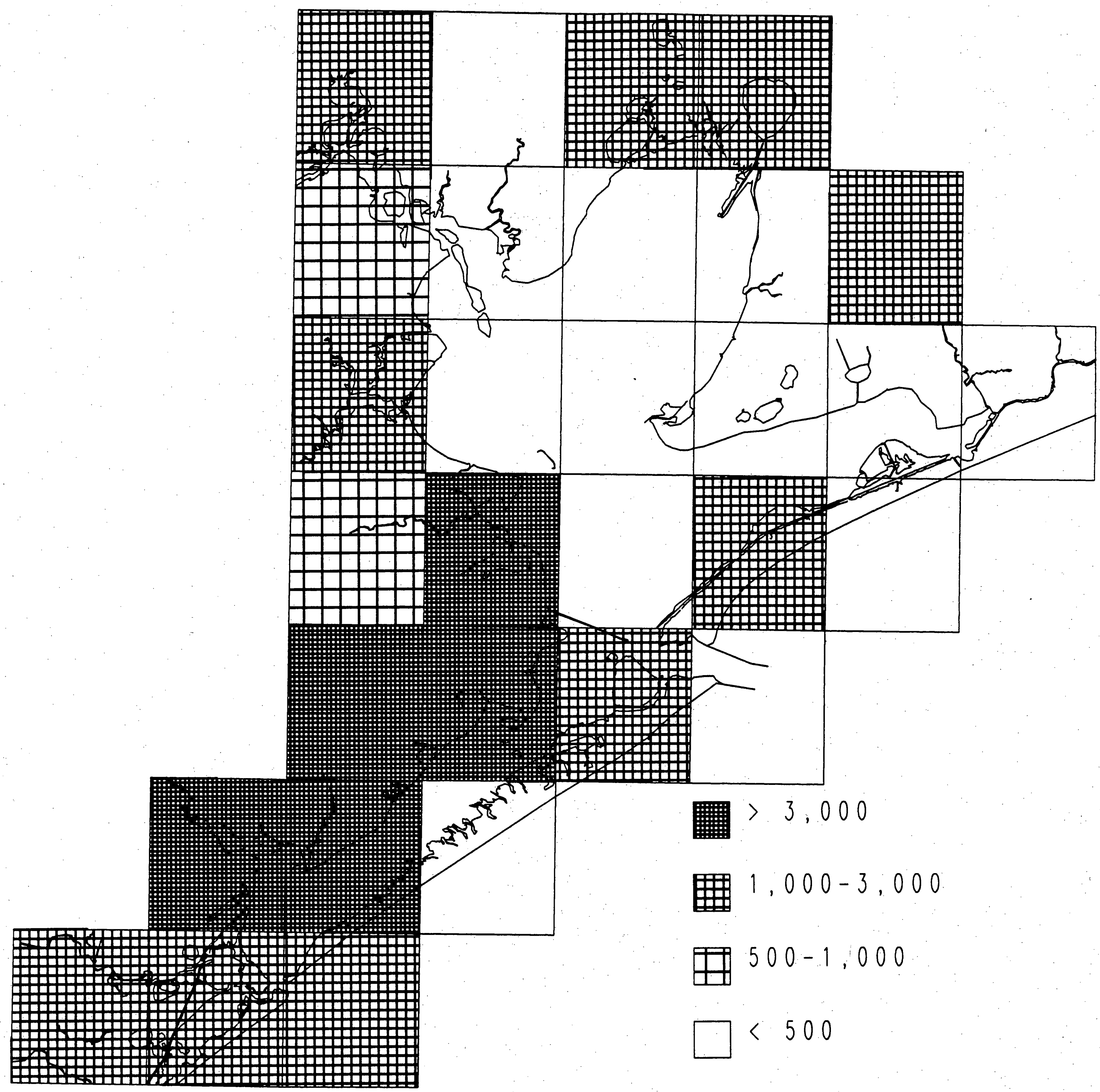


Figure 34. Map showing distribution of emergent wetland net losses (in acres), 1950's to 1989, for 7.5-minute quads defining the Galveston Bay study area.

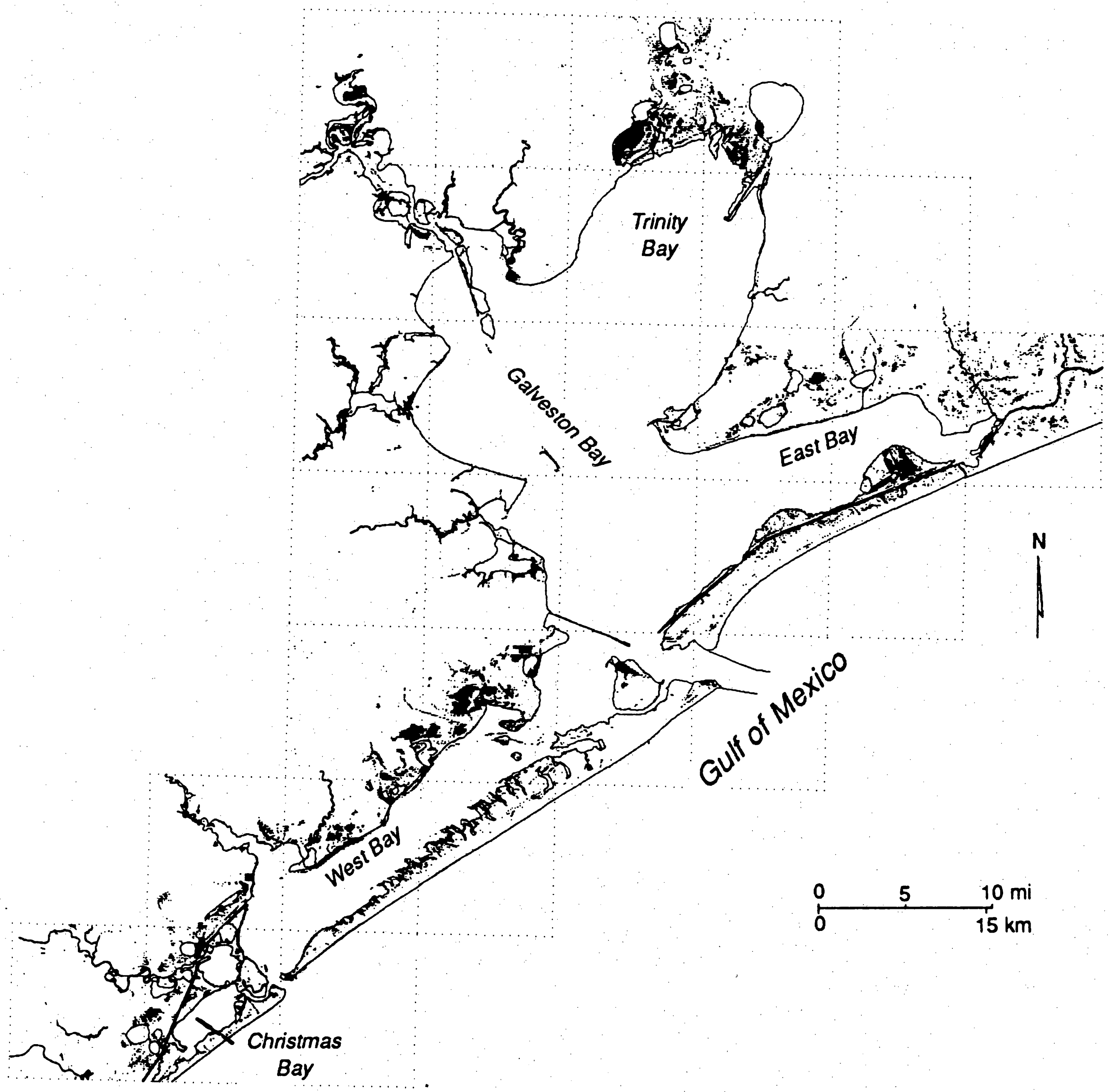


Figure 35. Distribution of emergent wetlands (marshes) (shaded areas) that were displaced by water and barren flats between the 1950's and 1989. Areas where losses were extensive include the Trinity River delta at the head of Trinty Bay (fig. 59), inland margin of West Bay (figs. 55 and 56), and fan-like feature on Bolivar Peninsula Gulfward of East Bay (figs. 52 and 60).

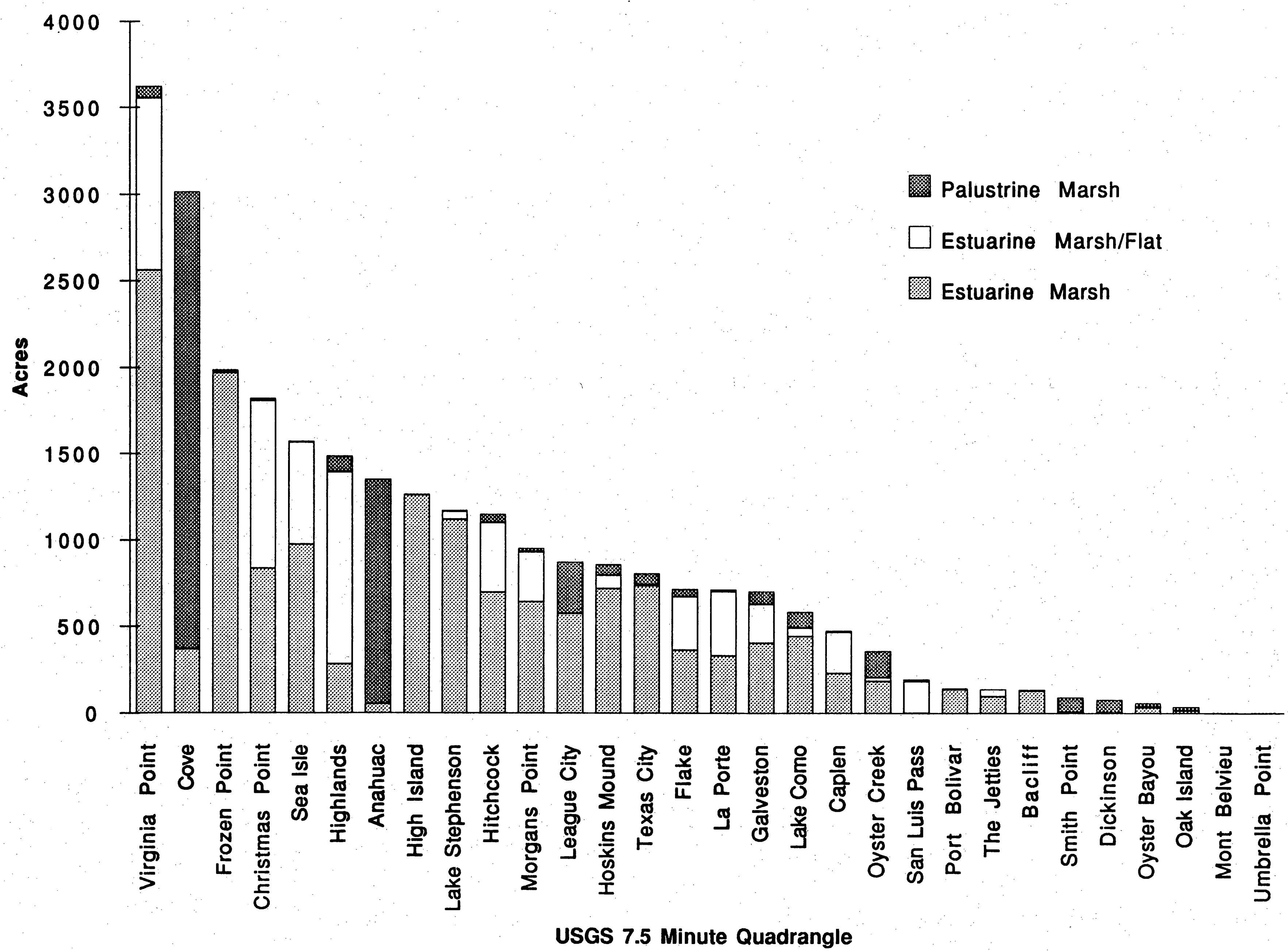


Figure 36. Bar graph showing the extent of losses in emergent wetlands (marshes) in each quad due to conversion to open water and barren flats, 1950's to 1989.

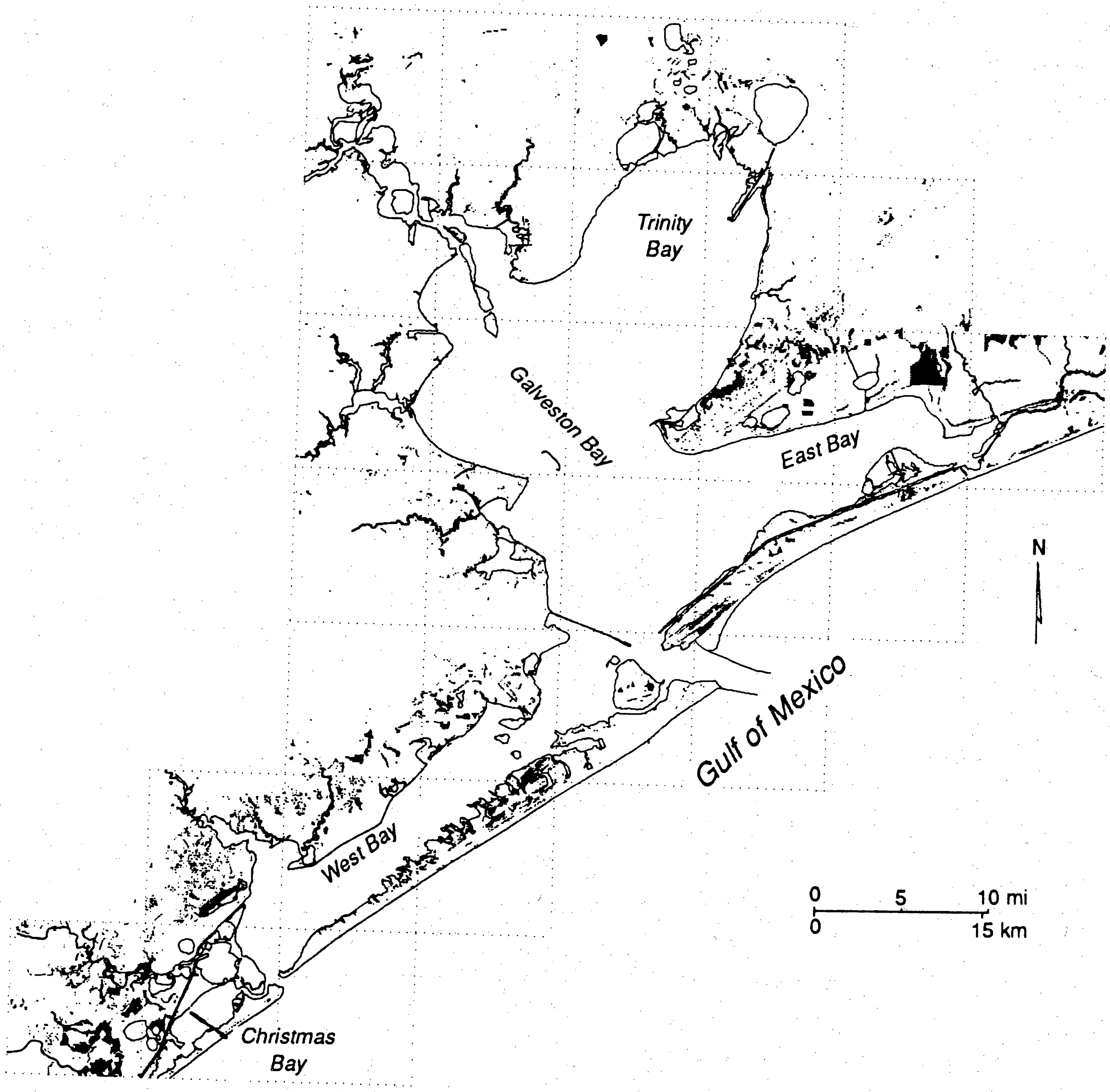


Figure 37. Distribution of areas that changed from uplands in the 1950's to emergent wetlands (marshes) in 1989. The extent of these changes are shown on figures 38 to 42.

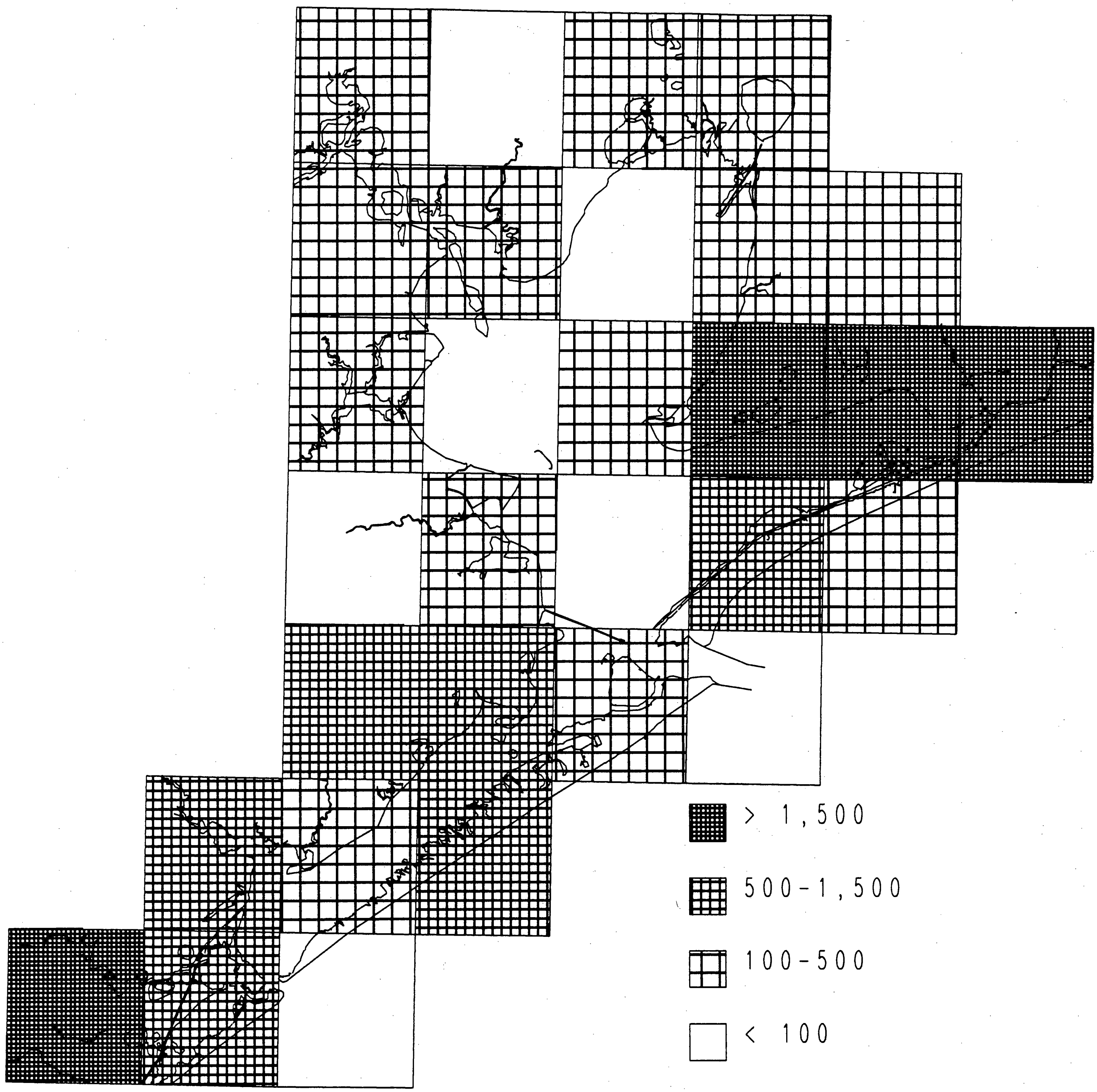


Figure 38. Map of 7.5-minute quads showing the geographic distribution and extent (in acres) of areas that changed from uplands to emergent wetlands (marshes) from the 1950's to 1989. See figures 40 to 42 for more specific changes in quads.

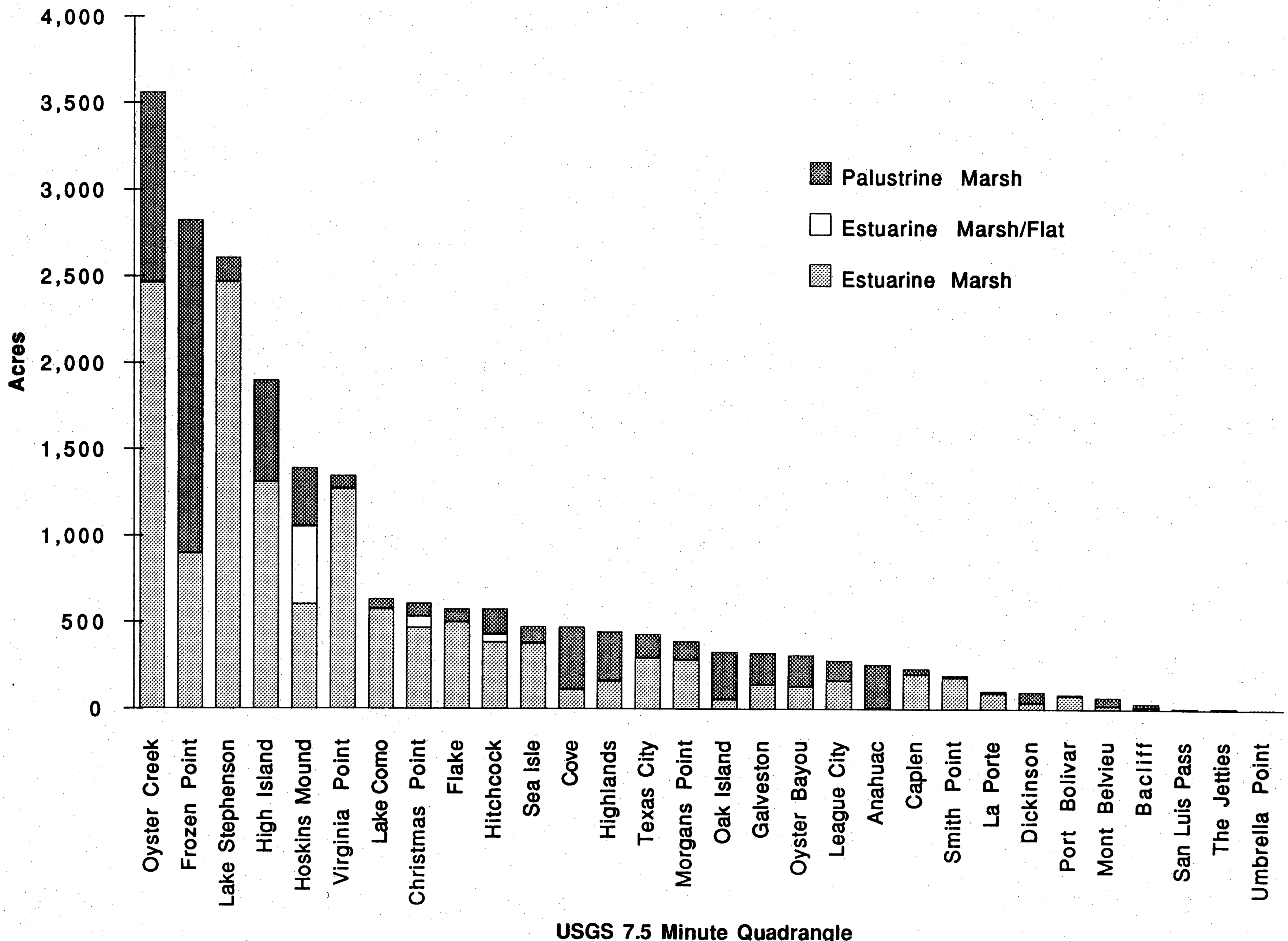


Figure 39. Bar graph of 7.5-minute quads showing extent (in acres) of areas that changed from uplands to emergent wetlands (marshes), 1950's to 1989.

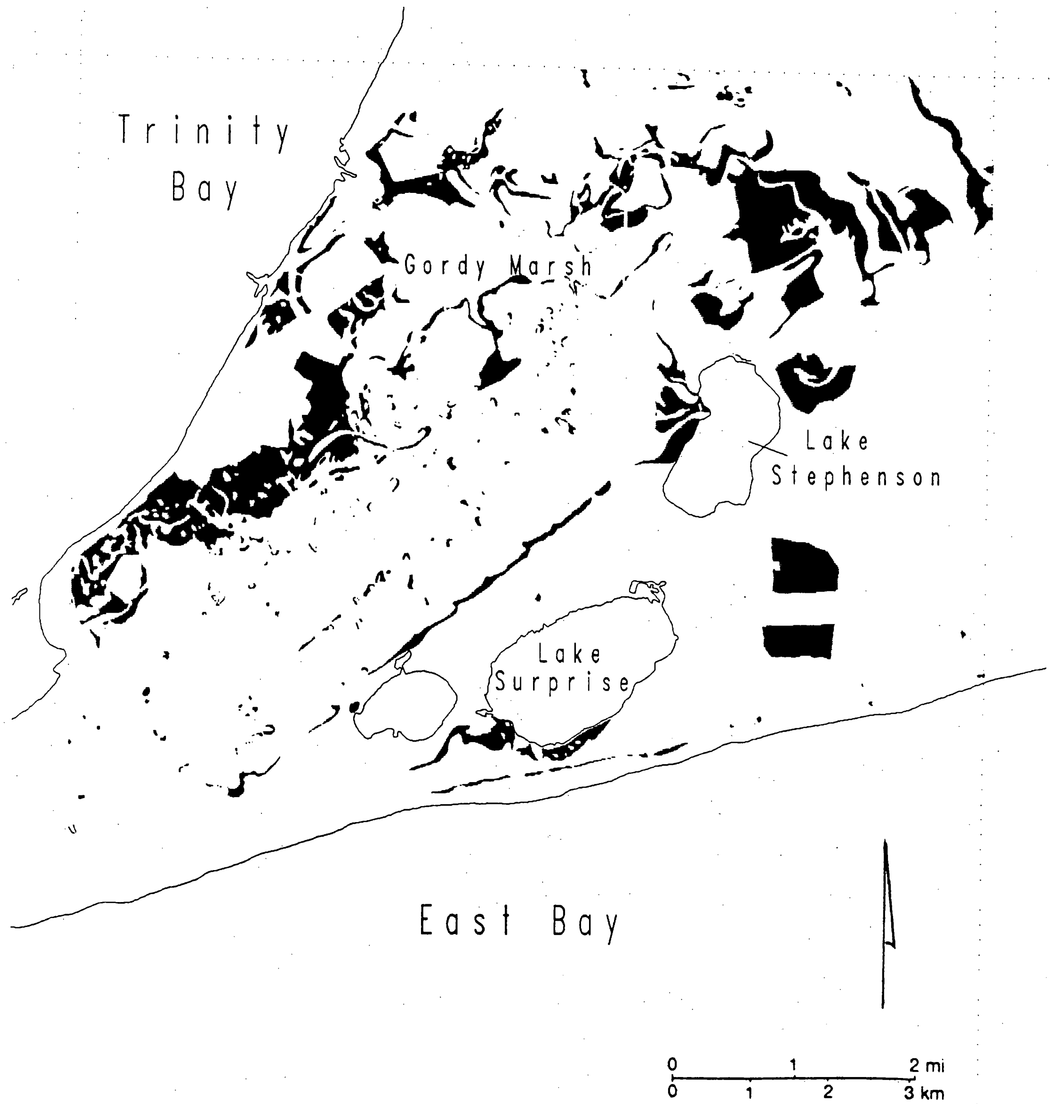


Figure 40. Distribution of areas (shaded) that changed from uplands (1950's) to emergent wetlands (1989) in the Lake Stephenson quad. Subsidence associated with the fault shown in figure 61 is suspected of having contributed to this change.

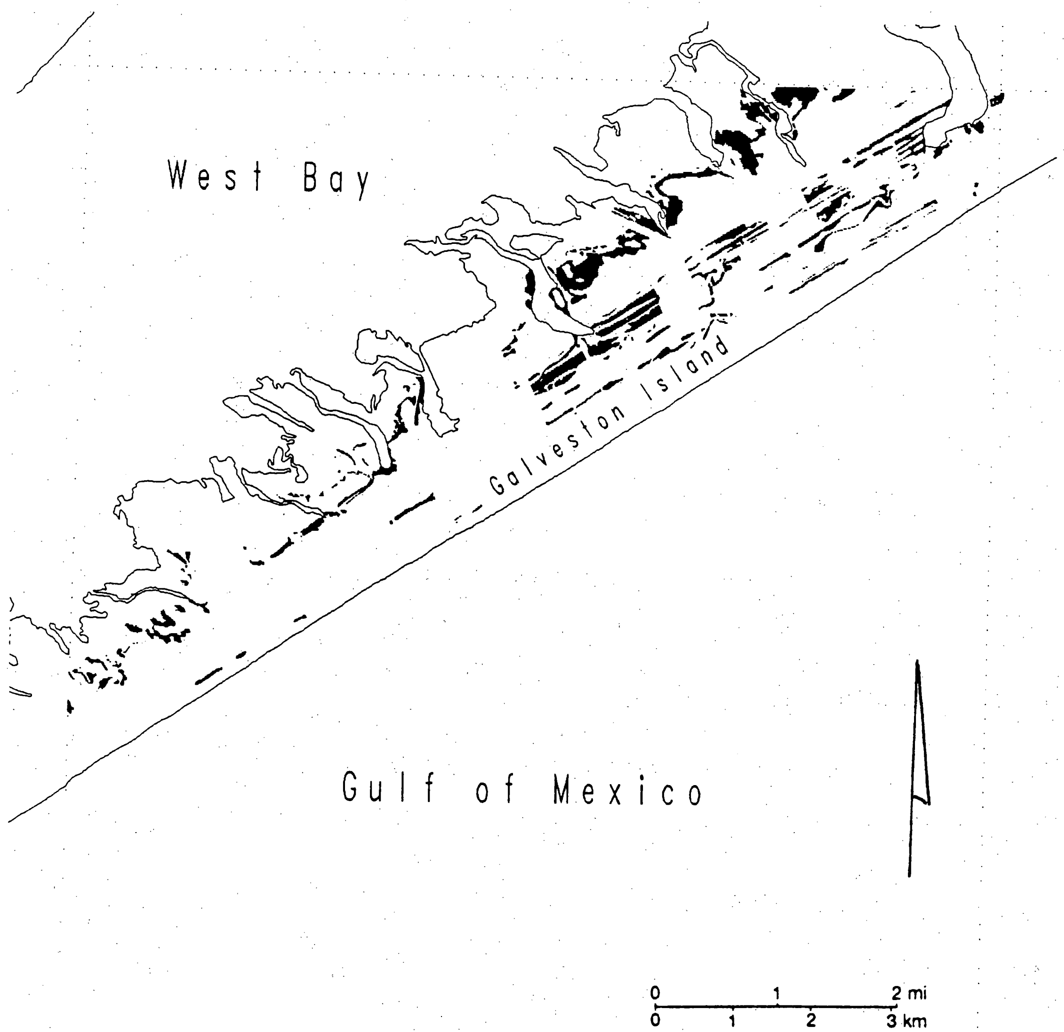


Figure 41. Distribution of areas (shaded) that changed from uplands (1950's) to emergent wetlands (1989) in the Lake Como quad. Linear features in the central part of Galveston Island are wetland increases in swales between relict beach ridges. Increases on the bayward side of the island is perhaps due to subsidence on Galveston Island reported by Zimmerman and others (1991).

inland from West Bay and Christmas Bay (Oyster Creek quad, fig. 42). The conversion of uplands to wetlands generally took place in transitional areas peripheral to existing wetlands. Additional increases in emergent wetlands resulted from the spread of emergent vegetation over areas previously mapped as intertidal flats. This type of change was confirmed by comparing aerial photographs. Such changes occurred on some intertidal sand flats on Galveston Island and Bolivar Peninsula. Still, the reverse of this type of change, the conversion of emergent wetlands to flats, was more extensive on these barrier islands.

Scrub-Shrub and Forested Wetlands

The general trend in scrub-shrub wetlands for the 1950's to 1989 period was one of net loss. This trend was countered by forested wetlands, which had a significant net gain. Scrub-shrub wetlands decreased by nearly 900 acres, representing a loss of about 25 percent of the 1950's resource. Forested wetlands, on the other hand, increased in area by approximately 3,600 acres, an increase of about 1.8 times the 1950's area (fig. 43).

For the 1950's, more than 90 percent of the mapped scrub-shrub habitat was contained in two quads centered on the Trinity River alluvial valley; the quads are Cove and Anahuac, which together account for more than 3,100 acres. The bulk of the loss in the scrub-shrub habitat between the 1950's and 1989 occurred in these two quads. Much of the loss (about 2,900 acres) in these two areas, however, was offset by gains in other quads. In fact, 22 quads had gains in scrub-shrub habitats (fig. 43).

The Cove and Anahuac quads are also important forested wetland sites, accounting for 84 percent of the 1950's forested wetland habitat, and 75 percent of the 1989 forested wetland habitat. The 3,600-acre increase in forested wetlands across the Galveston Bay system occurred primarily in these two quads, although there were apparent increases in forested wetlands in most quads where this habitat was mapped (fig. 43).

Estuarine Aquatic Beds

Submerged vascular vegetation (E1AB on 1950's maps and E1AB3L on 1989 maps) decreased from about 2,500 acres in the 1950's to approximately 700 acres in 1989. The acreage for 1989 was determined by subtracting 245 acres from the actual mapped total to delete misclassifications and inland aquatic beds. Using these acreages the decline in submerged vegetation is 1,800 acres, or more than 70 percent of the 1950's habitat. This may be an underestimate as discussed below and in the section on probable causes for losses.

The most extensive losses in submerged vegetation occurred in West Bay (fig. 28) (Lake Como, Sea Isle, and San Luis Pass quads), where the entire 1950's resource of almost 2,200 acres disappeared by 1989. Another area of loss occurred in western Galveston Bay near Clear Lake (fig. 28) (League City and La Porte quads), where at least 50 acres disappeared before 1989.

There is little doubt that a loss of submerged vegetation has occurred in the Galveston Bay system since the 1950's; losses have been reported by other studies (Pulich and White, 1991, for example). The magnitude of loss appears to be larger than the 1950's and 1989 map series reveal. For instance, approximately 5,000 acres of submerged vegetation were mapped in the Galveston Bay system by Fisher and others (1972) using 1956 aerial photographs. These photographs were taken during a drought when low water conditions and low turbidities possibly promoted both the maximum distribution of marine grasses (Pulich and White, 1991) and their interpretation on aerial photographs.

Figure 42. Distribution of areas (shaded) that changed from uplands (1950's) to emergent wetlands (1989) in the Oyster Creek quad. While some of the changes might be the result of photointerpretation, subsidence and faulting in this area are thought to have contributed to local changes from uplands to wetlands.

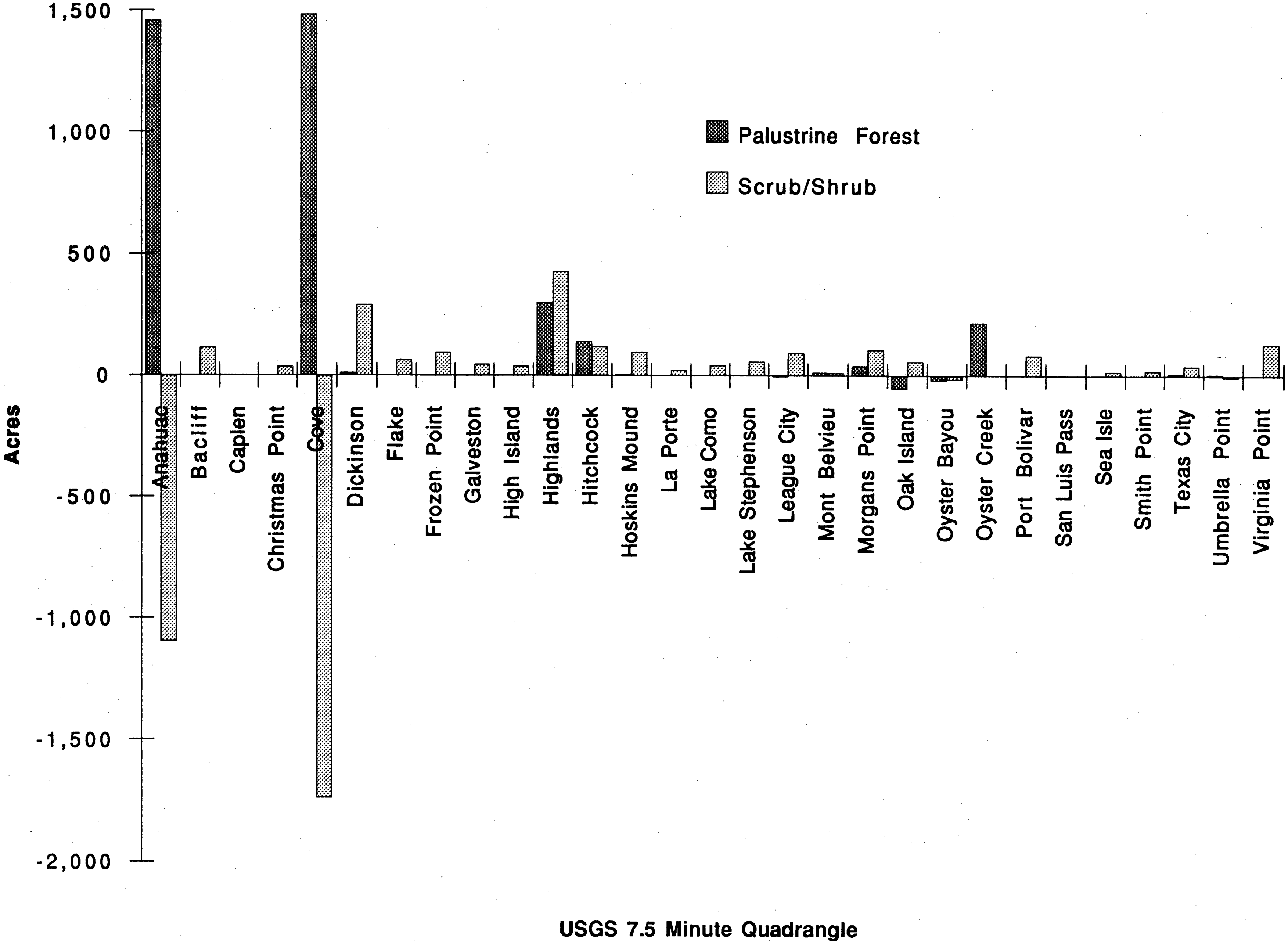


Figure 43. Net losses and gains (acres) in scrub-shrub and forested wetlands from the 1950's to 1989 for 7.5-minute quads in Galveston Bay system.

Comparison of 1950's acreages (used in this study) with acreages from 1975 and 1987 (Pulich and White, 1991) indicates a striking, steady decline from about 300 to near 200 acres in marine grass distribution in Christmas Bay (McFarlane, 1991a). However, the 1989 area of about 385 acres suggests a reversal in this trend. The previously defined downward trend may be due to annual and seasonal differences in distribution patterns of marine grasses, and to bay-water conditions that can enhance or interfere with the discernment of submerged vegetation on aerial photographs.

Accurate delineation of submerged aquatic vegetation on photographs can be inhibited by water turbidities and seasonal changes in distribution. Neither the 1950's nor the 1989 maps accurately reflects the total distribution of submerged vegetation that existed during maximum annual growth for those years. This is especially true in upper Trinity Bay, where fresher conditions exist and species with limited seasonal distribution such as *Vallisneria* are part of the rooted vegetation assemblage (Pulich and others, 1991) (fig. 29). In Christmas and West Bays, where extensive marine grasses were present in the 1950's, it appears that the true distribution could have been underestimated on the 1950's photographs because of high local turbidities. In contrast, conditions were favorable in Christmas Bay for delineation of the aquatic beds on the 1989 photographs because of low tides and turbidities. Thus, in Christmas Bay, part of the apparent gain in submerged vegetation from about 300 acres in the 1950's to about 385 acres in 1989, is due to photointerpretation. Still, these acreages suggest that the distribution of marine grass in Christmas Bay, while possibly fluctuating on an annual and seasonal basis (Pulich and White, 1991), has not changed substantially since the 1950's.

Trends: 1950's to 1979 to 1989

The mapped distributions of vegetated wetlands for the 1950's, 1979, and 1989 indicate substantial net losses over both periods. This downward trend is illustrated by acreages of 171,000 in the 1950's, 146,000 in 1979, and 138,600 in 1989. The rate of loss, however, decreased over time from about 1,000 acres per year between 1953 and 1979, to about 700 acres per year between 1979 and 1989. The rate of loss between 1979 and 1989 would be lower, less than 500 acres, if inaccuracies in wetland interpretation on the 1979 photographs were taken into account. Emergent wetlands decreased in area overall, whereas, together, scrub-shrub and forested wetlands increased in area (table 6, fig. 33).

Estuarine and Palustrine Emergent Wetlands

Estuarine and palustrine emergent wetlands represent, by far, the largest wetland system in the Galveston Bay complex for all periods (figs. 24, 30, and 31; plates I–III [at back]). The data on wetland distribution indicate that the most extensive losses occurred in palustrine emergent wetlands (table 6), which had apparent net losses of 15,600 acres from the 1950's to 1979, and about 10,000 acres from 1979 to 1989. In contrast, estuarine emergent wetlands appear to have decreased by 11,760 acres from the 1950's to 1979, and increased by almost 2,300 acres between 1979 and 1989. Because of photointerpretation problems and inconsistencies in emergent wetland classification for the different periods (see methods section and section on possible photointerpretation errors), emphasis is placed on estuarine and palustrine emergent wetlands as a whole. Trends in estuarine versus palustrine emergents are depicted in a general way in various illustrations.

The overall trend in emergent wetlands is one of net decline (fig. 33), from about 165,500 acres in the 1950's to 138,100 acres in 1979, to 130,400 acres in 1989. Sixteen of the 30 quads show a systematic net loss in marshes (emergent wetlands) from the 1950's to 1979 and from 1979 to 1989 (fig. 44). Most other quads show net losses from the 1950's to 1979, followed either by little change or a small net gain from 1979 to 1989. Only two (High Island and Lake Stephenson) had larger areas of emergent wetlands in the more recent years (1979 and 1989)

Table 6. Areal extent of vegetated wetland habitats in the 1950's, 1979, and 1989, Galveston Bay system.

WETLAND HABITAT	NWI Wetland CLASSIFICATION	1950's acreage	1979 acreage	1989 acreage
Salt and Brackish Marsh	Estuarine Emergent (E2EM)	117,640	105,880	108,160
Fresh or Interior Marsh	Palustrine Emergent (PEM)	47,850	32,250	22,210
Scrub/Shrub	Palustrine Scrub/Shrub (PSS)	3,430	2,300	2,570
Forested	Palustrine Forested (PFO)	2,040	5,580	5,650
Total		170,960	146,010	138,590

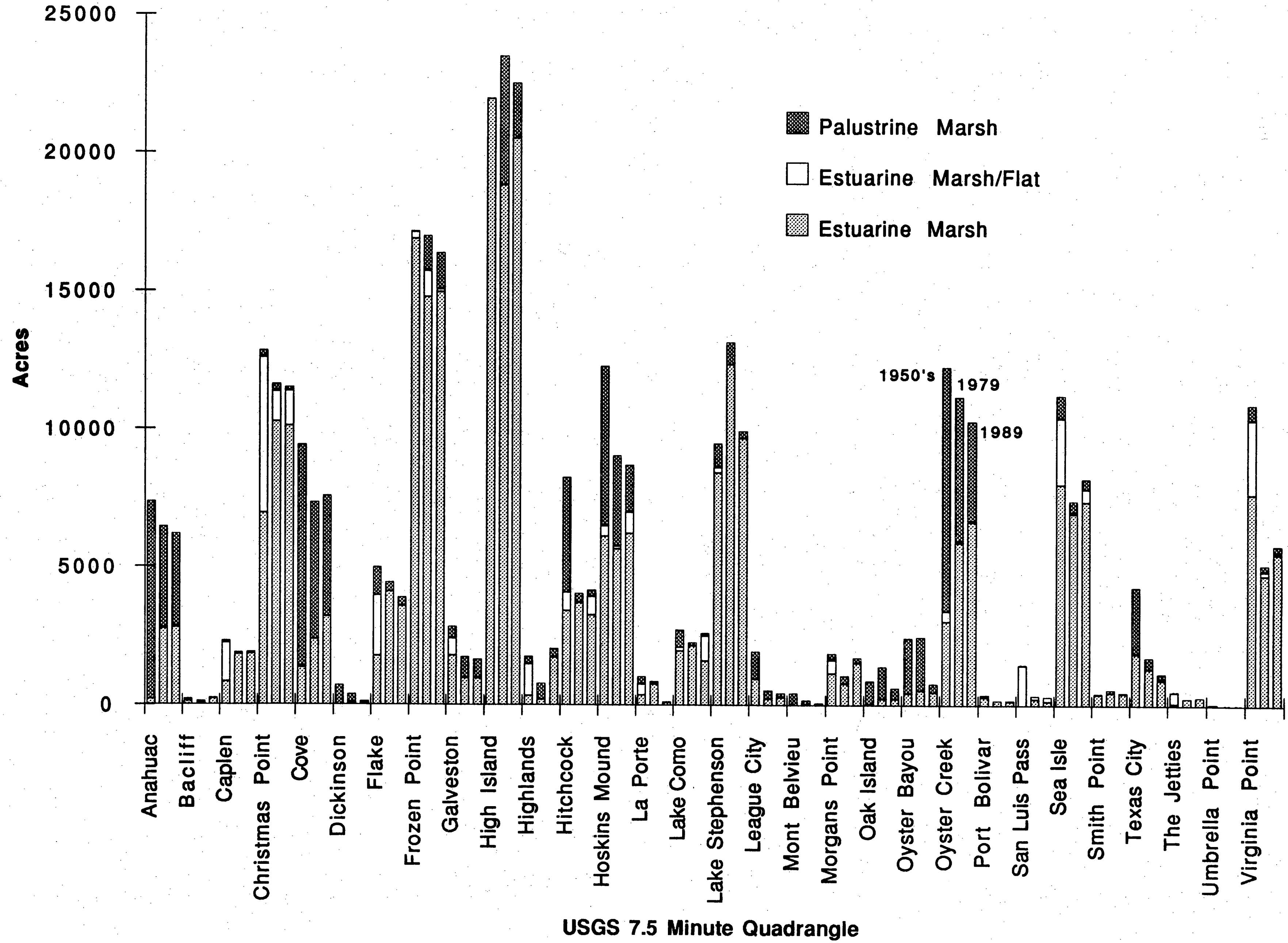


Figure 44. Areal extent of emergent wetlands (marshes) in the 1950's, 1979, and 1989, for the 30 quads defining the Galveston Bay system.

than in the 1950's. In both quads the wetland resource in 1979 was largest, indicating a gain from the 1950's to 1979, followed by a loss from 1979 to 1989 (fig. 44). The anomalously large area of emergent wetlands in the Lake Stephenson quad in 1979, however, is primarily the result of photointerpretation (see previous section on possible photointerpretation errors). Although wetlands may have increased in size during 1979 because of abnormally high precipitation, the 3,700-acre increase shown by the 1979 data for Lake Stephenson is unrealistic. The net increase from the 1950's to 1989 in this quad was less than 500 acres.

Quads with the largest net losses from the 1950's to 1979 are generally the ones with large losses discussed previously for the 1950's to 1989 period. They are Virginia Point, Hitchcock, Sea Isle, Hoskins Mound, Texas City, and Cove (fig. 44). The range in net loss in these areas is about 2,400 to 5,800 acres. This downward trend did not necessarily continue in each quad during the 1979 to 1989 period. In fact, the data show that in four of the six quads net gains occurred between 1979 and 1989 (Cove, Hitchcock, Sea Isle, and Virginia Point). Losses continued in Hoskins Mound and Texas City.

Scrub-Shrub and Forested Wetlands

Scrub-shrub and forested wetlands, together, increased in area over the two periods. Total area of these resources increased from 5,470 acres in the 1950's to 7,880 acres in 1979, to 8,220 acres in 1989. The scrub-shrub wetland habitat decreased from about 3,430 acres in the 1950's to 2,300 acres in 1979; it increased to about 2,570 in 1989. Mapped forested wetlands showed a systematic increase from about 2,040 acres in the 1950's to 5,580 acres in 1979 to 5,650 in 1989.

Major areas of scrub-shrub and forested habitats are confined to about four or five quads (fig. 45). These habitats commonly occur in the valleys of major rivers and streams, for example, the Trinity River (Anahuac and Cove quads), the San Jacinto River (Highlands quad), and Oyster Creek and Oyster Bayou (in quads of the same name).

Systematic trends are recognized in Cove and Anahuac quads where scrub-shrub wetlands decreased over each period, while forested wetlands increased (fig. 45). In the Highlands quad, which encompasses part of the San Jacinto River valley, scrub-shrub and forested wetlands, together, increased from the 1950's to 1979, and from 1979 to 1989. Over the latter period, maps of the Highland quad indicate an increase of scrub-shrub and forested wetlands from about 200 acres in 1979 to more than 800 acres in 1989. In the Oyster Creek quad, forested areas increased systematically from about 450 acres (1950's) to 650 acres (1979) to 675 acres (1989). In two areas (Oyster Bayou and Morgans Point), the 1979 scrub-shrub and forested wetland resources are considerably larger than in the 1950's and 1989 (fig. 45).

Estuarine Aquatic Beds

Estuarine aquatic beds could not be adequately mapped on the 1979 aerial photographs because of abnormally high tides and turbidities. For a discussion on changes, see the section on trends for the 1950's to 1989.

PROBABLE CAUSES OF WETLAND LOSSES AND LOCAL GAINS

The causes of wetland losses include both natural and artificial factors. Among them are relative sea-level rise (subsidence + eustatic sea-level rise) and draining and filling of wetlands for

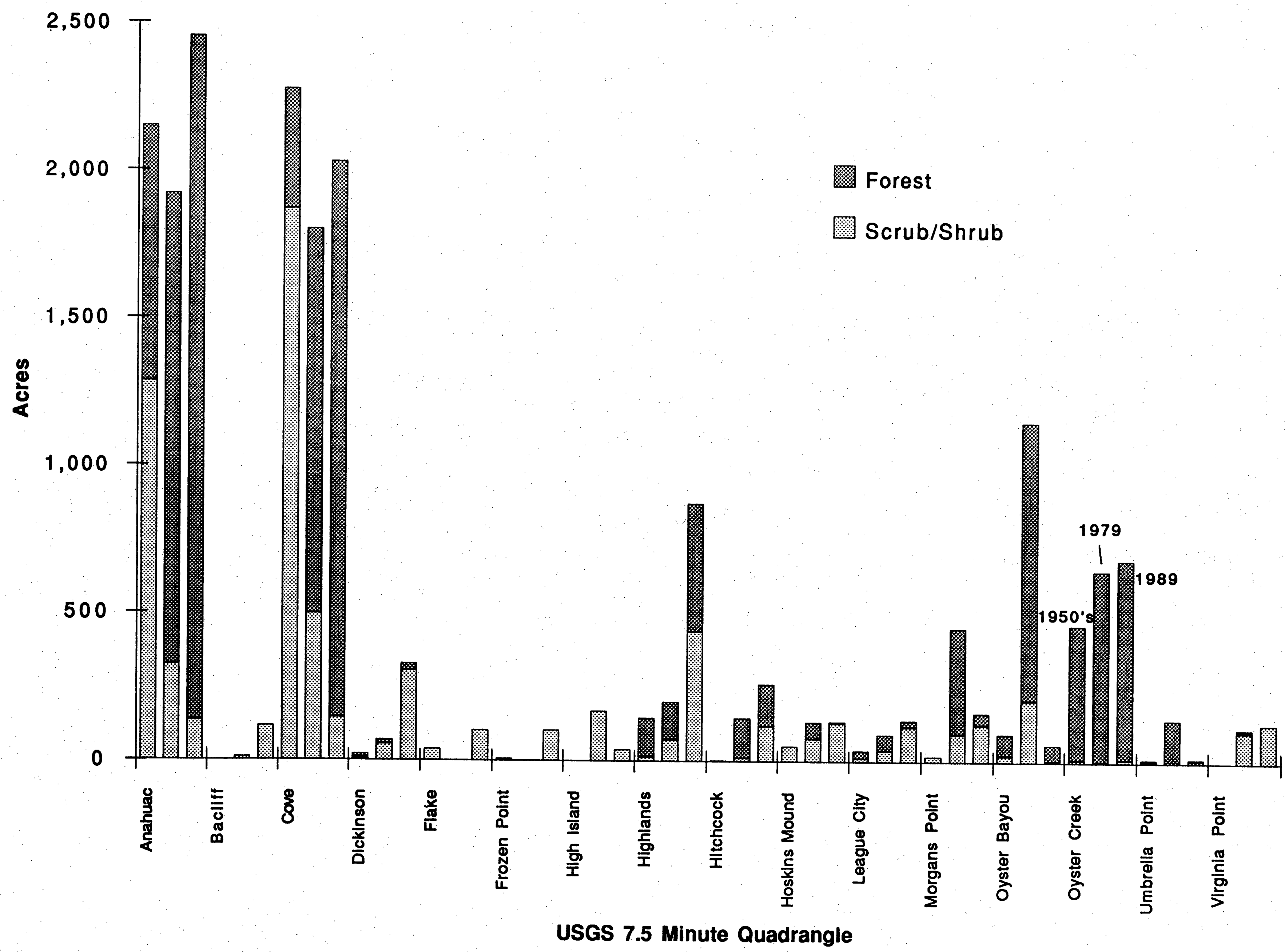


Figure 45. Areal extent of scrub-shrub and forested wetlands in the 1950's, 1979, and 1989, for 16 quads in which these wetlands were most abundant.

agricultural, transportational, industrial, residential, commercial, and recreational purposes. Various activities can have a direct and indirect impact on wetlands (table 7).

Emergent Wetlands

As noted in the previous section on trends in wetland distribution, extensive losses occurred in estuarine and palustrine emergent wetlands, or marshlands. Net losses approximated 35,000 acres from the 1950's to 1989. Gross losses, exclusive of offsetting gains in other areas, are considerably larger, approximately 88,500 acres. It should be noted that much of this gross "loss" is not a true loss in marsh area, but rather reflects a change in wetland classification, as for example, from palustrine emergent to estuarine emergent.

Much of the marsh loss (approximately 26,450 acres) was due to conversion of these areas to open water and flats (fig. 46; also figs. 35 and 36). Although many activities (for example, reservoir development and dredging) may lead to this kind of conversion on a localized scale, there is evidence that the major contributing factor in this change is relative sea-level rise, the major component of which is subsidence. Local wetland losses due to subsidence in the Galveston Bay system have been reported in other studies (Johnston and Ader, 1983; White and others, 1985; White and Calnan, 1991; McFarlane, 1991b).

The threat of relative sea-level rise to wetlands can be stated very simply: if emergent wetlands do not build vertically at a rate that is equal to or greater than the rate of sea-level rise, then the wetlands will ultimately drown and be replaced by "barren" shallow subaqueous flats or open water. The rate at which marshes build or aggrade is influenced by many variables including sediment supply, tidal range, frequency and duration of flooding, type of vegetation, storm frequency, and subsidence (Oenema and DeLaune, 1988). The highest rates of marsh aggradation or vertical accretion may exceed 10 mm/yr, but generally, the rates are lower (table 8). Subsidence-related losses in vegetated wetlands also may result from encroachment of saline waters into fresh-water marshes.

Because of the apparent importance of subsidence and sea-level rise in wetland loss on a regional scale in the Galveston Bay system, it has received special attention in the following discussion.

Subsidence and Sea-Level Rise

Relative Sea-Level Rise

Relative sea-level rise as used here refers to a rise in sea level with respect to the surface of the land, whether it is caused by actual sea-level rise or land-surface subsidence; the current general trend along the Texas coast, and in the Galveston Bay area, involves both of these processes working together.

It is generally accepted that over the past century sea level has been rising on a worldwide (eustatic) basis at a rate of about 1 to 1.5 mm/yr, with a rate in the Gulf of Mexico and Caribbean region approximating 2.4 mm/yr (Gornitz and Lebedeff, 1987). Adding "natural" compactional subsidence to these rates yields a relative sea-level rise that locally exceeds 10 mm/yr (Swanson and Thurlow, 1973; Penland and others, 1988; table 8).

Table 7. Major causes of wetland loss and degradation. Modified from Tiner (1984) as compiled from Zinn and Copeland (1982) and Gosselink and Baumann (1980). Relative importance of causes in the Galveston Bay system shown in parenthesis.

HUMAN THREATS

Direct:

1. Drainage for crop production and expansion of upland rangeland (Major)
2. Dredging and stream channelization for navigation channels, flood coastal housing developments, and reservoir maintenance (Moderate)
3. Filling for dredged spoil and other solid waste disposal, roads and highways, and commercial, residential and industrial development (Moderate)
4. Construction of dikes, dams, levees and seawalls for flood control, water supply, industrial purposes, irrigation and storm protection (Major)
5. Discharges of materials (e.g., pesticides, herbicides, other pollutants, nutrient loading from domestic sewage and agricultural runoff, and sediments from dredging and filling, agricultural and other land development) into waters and wetlands (Undetermined)
6. Mining of wetland soils for sand, gravel, peat, and other materials (Minor)

Indirect:

1. Sediment diversion by dams, deep channels, and other structures (Undetermined)
2. Hydrologic alterations by canals, spoil banks, roads and other structures (Undetermined)
3. Subsidence due to extraction of groundwater, oil, gas, sulphur, and other minerals (Major)
4. Salt-water intrusion resulting from indirect threats noted above (Undetermined)

NATURAL THREATS

1. Subsidence (including natural rise of sea level) (Minor)
2. Droughts (Undetermined)
3. Hurricanes and other storms (Undetermined)
4. Erosion (Moderate)
5. Biotic effects (e.g., muskrat, nutria and goose "eat-outs") (Undetermined)

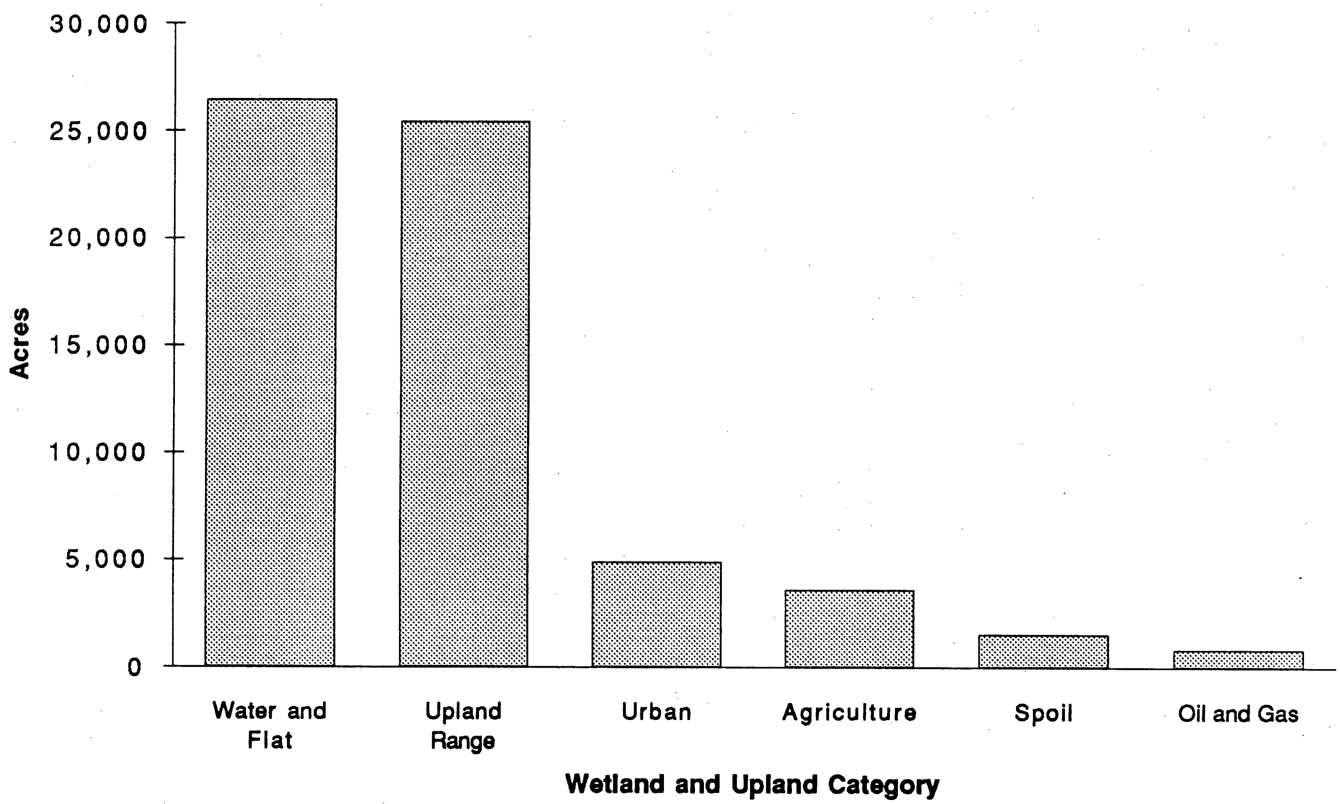


Figure 46. Bar graph showing the area of emergent wetlands (marshes) that were converted to other types of habitats and land uses between the 1950's and 1989. The most significant single change (>26,000 acres) in these categories was from emergent wetlands to areas of open water and barren flat. Changes of marshes to upland categories total about 35,800 acres.

Table 8. Marsh aggradation (vertical accretion) rates measured in coastal Louisiana and Texas, and along the United States Atlantic coast. Modified from Boesch and others (1983).

Location	Marsh type	Marsh accretion rate (mm/yr)	Mean sea-level rise (mm/yr)	Source
Louisiana Deltaic Plain	Freshwater		11.0	Hatton and others (1983)
	streamside	10.6		
	backmarsh	6.5		
	Intermediate (*Spartina patens*)			Hatton and others (1983)
	streamside	13.5		
	backmarsh	6.4		
	Brackish (*Spartina patens*)			Hatton and others (1983)
	streamside	14.0		
	backmarsh	5.9		
	Saline (*Spartina alterniflora*)		13.0	DeLaune and others (1978); Baumann (1980)
	streamside	13.5		
	backmarsh	7.5		
Chenier Plain	Salt-brackish (*Spartina patens*)	7.0	12.0	Baumann and DeLaune (1982)
Texas bayhead deltas	Colorado River Saline *Spartina alterniflora* backmarsh	7.5	<7?	White and Calnan (1990)
	Trinity River Brackish *Alternanthera philoxeroides* backmarsh	5.4	7.5	White and Calnan (1990)
Georgia	*Spartina alterniflora*	3–5		Summarized by Hatton and others (1983)
Delaware	*Spartina alterniflora*	5.0–6.3	3.8	Summarized by Hatton and others (1983)
New York	*Spartina alterniflora*	2.5–6.3	2.9	Summarized by Hatton and others (1983)
Connecticut	*Spartina alterniflora*	8–10	2.5	Summarized by Hatton and others (1983)
	Spartina patens	2–5		
Massachusetts	*Spartina alterniflora*	2–18	3–4	Redfield (1972)

Man-Induced Subsidence

Rates of natural subsidence are dwarfed by rates associated with man-induced subsidence, which is a major factor in the relative sea-level rise equation in the Galveston Bay area (fig. 47). The major cause of man-induced subsidence is the withdrawal of underground fluids, principally water (Winslow and Doyel, 1954; Gabrysch, 1969; Gabrysch and Bonnet, 1975). Production of oil and gas can also cause subsidence (Pratt and Johnson, 1926; Kreitler, 1977; Verbeek and Clanton, 1981; Kreitler and others, 1988). Extreme local subsidence has occurred in relation to sulfur mining around salt domes along the Texas Coast (Ratzlaff, 1980; Mullican, 1988).

According to Gabrysch and Bonnet (1975), subsidence due to withdrawal of ground water from an artesian aquifer results from a decrease of hydraulic pressure and attendant movement of water from clays to adjacent sands leading to compaction of the clays. Most of the compaction is permanent because of the inelastic nature of the clay; thus, even with total recovery of artesian pressure, less than 10 percent rebound can be expected (Gabrysch and Bonnet, 1975).

Subsidence in the Houston–Galveston Area

In the Houston-Galveston area, up to 3 m (10 ft) of man-induced subsidence has occurred between 1906 and 1987 (Gabrysch and Coplin, 1990) (fig. 48). Subsidence of more than 30 cm (1 ft) encompasses an area of approximately 2,330,000 acres. The subsidence "bowl" stretches from north of the Highlands quad to the south where it merges with a smaller bowl with as much as 1.8 m (6 ft) of subsidence centered on Texas City (fig. 47). Another smaller subsidence bowl centered on Freeport extends into the Oyster Creek and Christmas Point quads at the south end of the study area (Ratzlaff, 1980).

Rates of subsidence have varied both spatially and temporally (Gabrysch and Coplin, 1990; McFarlane, 1991b; Zimmerman and others, 1991). Average maximum rates of subsidence at the center of the "bowl" have been as high as 122 mm/yr (0.4 ft/yr) for the period 1964 to 1973 (Gabrysch and Bonnet, 1975). Gabrysch and Coplin (1990) reported that the rate of subsidence in the eastern part of the region (Pasadena area) decreased from about 90 mm/yr (0.3 ft/yr) from 1973 to 1978 to approximately 9 mm/yr (0.03 ft/yr) from 1978 to 1987. However, subsidence in the western part of the region increased from a maximum rate of about 61 mm/yr (0.20 ft/yr) during 1973 to 1978 to about 67 mm/yr (0.22 ft/yr) during 1978 to 1987. The decline in subsidence rates in the eastern part of the region was due to curtailment of ground-water pumpage and the subsequent rise in aquifer water levels, whereas the acceleration in subsidence in the western part of the region was due to a continuing decline in aquifer levels as ground-water pumpage increased to the west (Gabrysch and Coplin, 1990).

Faulting and Subsidence

In some areas, faulting and subsidence may be accompanied by active surface faults. The major zone of surface faulting along the Texas coast is in the Houston–Galveston area where 95 linear mi (150 linear km) of faulting has been reported (Reid, 1973; Brown and others, 1974). Surface faults correlate with, and appear to be extensions of, subsurface faults in many areas (Weaver and Sheets, 1962; Van Siclen, 1967; Kreitler, 1977; Verbeek and Clanton, 1981). Most of the surface faulting in the Houston metropolitan area has apparently taken place during the last few decades (Verbeek and Clanton, 1981), largely due to fluid withdrawal (water, oil, and gas), which has reinitiated and accelerated fault activity (Reid, 1973; Kreitler, 1977; Verbeek and Clanton, 1981).

The range in measurable vertical displacement of surface traces of faults is from 0 to 3.9 m (12 ft) (Reid, 1973). Rates of fault movement commonly range between 5 and 20 mm/yr

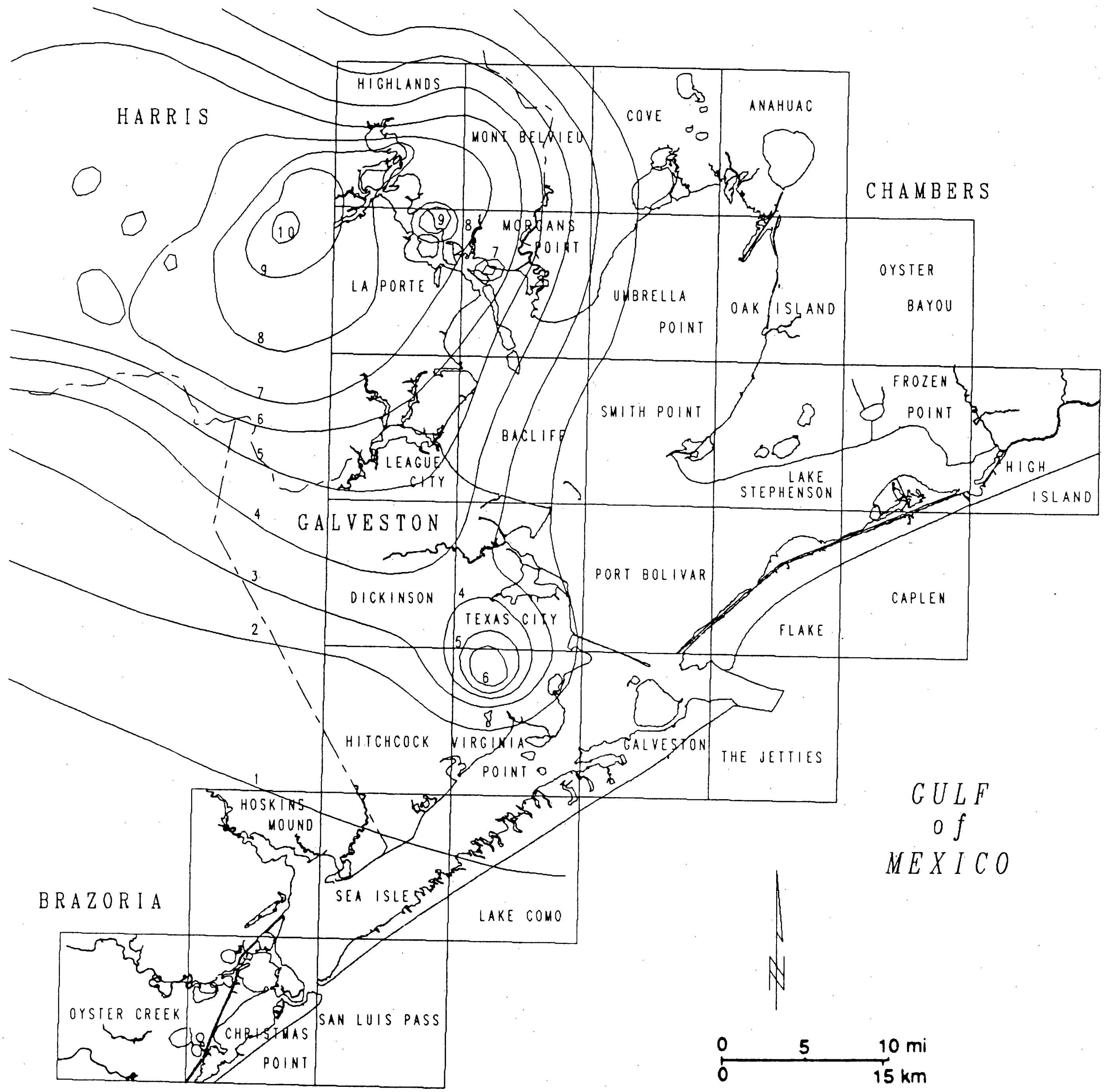


Figure 47. Land-surface subsidence in the Galveston Bay area, 1906 to 1987. Subsidence contours (contour interval = 1 ft) are from Gabrysch and Coplin (1990).

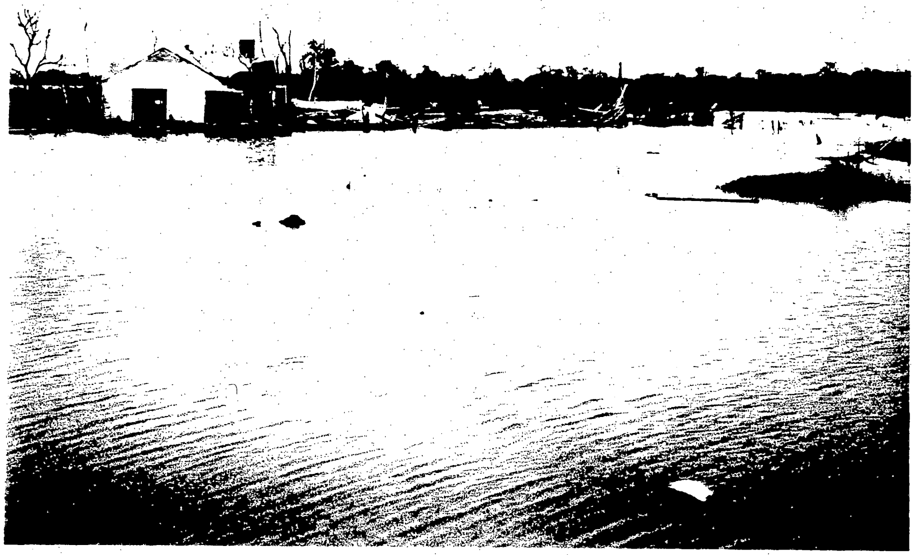


Figure 48. Effects of subsidence near the head of Galveston Bay at Baytown.

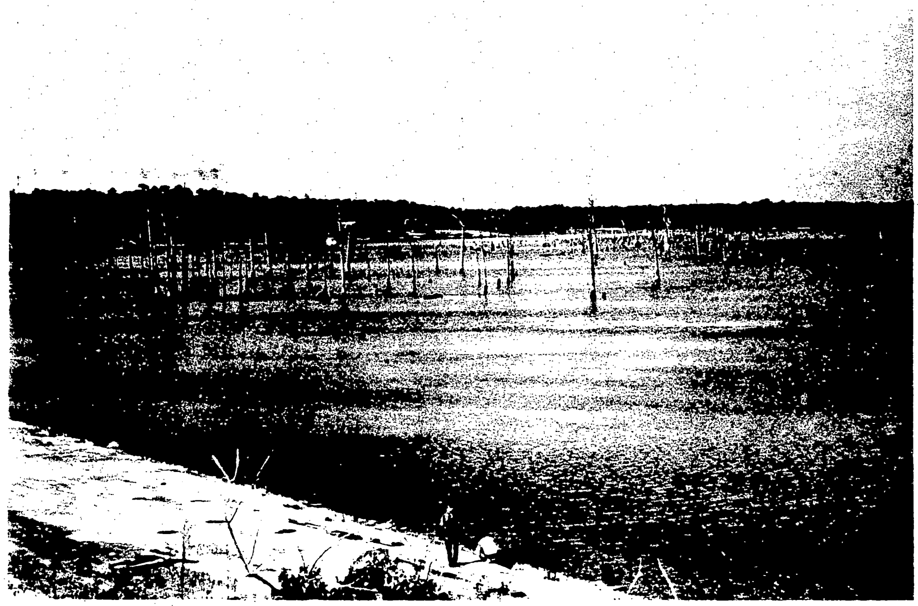


Figure 49. Example of the effects of subsidence on woodlands along the San Jacinto River in the Highlands quad. Site located about 0.6 mi (~1 km) northwest of field site 31-4 (fig. 11).

(0.2 and 0.8 inch/yr) (Verbeek and Clanton, 1981), but many exceed 40 mm/yr (1.6 inches/yr) (Van Siclen, 1967; Reid, 1973; Everett and Reid, 1981). Movement along surface faults apparently occurs episodically (Reid, 1973). Highways, railroads, industrial complexes, airports, homes, and other structures placed on active faults in the Houston area have undergone millions of dollars of damage annually (Clanton and Verbeek, 1981).

Effects of Subsidence and Faulting on Wetlands

Subsidence in the Houston–Galveston area has had a significant effect on wetlands (Johnston and Ader, 1983; White and others, 1985). One of the most dramatic examples of habitat losses (wetland and upland areas) due to subsidence is along the San Jacinto River. More than 1,389 acres of fluvial woodlands (fig. 49), swamps, and marshes were displaced by open water between the 1950's and 1979 (White and others, 1985) (fig. 50). The lower reach of the San Jacinto River, near its confluence with Buffalo Bayou and the Houston Ship Channel, is near the heart of the subsidence bowl (fig. 47).

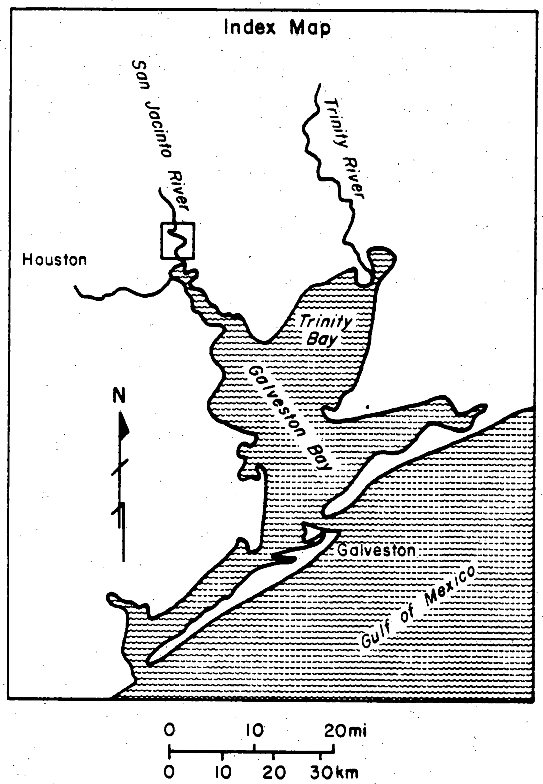
The change in habitats along the lower San Jacinto River valley is pronounced because of the proximity of the valley to the center of maximum subsidence. However, wetlands associated with other streams and valleys located around the Trinity and Galveston Bay systems are also changing as a result of human-induced subsidence and accompanying relative sea-level rise.

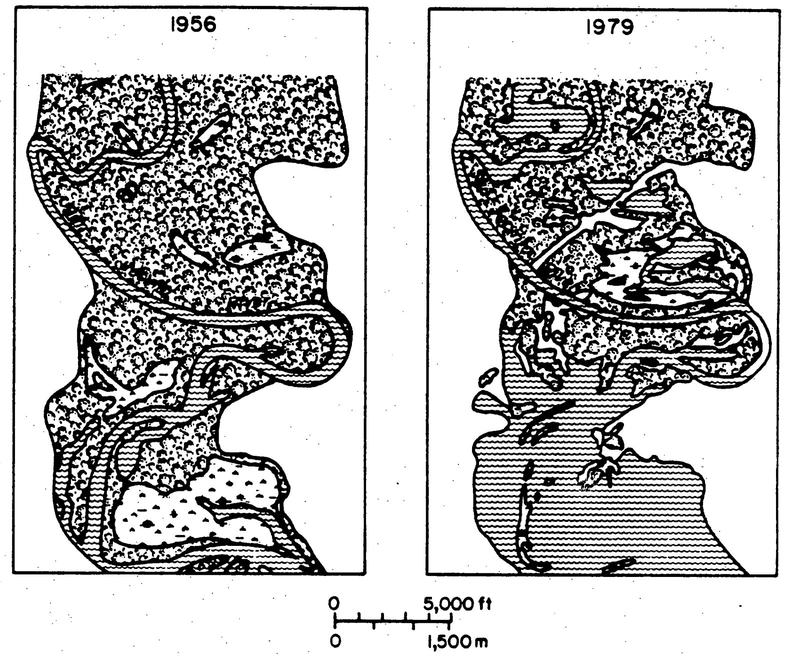
Faults have affected wetlands in several areas in the Galveston Bay system (White and others, 1985). As vertical displacement occurs along a fault that intersects a marsh, more frequent and eventually permanent inundation of the surface on the downthrown side of the fault can lead to replacement of marsh vegetation by open water if marsh sedimentation rates do not keep pace with submergence rates (fig. 51). This has occurred at several locations along the upper Texas coast as exemplified by a marsh system on the bayward side of Bolivar Peninsula, where approximately 1,230 acres of salt-water marsh was replaced primarily by shallow subaqueous flats and open water (fig. 52). In this area, at least two surface faults intersect marsh substrates. Benchmark releveling profiles along State Highway 87 indicate the faults are active; a marked increase in subsidence occurs on the downthrown side (fig. 53). More than 25 faults that cross wetlands along the upper coast (Freeport area to Sabine Pass) have been identified on aerial photographs. Most of the identified faults are in the Galveston Bay project area (White and others, 1985) (fig. 22, for example).

Subsidence-Related Losses in Emergent Wetlands

Transformation of emergent wetlands, or marshes, to areas of water and flats has occurred to some degree throughout the study area (fig. 54). Total loss across all quads has exceeded 26,000 acres, accounting for about 30 percent of the total loss (gross loss excluding gains was about 88,500 acres) in the Galveston Bay system. This type of conversion, from vegetated to nonvegetated areas, has been most pronounced in 15 quads in which more than 800 acres of marshland per quad was lost (fig. 36). Not all of this loss can be attributed to subsidence, but throughout the region as a whole, subsidence has been documented as the major contributing factor to the replacement of emergent wetlands by open water and flats.

At the head of the list is Virginia Point, where more than 3,600 acres of marshland was replaced by open water and mud flat between the 1950's and 1989. Losses in the Virginia Point area have previously been reported by Johnson and Ader (1983), White and others (1985) (fig. 55), and Tremblay (1992). Significant subsidence has been documented in this area (Gabrysch and Coplin, 1990) (figs. 47 and 56). Loss of marshland has been most extensive northwest and west of Jones Bay, where salt marshes have been converted to estuarine unconsolidated shore (E2US, intertidal flat) and estuarine unconsolidated bottom (E2SB, open water) (fig. 56).





Wetland Map Unit	1956		1979		Net Change	
	Acres	Hectares	Acres	Hectares	Acres	Hectares
Water	875	355	2,295	930	+1,420	+575
Fluvial Woodlands & Swamps	3,480	1,410	2,090	845	−1,390	−565
Fresh to Brackish Marsh	650	265	300	120	−350	−145

QA 937

Figure 50. Changes in distribution of wetlands between 1956 and 1979 in a subsiding segment of the San Jacinto River (Highlands quad). From White and others (1985). Among the changes are a loss in forested areas (fig. 49).

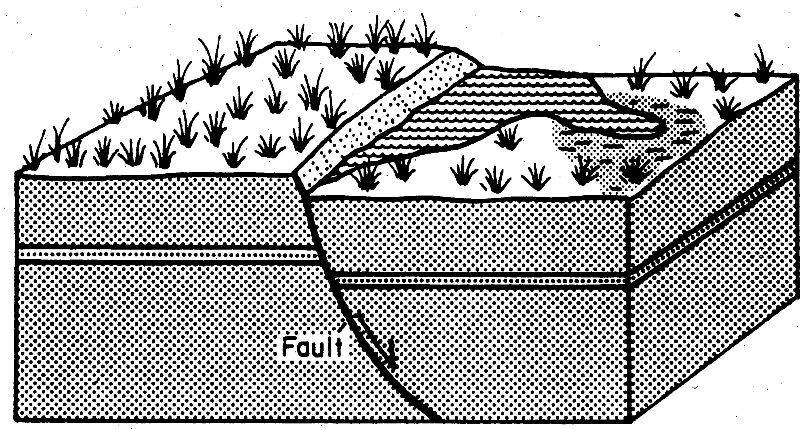
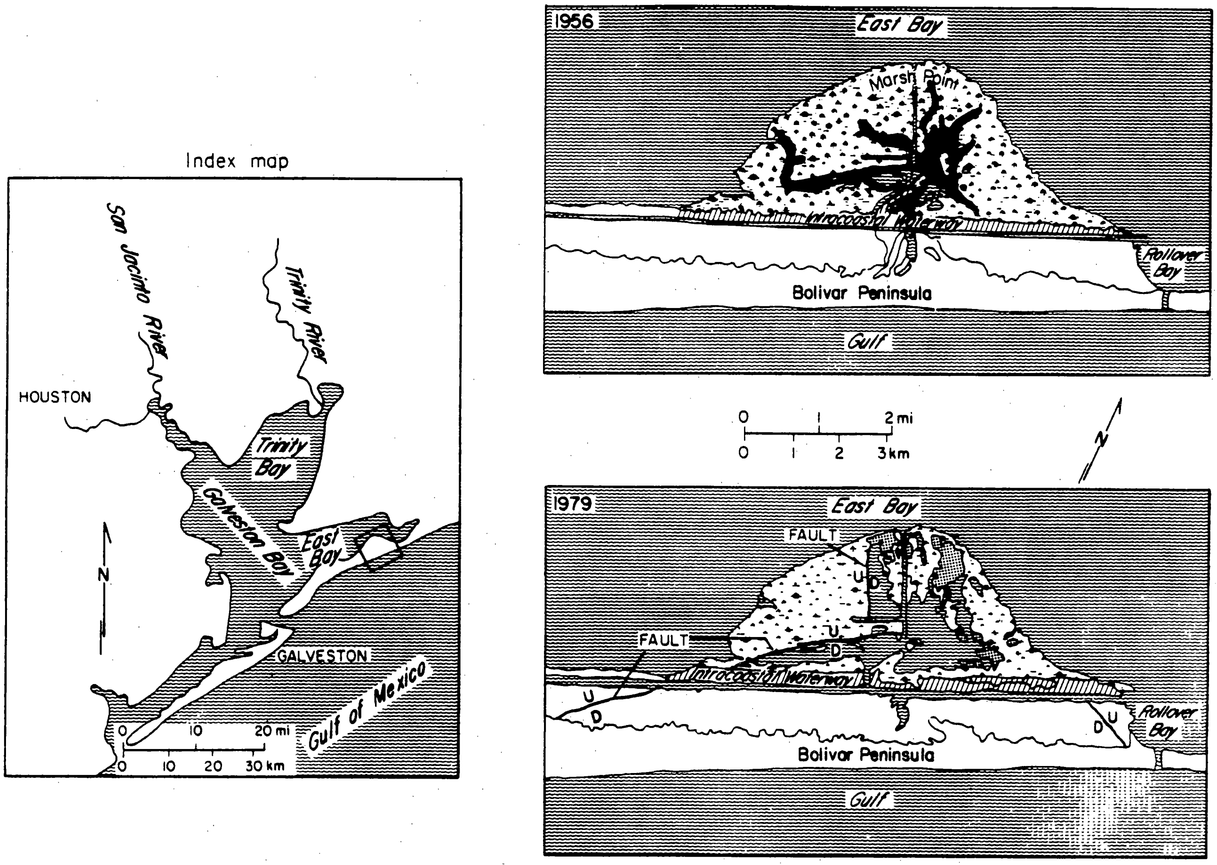


Figure 51. Block diagram of changes in wetlands that can occur along an active surface fault. There is generally an increase in low marshes, shallow subaqueous flats, and open water on the downthrown side of the fault relative to the upthrown side.



Wetland Map Unit	1956		1979		Net Change	
	Acres	Hectares	Acres	Hectares	Acres	Hectares
Water	140	57	1130	458	+990	+401
Marsh	3480	1409	2560	1037		
Marsh-covered tidal channels	640	259				
TOTAL MARSH	4120	1668	2560	1037	-1560	-631
Barren tidal flats			270	109	+270	+109
Dredged spoil/uplands	520	211	720	292	+200	+81
TOTAL	4780	1936	4680	1896	-100*	-40*

*Most of the loss in total area is probably due to erosion of marsh along the margins of East Bay. Historical monitoring indicates that this shoreline is undergoing erosion at rates of up to 3ft (1 m) per year (Paine and Morton, in preparation).

(Areas were calculated using a square-count method; smallest squares used were equivalent to 6.4 acres, or 2.6 hectares).

QA 1774

Figure 52. Changes in distribution of wetlands between 1956 and 1979 near Marsh Point on the bayward side of Bolivar Peninsula. Increases in the areal extent of open water and decreases in the areal extent of marsh are apparently related to localized subsidence and active faults (D = downthrown side of fault, U = upthrown side). From White and others (1985).

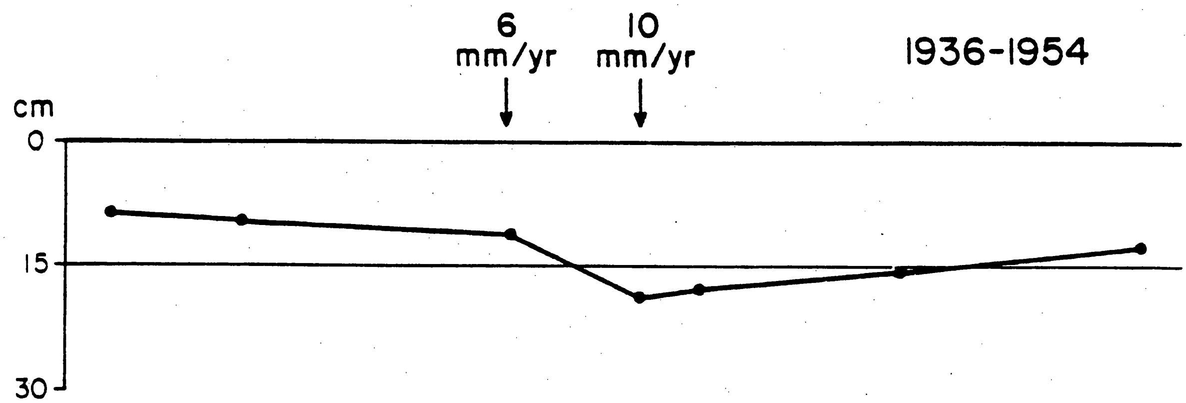


Figure 53. Land-surface subsidence profile based on benchmark-releveling data along Highway 87 on Bolivar Peninsula. The increase in subsidence along the profile indicates that it crosses an active fault, probably an extension of the fault with the NE-SW strike in figure 52.

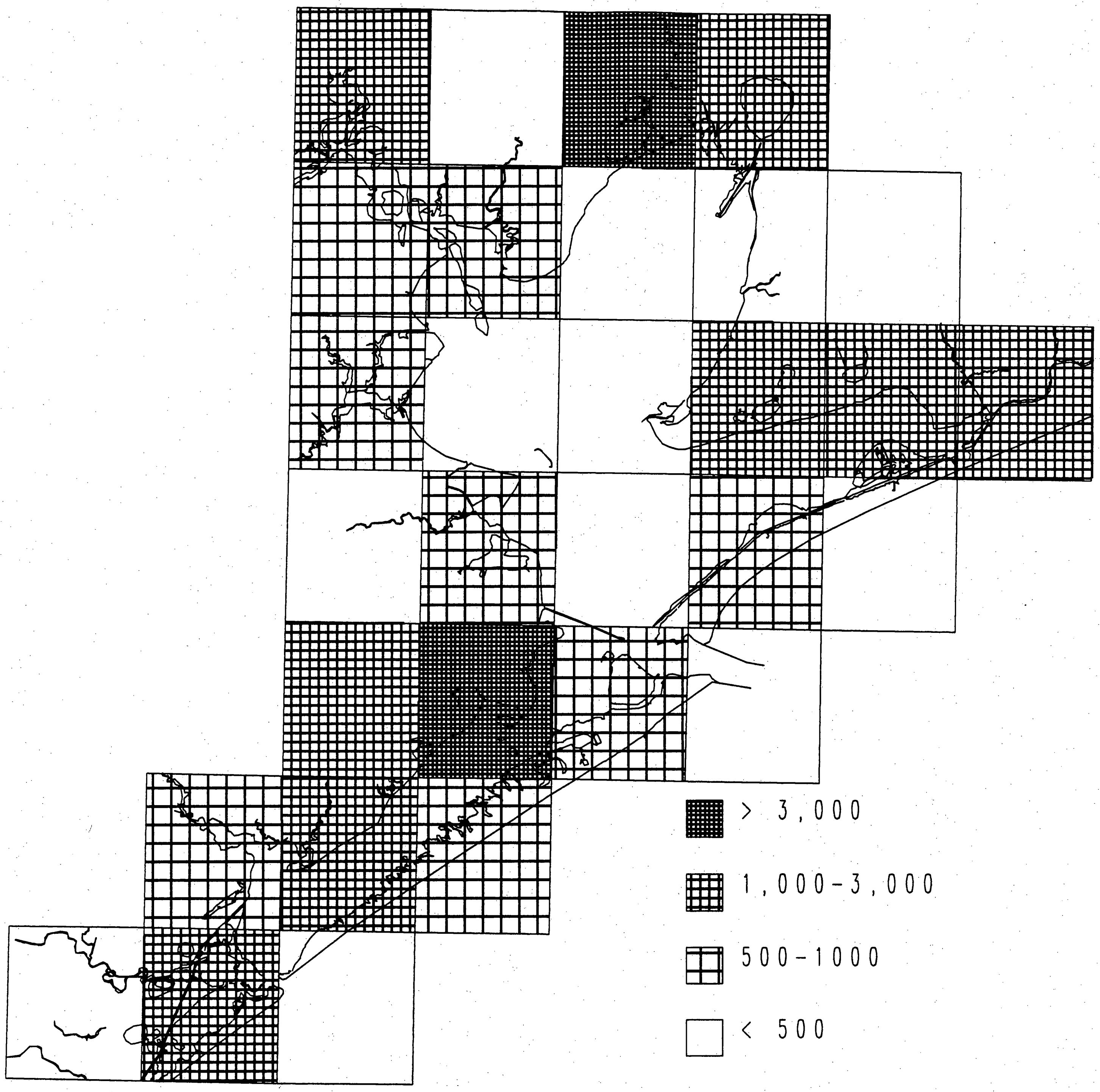


Figure 54. Map of 7.5-minute quads showing the geographic distribution and extent (in acres) of emergent-wetland losses resulting from displacement by open water and flats between the 1950's and 1989. Losses in the Cove and Virginia Point quads each exceed 3,000 acres.

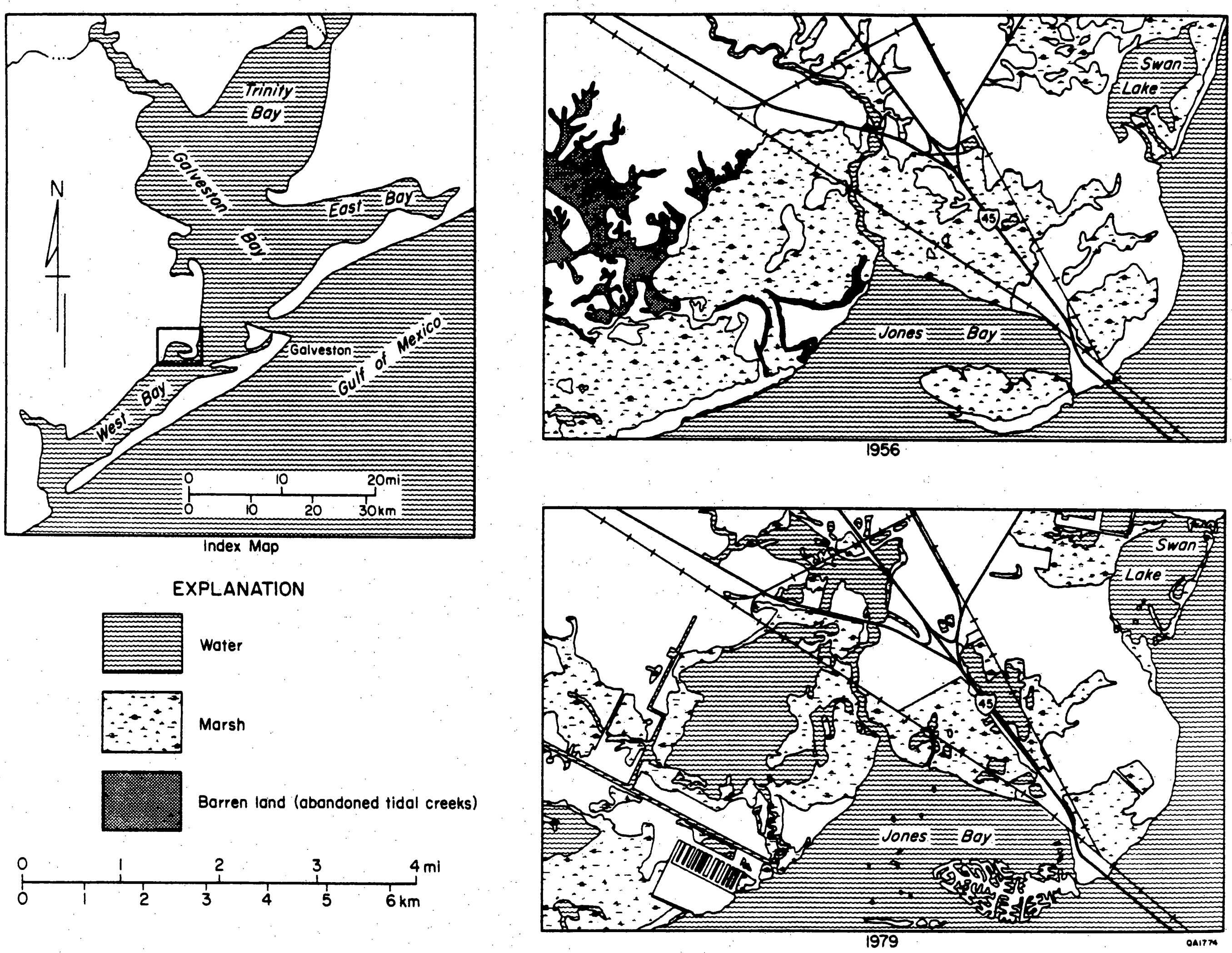


Figure 55. Changes in the distribution of wetlands between 1956 and 1979 near Jones Bay and Swan Lake. Note increase in open water at the expense of marshes in 1979. From White and others (1985).

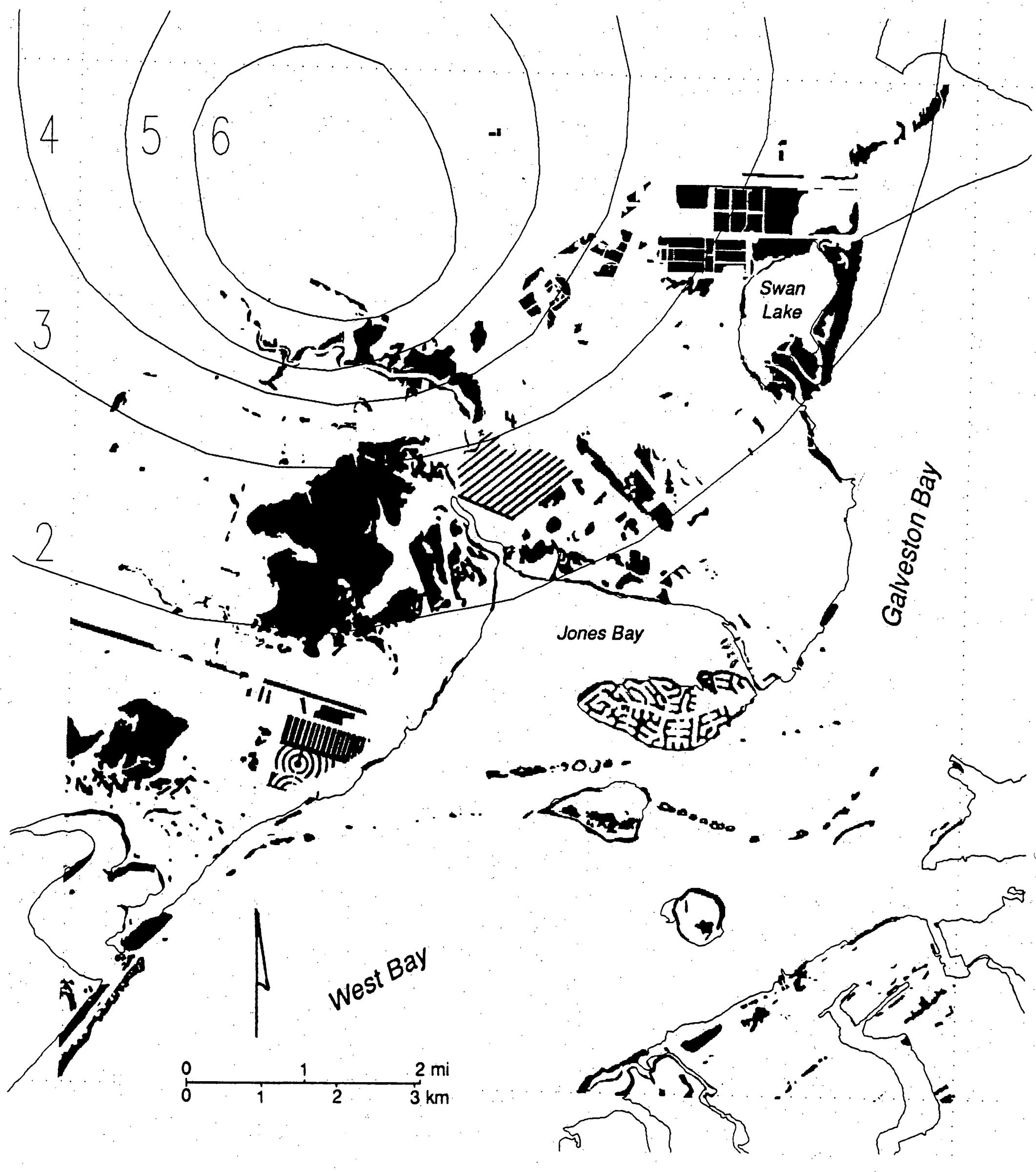


Figure 56. Relationship between subsidence and losses in emergent wetlands (shaded) by conversion to water and barren flats in the Virginia Point quad. Contours (in feet) show amount of subsidence that occurred between 1906 and 1987 (based on maps from Gabrysch and Coplin, 1990).

Additional losses occurred along the margins of Swan Lake (fig. 56). Open water and flats also encroached into marshes in the adjacent Hitchcock quad. Approximate land-surface subsidence in the Virginia Point quad from 1906 to 1987 ranged from slightly less than 0.6 to 1.8 m (<2 to 6 ft) (fig. 56). Estimated rates of subsidence in the area northwest of Jones Bay for the period of 1943 to 1987, exceed 14 mm/yr (0.05 ft/yr) Gabrysch and Coplin (1990). This rate apparently was higher than rates of marsh aggradation in this area. On Galveston Island across West Bay from Virginia Point, there is also evidence that subsidence rates locally exceed marsh aggradation rates (Zimmerman and others, 1991).

The League City quad offers another example of the effect of land-surface subsidence and the subsequent intrusion of open water and shallow flats into vegetated wetlands (fig. 35). Losses in emergent wetlands along Armand Bayou exceeded 91 percent of the resource between the 1950's and 1979 (McFarlane, 1991b), so there was little additional change in this area between 1979 and 1989. The League City quad (fig. 57) is representative of the trend occurring along the valleys of bayous and creeks located on the north and west sides of Galveston Bay. The trend is one of expansion of open water and flats at the expense of marshes and woodlands, as subsidence promotes the encroachment of estuarine water up the valleys. The development, locally, of marshes along the valleys in more inland and marginal areas represents only a small fraction of the total amount of marsh lost.

The Trinity River delta (Anahuac and Cove quads) is another area where extensive areas of emergent wetlands have been converted to open water and intertidal flats (figs. 58 and 59). The magnitude of this change in the Anahuac and Cove quads exceeds 4,300 acres for the period 1953 to 1989 (fig. 36). About 60 percent of the change can be attributed to submergence related to subsidence. Approximately 40 percent of the change in emergent wetlands is due to construction of a power plant cooling reservoir (>2,500 acres in size) south of Cotton Lake in the Cove quad (fig. 59). In the delta and alluvial valley as a whole, subsidence appears to be a significant contributing factor to marsh loss at least up to the 1970's. Based on subsidence maps (Gabrysch, 1984), White and Calnan (1990) estimated subsidence rates in the delta to be about 6.5 mm/yr for the period 1943 to 1978. Subsidence rates from 1943 to 1973 may have approached 7.5 mm/yr (based on maps in Gabrysch and Bonnet, 1975). Estimated rates of marsh aggradation (from lead isotope analysis) over the past 50 to 100 years in the Trinity River delta average 5.4 mm/yr, and range as low as 4.2 mm/yr (White and Calnan, 1990). The higher rates of subsidence compared to aggradation suggest that subsidence is a contributing factor to the marsh loss. Rates of marsh aggradation (sedimentation) may have declined through time as a result of reductions in marsh sediment supply from upstream reservoir development (Paine and Morton, 1986; White and Calnan, 1990). However, the rate at which marshes are being lost in the Trinity River delta appears to have decreased during more recent periods (1974 to 1988; White and Calnan, 1990). This change in rate may be due partly to the sharp declines in rates of subsidence on the east side of the subsidence bowl after 1978 as a result of reductions in the pumpage of groundwater (Gabrysch and Coplin, 1990).

Conversion of marsh to open water and flats along active faults has occurred in several areas including Bolivar Peninsula in the Frozen Point and Caplen quads (figs. 52 and 60). At least two active faults in this area have contributed to changes (exceeding 1,000 acres of marsh loss); emergent vegetation has been submerged and replaced by open water and shallow subaqueous flats on the downthrown side of the faults (figs. 51, 52, 53, and 60). Other portions of the Galveston Bay system, where changes in wetlands are related to active faults, include areas in the following quads: Lake Stephenson, Flake, Virginia Point, Hoskins Mound, Christmas Point, and Oyster Creek (figs. 40 and 61).

Losses Caused by Erosion

Shoreline erosion contributes to the conversion of vegetated wetlands to open water. Subsidence and sea-level rise are among several processes contributing to shoreline erosion in the Galveston Bay system (Paine and Morton, 1986). Marshes are the dominant type of

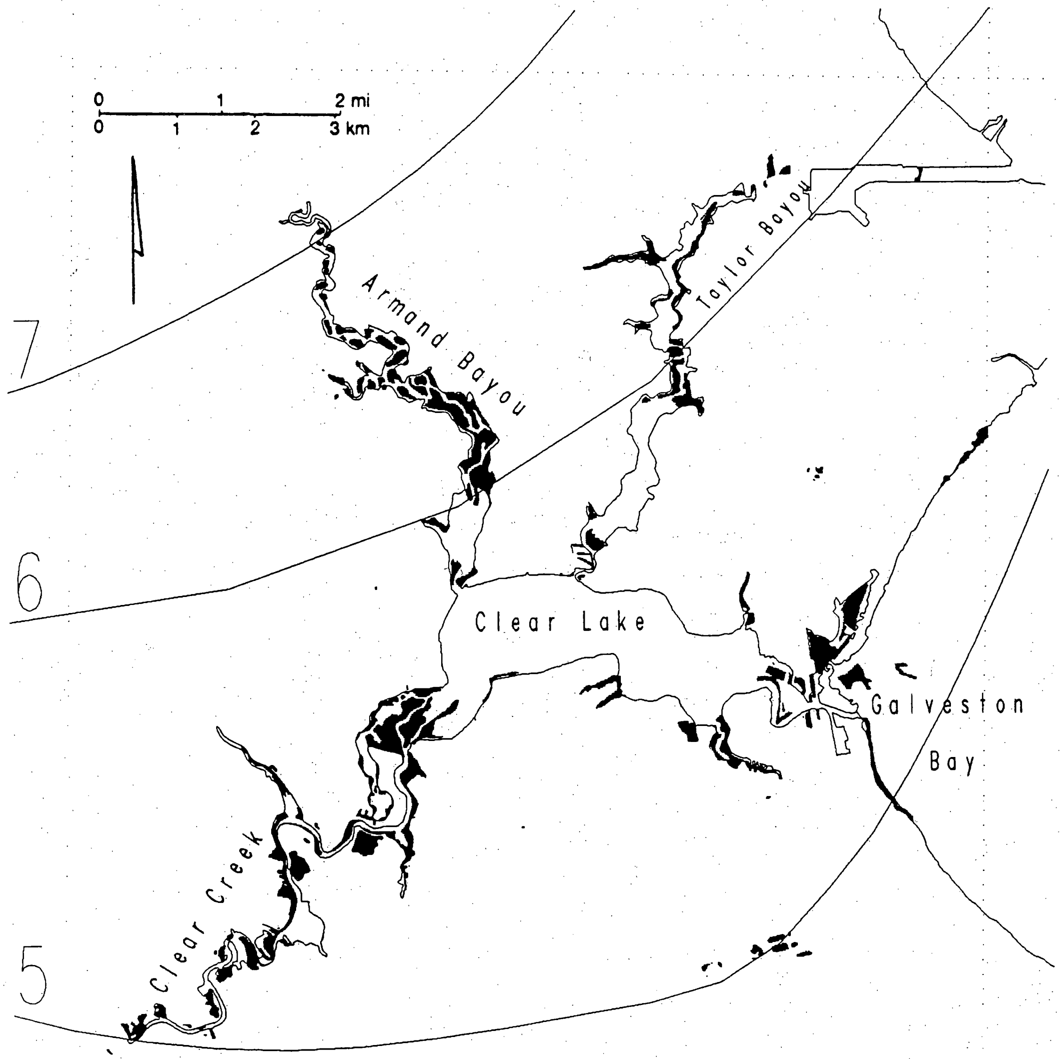
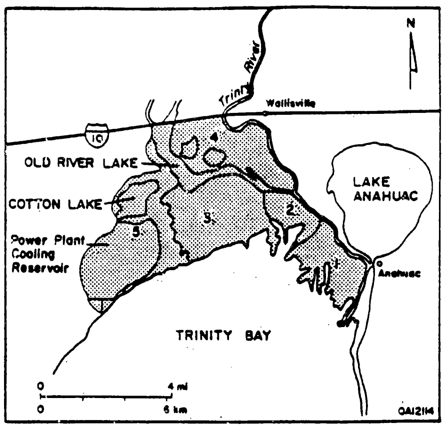
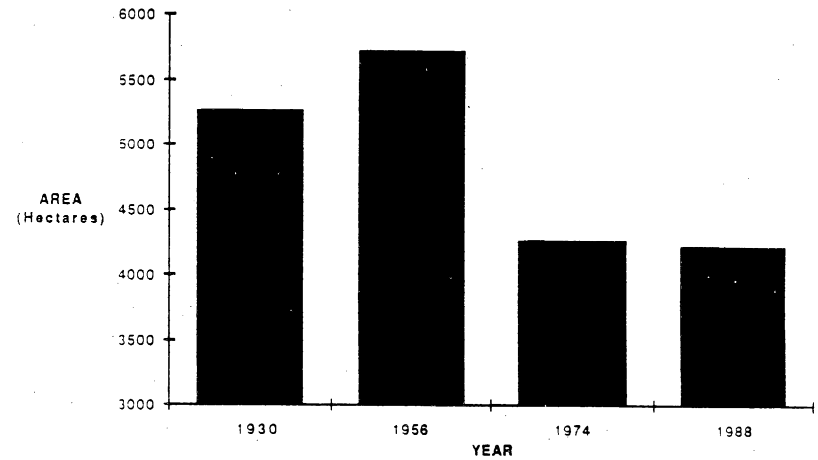


Figure 57. Relationship between subsidence and losses in emergent wetlands (shaded) by conversion to water and barren flats in the Clear Lake area, League City quad. Contours (in feet) show amount of subsidence that occurred between 1906 and 1987 (based on maps from Gabrysch and Coplin, 1990).



Trinity River delta index map and historical sequence of vegetated areas (in black) for the years 1930, 1956, 1974, and 1988.



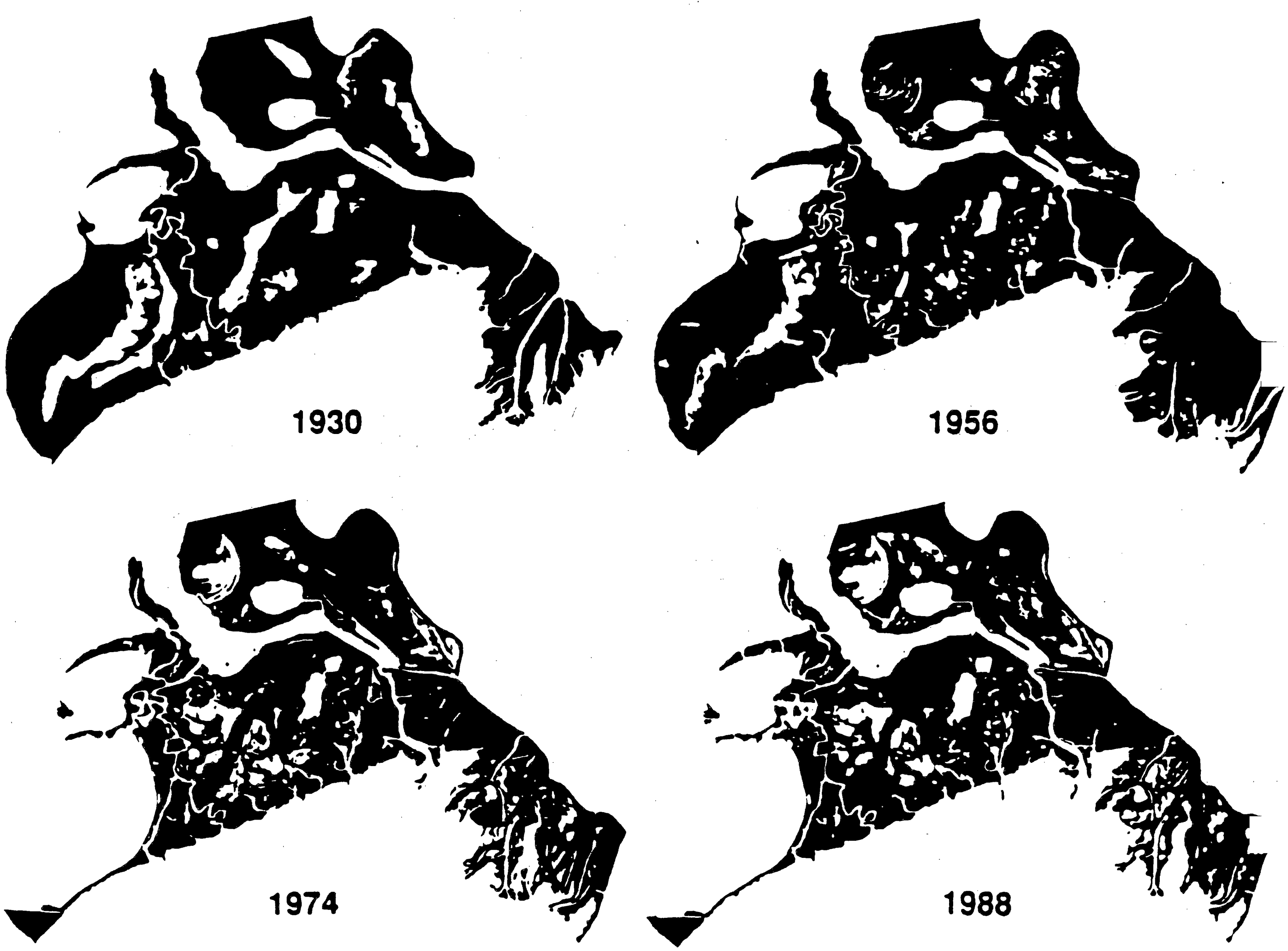


Figure 58. Changes in the distribution of vegetated areas (in black) in the Trinity River delta from 1930 to 1988. White areas represent water and barren flats. Note loss in vegetated areas after 1956. From White and Calnan (1990).

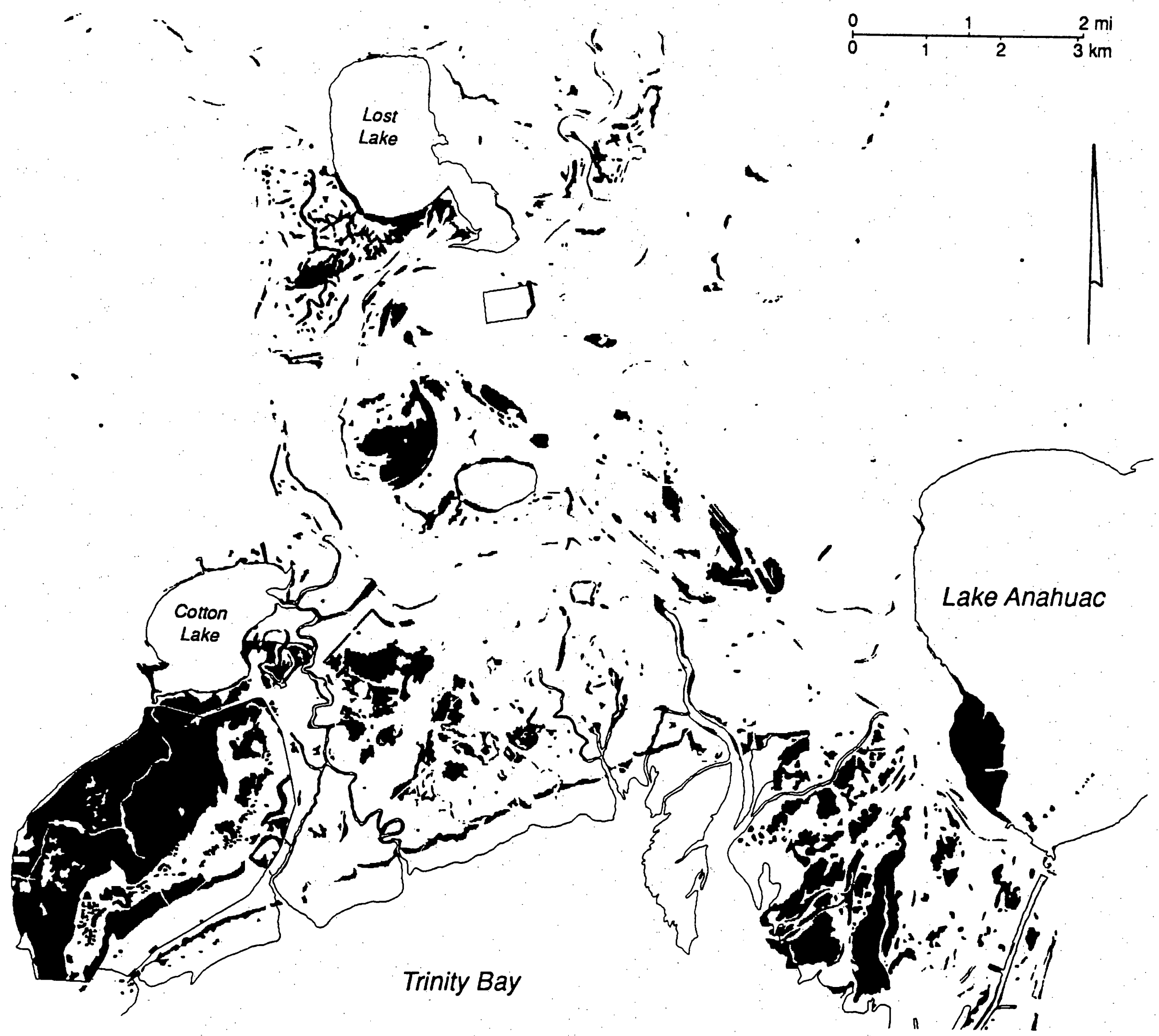


Figure 59. Distribution of emergent wetlands (marshes) (shaded areas) in the Trinity River delta (Anahuac and Cove quads) that were displaced by water and barren flats between the 1950's and 1989. Note similarity between shaded areas in this figure with white areas in preceding figure. The extensive shaded area south of Cotton Lake is the site of a power plant cooling reservoir.

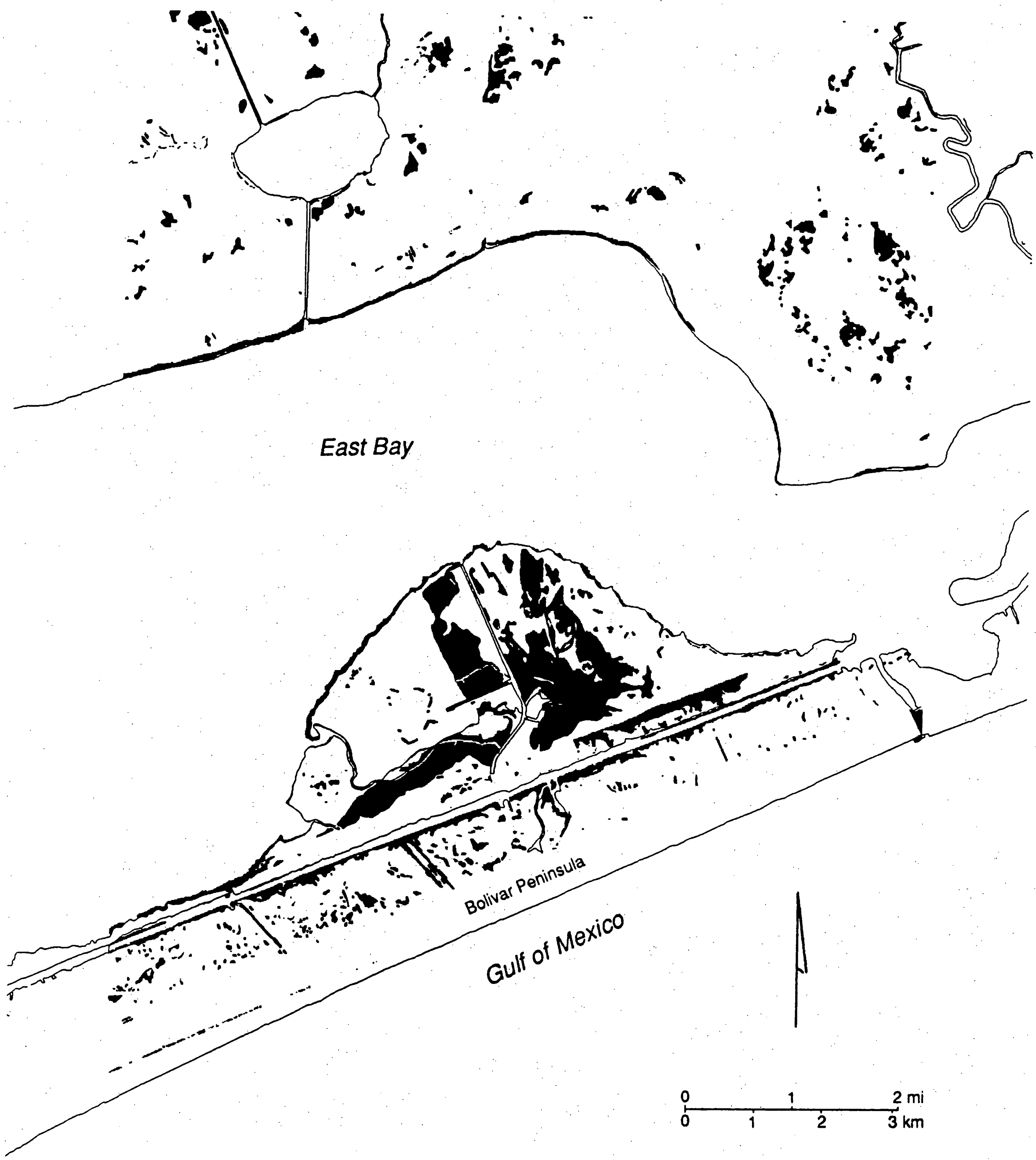


Figure 60. Losses in emergent vegetation (shaded areas) on Bolivar Peninsula (Frozen Point and Caplen quads) due to encroachment of open water and barren flats between the 1950's and 1989. Note similarities between this figure and the 1979 map in figure 52. Losses in wetlands are apparently associated with active faults that intersect marshes in this area (fig. 52).

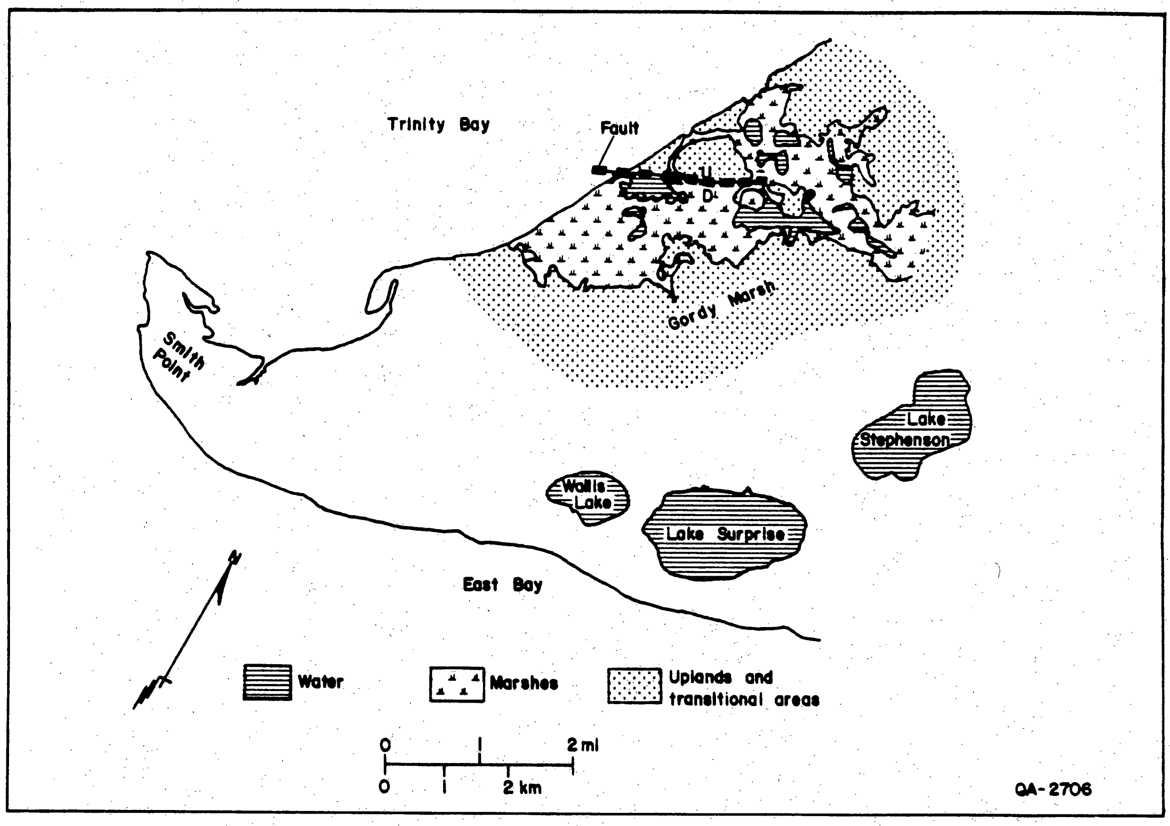


Figure 61. Simplified illustration of a fault that intersects Gordy Marsh in the Lake Stephenson quad. Marshes and ponded water characterize the downthrown side of the fault (D). From White and others (1989). Subsidence along the fault has apparently contributed to expansion and local losses in wetlands between the 1950's and 1989 (fig. 40).

shoreline, accounting for 61 percent of the total length of shoreline bordering the bay-estuary-lagoon system (Morton and Paine, 1990). Approximately 78 percent of the shorelines are erosional. Average rates of erosion have increased from 1.8 ft/yr between the 1850's and 1930, to 2.4 ft/yr between 1930 and 1982 (Paine and Morton, 1986).

The estimated rate of marsh loss due to erosion of Galveston Bay primary shorelines (i.e., excluding losses along Intracoastal Waterway shorelines and interior wetland shorelines) is 46.5 acres/yr for the period 1930 to 1982 (Morton and Paine, 1990). This translates to about 2,400 acres of marsh loss over this 52-year period. This magnitude of loss, while occurring over a longer period than investigated here, represents 9 percent of the total acreage of emergent wetlands converted to open water and flats from the 1950's to 1989. Rates of erosion have increased during more recent periods (Paine and Morton, 1986; Pulich and White, 1991).

Local Gains in Wetlands Related to Subsidence

Mapped distributions of wetlands indicate that losses are offset to some degree by gains. In fact, a substantial amount of 1950's uplands, more than 20,000 acres, was mapped as emergent wetlands in 1989 (figs. 37 to 39). Part of this increase was due to photointerpretation. But increases in some areas, for example the Anahuac National Wildlife Refuge (Frozen Point and High Island quads), are partly the result of the implementation of extensive water management programs for waterfowl habitats (Jim Neaville, USFWS). The artificially flooded modifier (k) was used with seasonal or semipermanent water regimes to identify these managed marshes. This situation apparently applies to the substantial increase (almost 2,000 acres) in emergent wetlands inland from the east end of East Bay in the Frozen Point quad (fig. 37). Some upland rice fields abandoned after the 1950's were mapped as palustrine emergent wetlands. In addition, a large transitional area, mapped as uplands in the 1950's (and 1979), became primarily a palustrine emergent wetland habitat (PEM) in 1989 (fig. 39).

Development and expansion of wetlands in some areas appear to be associated with subsidence and faulting. Changes toward wetter conditions occur as land-surface subsidence drops surface elevations thereby increasing the frequency and duration of inundation. Transitional areas and uplands with gently sloping surfaces that grade into adjacent intertidal wetlands are prime candidates for this type of conversion. Among the areas where such changes have occurred is Gordy Marsh in the Lake Stephenson quad. On the landward margin of southwestern extension of the marsh system, both faulting (fig. 61) and subsidence have apparently contributed to the expansion of marshes into areas previously mapped as uplands (fig. 40). Other probable examples (possible among many) of subsidence-related marsh expansion include parts of Galveston Island (fig. 41), and the area near Salt Lake in the Oyster Creek quad (fig. 42). Conversion of uplands to wetlands is negligible in areas characterized by rapid rates of subsidence and steep upland gradients.

Although newly established wetlands provide some measure of offset to net wetland losses in terms of area, there is not necessarily a corresponding offset in terms of immediate functional value. Some researchers suggest that several years of development may be necessary for newly formed marshes to reach overall functional equivalency to older marshes (Minello and Zimmerman, 1992).

Other Causes of Major Losses in Emergent Wetlands

Many losses and changes in wetland habitats are caused by processes or activities other than subsidence (table 7). Among human activities in the Galveston Bay system that have a direct effect on wetlands and can be quantified to some degree through photoanalysis are: construction of levees and dams to impound water; excavation (dredging) for purposes such as navigation, flood control, and mineral (sand) extraction; drainage for conversion to other land uses such as agriculture; and filling for purposes of spoil disposal or residential-commercial-industrial development. These kinds of activities will be the focus of the following discussion.

Indirect losses due to such activities as chemical discharges, hydrologic alterations, and sediment diversion cannot adequately be determined through photoanalysis and will only be mentioned as possible contributing agents in some changes. Natural changes such as goose and nutria "eat-outs," which can cause direct losses in emergent vegetation, could not be adequately assessed.

Activities causing direct changes that were assessed through photoanalysis can be classified into two broad categories: (1) activities that convert emergent wetlands into flats and open water such as constructing impoundments and dredging (excavating) and (2) activities that convert wetlands into uplands such as draining, altering hydrology, and filling. For these latter types of activities (those that convert wetlands to uplands) the type of land use (urban, spoil, agriculture, and rangeland, for example) is the focus of the analysis and discussion.

Impoundment and Excavation of Wetlands

Conversion of emergent wetlands to open water and flats in many areas has been caused by processes or activities other than subsidence. For example, the largest contiguous loss of marshland in the Galveston Bay system occurred at the site of a cooling reservoir (approximately 2,500 acres) in the Cove quad (figs. 58 and 59). Almost 2,200 acres of wetlands, of which more than 1,500 acres were mapped as marsh on 1950's photographs, were replaced by open water impounded by the reservoir (fig. 59).

Losses due to construction of reservoirs and impoundments occurred in many other areas but on a smaller scale. For example, inland from East Bay in the Lake Stephenson quad, impounded areas replaced portions of a brackish marsh (see shaded area east of lake in fig. 35).

Six quads were analyzed using the 1950's and 1989 data to provide a partial measure of the magnitude of changes in emergent wetlands caused by impoundments and excavations. Special modifiers assigned to impounded (h) and excavated (x) areas on the 1989 map series provided the necessary classification to make the analyses. The map areas analyzed are Anahuac, Christmas Point, Cove, Lake Como, Texas City, and Virginia Point. In these six quads, more than 3,300 acres of marsh in the 1950's was replaced, by 1989, with water and flats at impounded and excavated sites. The largest impact resulted from the cooling reservoir in the Cove quad (fig. 59). The palustrine emergent habitat was the class most heavily affected in the six quads, accounting for 53 percent of the area. This large impact on the palustrine system occurred primarily because the cooling reservoir in the Cove quad was located in an area mapped as palustrine emergent on 1950's photographs. Estuarine emergent wetlands represented about 33 percent of the impacted emergent habitats, and undifferentiated mixtures of emergents and flats (E2EM/FL or E2EM/US) the remainder.

Second to the Cove quad in terms of total area affected by impoundments and excavations was Virginia Point, where about 900 acres of emergent wetlands (PEM, E2EM, and E2EM/FL) existing in the 1950's were replaced by water and flats at impounded and excavated sites (fig. 62). Total wetland losses caused by channel dredging was larger than this because of associated filling of adjacent wetlands to produce upland sites for urban development. These associated impacts due to upland development are included with acreages presented in the following section on conversion of wetlands to upland urban areas.

Obviously, impoundments and excavated areas produced gains in water habitats and locally emergent wetland habitats. They also are responsible for local expansion and creation of new vegetated wetlands. For example, an impoundment for water and habitat management by the USFWS in the Frozen Point quad has expanded the total acreage of emergent wetlands in that quad. The overall affect of impoundments and excavated areas, however, appears to be one of net losses in emergent wetlands.

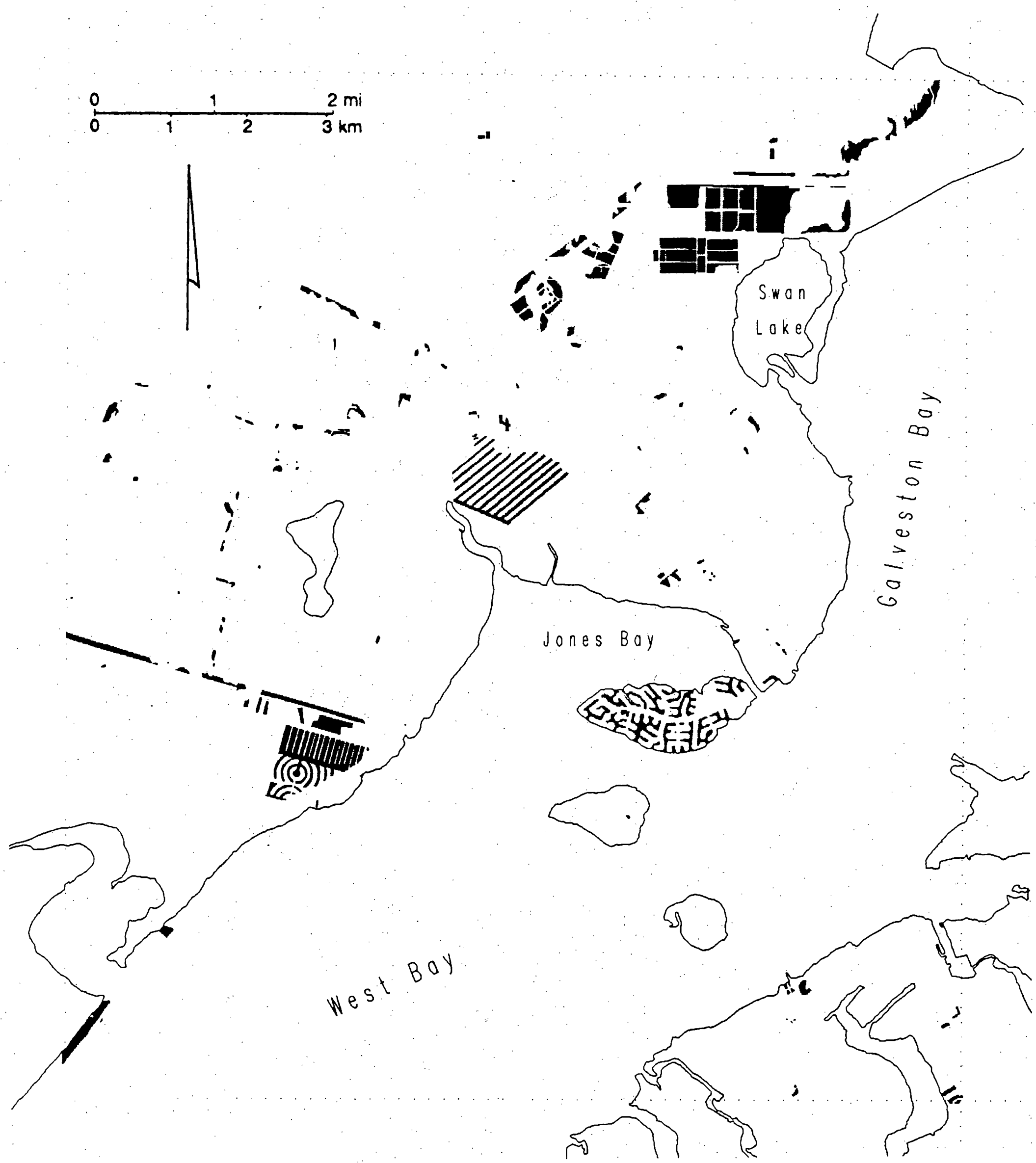


Figure 62. Distribution of emergent wetland habitats (shaded) in the 1950's that became excavated or impounded areas of open water and barren flats by 1989 in the Virginia Point quad. Excavated channels for existing or proposed residential developments surround Jones Bay, and industrial impoundments characterize the area northwest of Swan Lake in the Texas City area.

Conversion of Wetlands to Uplands

As mentioned in the analysis of trends section of this report, large areas mapped as emergent wetlands on the 1950's photographs were mapped as uplands on 1989 photographs (and 1979 photographs). The magnitude of this change is approximately 35,800 acres from the 1950's to 1989 (fig. 46). Some of the change is undoubtedly due to photointerpretation (see section on possible errors in photointerpretation), but much of the change appears to be real. The wetland system and class most heavily impacted by this type of change is the palustrine emergent wetland class (fresh-water or inland marshes). Among methods that are used to convert wetlands to uplands is construction of drainage ditches to drop water levels and dry out the wetlands for grazing and rice farming. This was a common practice in the Galveston Bay project area (fig. 63) as well as in other parts of the United States, especially between the 1950's and 1970's (Tiner, 1984). Restrictions placed on the alteration and destruction of wetlands since the 1970's has probably been one factor causing a decline in the rate of loss during more recent periods (1979 to 1989) (see section on trends 1950's to 1979 to 1989).

The areal extent of the loss of emergent wetlands to uplands was determined for the following upland classes: urban, oil and gas, spoil, agriculture (cropland), and rangeland. Documentation of these changes was possible because of the use of upland classes and modifiers (fig. 5) in mapping uplands on 1989 (and 1979) photographs.

Conversion to Upland Urban Areas. Approximately 5,700 acres of emergent wetlands were converted to upland urban use from the 1950's to 1989 (figs. 64–66). Losses were highest in the Virginia Point quad where they exceeded 1,000 acres (fig. 66). Conversion of wetlands to uplands occurred in several areas in conjunction with dredging and filling operations to create navigation channels and upland sites for residential development around Jones Bay and industrial development near Swan Lake (figs. 55 and 62). Losses due to dredging of channels and filling of wetlands for upland urban development in the Virginia Point quad totaled approximately 2,000 acres.

Other areas in which losses were highest are located on the south and west side of the Galveston Bay system, where urban activities are most common (fig. 65). Areas, other than Virginia Point, where losses exceed 300 acres include the Galveston, Texas City, League City, and Sea Isle quads (fig. 66).

Displacement of emergent wetlands by mapped upland oil and gas production facilities amounted to more than 800 acres (this area is included in upland urban areas presented in the preceding paragraph). Virginia Point, Hoskins Mound, and Texas City accounted for about 70 percent of the change (fig. 67).

Conversion to Uplands by Spoil Disposal. Between the 1950's and 1989, more than 1,500 acres of emergent wetlands were displaced by upland spoil ridges and mounds (fig. 68). As expected, The largest impact was in estuarine emergent wetlands, which are located along the margins of the estuarine water bodies where dredged channels are concentrated. The two quads where changes due to spoil disposal were largest are Christmas Point and High Island; losses in each of these quads was about 300 acres. The Intracoastal Waterway crosses both quads, and much of the impact occurred from spoil disposal along the dredged channel. Other areas where losses exceeded 100 acres include Sea Isle, Virginia Point, Flake, and Frozen Point (fig. 68).

The changes noted here are direct impacts where marshes were converted to upland areas by spoil disposal as interpreted on aerial photographs. Sites of spoil disposal that were not identified and mapped on the photographs were, of course, not included in this impact analysis. Other types of wetland changes associated with spoil disposal may include conversions to another habitat type such as flat, or alterations in hydrology and sedimentation, which may produce indirect impacts on wetlands. Most of the changes in wetland habitats due to dredging and disposal of dredged material occurred before the 1950's and are therefore not part of this assessment.

Figure 63. Example of emergent wetland areas (marshes) in the Oyster Creek quad that were modified by a drainage ditch (PEM1Fx) that connects to Oyster Creek. The shaded areas are emergent wetlands that existed in the 1950's but not in 1989. Dash lines represent the 1989 marsh boundary and dotted lines the 1950's boundary.

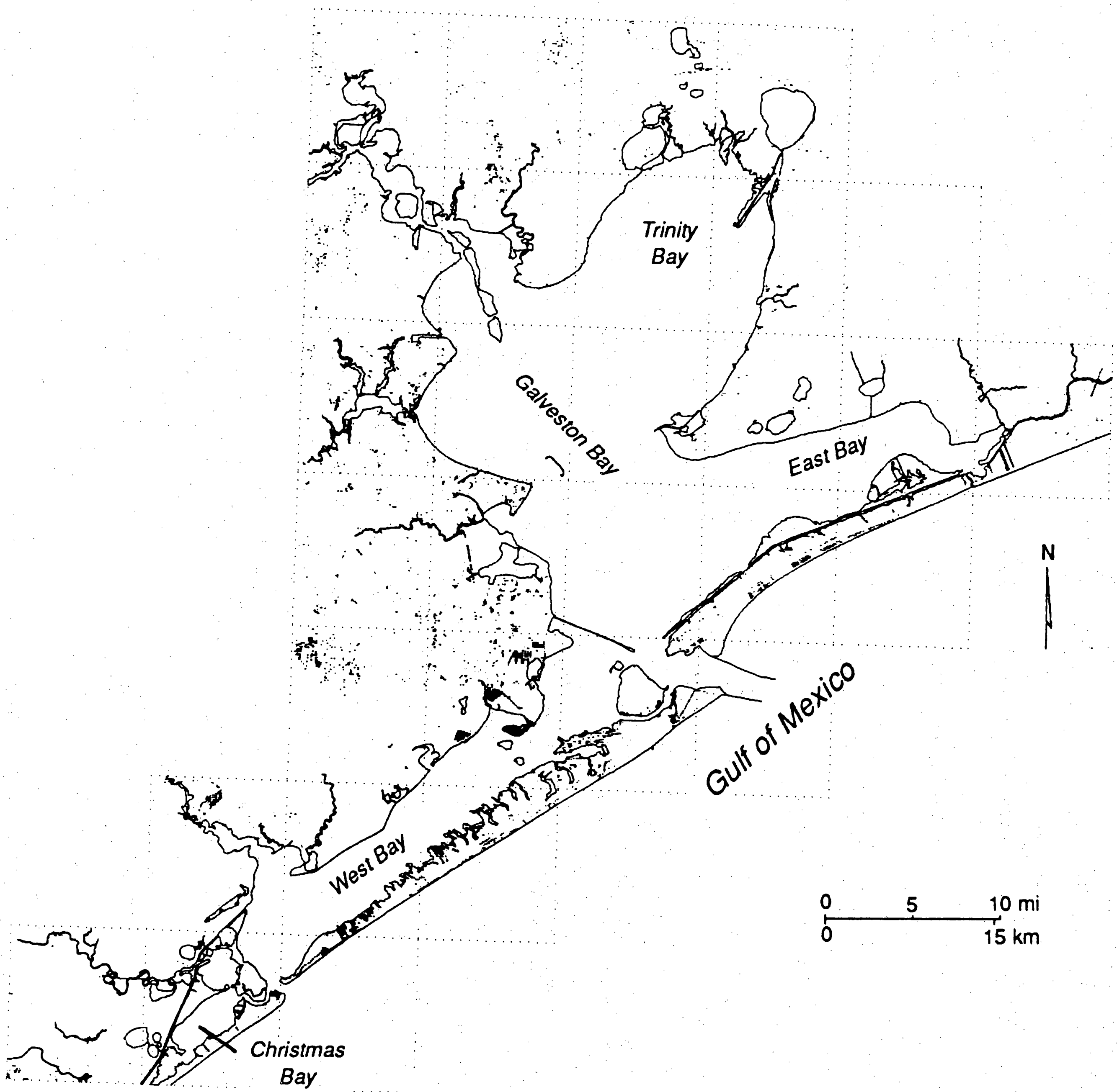


Figure 64. Distribution of emergent wetland habitats (shaded) that were replaced by upland urban areas between the 1950's and 1989. Compare with figures 65 to 67.

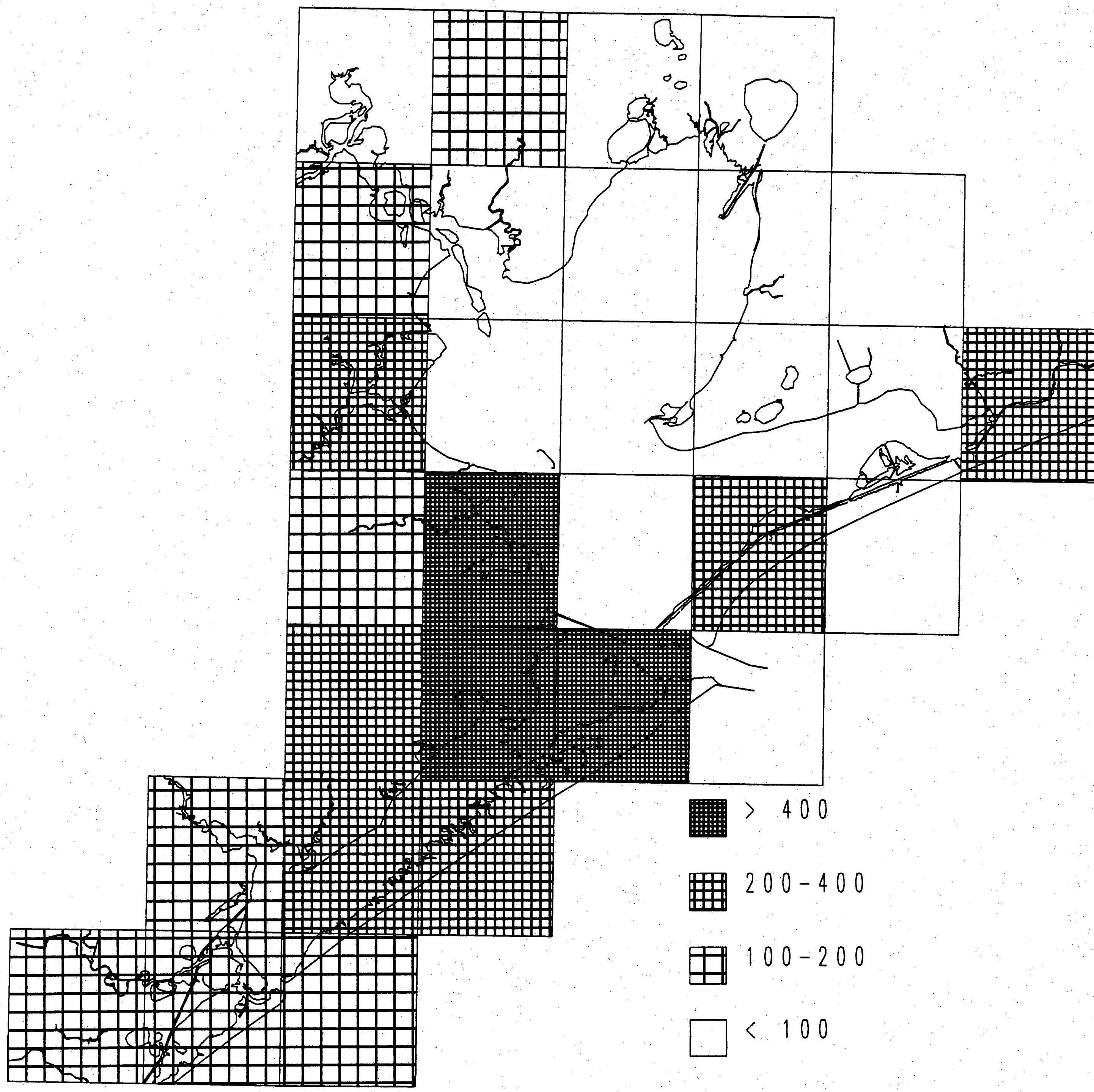


Figure 65. Map of 7.5-minute quads showing the distribution and extent (in acres) of areas that changed from emergent wetlands (marshes) to upland urban between the 1950's and 1989.

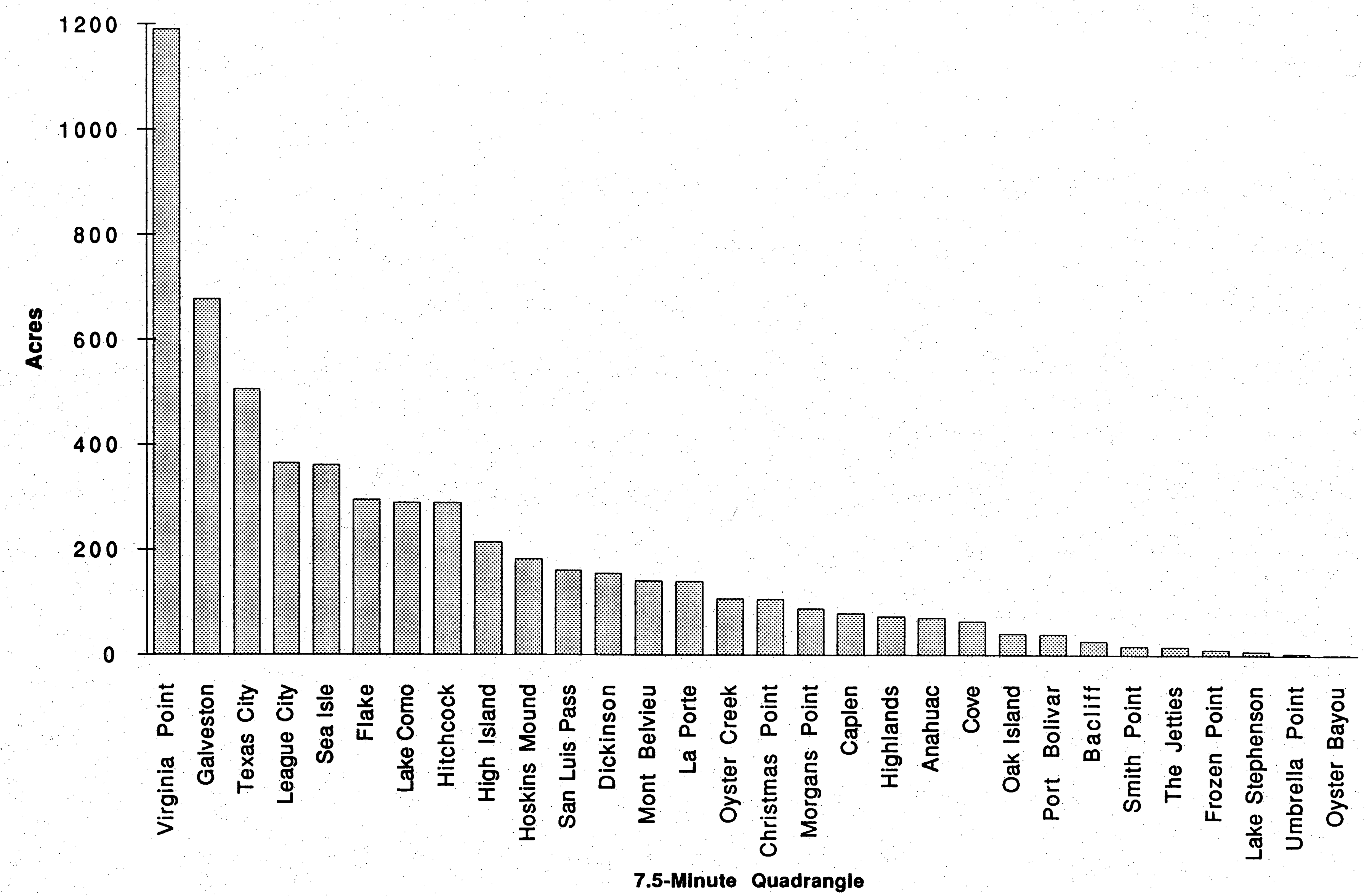


Figure 66. Bar graph showing the extent of areas in each quad that changed from emergent wetlands (marshes) to upland urban between the 1950's and 1989. Areas include oil and gas production facilities, which are shown separately in figure 67.

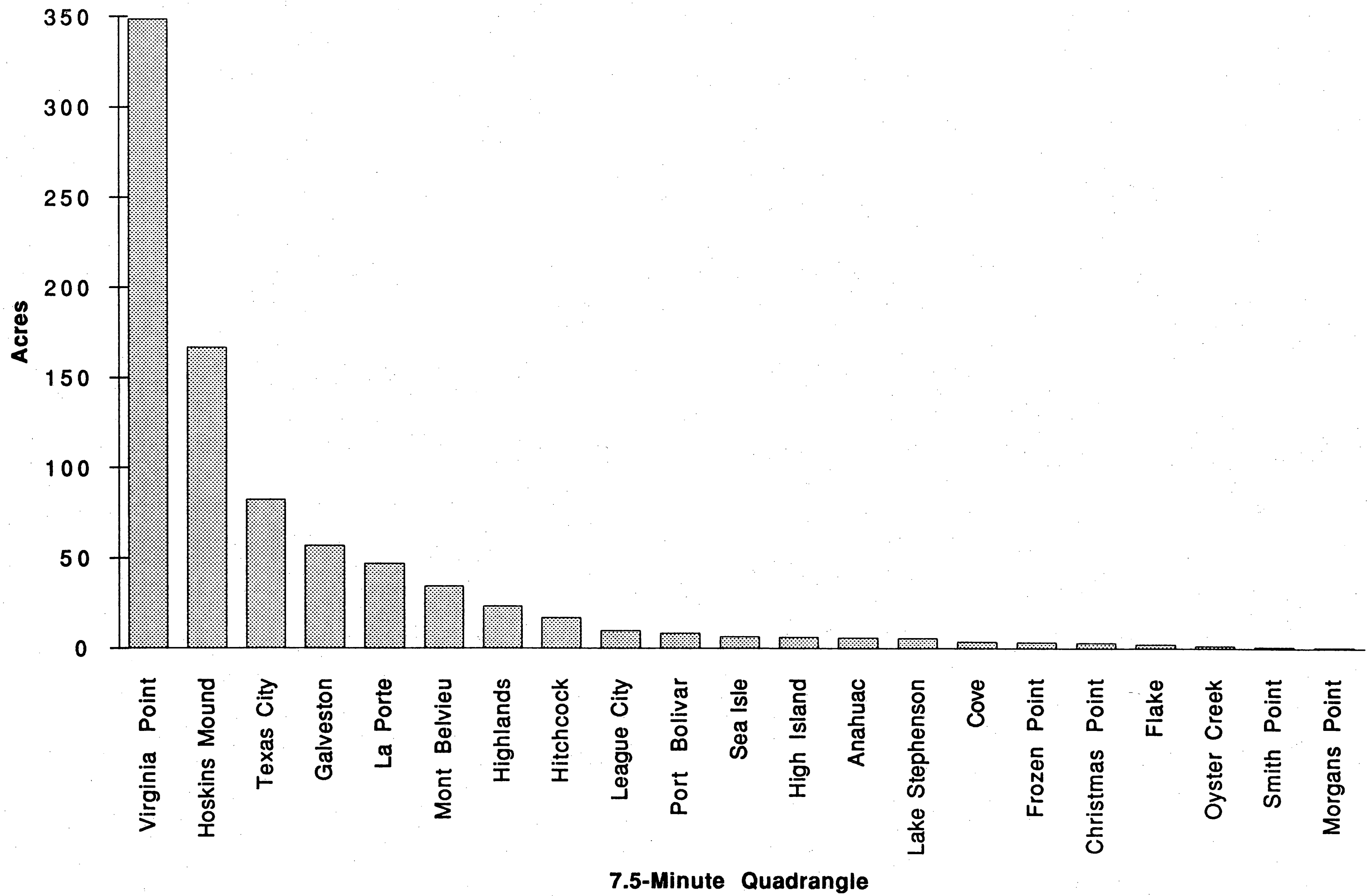


Figure 67. Bar graph showing the extent of areas in each quad that changed from emergent wetlands (marshes) to uplands due to construction of oil and gas production facilities, between the 1950's and 1989.

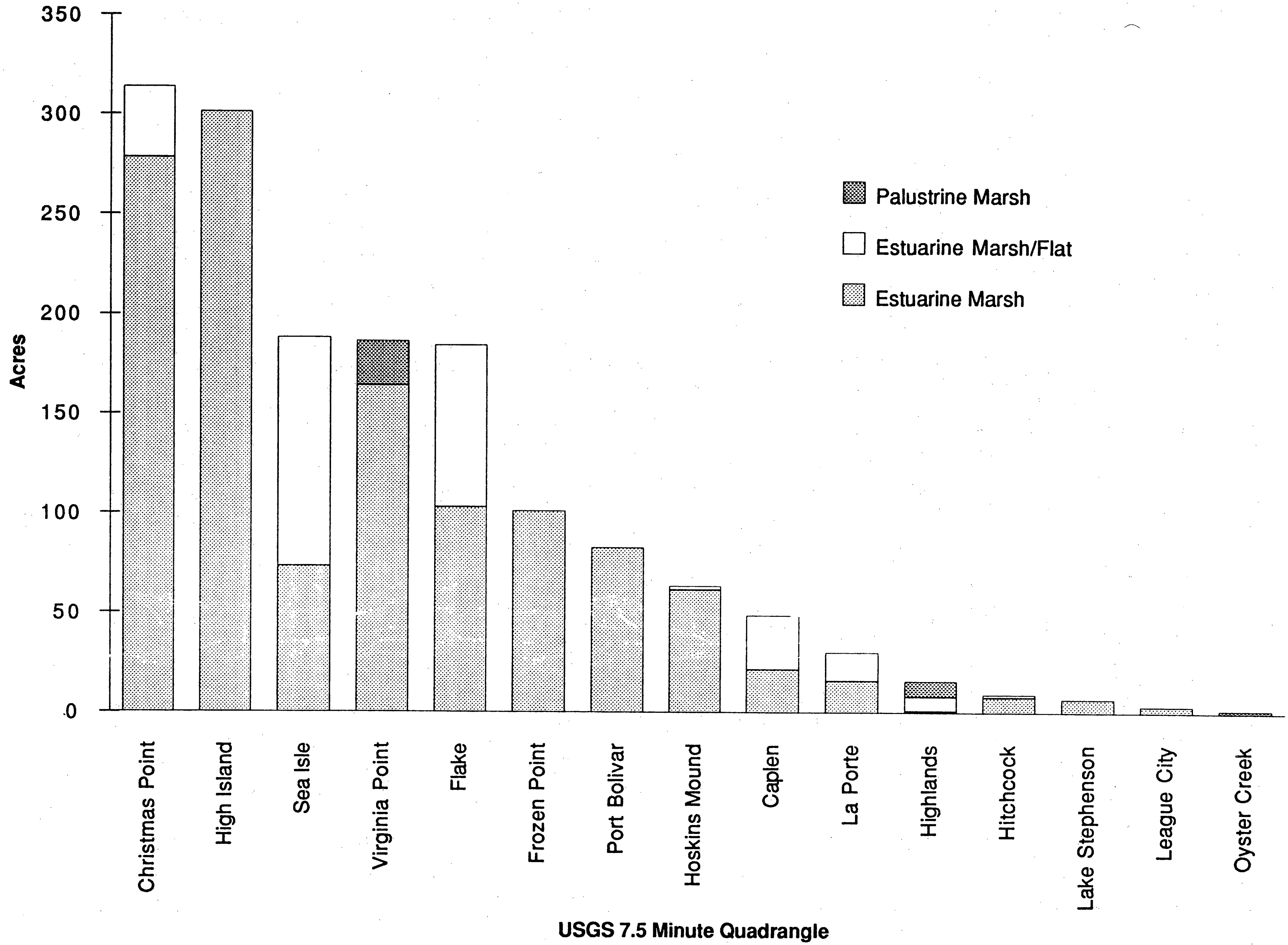


Figure 68. Bar graph showing extent and type of emergent wetlands (marshes) that were displaced by spoil (disposed dredged material), which formed uplands, between the 1950's and 1989.

Gains in Emergent Wetlands in Spoil Areas. Some of the losses due to spoil disposal in emergent wetlands were offset by gains in wetlands on spoil islands and other disposal sites. Good examples of the spread of emergent wetlands on dredged materials are in the Morgans Point and Bacliff quads in upper Galveston Bay, where spoil islands line the Houston Ship Channel. Islands in a chain that extends from the west-central part of the Morgans Point quad into the northern part of the Bacliff quad (fig. 2) are sites where wetlands expanded, yielding a gross gain in estuarine emergent wetlands that exceeded 1,000 acres between the 1950's and 1989. The total area of wetlands mapped on spoil deposits exceeded 2,000 acres on the 1989 photographs.

Although this gain in wetlands was trimmed by local losses on the islands, the gain provides a measure of areal offset to losses in other quads due to spoil disposal. However, gains on spoil deposits provide only partial compensation for losses of wetlands in other areas because existing wetland habitats may have been impacted by the spoil, and because newly created wetlands are not functionally equivalent to older, natural wetlands (Minello and Zimmerman, 1992). In addition, much of the gain in wetlands on spoil islands along the Houston Ship Channel are temporary because of expected burial of the wetlands during future channel maintenance dredging activities.

Conversion of Emergent Wetlands to Upland Agriculture. Areas that changed from emergent wetlands in the 1950's to areas mapped as upland agriculture in 1989 amounted to about 3,600 acres (figs. 69–71). The upland agriculture map category includes cropland and improved pastureland but not rangeland, which is discussed in the following section. As mentioned previously, conversion of wetlands to other land uses was a common practice between the 1950's and 1970's. Geographically, the areas affected most by development of cropland were the Hitchcock, Oyster Bayou, and Hoskins Mound quads (figs. 70 and 71). These three quads account for almost 60 percent of the change. Hitchcock alone, with a loss of 1,200 acres, accounted for approximately 30 percent of the total loss. Rice cultivation was the primary type of cropland that displaced palustine emergent wetlands and locally estuarine emergent wetlands in the Hitchcock quad, and probably accounted for most of the agricultural, or cropland, related changes in other quads as well. More than 10,000 acres of rice farmland was mapped in the Hitchcock quad on 1989 photographs. Conversely, some areas of cropland in the 1950's (mapped as uplands on 1950's photographs) had reverted to wetlands by 1989, which produced local gains in wetlands between the 1950's and 1989. An example of this type of change is in the Lake Stephenson quad where two areas totaling more than 200 acres, located between Lake Stephenson and East Bay (fig. 40), reverted from cropland or improved pastureland in the 1950's to emergent wetlands in 1989.

Conversion of Emergent Wetlands to Upland Range. This type of upland change, from emergent wetlands in the 1950's to upland range in 1989, was by far the most extensive, areally, representing more than 25,000 acres (fig. 46). The most extensive changes occurred inland from West and Christmas Bays (fig. 72) in the Oyster Creek, Hoskins Mound, Hitchcock and Texas City quads, which together accounted for more than 50 percent of the changes in the 30-quad area (fig. 73). Combined changes of more than 9,000 acres in Oyster Creek and Hoskins Mound (fig. 74) represented about 35 percent of the total in all quads. Hitchcock (fig. 75) and Texas City quads each had more than 2,000 acres of wetlands that changed to upland range. Palustrine emergent wetlands were most extensively affected by this type of change (fig. 73).

The exact reason for such extensive changes is not clearly understood. This type of change, wetlands to upland rangeland, has the highest probability of being, in part, related to photointerpretation, at least relative to more distinctly interpretable changes such as from wetlands to urban or open water areas. While it is clear that many areas were drained, as shown in figures 63 and 74, a review of 1950's photographs indicates that seasonally wet conditions at the time the photographs were taken may have inflated the 1950's wetland acreages, resulting in a larger estimate of loss than actually occurred. On the other hand, 1979 was also a wet year, producing more extensive wetlands in some areas. Yet, losses were also extensive between the 1950's and 1979 in some quads, Hoskins Mound and Hitchcock, for example (fig. 44).

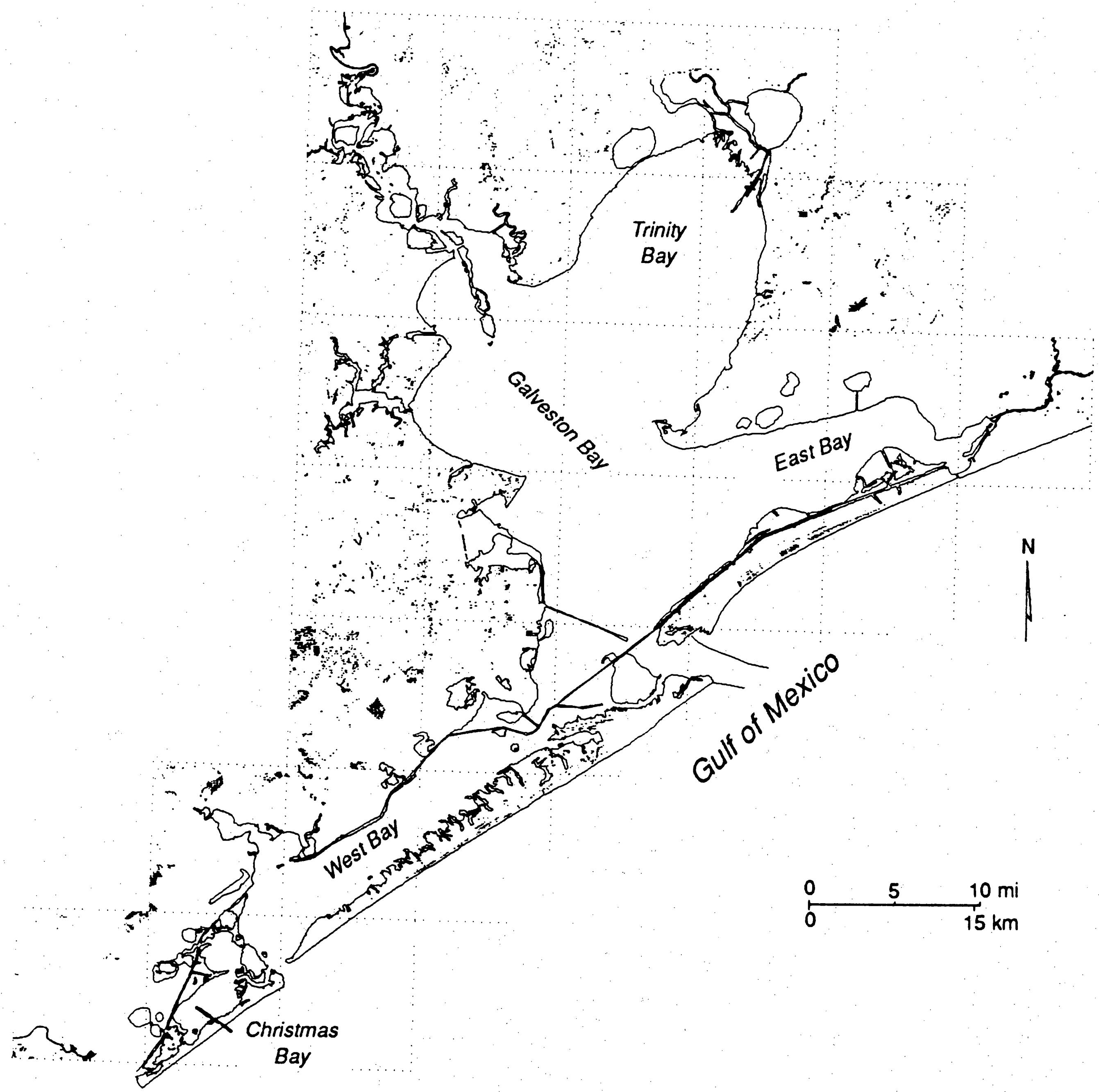


Figure 69. Distribution of emergent-wetland habitats (shaded) that were displaced by agricultural (cropland) areas between the 1950's and 1989, in the Galveston Bay system.

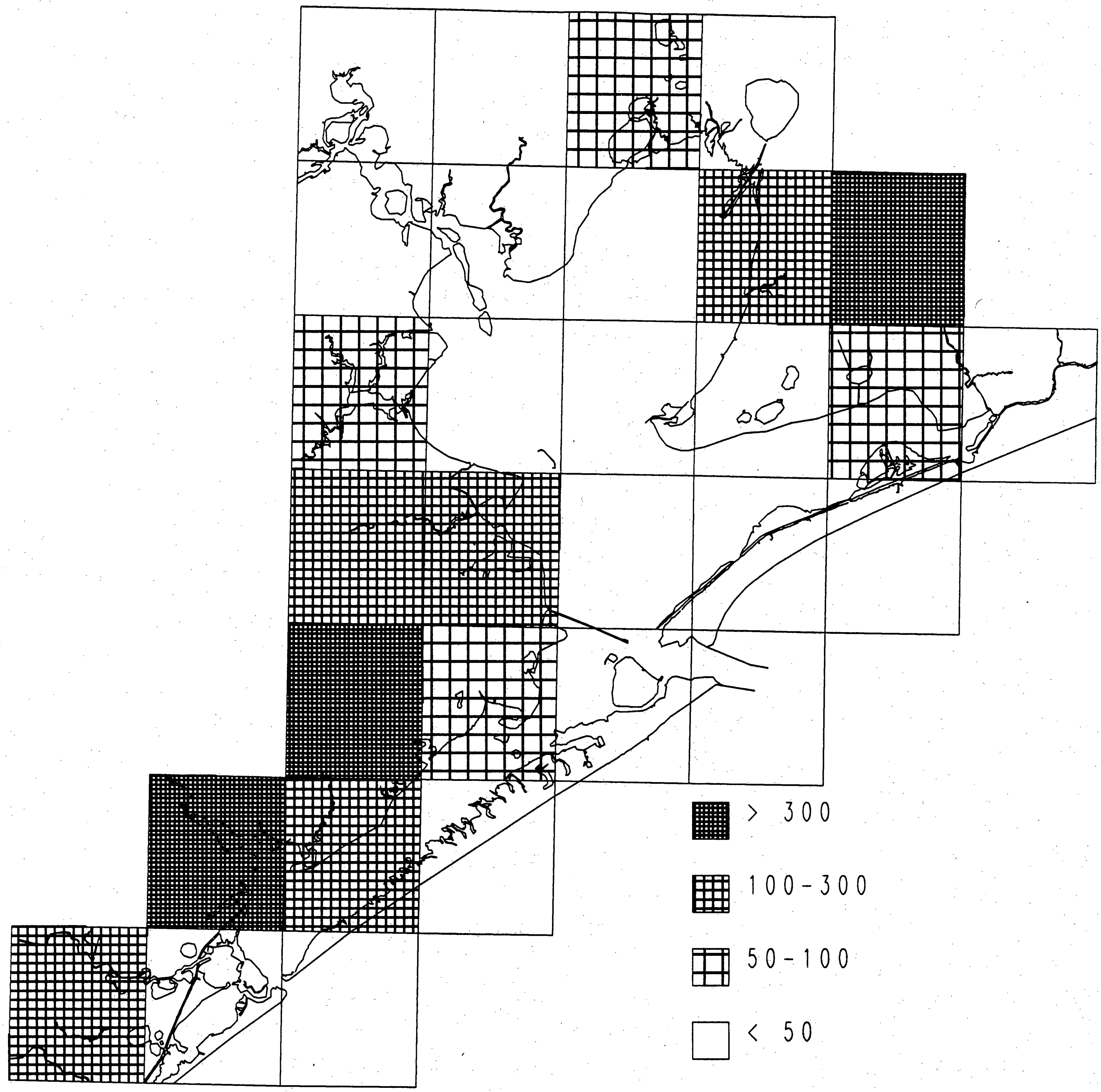


Figure 70. Map of 7.5-minute quads showing the distribution and areal extent (in acres) of areas that changed from emergent wetlands to upland agricultural areas between the 1950's and 1989. Quads where this process exceeded 300 acres include Hitchcock, Oyster Bayou, and Hoskins Mound. See figure 71 for more specific acreages.

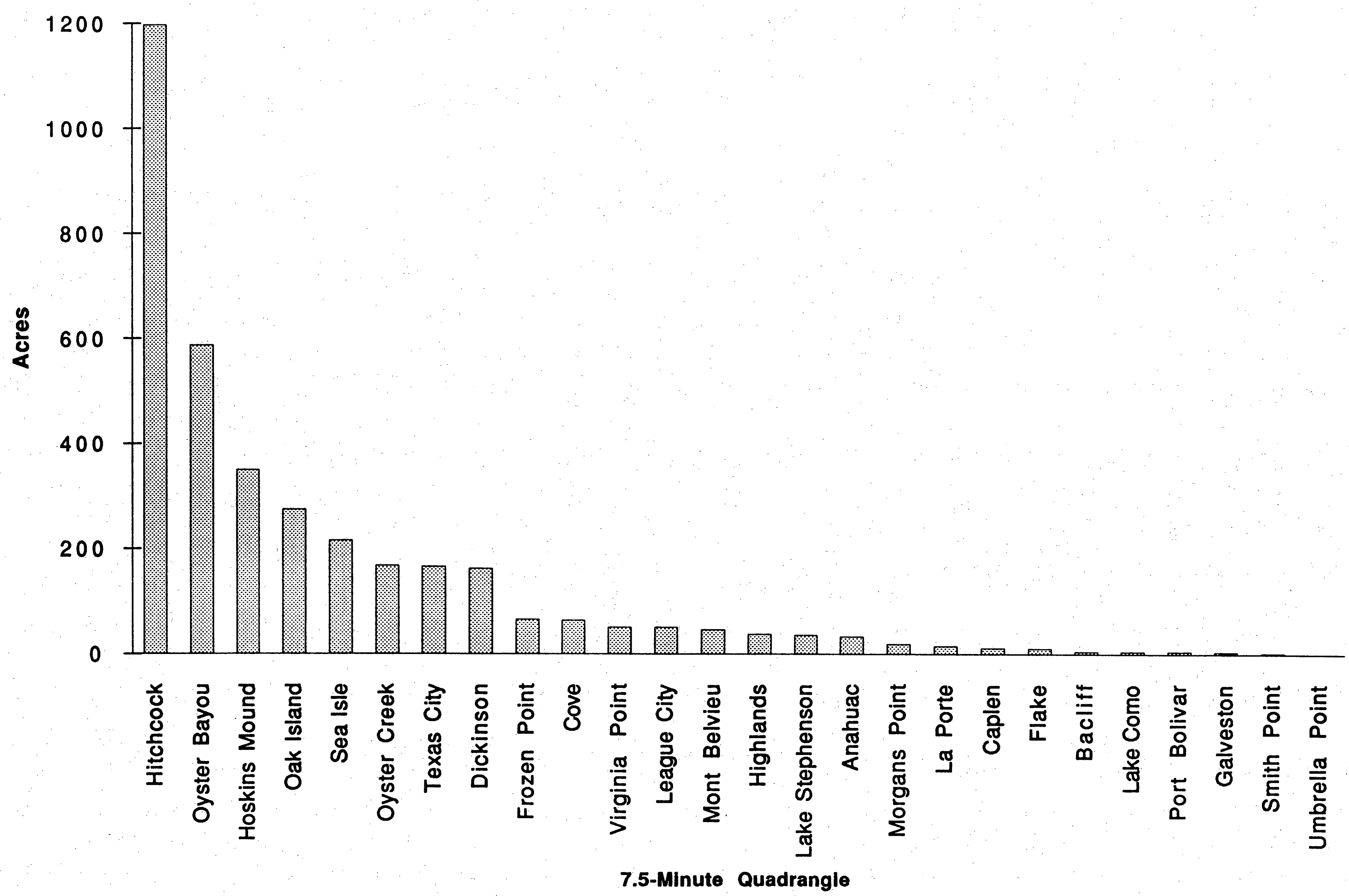


Figure 71. Bar graph showing extent of areas in each quad that changed from emergent wetlands (marshes) to upland agriculture between the 1950's and 1989.

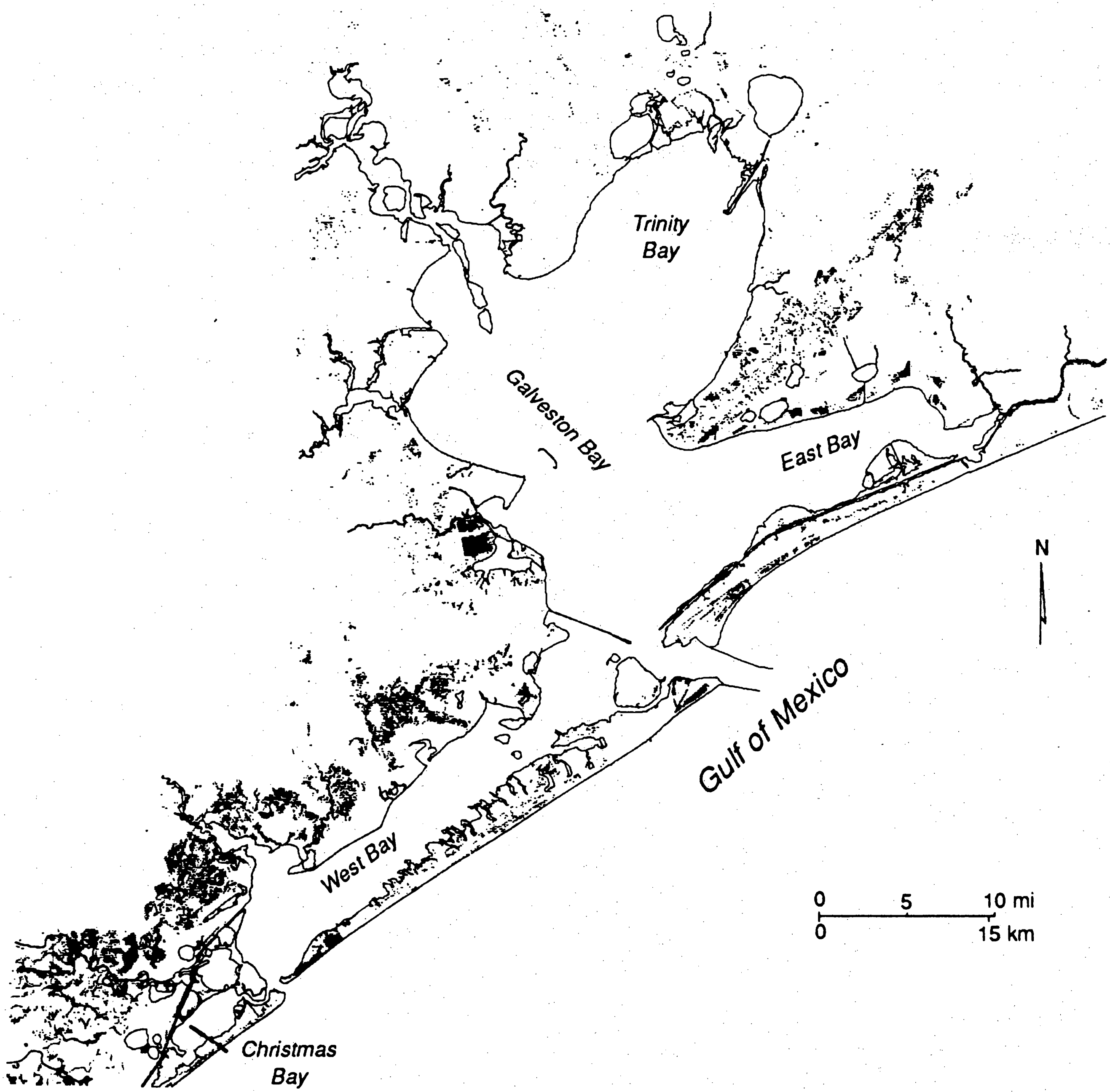


Figure 72. Distribution of emergent-wetland habitats (shaded) that changed to upland rangeland between the 1950's and 1989. The most extensive changes occurred inland from West Bay. More specific information on changes are presented in figures 73 to 75.

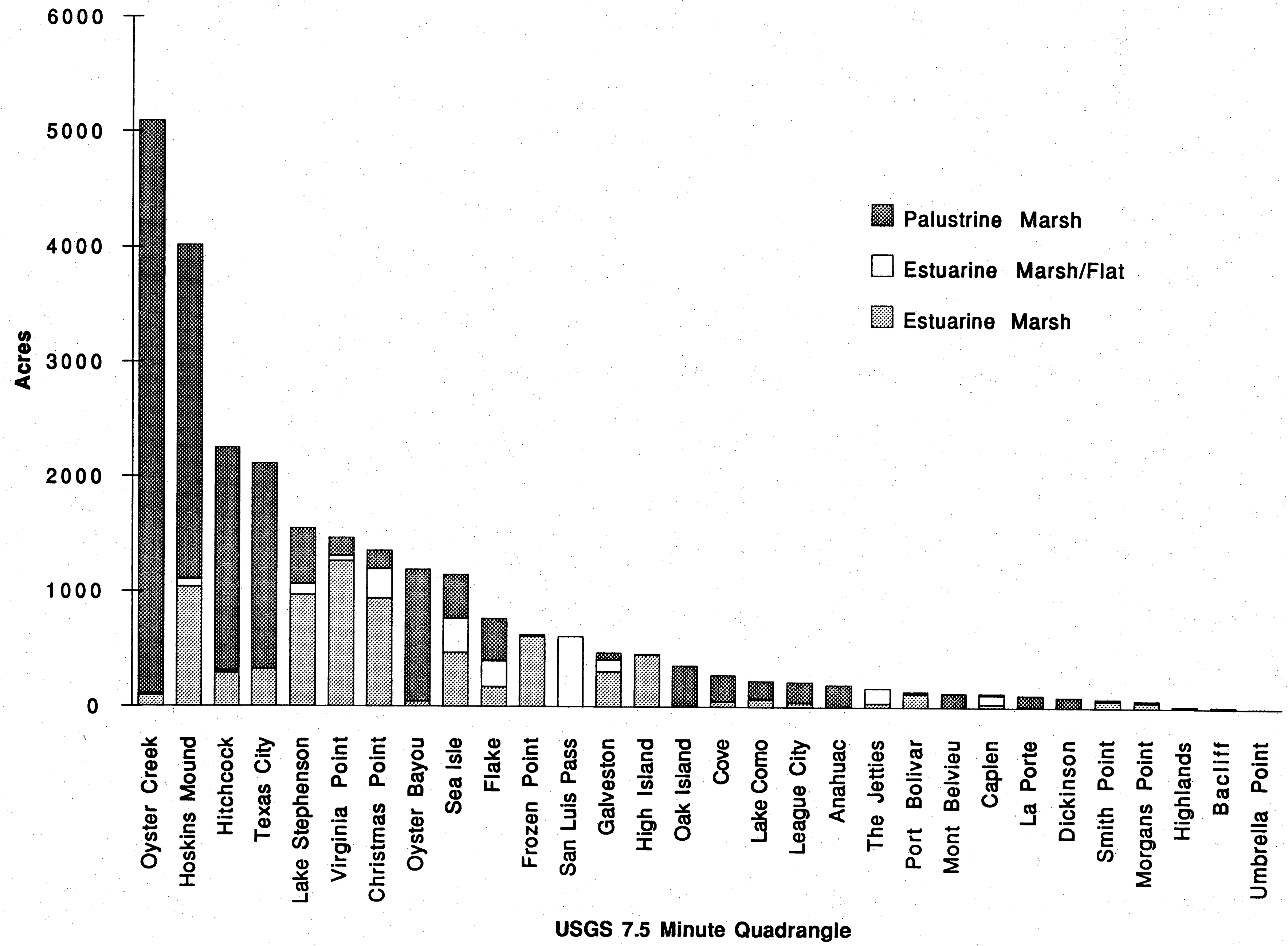


Figure 73. Bar graph showing the extent and type of emergent wetlands (marshes) mapped in the 1950's that became upland rangeland habitats by 1989.

Figure 74. Distribution of emergent wetland areas (shaded) that changed to upland rangeland and agricultural areas from 1950's to 1989 in the Hoskins Mound quad. Although some of these changes are due to photointerpretation and perhaps natural changes, some are due to efforts to drain wetlands for conversion to other land uses. For example, drainage ditches were placed in the linear wetlands north of Chocolate Bayou in the mid-1950's apparently for development of cropland.

Figure 75. Distribution of emergent wetland areas (shaded) that changed to upland rangeland and agricultural areas from the 1950's to 1989 in the Hitchcock quad.

It appears that some changes are related to natural conditions such as annual (and seasonal) changes in moisture levels, which affected photointerpretation; but a substantial amount of the change appears to be related to man-made features consisting of a network of ditches that were placed across wetlands and along drainages for the purposes of reducing flooding and increasing the area of upland rangeland and cropland. As mentioned before, this has been a common practice, especially between the 1950's and 1970's (Tiner, 1984). In fact, Tiner (1984) concluded that 87 percent of the nation's losses in wetlands (all types of wetlands) between the mid-1950's and mid-1970's was related to agricultural development. Dahl and others (1991) concluded that from the mid-1970's to mid-1980's, agricultural land uses accounted for 54 percent of all wetland loss for that period. In the Galveston Bay area, agricultural development (including both rangeland and cropland) accounts for about 33 percent of the gross loss in emergent wetlands (gross loss is about 88,500 acres) between the 1950's and 1989.

Scrub-Shrub and Forested Wetlands

As mentioned in the section on trends, there was a net loss of about 900 acres in scrub-shrub wetlands, but this loss was offset by an increase in forested wetlands of approximately 3,600 acres (fig. 43). Approximately 1,600 acres of the 1950's scrub-shrub habitat in Anahuac and Cove apparently changed to forested wetland habitat by 1989 (fig. 76). Scrub-shrub habitats consist of shrubs and trees less than 6 m (<20 ft) tall, so growth of the trees in these areas to heights of more than 6 m (>20 ft) apparently led to the change in wetland class to forested. Some of the apparent changes in scrub-shrub are due to changes from scrub-shrub to emergent wetlands, and vice versa.

Many of the changes in scrub-shrub and forested wetlands from the 1950's to 1979 and 1989 (fig. 45) appear to be the result of photointerpretation related in part to differences in visible conditions, such as hydrology, at the time the photographs were taken. In some cases the upland forested areas were misinterpreted as forested wetland areas. Extreme changes in forested wetlands for one of the map years, for example 1979 in the Oyster Bayou quad (fig. 45), appear to be interpretational changes. The large increase in forested wetlands in the Highlands quad (fig. 45), which occurred along the San Jacinto River, may be due in part to subsidence in this area contributing to wetter conditions through time. Of course subsidence can eventually lead to losses in forested wetlands (fig. 49). Some of the forested and scrub-shrub gain was caused by the spread of Chinese tallow, which is an invader, exotic, and a rapid grower.

Some local losses, however, appear to be due to human activities. For instance, an area on the south side of Oyster Creek (Oyster Creek Quad) was mapped as a forested wetland area in the 1950's and as an upland forested area in 1979 and 1989. Although part of the forested area was cleared after the 1950's, the major reason for the loss in forested wetland appears to be due to a change in hydrology (less frequent flooding) as a result of an artificial levee constructed along Oyster Creek.

Aquatic Beds

The distribution in submerged vascular vegetation, or aquatic beds (E1AB3L), decreased in areal extent from about 2,500 acres in the 1950's to approximately 700 acres in 1989, a loss of 1,800 acres or about 70 percent of the resource. As mentioned previously, there is evidence that losses in the Galveston Bay system were more extensive than revealed by these numbers. Fisher and others (1972) reported the occurrence of more than 5,000 acres in grassflats (submerged vegetation) in the Galveston Bay system as revealed by aerial photographs taken in 1956. Comparing this area with the 1989 area yields a loss of 4,300 acres, or about 86 percent of the mid-1950's resource.

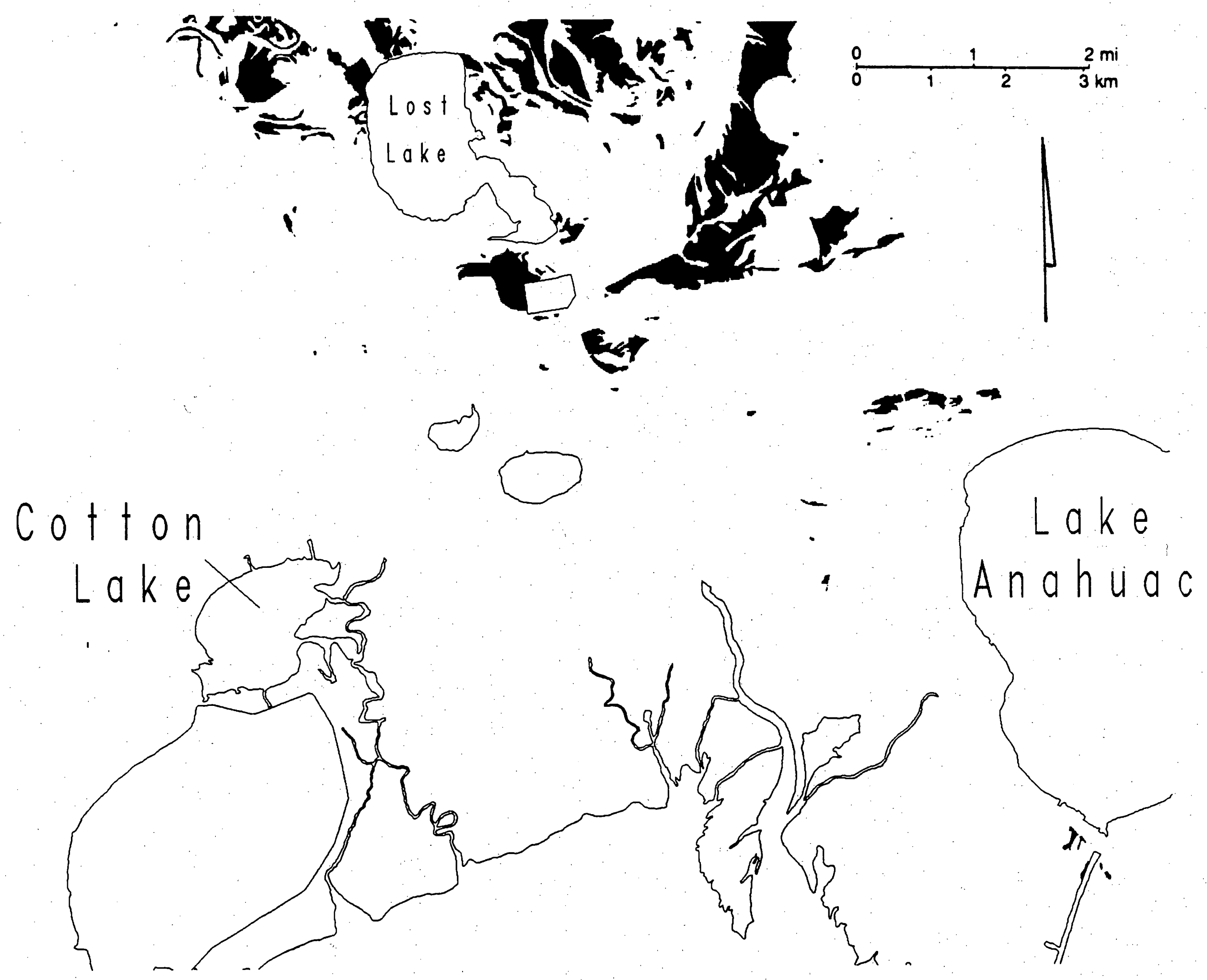


Figure 76. Distribution of areas (shaded) that changed from scrub-shrub wetlands to forested wetlands between the 1950's and 1989 in the Trinity River valley, Anahuac and Cove quad.

Both sets of data indicate major losses, which is a trend supported by other studies (Pulich and White, 1991). The most significant losses were in West Bay and along the margins of west Galveston Bay (fig. 28). Pulich and White (1991) concluded that losses along the margins of west Galveston Bay (League City and Bacliff quads) were related to Hurricane Carla and subsidence. This area was affected by a hurricane surge of 4.3 m (14.2 ft) and intense wave and current action generated by strong onshore winds. Increasing nearshore water depths as a result of subsidence placed a stress on submerged vegetation before Hurricane Carla and inhibited its recovery after the storm (Pulich and White, 1991). In West Bay, the apparent complete loss of submerged vegetation is thought to be due primarily to human activities including industrial, residential and commercial development, wastewater discharges, chemical spills, and increased turbidity from boat traffic and dredging activities (Pulich and White, 1991).

CONCLUSIONS

Wetland Status (1989)

- Wetlands and aquatic habitats in the Galveston Bay system are dominated by an estuarine system that encompasses approximately 507,500 acres and represents 89 percent of the wetland and deep-water habitats. The palustrine system is second at 6 percent (34,100 acres), followed by the lacustrine (4 percent), riverine (0.5 percent), and marine (0.4 percent, excluding open water).

- Vegetated wetlands (marshes, scrub-shrub, and forested wetlands) have a total area of about 138,600 acres, 94 percent (130,400 acres) of which consists of marshes (estuarine and palustrine emergent wetlands).

- Salt and brackish marshes (estuarine intertidal emergent wetlands) constitute 83 percent (108,200 acres) of the marsh system; fresh or inland marshes (palustrine emergent wetlands) make up the remaining 17 percent (22,200 acres).

- Forested (5,650 acres) and scrub-shrub (2,560 acres) wetlands have a total area of about 8,200 acres, representing approximately 6 percent of all vegetated wetland habitats.

- Submerged vascular vegetation (estuarine subtidal aquatic bed) has a total area of about 700 acres, the largest area (386 acres) occurring in Christmas Bay.

- Approximately 17,800 acres of sand and mud flats and bay beaches (estuarine intertidal unconsolidated shores) were mapped on late 1980's photographs. This acreage is higher than normal because of extremely low tides during the 1989 photographic mission, which exposed shallow areas that are usually submerged.

Wetland Trends

- The trend in vegetated wetlands is one of net loss as revealed by acreages of 171,000 in the 1950's, 146,000 in 1979, and 138,600 in 1989. The rate of loss, however, declined over time from about 1,000 acres per year between 1953 and 1979, to about 700 acres per year between 1979 and 1989. The rate of loss for the period 1979 to 1989 would be lower (less than 500 acres/yr) if inaccuracies in wetland interpretation on the 1979 photographs are taken into account.

- Marshes (emergent wetlands) experienced the most extensive wetland losses. Net losses in these habitats exceeded 35,000 acres, or about 21 percent of the 1950's resource. The actual loss when adjusted for photointerpretation problems is somewhat lower, probably below 19 percent. Although the net loss in emergent wetlands (marshes) from the 1950's to 1989 encompassed about 35,000 acres, the gross "loss," exclusive of offsetting gains in other areas, was considerably larger—approximately 88,500 acres.

Causes of Trends

Marshes (Emergent Wetlands)

- Conversion of emergent wetlands to open water and flats from the 1950's to 1989 exceeded 26,400 acres, accounting for about 30 percent of the total gross loss in marshes in the Galveston Bay system. There is evidence that humanly induced subsidence and associated relative sea-level rise are the major factors contributing to this type of loss. Subsidence along active surface faults also contributed to replacement of marshes by water and flat in some areas.

- Major losses in interior, or fresh, marshes occurred as large areas of palustrine emergent wetlands were transformed to uplands. The magnitude of this change is approximately 35,800 acres from the 1950's to 1989, and accounts for about 40 percent of the total gross loss in palustrine and estuarine emergent wetlands. The change from emergent wetlands in the 1950's to upland rangeland in 1989 encompassed 25,400 acres. Conversion of wetlands to urban upland areas amounted to 5,700 acres, and to cropland and pastureland, 3,600 acres. It appears that some changes of wetlands to uplands are related to natural conditions, such as annual (and seasonal) changes in moisture levels, which affected photointerpretation, but a substantial amount of the change appears to be due to draining of wetlands, a common practice, especially from the 1950's to 1970's. Approximately 33 percent of the gross loss in emergent wetlands is attributed to their replacement by upland rangeland and cropland.

Scrub-Shrub and Forested Wetlands

- The general trend in scrub/shrub wetlands for the 1950's to 1989 period was one of net loss. Scrub-shrub wetlands declined by approximately 850 acres, or about 25 percent of the 1950's resource. The net loss in scrub-shrub wetlands was countered by a net gain in forested wetlands, which increased by approximately 3,600 acres—1.8 times the 1950's forested wetland area. Much of this gain in forested wetlands was due to (a) taller growth of shrubs and trees in areas previously mapped as scrub-shrub wetlands, and (b) photointerpretation inconsistencies. Locally, losses in forested wetlands were due to alterations in hydrology.

Estuarine Submerged Vegetation (Aquatic Beds)

- An extensive net loss occurred in submerged vascular vegetation. This habitat decreased from about 2,500 acres in the 1950's to approximately 700 acres in 1989, reflecting a decline of 1,800 acres, or more than 70 percent of the 1950's habitat. The loss of submerged vegetation is even greater, 86 percent of the mid-1950's resource, using the area of 5,000 acres reported by Fisher and others (1972) for submerged vegetation in 1956. Loss of submerged vegetation has been attributed to subsidence and Hurricane Carla in parts of Galveston Bay, and to human activities including development, wastewater discharges, chemical spills, boat traffic, and dredging activities in West Bay (Pulich and White, 1991).

Local Gains in Wetlands

- Losses in emergent wetlands in some areas were partly offset by gains in emergent wetlands in other areas. Conversion of uplands to emergent wetlands, in part due to subsidence, accounted for an increase of about 21,000 acres. Additional increases in emergent wetlands resulted from the spread of emergent vegetation over areas previously mapped as intertidal flats.

- Although newly established wetlands provide some measure of areal offset to net wetland loss, there is not necessarily a corresponding offset in terms of functional value. Some researchers suggest that several years of development may be necessary for newly formed marshes to reach overall functional equivalency to older marshes (Minello and Zimmerman, 1992). It is possible that they may never become totally equivalent.

- The declining rate of loss of wetlands over the more recent period (1979–1989), coupled with local gains in wetland habitats in some areas, provide a cautionary measure of hope that planning and proper management of wetlands can help mitigate the trend toward net loss of these valuable resources in the Galveston Bay system.

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Appendix A

Site Survey numbers, locations including UTM, soils and general wetland units.

Quadrangle	Site Number Quad	Site	County	UTM Coordinates Easting	Northing	Soil*	Classification
Freeport	1	1	Brazoria	274150	3209100	10	
Freeport	1	2	Brazoria	278955	3207845	44	
Freeport	1	3	Brazoria	280480	3207620	30,31	
Christmas Point	3	1	Brazoria	281040	3216595	20,39	UR
Christmas Point	3	2	Brazoria	281300	3221205	32	E2EM1P
Christmas Point	3	3	Brazoria	281620	3208600	30,31,16	NOT MAPPED
Christmas Point	3	4	Brazoria	283000	3215800	19	E2EM1P
Christmas Point	3	5	Brazoria	283350	3221240	19	E2EM1N;E1UBL
Christmas Point	3	6	Brazoria	283905	3220980	19	PEM1Fhx
Christmas Point	3	7	Brazoria	283995	3211210	31,16	E2EM1N
Christmas Point	3	8	Brazoria	284210	3220750	19	E2EM1N
Christmas Point	3	9	Brazoria	284775	3220460	19	PEM1Fhx
Christmas Point	3	10	Brazoria	284860	3220745	19	E2EM1N
Christmas Point	3	11	Brazoria	286485	3213510	16	E2EM1N
Christmas Point	3	12	Brazoria	292720	3217345	30,31	E2EM1N;UR
Oyster Creek	4	1	Brazoria	273610	3212160	36	UR;L1UBHx
Oyster Creek	4	2	Brazoria	272260	3213300	water	PEM1F;L2AB3H
Oyster Creek	4	3	Brazoria	273860	3212000	38	PEM1A
Oyster Creek	4	4	Brazoria	274070	3210700	12	PEM1C;UR;UF8
Oyster Creek	4	5	Brazoria	279750	3216610	water	PEM1F
Oyster Creek	4	6	Brazoria	279850	3216575	39	UR
Oyster Creek	4	7	Brazoria	280035	3216575	39	E2EM1N;E2EM1P
Lake Como	5	1	Galveston	312785	3234040	Mt/Mn	E2EM1N;E1UBL
Lake Como	5	2	Galveston	313770	3234075	Gc	E1UBL;E2EM1N
Lake Como	5	3	Galveston	316380	3236780	Gc	E2EM1P
Lake Como	5	4	Galveston	316480	3236400	Gc	E2EM1N
Lake Como	5	5	Galveston	309310	3231800	Ka	E2EM1N
Lake Como	5	6	Galveston	306510	3231330	Ka	E2EM1N;E2US/EM1N
Sea Isle	6	1	Galveston	304440	3236280	ImA	USSs
Sea Isle	6	2	Galveston	301170	3225900	Ka	E2EM1N
Hoskins Mound	7	1	Brazoria	283870	3226410	32	UR;E2EM1P
Hoskins Mound	7	2	Brazoria	285660	3233485	16	E2EM1P;E23M1P/US;E2EM1N
Galveston	9	1	Galveston	318655	3237310	Mn	E2EM1N;E2EM1P
Galveston	9	2	Galveston	323540	3245640	SeB	E2EM1P
Galveston	9	3	Galveston	326000	3245410	ImA,ImB	UR;PEM1C;PEM1KAhs
Virginia Point	10	1	Galveston	306000	3238420	Tm/Pd	E2EM1N
Virginia Point	10	2	Galveston	306065	3238350	Tm/Pd	E2EM1N
Virginia Point	10	3	Galveston	306125	3238280	Tm/Pd	E2EM1N
Virginia Point	10	4	Galveston	307880	3240450	Vx	E2EM1N
Virginia Point	10	5	Galveston	307925	3240390	Vx	E2EM1P;E2EM1N
Virginia Point	10	6	Galveston	307950	3240340	Vx	E2EM1P;E2USN
Virginia Point	10	7	Galveston	311740	3244810	Tx	E2EM1N
Virginia Point	10	8	Galveston	312500	3245410	Tx	E2EM1N;E2USM
Virginia Point	10	9	Galveston	314535	3237970	Ka	E2EM1N;E2USM
Virginia Point	10	10	Galveston	314725	3243510	Tx	E2EM1P;E2USP
Virginia Point	10	11	Galveston	313310	3248440	Na	E2EM1P
Virginia Point	10	12	Galveston	315660	3238040	Mt	E2EM1P
Virginia Point	10	13	Galveston	315980	3237480	Nx	E2EM1P;E1UBL
Virginia Point	10	14	Galveston	317130	3239220	Mt	E2EM1P;E2EM1N
Virginia Point	10	15	Galveston	317490	3238810	Mu/Gc	E2EM1P;E2USP
Virginia Point	10	16	Galveston	317675	3238510	Mu	E2EM1P;E1UBL
Virginia Point	10	17	Galveston	317780	3239330	Mn	UR
Hitchcock	11	1	Galveston	296540	3244420	Be	R2UBHx
Hitchcock	11	2	Galveston	302820	3249020	Ba	UF8

Quadrangle	Site Number Quad	Site	County	UTM Coordinates Easting	Northing	Soil*	Classification
Caplen	12 —	1	Galveston	347305	3262445	Vx	E2EM1P;USS
Flake	13 —	1	Galveston	332245	3251545	Ms	E2EM1N;E2EM1P;UR;E2USP
Flake	13 —	2	Galveston	332250	3251870	Mt	E2EM1N
Flake	13 —	3	Galveston	332435	3251680	Mn	E2EM1N;UR
Flake	13 —	4	Galveston	334900	3257000	Vx, Ka	E2EM1N;E2EM1P
Flake	13 —	5	Galveston	336520	3256410	Mt	PEM1C
Flake	13 —	6	Galveston	337625	3258655	Vx	E2EM1P;E2USP
Texas City	15 —	1	Galveston	309340	3261240	Be	E2EM1N;E2USM
Texas City	15 —	2	Galveston	309800	3256070	Fo	E2EM1N;E2USM
Texas City	15 —	3	Galveston	312050	3255500	Fo	E2EM1N
Texas City	15 —	4	Galveston	312740	3263430	Fo	E2EM1P;E2USM
	15 —	5	Site No. not used				
Texas City	15 —	6	Galveston	314350	3263740	Md	PEM1C
Texas City	15 —	7	Galveston	314400	3255060	Vx	UR
Texas City	15 —	8	Galveston	316260	3256060	Fo	E2EM1N
Texas City	15 —	9	Galveston	316480	3257140	Vx	E2EM1N;UR
Dickinson	16 —	1	Galveston	299050	3259710	Va	R2UBH;E2USM
Dickinson	16 —	2	Galveston	299485	3260040	LaB	E1UBL
Dickinson	16 —	3	Galveston	304340	3261070	Ba	E2SS1P
High Island	17 —	1	Galveston	363320	3269905	Pd	E2EM1P
High Island	17 —	2	Galveston	363340	3271955	Pd	E2EM1P
High Island	17 —	3	Galveston	365095	3273830	Pd	E2EM1P
Frozen Point	18 —	1	Galveston	346785	3266695	Ca	E2EM1P
Frozen Point	18 —	2	Galveston	346900	3266900	Ct/Ca	E2EM1N
Frozen Point	18 —	3	Galveston	346900	3267040	Ct	32EM1N
Frozen Point	18 —	4	Galveston	347780	3267550	Ct	E2EM1P
Frozen Point	18 —	5	Galveston	347830	3267500	Ct	E2EM1N
Frozen Point	18 —	6	Galveston	349340	3267320	Ct	E2EM1N
Frozen Point	18 —	7	Galveston	349360	3267420	Ct	E2EM1P
Frozen Point	18 —	8	Chambers	351620	3273900	Ha	E2EM1P
Frozen Point	18 —	9	Chambers	352140	3273220	Ha	E2EM1P
Frozen Point	18 —	10	Chambers	352400	3268760	Ve	UR
Frozen Point	18 —	11	Chambers	352690	3268800	Ve	E2EM1P
Frozen Point	18 —	12	Galveston	353765	3265090	Vx	E2EM1/USN
Lake Stephenson	19 —	1	Chambers	337640	3275970	Ha	E2EM1P
Smith Point	20 —	1	Chambers	326700	3269590	Ve	E2EM1P;E2USP
Bacliff	21 —	1	Chambers	310890	3278320	Im	E2EM1/SSPs
Bacliff	21 —	2	Chambers	311050	3278360	Im	E2EM1/SSPs
Bacliff	21 —	3	Chambers	311960	3277930	water	E2EM1Ns
League City	22 —	1	Galveston	297100	3268610	Vx	E2EM1P;E2SS/EM1P;E1UBL
League City	22 —	2	Harris	298020	3275400	Na	E2EM1N
League City	22 —	3	Harris	299380	3274600	AtB	E2EM1P;E2USM
League City	22 —	4	Harris	302510	3276460	VaB	E2EM1P;UF8;E2USM
League City	22 —	5	Harris	303160	3271750	AtB	E2EM1P
Morgans Point	26 —	1	Harris	307935	3284355	Na	E2EM1P
Morgan's Point	26 —	2	Chambers	308750	3285730	Im	E2USNs;E2EM1Ps;E1UBLx
Morgan's Point	26 —	3	Chambers	309280	3284850	Im	E2EM1Ns;E2EM1Ps;E2USMs
Morgan's Point	26 —	4	Chambers	309710	3283040	Im	E2EM1Ns;E2EM1Ps
Morgan's Point	26 —	5	Chambers	311070	3280480	Im	E2EM1Ns
Morgan's Point	26 —	6	Chambers	311150	3280380	water	E2EM1Ps
Morgan's Point	26 —	7	Chambers	314130	3282425	Im	E2EM1N
Morgan's Point	26 —	8	Chambers	314560	3282320	LaB	E2EM1N;PSS1R
Morgan's Pointt	26 —	9	Chambers	314910	3285395	Ha	E2EM1P
La Porte	27 —	1	Harris	299420	3292140	LcB	UU
Anahuac	28 —	1	Chambers	332330	3295850	Ha	E2EM1P
Anahuac	28 —	2	Chambers	333420	3297190	Ha	E2EM1P
Anahuac	28 —	3	Chambers	333460	3297270	Ha	E2EM1P
Anahuac	28 —	4	Chambers	333490	3297320	Ha	E2EM1P
Anahuac	28 —	5	Chambers	333520	3297360	Ha	E2EM1P
Anahuac	28 —	6	Chambers	333560	3297420	Ha	E2EM1P
Anahuac	28 —	7	Chambers	334570	3298880	Ka	PEM1Fh
Anahuac	28 —	8	Chambers	335100	3293100	Ha	E2EM1P
Anahuac	28 —	9	Chambers	335150	3293170	Ha	E2USM
Anahuac	28 —	10	Chambers	336405	3293860	Ha	E2EM1P

Quadrangle	Site Number Quad	Site	County	UTM Coordinates Easting	Northing	Soil*	Classification
Anahuac	28 —	11	Chambers	336465	3293860	Ha	E2EM1P
Anahuac	28 —	12	Chambers	337000	3300540	Ha	PEM1F
Cove	29 —	1	Chambers	327000	3297800	Ha	E2EM1P
Cove	29 —	2	Chambers	327220	3298140	Ha	E2EM1P
Cove	29 —	3	Chambers	328370	3301790	Ka/Ha	PFO1/2R
Cove	29 —	4	Chambers	328655	3298960	reservoir	PEM1T
Cove	29 —	5	Chambers	328680	3299080	reservoir	PEM1T
Cove	29 —	6	Chambers	330190	3301000	reservoir	UR
Cove	29 —	7	Chambers	330340	3300920	reservoir	PEM1T
Cove	29 —	9	Chambers	330720	3300550	reservoir	PEM1T
Cove	29 —	10	Chambers	330120	3302400	Mo	UF6
Highlands	31 —	1	Harris	296500	3296740	An	UU;UF8
Highlands	31 —	2	Harris	298460	3302465	Ka	PEM1T
Highlands	31 —	3	Harris	298720	3293845	Is	E1UBLx
Highlands	31 —	4	Harris	298960	3297900	Ku	PUBHx
Highlands	31 —	5	Harris	300000	3302300	Ka	UF8;PEM1T
Highlands	31 —	6	Harris	300100	3302300	Ka	PEM1T;UF8
Highlands	31 —	7	Harris	300180	3302400	Ka	PSS1S;PEM1T
Highlands	31 —	8	Harris	300580	3295820	VaB	USS
Highlands	31 —	9	Harris	300265	3302280	Ka	PEM1T
Highlands	31 —	10	Harris	300000	3297805	Bo	E2SS/EM1P

* Soil names and identifying codes. From USDA soil surveys of Brazoria, Chambers, Galveston, and Harris Counties.

Soil Name	Identifying Code	Soil Name	Identifying Code
Aldine-urban land complex	An	Mocarey-leton complex	Md
Asa silty clay loam	10	Morey silt loam	Me
Atasco fine sandy loam, 1 to 4% slopes	AtB	Morey silt loam, levelled	Mo
Bacliff clay	Ba	Mustang fine sand	Mn, 30
Bernard clay loam	Be	Mustang fine sand, strongly saline and saline	Ms, 31
Boy loamy fine sand	Bo	Mustang-Nass complex	Mt
Caplen mucky silty clay loam	Ca	Narta fine sandy loam	Na, 32
Caplen-Tracosa complex	Ct	Nass Very fine sand loam	Ns
Clemville silty clay loam	12	Nass-Galveston complex, shell substratum	Nx
Follet clay loam	16	Placedo clay	Pd
Follet Loam	Fo	Pledger clay	36
Galveston-Nass complex	Gc	Sievers loam, 0 to 3% slopes	SeB
Harris-Tracosa complex	20	Sumpf clay	38
Harris clay	Ha, 19	Surfside clay	39
Ijam clay, 0-2% slopes	ImA	Tatlum clay Loam	40
Ijam clay, 2-8% slopes	ImB	Tracosa mucky clay	Tm
Ijam soils	Im	Tracosa mucky clay-clay, low complex	Tx
Kaman clay	Ka (Harris Co.)	Vamont clay	Va
Karankawa mucky Loam	Ka (Galveston Co.)	Vamont clay, 1 to 4% slopes	VaB
Kaufman clay	Ka (Chambers Co.)	Velasco clay	42
Kemah-urban land complex	Km	Verland silty clay loam	Ve
Lake Charles clay, 1-3% slopes	LcB	Veston loam	Vx
Lake Charles clay, 1-5% slopes	LaB	Veston silty clay Loam	44

Appendix B

APPENDIX B. List of Plant Species by Survey Site Number.

General Location	Site Number on Photo (Aerial photo + location No.) General descriptions	Site number Quad No.	Site No.	Prevalent Species
	GHGH 8011 5	1	1	*OUT OF MAP AREA*
		1	1	*Paspalum urvillei-collected*
Follets Island				
	GHKL 8098 1	1	2	*Batis-Monanthochloe community*
		1	2	*Distichlis spicata*
		1	2	*Distichlis-Batis community*
		1	2	*Batis, Borrichia, Spartina alterniflora (around water)*
		1	2	*Distichlis-Monanthochloe, mixed with Batis*
		1	2	*Lycium carolinianum (sparse)*
		1	2	*Juncus roemerianus (along some ponds)*
	Disturbed areas (spoil)	1	2	*Iva frutescens*
		1	2	*Spartina patens*
		1	2	*Borrichia frutescens*
		1	2	*Spartina spartinae*
		1	2	*Batis maritima*
		1	2	*Suaeda sp.*
		1	2	*Aster sp.*
		1	2	*Limonium nashii*
		1	2	*Monanthochloe littoralis*
		1	2	*Salicornia sp.*
	Depression	1	2	*Spartina patens-Batis*
	Margins of depression	1	2	*Iva frutescens*
		1	2	*Setaria sp., composites*
	GHKL 8098 2	1	3	
	near hwy and generators	1	3	
	Upland belt of scrub/shrub	1	3	*Baccharis halimifolia*
	Along upper margins of marsh	1	3	*Iva frutescens-Borrichia*
	Bayward transect	1	3	*Spartina patens*
		1	3	*Scirpus americanus*
		1	3	*Spartina patens*
		1	3	*then Monanthochloe*
		1	3	*Salicornia*
		1	3	*Suaeda*
		1	3	*Limonium*
		1	3	*Batis*
		1	3	*Distichlis*
		1	3	*Aster*
	Tidal channel/pond	1	3	*Batis (dead)*
		1	3	*Scirpus maritimus*
		1	3	*Batis*
		1	3	*Juncus roemerianus*
	Higher margins	1	3	*Iva*
		1	3	*Borrichia*
		1	3	*Spartina patens*
		1	3	*Distichlis*
	GHGH 8012 3	3	1	
	Elevation transect	3	1	
	Higher side of fault	3	1	*Spartina spartinae (80%)*
		3	1	*Setaria geniculata*
		3	1	*Aster sp.*
		3	1	*Cyperus sp.*
	Lower side of fault	3	1	
	Flat/emergent	3	1	*Monthochloe-Salicornia-Batis*
	Lower side of fault	3	1	*Distichlis (80%)*
		3	1	*Salicornia (20%)*

General Location	Site Number on Photo (Aerial photo + location No.) General descriptions	Site number Quad No. — Site No.	Prevalent Species
		3 — 1	*Spartina alterniflora*
	GHCD 7931 3	3 — 2	*SEE HOSKINS MOUND TRANSECT 7 (WINDMILL TRANSECT)*
	GHGH 8012 1a	3 — 3	*Batis-Salicornia bigelovii-Spartina alterniflora*
	Lower area	3 — 3	*Monanthochloe-Distichlis-Batis*
	Landward margin	3 — 3	*Borrichia*
		3 — 3	*Baccharis halimifolia*
		3 — 3	*Spartina spartinae*
		3 — 3	*Spartina patens*
		3 — 3	*Batis grades into Spartina alterniflora*
	Highest assemblage toward Hwy	3 — 3	*Paspalum monostachyum-collected*
		3 — 3	*Hydrocotyle bonariensis*
		3 — 3	*Borrichia*
		3 — 3	*Fimbristylis*
		3 — 3	*Andropogon glomeratus*
		3 — 3	*composites, other species*
Follets Island	GHGH 8012 1a	3 — 3	
	SEE SURVEY LINE FOR THIS SITE	3 — 3	
Brazoria National Wildlife Refuge			
	GHGH 8012 2b	3 — 4	*Salicornia-Distichlis*
		3 — 4	*Batis (scattered)*
		3 — 4	*Spartina patens (patches)*
	GHCD 7932 3b	3 — 5	*Distichlis - Spartina patens - Paspalum vaginatum dominance*
	Wet areas in distance	3 — 5	*Phragmites australis*
	Higher area above fringing flat	3 — 5	*Spartina spartinae*
		3 — 5	*Setaria sp.*
		3 — 5	*Aster sp.*
		3 — 5	*Cyperus articulatus*
		3 — 5	*Solidago sp.*
		3 — 5	*composites*
	Flat/Emergent area	3 — 5	*Distichlis, Salicornia, Monanthochloe*
	GHCD 7932 3a	3 — 6	*Distichlis spicata*
	In water	3 — 6	*Paspalum vaginatum*
		3 — 6	*Spartina patens dominant in distance*
		3 — 6	*Salicornia virginica and Suaeda sp.*
		3 — 6	*Juncus roemerianus*
		3 — 6	*Spartina alterniflora (small patch)*
	GHGH 8013 2	3 — 7	*Spartina alterniflora-Batis-Distichlis*
	Adjacent lower areas	3 — 7	*Spartina alterniflora (100%)*
	Slightly higher	3 — 7	*Distichlis & Batis*
	Landward	3 — 7	*Salicornia*
	Depressions	3 — 7	
	Rims	3 — 7	*Distichlis, Batis*
		3 — 7	*some Borrichia*
	Lower zones adjacent to rims	3 — 7	*Salicornia, and others*
		3 — 7	*Spartina alterniflora, patches*
	Spoil mound on edge of ICWW	3 — 7	*Iva frutescens, Borrichia, Spartina spartinae-Dominants*
		3 — 7	*Spartina patens, Opuntia sp.*
	GHCD 7932 3	3 — 8	*Distichlis spicata dominant*
		3 — 8	*Scattered Salicornia*
	In distance	3 — 8	*Phragmites australis*
		3 — 8	*Eleocharis microcarpa*
	Disturbed area adjacent to site 3	3 — 8	*Cynodon dactylon*
	From higher to lower areas	3 — 8	*Andropogon glomeratus*
		3 — 8	*Machaeranthera*

General Location	Site Number on Photo (Aerial photo + location No.) General descriptions	Site number Quad No. — Site No.	Prevalent Species
		3 — 8	*Borrichia*
		3 — 8	*Spartina spartinae*
		3 — 8	*Spartina patens*
		3 — 8	*Distichlis spicata*
		3 — 8	*Typha sp.*
		3 — 8	*Bacopa*
		3 — 8	*Cyperus sp.*
		3 — 8	*Eleocharis sp.*
		3 — 8	*Paspalum vaginatum*
Hoskins Mound S.			
	GHCD 7932 2	3 — 9	
	Disturbed (diked) area at well site	3 — 9	
	Saline areas around diked pond	3 — 9	*Spartina spartinae, Borrichia, Distichlis, Machaeranthera, Iva*
		3 — 9	*Monanthochloe, Salicornia*
	In fresher diked area	3 — 9	*Typha sp., Bacopa monnieri, Cyperus oxylepis-collected*
		3 — 9	*Iva frutescens, Borrichia, Distichlis, Spartina spartinae*
		3 — 9	*Fimbristylis castanea, Andropogon glomeratus, Monanthochloe*
	Flat/Emergent south of diked area	3 — 9	*Salicornia-Monanthochloe dominant*
	Adjacent to ICWW	3 — 9	*Distichlis spicata (dominant)-Spartina alterniflora-Batis*
	Dark patches in water	3 — 9	*Brown algae*
	(No sea grasses in drift line)	3 — 9	
	SE corner of diked area	3 — 9	*Spartina patens*
	GHCD 7932 2a	3 — 10	
	Flat/Emergent assemblage	3 — 10	*Monanthochloe, Salicornia, Spartina spartinae, Batis,*
		3 — 10	*Limonium, Borrichia*
	GHGH 8013 1a	3 — 11	Patches of vegetation included
	sand flats/emergents	3 — 11	*Monanthochloe*
		3 — 11	*Batis*
		3 — 11	*Saliconia*
			Algal mats on flats, damp soils near vegetation
	GHGH 8014 1	3 — 12	
	Brackish/Intermediate	3 — 12	*Typha - dominant*
	Gufward of Rd.	3 — 12	*Juncus*
		3 — 12	*Scirpus americanus*
		3 — 12	*Spartina patens*
		3 — 12	*Phragmites*
		3 — 12	*Paspalum vaginatum*
		3 — 12	*Baccharis halimifolia*
	Salt/brackish	3 — 12	*Spartina patens dominant*
	Bayward of Rd.	3 — 12	*Scirpus americanus*
		3 — 12	*Juncus roemerianus*
		3 — 12	*Borrichia*
	Adjacent area	3 — 12	
	grading from	3 — 12	*Spartina patens - dominant*
		3 — 12	*Batis*
		3 — 12	*Juncus roemerianus*
		3 — 12	*Scirpus maritimus*
		3 — 12	*Batis*
	GHGH 8011 3	4 — 1	*Uplands*
	Water	4 — 1	*Trees appear dead*
	Margin of water	4 — 1	*Sesbania, Celtis sp., Sapium sebiferum*
		4 — 1	*Andropogon golmeratus*
Lake Jackson Area			
	GHGH 8011 1	4 — 2	
	Stubblefield Lake	4 — 2	*Scirpus californicus dominant*
		4 — 2	*Nelumbo lutea*

General Location	Site Number on Photo (Aerial photo + location No.) General descriptions	Site number Quad No. — Site No.	Prevalent Species
	On margin of lake	4 — 2	*Phragmites australis*
		4 — 2	*Polygonum sp.*
		4 — 2	*Bacopa monnieri*
		4 — 2	*Salix nigra*
		4 — 2	*Sesbania sp.*
		4 — 2	*Cyperus articulatus*
		4 — 2	*Scirpus americanus*
		4 — 2	*Andropogon glomeratus*
		4 — 2	*Spartina spartinae*
		4 — 2	*Spartina patens*
		4 — 2	*Aster sp.*
		4 — 2	*Typha sp.*
		4 — 2	*Setaria sp.*
		4 — 2	*Solidago sp.*
		4 — 2	*Baccharis halimifolia*
	GHGH 8011 2	4 — 3	
	Ditch has drained water	4 — 3	*Sesbania sp.*
		4 — 3	*Cyperus sp.*
		4 — 3	*Cynodon dactylon (probably)*
		4 — 3	
	GHGH 8011 4	4 — 4	*Spartina spartinae*
		4 — 4	*Scirpus or Juncus*
		4 — 4	*Ulmus crassifolia*
		4 — 4	*Celtis laevigata*
		4 — 4	*Quercus virginiana*
		4 — 4	*Sabal minor*
		4 — 4	*Sapium sebiferum*
		4 — 4	*Baccharis halimifolia ?*
	GHGH 8012 5	4 — 5	*Scirpus californicus dominant*
	GHGH 8012 4	4 — 6	*Spartina spartinae dominant*
	GHGH 8012 3a	4 — 7	
	Brackish/Intermediate	4 — 7	*Paspalum vaginatum*
		4 — 7	*Typha sp.*
		4 — 7	*Scirpus olneyi*
		4 — 7	*Spartina patens*
		4 — 7	*Echinochloa crusgalli*
		4 — 7	*Spartina spartinae*
		4 — 7	*Aster*
		4 — 7	*Cyperus sp.*
Galveston Island			
	GHEF 7947 2	5 — 1	*Salicornia*
		5 — 1	*Spartina patens*
		5 — 1	*Borrichia*
		5 — 1	*Iva frutescens*
		5 — 1	*Aster*
		5 — 1	*Batis (along channel)*
	GHEF 7946 2a	5 — 2	*Spartina alterniflora*
		5 — 2	*Juncus roemerianus*
	GHEF 7945 9	5 — 3	
	Heavily grazed, grass unidentified	5 — 3	*Cynodon dactylon possibly*
	Across road (southwest)	5 — 3	*Scirpus californicus*
	small ponded area	5 — 3	*Bacopa monnieri*
		5 — 3	*Cyperus articulatus*
		5 — 3	*Sesbania sp.*
		5 — 3	*Cynodon dactylon*

General Location	Site Number on Photo (Aerial photo + location No.) General descriptions	Site number Quad No. — Site No.	Prevalent Species
	GHEF 7945 10	5 — 4	
	Lower area (southwest)	5 — 4	*Distichlis dominant*
	surrounding higher flats	5 — 4	*Salicornia*
	Toward northeast of road	5 — 4	*Distichlis dominant*
	On flats	5 — 4	*Salicornia*
		5 — 4	*Distichlis*
		5 — 4	*Machaeranthera*
		5 — 4	*Limonium*
		5 — 4	*Borrichia*
		5 — 4	*Monanthochloe*
	GHEF 7947 4b	5 — 5	
	along channel	5 — 5	*Spartina alterniflora dominant*
	grading upward above channel	5 — 5	*Distichlis, Spartina patens, Juncus roemarianus*
	higher zones	5 — 5	*Iva frutescens, Spartina spartinae, Spartina patens*
		5 — 5	*Andropogon, Setaria, Hydrocotyle*
	GHEF 7948 7	5 — 6	*Spartina alterniflora dominant*
	above smooth cordgrass	5 — 6	*Batis, Salicornia, Scattered Distichlis*
	near road	5 — 6	*Juncus roemarianus, Spartina patens*
	along road	5 — 6	*clumps of Baccharis, Iva, and Spartina spartinae*
	GHEF 7948 3a		
	Spoil island-local algal flat and	6 — 1	*Suaeda linearis*
	patches of emergent vegetation	6 — 1	*Batis maritima*
		6 — 1	*Spartina patens*
		6 — 1	*Spartina spartinae*
		6 — 1	*Borrichia frutescens*
		6 — 1	*Iva frutescens*
		6 — 1	*Limonium nashii*
		6 — 1	*Opuntia in higher areas*
		6 — 1	*Setaria*
		6 — 1	*Cynodon dactylon*
		6 — 1	*Distichlis spicata*
		6 — 1	*Acacia angustissima*
		6 — 1	*Salicornia bigelovii*
		6 — 1	*Iva annua*
		6 — 1	*other composites*
	GHEF 7934 1	6 — 2	*Spartina alterniflora dominant (100%)*
Hoskins Mound area			
	GHCD 7932 1	7 — 1	*Cyperus oxylepis-collected*
	SEE SURVEY LINE FOR THIS SITE	7 — 1	*Iva augustifolia-collected*
		7 — 1	*Cyperus virens-collected*
		7 — 1	*Paspalum floridanum-collected*
		7 — 1	*Andropogon glomeratus-collected*
		7 — 1	*Eragrostis spectabilis-collected*
		7 — 1	*Eleocharis cellulosa-collected*
Chocolate Bayou area			
	GHEF 7951 1	7 — 2	*Juncus roemerianus dominant*
		7 — 2	*Spartina alterniflora*
		7 — 2	*Scirpus maritimus*
	Away from water	7 — 2	*Distichlis spicata dominant*
		7 — 2	*Spartina patens*
		7 — 2	*Scattered Aster sp.*
	vegetation/flat mix	7 — 2	*Distichlis spicata/dry flats*
Galveston Island			
	GHEF 7945 1	9 — 1	
	low marsh	9 — 1	*Distichlis spicata-Spartina alterniflora assemblage*

General Location	Site Number on Photo (Aerial photo + location No.) General descriptions	Site number Quad No.	Site No.	Prevalent Species
		9	1	*Spartina alterniflora abundance increases toward bayou*
		9	1	*Salicornia bigelovii*
	high marsh	9	1	*Borrichia frutescens (dominant)*
		9	1	*Spartina spartinae (scattered)*
		9	1	*Machaeranthera phyllocephala*
		9	1	*Fimbristylis castanea*
		9	1	*Solidago sp.*
	sand flat/emergent mix	9	1	*Salicornia*
		9	1	*Batis*
		9	1	*Limonium nashii*
		9	1	*Suaeda sp.*
		9	1	*Monanthochloe littoralis*
		9	1	*Lycium carolinianum*
	fresher small marsh near road	9	1	*Typha sp.*
	GHAB 7868 2	9	2	*Borrichia frutescens - Distichlis spicata dominance*
		9	2	*Limonium nashii*
		9	2	*Suaeda sp.*
		9	2	*Salicornia bigelovii*
Pelican Island				
	GHAB 7868 1 and area	9	3	*Borrichia frutescens*
		9	3	*Distichlis spicata*
		9	3	*Machaeranthera*
	Depressions	9	3	*Typha sp.*
		9	3	*Scirpus maritimus*
	Trees and shrubs on Island include	9	3	*Sapium sebiferum*
		9	3	*Tamarix gallica*
		9	3	*Celtis sp.*
		9	3	*Sesbania spp.*
		9	3	*Baccharis halimifolia*
		9	3	*Iva frutescens*
Virginia Point Quad.	GHEF 7948 2c	10	1	*Distichlis spicata 35% water depth 6-7cm*
		10	1	*Spartina alterniflora 60%*
		10	1	*Batis maritima 5%*
	GHEF 7948 2b	10	2	*Distichlis spicata 60% water depth 3cm*
		10	2	*Spartina alterniflora 40%*
	GHEF 7948 2a	10	3	*Distichlis spicata 75% water depth 1cm*
	transect	10	3	*Spartina alterniflora 15%*
		10	3	*Batis maritima 5%*
	GHEF 7948 1c	10	4	*Spartina alterniflora 100%*
	GHEF 7948 1b	10	5	*Distichlis spicata 60%*
		10	5	*Spartina alterniflora 40%*
		10	5	*Salicornia 1%*
Mainland shore				
West Bay	GHEF 7948 1a	10	6	*Batis maritima*
	transect	10	6	*Borrichia frutescens*
		10	6	*Limonium nashii*
		10	6	*Spartina spartinae*
		10	6	*Lycium carolinianum*
West of Jones Bay				
	GHAB 7870 2a	10	7	*Spartina alterniflora (dominant, 100%)*
	GHAB 7870 2b	10	8	*Spartina alterniflora (dominant, > 90%)*
		10	8	*Salicornia sp.*

General Location	Site Number on Photo (Aerial photo + location No.) General descriptions	Site number Quad No. Site No.	Prevalent Species
		10 — 8	*Distichlis spicata*
		10 — 8	*Batis maritima*
	GHEF 7945 6 (GHEF 7946 8b)	10 — 9	*Spartina alterniflora (dominant, > 90%)*
		10 — 9	*scattered Batis, Distichlis, Salicornia locally*
	GHAB 7870 3	10 — 10	*Juncus roemerianus*
		10 — 10	*Batis maritima*
		10 — 10	*Distichlis spicata*
		10 — 10	*Scirpus maritimus*
		10 — 10	*Moist algal flats*
Texas City area			
	GHAB 7870 1	10 — 11	*Spartina alterniflora (dominant)*
	(east side of highway)	10 — 11	*Scirpus maritimus*
		10 — 11	*Distichlis spicata*
		10 — 11	*Juncus roemerianus*
		10 — 11	*Iva frutescens*
		10 — 11	*Aster sp.*
	(Ponds on west side of highway)	10 — 11	*Typha sp.*
	GHEF 7945 7	10 — 12	
	flat/emergent mix (Southwest)	10 — 12	*Monanthochloe, Salicornia spp., Suaeda, Limonium, Lycium*
	In distance	10 — 12	*Spartina patens dominant*
		10 — 12	*Juncus roemerianus (less dominant)*
		10 — 12	*Scirpus californicus (patch)*
		10 — 12	*Eleocharis cellulosa-collected*
	GHEF 7945 8	10 — 13	
	(Southwest)	10 — 13	*Spartina patens-Juncus roemerianus dominant*
		10 — 13	*Tamarix nearby*
	Standing water across road	10 — 13	*Bacopa on margins of water*
	higher areas	10 — 13	*Spartina patens-Juncus roemerianus dominant*
		10 — 13	*Iva frutescens*
	GHEF 7945 3	10 — 14	*Juncus roemerianus (dominant in some areas)*
		10 — 14	*Distichlis spicata (codominant with S. patens locally)*
		10 — 14	*Spartina patens*
	on flats in distance	10 — 14	*Monanthochloe littoralis*
		10 — 14	*Batis*
		10 — 14	*Salicornia spp.*
	GHEF 7945 4	10 — 15	
	flats on swale	10 — 15	*Monanthochloe littoralis (dominant)*
		10 — 15	*Salicornia bigelovii*
		10 — 15	*Distichlis spicata-collected*
	flanks of swale in distance	10 — 15	*Batis*
	fringing water	10 — 15	*Spartina alterniflora*
	slightly higher marsh near road	10 — 15	
	lows	10 — 15	*Monanthochloe littoralis*
	slightly higher	10 — 15	*Batis-Borrichia-Distichlis*
	slightly higher	10 — 15	*Iva-Spartina spartinae*
	other less abundant species	10 — 15	*Suaeda sp.*
		10 — 15	*Lycium carolinianum*
		10 — 15	*Limonium nashii*
		10 — 15	*Juncus roemerianus*
	ridge assemblage near flat	10 — 15	*Spartina spartinae*
		10 — 15	*Spartina patens*
		10 — 15	*Iva frutescens*
		10 — 15	*Juncus roemerianus*
	toward bay	10 — 15	*Spartina patens-Juncus-Iva assemblage*

General Location	Site Number on Photo (Aerial photo + location No.) General descriptions	Site number Quad No.	Site No.	Prevalent Species
	GHEF 7945 5	10	16	
	saltier assembage near road and NE	10	16	*Distichlis-Batis-Salicornia*
		10	16	*Juncus, Iva, Spartina patens, Limonium*
		10	16	
	fresher west of dike	10	16	*Spartina patens*
		10	16	*Distichlis spicata*
		10	16	*Bacopa monnieri*
		10	16	*Sesbania sp.*
		10	16	*Typha sp.*
		10	16	*Scirpus californicus ? (in distance)*
		10	16	*Paspalum vaginatum (probable)*
	swale across road (NE)	10	16	
	flat/emergent mix	10	16	*Distichlis, Salicornia, short S. patens, Suaeda,*
		10	16	*Machaeranthera and Cynodon dactylon*
	GHEF 7945 2	10	17	
	sand flat/emergent mix	10	17	*Salicornia bigelovii*
		10	17	*Salicornia virginica*
		10	17	*Distichlis spicata*
		10	17	*Limonium nashii*
	slightly higher	10	17	*Borrichia frutescens*
		10	17	*Spartina spartinae*
		10	17	*Juncus*
	GHAB 7873 1	11	1	
	Willow Bayou	11	1	
	Forested margin	11	1	*Sapium sebiferum*
		11	1	*Salix nigra*
		11	1	*Celtis laevigata*
	Along stream	11	1	*Alternanthera philoxeroides*
		11	1	*Panicum dichotomiflorum*
		11	1	*Sagittaria sp.*
		11	1	*Sesbania sp.*
		11	1	*Ambrosia sp.*
Hitchcock area				
	GHAB 7872 3 and 3a	11	2	*Pinus sp.*
	Highland Bayou	11	2	*Ulmus crassifolia*
		11	2	*Quercus virginiana*
		11	2	*Ilex vomitoria*
		11	2	*Carya illinoensis*
		11	2	*Platanus occidentalis*
		11	2	*Salix nigra*
		11	2	*Juniper*
	GHGH 7513 1a	12	1	
	Low areas	12	1	*Spartina alterniflora (dominant in lows)*
	Slightly higher	12	1	*Distichlis spicata (dominant overall)*
		12	1	*Spartina patens (abundant)*
		12	1	*Aster, Batis, Borrichia (scattered)*
	Flat	12	1	*Monanthochloe littoralis (dominant on flats)*
	Higher areas	12	1	*Spartina spartinae, Borrichia, Iva, Lycium, Limonium*
		12	1	*Salicornia, Suaeda, Macharanthera, Solidago*
	GHIJ 7568 2a	13	1	
	Higher flanks of swale	13	1	*Spartina patens (60-70%)-Borrichia frutescens (30-40%)*
	Edge of flats	13	1	*Juncus roemerianus*
	Flats	13	1	*Monanthochloe littoralis, Salicornia spp., Distichlis, Batis*
	In distance toward Boliv. Rds	13	1	*Spartina alterniflora*
	Beach ridge-- prairie assemblage	13	1	*Andropogon glomeratus, Dichromena colorata, Fimbristylis*
		13	1	*castanea, Iva frutescens, Solidago sp., Aristida sp., Paspalum*
		13	1	*monostachym, other composites*

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	Next swale (gulfward but cutoff	13	1	*Spartina patens, Distichlis, Batis, Juncus in lows*
	from marine waters--no flat)	13	1	*Scirpus americanus locally abundant*
		13	1	*Borrichia, Limonium, Lycium*
Bolivar Peninsula				
	GHIJ 7568 1	13	2	*Juncus roemerianus-Batis dominant*
	Edge of flat	13	2	*Salicornia*
	In depression	13	2	*Spartina alterniflora scattered*
	Higher areas	13	2	*Borrichia frutescens*
	GHIJ 7569 1a	13	4	*Spartina alterniflora dominant*
	higher prairie	13	4	*Spartina spartinae*
	GHIJ 7569 1	13	5	*Typha, Cyperus articulatus, Hydrocotyle*
		13	5	*Scirpus americanus, Sesbania*
	Higher clumps	13	5	*Setaria*
	Wetter, narrow zone in swale	13	5	*Scirpus californicus (?) in distance*
		13	5	*Polygonum hydropiperoides-collected*
	GHIJ 7569 2	13	6	*Distichlis dominant, Spartina alterniflora in lows*
		13	6	*Batis, Aster, Borrichia*
	GHIJ 7565 4	15	1	
	(low marsh to higher areas)	15	1	*Spartina alterniflora (codominant with Juncus in low marsh)*
		15	1	*Juncus roemerianus (codominant with S. alterniflora)*
		15	1	*Distichlis spicata*
		15	1	*Salicornia sp.*
		15	1	*Spartina patens*
		15	1	*Borrichia frutescens*
		15	1	*Iva frutescens*
		15	1	*Aster tenuifolius ?*
		15	1	*Lycium carolinium*
		15	1	*Spartina spartinae*
		15	1	*Andropogon glomeratus*
		15	1	*Cynodon dactylon*
	GHIJ 7565 1	15	2	*Spartina alterniflora (dominant)*
	GHIJ 7565 3	15	3	*Spartina alterniflora (dominant)*
	(edge of Moses Lake)	15	3	*Juncus roemerianus (patch)*
		15	3	*Distichlis spicata*
		15	3	*Spartina patens*
		15	3	*Iva frutescens*
		15	3	*Borrichia frutescens*
		15	3	*Aster sp.*
		15	3	*Limonium nashii*
		15	3	*Salicornia sp.*
		15	3	*Spartina spartinae*
	GHIJ 7565 5 (Factory Bayou)	15	4	*Scirpus maritimus*
		15	4	*Juncus roemerianus*
		15	4	*Distichlis spicata*
		15	4	*Spartina alterniflora (margins of channel)*
	high marsh	15	4	*Iva frutescens*
		15	4	*Spartina patens*
		15	4	*Distichlis spicata*
		15	4	*Spartina spartinae*
	others	15	4	*Limonium nashii*
		15	4	*Lycium carolinium*
		15	4	*Phragmites australis*
	mud flats (low tide)	15	4	

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		15 — 5	This site number was not used
San Leon			
	GHIJ 7565 6	15 — 6	*Eleocharis quadrangulata (dominant, 90%)*
		15 — 6	*Sesbania sp.*
	(forested area mostly willow)	15 — 6	*Salix nigra*
		15 — 6	*Sapium sebiferum*
		15 — 6	*Hymenocallis caroliniana*
	GHIJ 7565 2a	15 — 7	*Typha sp.*
	(exact location not confirmed	15 — 7	*Rhynchospora sp.*
	because of new housing develop.)	15 — 7	*Panicum sp.*
	Site in relatively small drainage.	15 — 7	*Sesbania sp.*
		15 — 7	*Andropogon glomeratus*
		15 — 7	*Setaria sp.*
		15 — 7	*Aristida sp.*
		15 — 7	*Aster tenuifolius?*
	GHIJ 7566 1	15 — 8	*Spartina alterniflora (dominant)*
	(from low to high marsh)	15 — 8	*Distichlis spicata (abundant)*
		15 — 8	*Scirpus maritimus (abundant)*
		15 — 8	*Spartina patens (abundant)*
		15 — 8	*Iva frutescens (higher fringe)*
	GHIJ 7566 2	15 — 9	*Distichlis spicata (dominant)*
		15 — 9	*Spartina alterniflora (dominant near water)*
	mud/sand flat	15 — 9	*Salicornia virginica*
		15 — 9	*Salicornia bigelovii*
		15 — 9	*Monanthochloe littoralis*
		15 — 9	*Limonium nashii*
		15 — 9	*Suaeda sp.*
	higher marsh	15 — 9	*Iva frutescens*
		15 — 9	*Spartina spartinae*
		15 — 9	*Borrichia frutescens*
	margin of pond near road	15 — 9	*Scirpus maritimus*
Dickinson area			
	GHIJ 7563 1	16 — 1	*Ulmus crassifolia*
		16 — 1	*Ilex vomitoria*
		16 — 1	*Celtis laevigata*
		16 — 1	*Sabal minor*
		16 — 1	*Quercus nigra*
		16 — 1	*Pinus taeda*
		16 — 1	*Fraxinus sp.*
		16 — 1	*Liquidambar styraciflua*
	GHIJ 7563 1a	16 — 2	
	Magnolia Bayou	16 — 2	*Quercus phellos*
		16 — 2	*Quercus nigra*
		16 — 2	*Ilex vomitoria*
		16 — 2	*Ulmus crassifolia*
		16 — 2	*Quercus falcata*
		16 — 2	*Sabal minor*
		16 — 2	*Pinus taeda*
	GHIJ 7564 2	16 — 3	*Iva frutescens dominant*
		16 — 3	*Spartina spartinae*
		16 — 3	*Phragmites australis*
		16 — 3	*Solidago sp.*
		16 — 3	*Cynodon dactylon*
		16 — 3	*Ambrosia sp.*
		16 — 3	*Ilex vomitoria*

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		16	3	*Parkinsonia aculeata*
		16	3	*Ulmus crassifolia*
		16	3	*Sapium sebiferum*
High Island area	BPA-GH 7510 1b	17	1	*Spartina patens dominant*
		17	1	*Distichlis*
	Along channel	17	1	*Typha, Bacopa, Paspalum lividum ?*
	Back toward hwy	17	1	*Scirpus olneyi patch*
High Island Area				
	BPA-GH 7511 1	17	2	*Spartina patens - Scirpus maritimus co-dominant*
		17	2	*Distichlis abundant*
		17	2	*Scattered Aster, Phragmites, Spartina alterniflora*
	BPA-GH 7510 4	17	3	
	West of ICWW near High Island	17	3	*Spartina patens - Typha mix*
		17	3	*Scirpus olneyi*
		17	3	*Distichlis abundant*
	Near ICWW	17	3	*Phragmites*
	GHGH 7513 4c	18	1	*Distichlis spicata*
		18	1	*Spartina patens*
		18	1	*patches of Scirpus maritimus*
		18	1	*patches of Juncus roemerianus*
	GHGH 7513 4b	18	2	*Spartina alterniflora*
		18	2	*Scirpus maritimus*
	GHGH 7513 4a	18	3	*Scirpus maritimus*
		18	3	*Spartina patens*
		18	3	*small Borrichia*
		18	3	*Spartina alterniflora*
	GHGH 7513 3a	18	4	*Scirpus maritimus*
		18	4	*Spartina patens*
		18	4	*Spartina alterniflora*
		18	4	*scattered aster*
	GHGH 7513 3b	18	5	*Spartina alterniflora*
		18	5	*Distichlis spicata*
		—		
	GHGH 7513 2b	18	6	*Spartina alterniflora*
		18	6	*scattered Scirpus maritimus*
		18	6	*scattered Distichlis spicata*
Bolivar Peninsula				
	GHGH 7513 2a	18	7	*Scirpus maritimus*
		18	7	*Spartina patens*
		18	7	*Spartina alterniflora*
		18	7	*Salicornia sp.*
Anahuac National Wildlife Refuge				
	GHGH 7513 1	18	8	
	Low Brackish/Intermediate	18	8	*Scirpus olneyi*
		18	8	*Typha*
		18	8	*Spartina patens*
		18	8	*Scirpus maritimus*
	Higher marsh near bay	18	8	*Spartina spartinae*
		18	8	*Setaria geniculata*
Anahuac NWR	BPA GH 7512 2	18	9	*SEE MARSH PROFILE*
		18	9	*Echinochloa crusgalli-collected*

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		18 — 9	*Panicum virgatum-collected*
		18 — 9	*Paspalum vaginatum-collected*
	GHGH 7512 5b	18 — 10	*Spartina spartinae*
		18 — 10	*Spartina patens*
		18 — 10	*Iva frutescens*
		18 — 10	*Borrichia frutescens*
		18 — 10	*Sporobolus virginicus*
		18 — 10	*Scirpus olneyi*
		18 — 10	*Scirpus americanus*
		18 — 10	*Juncus effusus*
		18 — 10	*others collected*
Frozen Point			
	GHGH 7512 5a	18 — 11	*Spartina patens*
		18 — 11	*Scirpus maritimus*
	GHGH 7512 1	18 — 12	
	Northeast (flat/emergents)	18 — 12	*Monanthochloe, Salicornia spp., Limonium*
	Higher mounds	18 — 12	*Batis, some Suaeda, Spartina spartinae*
	Toward bay	18 — 12	*Spartina alterniflora*
		18 — 12	*patches of Spartina spartinae, S. patens*
	Toward bay, wet conditions	18 — 12	*Distichlis dominant, Spartina patens, Spartina alterniflora*
		18 — 12	*Batis in distance*
Smith Point Area			
	GHCD 7464 1	19 — 1	
	Brackish/Intermediate	19 — 1	*Spartina patens*
		19 — 1	*Spartina spartinae*
		19 — 1	*Scirpus maritimus*
		19 — 1	*Juncus roemerianus*
		19 — 1	*Phragmites*
		19 — 1	*Spartina cynosuroides*
		19 — 1	*Paspalum vaginatum*
		19 — 1	*Typha*
	GHGH 7516 1	20 — 1	*Distichlis*
		20 — 1	*Spartina alterniflora*
		20 — 1	*Juncus roemerianus*
		20 — 1	*Scirpus maritimus*
		20 — 1	*Spartina patens*
		20 — 1	*Borrichia*
		20 — 1	*Spartina spartinae*
		20 — 1	*Iva frutescens*
Spoil Islands along Houston Ship Channel			
	GHCD 7469 2	21 — 1	*Borrichia frutescens*
		21 — 1	*Tamarix*
		21 — 1	*Sesbania drummondii*
		21 — 1	*Baccharis halimifolia*
		21 — 1	*Teucrium cubense*
		21 — 1	*Solidago altissima*
		21 — 1	*Acacia angustissima*
		21 — 1	*Ambrosia psilostachya*
	GHCD 7469 3	21 — 3	*Distichlis spicata*
		21 — 3	*Spartina alterniflora*
		21 — 3	*Spartina patens*
		21 — 3	*Borrichia frutescens*
		21 — 3	*Salicornia sp.*
Clear Creek	GHGH 7522 1	22 — 1	*Baccharis halimifolia-collected*
	east of highway	22 — 1	*Spartina patens*
		22 — 1	*Distichlis spicata*
		22 — 1	*Scirpus maritimus*

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		22 — 1	*Iva frutescens*
		22 — 1	*Solidago sp.*
		22 — 1	*Borrichia frutescens*
	west of highway	22 — 1	*Spartina patens (dominant)*
		22 — 1	*Iva frutescens*
		22 — 1	*Andropogon glomeratus*
		22 — 1	*Setaria sp.*
		22 — 1	*Solidago sp.*
		22 — 1	*Lycium carolinianum*
	wetter areas	22 — 1	*Typha sp.*
		22 — 1	*Scirpus maritimus*
Armand Bayou Bay Area Park	GHCD 7471 1	22 — 2	*Saggitaria sp.*
		22 — 2	*Polygonum sp.*
		22 — 2	*Scirpus maritimus*
		22 — 2	*Spartina patens*
		22 — 2	*Vigna luteola*
		22 — 2	*Iva frutescens*
		22 — 2	*Aster sp.*
		22 — 2	*Echinochloa crusgalli-collected*
	forested area	22 — 2	*Sabal minor*
		22 — 2	*Ulmus crassifolia*
		22 — 2	*Celtis laevigata*
		22 — 2	*Ilex vomitoria*
		22 — 2	*Carya illinoensis*
		22 — 2	*Pinus sp.*
		22 — 2	*Quercus aquatica*
		22 — 2	*Quercus phellos*
		22 — 2	*Ulmus americana*
A. B. Nature Center	GHCD 7471 2	22 — 3	*Spartina patens*
		22 — 3	*Spartina spartinae*
		22 — 3	*Scirpus maritimus*
		22 — 3	*Iva frutescens*
		22 — 3	*Spartina alterniflora (near water)*
		22 — 3	*Cyperus sp.*
		22 — 3	*Solidago sp.*
Taylor Bayou at Port Rd.			
	GHCD 7470 1	22 — 4	*Quercus phellos*
		22 — 4	*Ulmus crassifolia*
		22 — 4	*Ilex vomitoria*
		22 — 4	*Fraxinus sp.*
	In water	22 — 4	*Scirpus maritimus*
		22 — 4	*Iva frutescens*
		22 — 4	*Distichlis spicata*
		22 — 4	*Solidago sp.*
		22 — 4	*Typha sp.*
Clear Lake			
	GHGH 7521 1	22 — 5	*Spartina patens (dominant)*
		22 — 5	*Distichlis spicata (co-dominant)*
		22 — 5	*Scirpus maritimus*
		22 — 5	*Aster sp.*
		22 — 5	*Iva frutescens*
		22 — 5	*Suaeda sp.*
		22 — 5	*Spartina alterniflora (creek margins)*
Morgans Point			

General Location	Site Number on Photo (Aerial photo + location No.) General descriptions	Site number Quad No. — Site No.	Prevalent Species
	GHCD 7469 1	26 — 1	
	low marsh	26 — 1	*Juncus roemerianus*
		26 — 1	*Typha sp.*
		26 — 1	*Scirpus maritimus*
		26 — 1	*Distichlis spicata*
	high marsh	26 — 1	*Paspalum vaginatum*
		26 — 1	*Spartina patens*
		26 — 1	*Spartina spartinae*
		26 — 1	*Iva frutescens*
		26 — 1	*Cynodon dactylon*
		26 — 1	*Borrichia frutescens*
		26 — 1	*Andropogon glomeratus*
		26 — 1	*Solidago sp.*
		26 — 1	*Aster sp.*
		26 — 1	*Phragmites australis*
		26 — 1	*Arundo donax*
		26 — 1	*Sesbania sp.*
		26 — 1	*Andropogon sp.*
		26 — 1	*Baccharis sp.*
	forested area in adjacent upland	26 — 1	*Cetis laevigata*
		26 — 1	*Ulmus crassifolia*
		26 — 1	*Ilex vomitoria*
		26 — 1	*Carya illinoensis*
		26 — 1	*Sapium sebiferum*
		26 — 1	*Quercus nigra*
		26 — 1	*Quercus phellos*
	GHCD 7469 7	26 — 2	*lower area-Spartina alterniflora*
		26 — 2	*Suaeda*
		26 — 2	*Heliotropium*
		26 — 2	*Salicornia*
		26 — 2	*Batis*
		26 — 2	*higher area-Spartina patens*
		26 — 2	*Spartina patens*
		26 — 2	*Limonium nashii*
		26 — 2	*Tamarix*
		26 — 2	*Machaeranthera phyllocephala*
		26 — 2	*Ambrosia psilostachya*
		26 — 2	*Acacia angustissima*
		26 — 2	*Phyla lanceolata*
		26 — 2	*Eustachys petraea*
		26 — 2	*Spiranthes ovalis*
		26 — 2	*Juncus roemerianus*
		26 — 2	*Desmodium canadense*
		26 — 2	*Medicago minima*
	GHCD 7469 6	26 — 3	*Spartina alterniflora*
		26 — 3	*Scirpus maritimus*
		26 — 3	*Higher berms- Spartina patens*
		26 — 3	*Borrichia frutescens*
		26 — 3	*Iva frutescens*
		26 — 3	*Lycium carolinianum*
		26 — 3	*Alternanthera philoxeroides*
	GHCD 7469 5	26 — 4	*Spartina alterniflora*
	GHCD 7469 4b	26 — 5	*Spartina alterniflora*
	GHCD 7469 4a	26 — 6	*Distichlis spicata*
		26 — 6	*Borrichia frutescens*
		26 — 6	*Heliotropum curassivicum*

General Location	Site Number on Photo (Aerial photo + location No.) General descriptions	Site number Quad No. Site No.	Prevalent Species
Houston Point			
	GHCD 7468 1	26 — 7	
	low marsh	26 — 7	*Spartina alterniflora (dominant over whole area)*
		26 — 7	*Distichlis spicata*
	high marsh	26 — 7	*Spartina spartinae (fringes low marsh)*
		26 — 7	*Spartina patens*
		26 — 7	*Borrichia frutescenss*
		26 — 7	*Lycium carolinianum*
		26 — 7	*Iva frutescens*
		26 — 7	*Aster subulatus*
	fresher water drainage zone	26 — 7	*Paspalum vaginatum*
		26 — 7	*Scirpus maritimus*
	GHCD 7468 2 high marsh	26 — 8	*Iva frutescens*
		26 — 8	*Spartina spartinae*
		26 — 8	*Spartina patens*
		26 — 8	*Phragmites australis*
		26 — 8	*Arundo donax*
		26 — 8	*Solidago sp.*
		26 — 8	*Typha sp.*
	lower marsh along channel	26 — 8	*Scirpus maritimus*
		26 — 8	*Spartina alterniflora*
	shrubs	26 — 8	*Celtis laevigata*
		26 — 8	*Parkinsonia aculeata*
		26 — 8	*Baccharis halimifolia*
	GHCD 7468 3	26 — 9	
	Transitional assemblage	26 — 9	*Iva frutescens*
	(east side of highway)	26 — 9	*Aster sp.*
		26 — 9	*Lycium carolinianum*
		26 — 9	*Baccharis sp.*
	(west side of highway)	26 — 9	*Iva frutescens*
		26 — 9	*Baccharis halimifolia*
		26 — 9	*Setaria sp.*
		26 — 9	*Andropogon glomeratus*
		26 — 9	*Solidago sp.*
		26 — 9	*Aster sp.*
	more abundant off levee	26 — 9	*Scirpus maritimus*
	" " " "	26 — 9	*Distichlis spicata*
		26 — 9	*Spartina patens*
		26 — 9	*Spartina spartinae*
		26 — 9	*Lycium carolinianum*
San Jacinto Park			
	GHEF 7496 1	27 — 1	*Iva frutescens dominant*
		27 — 1	*Spartina patens*
		27 — 1	*Spartina alterniflora*
		27 — 1	*Borrichia frutescens*
		27 — 1	*Sesuvium portulacastrum*
		27 — 1	*Spartina spartinae*
		27 — 1	*Solidago sp.*
	shrubs	27 — 1	*Parkinsonia aculeata*
		27 — 1	*Celtis laevigata*
		27 — 1	*Ulmus crassifolia*
		27 — 1	*Baccharis halimifolia*
Trinity River Delta			
	GHAB 7451 4a	28 — 1	*Scirpus olneyi*
		28 — 1	*Panicum dichotomiflorum*
		28 — 1	*Echinochloa crusgalli*

General Location	Site Number on Photo (Aerial photo + location No.) General descriptions	Site number Quad No. — Site No.	Prevalent Species
		28 — 1	*Bacopa monnieri*
		28 — 1	*Eleocharis parvula*
		28 — 1	*Eleocharis sp.*
	GHAB 7451 9e (SEE TRANSECT 28-2, APP. B)	28 — 2	*Edge of Eleocharis*
		28 — 2	*Bacopa monnieri 60%*
		28 — 2	*Eleocharis sp.*
		28 — 2	*Polygonum hydropiperoides*
		28 — 2	*Zizaniopsis miliacea*
		28 — 2	*Crinum americanum*
		28 — 2	*Paspalum vaginatum?*
	GHAB 7451 9d	28 — 3	*Tall Eleocharis assemblage 90%*
		28 — 3	*Polygonum hydropiperoides*
		28 — 3	*Scirpus olneyi*
		28 — 3	*Bacopa monnieri*
	Transition zone between 28-3 and higher assemblage of 28-4 listed below	28 — 4	*tall grass Spartina patens?*
		28 — 4	*Paspalum vaginatum*
		28 — 4	*Polygonum hydropiperoides*
		28 — 4	*Cyperus articulatus*
		28 — 4	*Eleocharis sp.*
		28 — 4	*Alternanthera philoxeroides*
	GHAB 7451 9c	28 — 4	*Tall grass assemblage Spartina patens?*
		28 — 4	*Setaria geniculata*
		28 — 4	*Alternanthera philoxeroides*
		28 — 4	*Cyperus articulatus*
		28 — 4	*Lycium carolinianum*
	GHAB 7451 9b	28 — 5	*Panicum repens*
		28 — 5	*Alternanthera philoxeroides*
		28 — 5	*Polygonum hydropiperoides*
		28 — 5	*others collected-Physostegia intermedia*
		28 — 5	*Iva annua*
	GHAB 7451 9a Transect from edge of into backmarsh	28 — 6	*Salix nigra*
		28 — 6	*Sapium sebiferum*
		28 — 6	*Phragmites australis*
	GHAB 7452 4a	28 — 7	*Spartina patens (co-dominant)*
		28 — 7	*Paspalum vaginatum (co-dominant)*
		28 — 7	*Spartina spartinae*
		28 — 7	*Cyperus articulatus*
		28 — 7	*Borrichia frutescens*
	GHEF 7501 4a	28 — 8	*Alternanthera philoxeroides*
	GHEF 7501 4b	28 — 9	*Scirpus olneyi/barren flat*
	GHEF 7501 3b	28 — 10	*Alternanthera philoxeroides 90%*
		28 — 10	*Crinum americanum*
Trinity Delta	GHEF 7501 3a	28 — 11	*Phragmites australis*
		28 — 11	*Salix nigra*
		28 — 11	*Sapium sebiferum*
		28 — 11	*Alternanthera philoxeroides*
		28 — 11	*Celtis laevigata*
		28 — 11	*Ipomea tricolor*
		28 — 11	*Panicum repens*
		28 — 11	*Hymenocallis caroliniana*

General Location	Site Number on Photo (Aerial photo + location No.) General descriptions	Site number Quad No. — Site No.	Prevalent Species
		28 — 11	*Alternanthera philoxeroides*
		28 — 11	*Iva frutescens*
		28 — 11	*Polygonum hydropiperoides*
North of Lake Anahuac			
	GHAB 7452 1a	28 — 12	*Typha sp.*
		28 — 12	*Eichhornia crassipes*
		28 — 12	*Lemna sp.*
		28 — 12	*Juncus roemerianus*
		28 — 12	*Bacopa monnieri*
		28 — 12	*Scirpus americanus*
		28 — 12	*Cyperus articulatus*
		28 — 12	*Spartina patens*
		28 — 12	*Sesbania*
	GHAB 7451 6	29 — 1	*Paspalum vaginatum*
		29 — 1	*Spartina patens*
		29 — 1	*Eleocharis sp.*
		29 — 1	*Spartina patens*
		29 — 1	*Paspalum lividum*
		29 — 1	*Cyperus articulatus*
		29 — 1	*Eleocharis parvula*
		29 — 1	*Cynodon dactylon*
		29 — 1	*Polygonum sp.*
		29 — 1	*Lycium carolinianum*
		29 — 1	*Aster tenuifolius*
	GHAB 7451 5	29 — 2	*Alternanthera philoxeriodes*
		29 — 2	*Sagittaria falcata*
		29 — 2	*Sagittaria lancifolia*
		29 — 2	*Zizaniopsis miliacea*
	GHAB 7451 7	29 — 3	*Cyperus articulatus*
		29 — 3	*Scirpus californicus*
		29 — 3	*Zizaniopsis miliacea*
		29 — 3	*Sagittaria falcata*
		29 — 3	*Phragmites australis*
		29 — 3	*Alternanthera philoxeroides*
		29 — 3	*Polygonum sp.*
		29 — 3	*Aster spinosus (higher margins)*
		29 — 3	*Lycium carolinianum (scattered)*
		—	
	GHAB 7451 11a	29 — 4	*Phragmites australis*
		29 — 4	*Sapium sebiferum*
		29 — 4	*Crinum americanum*
		29 — 4	*Alternanthera philoxeroides*
		29 — 4	*Panicum dichotimiflorum*
		29 — 4	*Echinochloa crusgalli*
	GHAB 7451 11b	29 — 5	*Alternanthera philoxeroides*
Trinity Delta			
	GHAB 7451 10a levee woodlands	29 — 6	*Celtis laevigata*
		29 — 6	*Aster spinosus*
		29 — 6	*Sapium sebiferum*
		29 — 6	*Cynodon dactylon*
	GHAB 7451 10b	29 — 7	*Cynodon dactylon*
		29 — 7	*Paspalum vaginatum?*
		29 — 7	*Cyperus articulatus*
		29 — 7	*Juncus effusus*
		29 — 7	*Lycium carolinianum*

APPENDIX B. (cont.)

General Location	Site Number on Photo (Aerial photo + location No.) General descriptions	Site number Quad No. — Site No.	Prevalent Species
		29 — 7	*Eleocharis sp.?*
		29 — 7	*Polygonum hydropiperoides*
		29 — 7	*Setaria magna*
		29 — 7	*Bacopa monnieri*
	GHAB 7451 10c	29 — 8	*Spartina patens*
		29 — 8	*Polygonum hydropiperoides*
		29 — 8	*Cynodon dactylon*
	GHAB 7451 10d	29 — 9	*Spartina patens*
		29 — 9	*Scirpus californicus (around ponds)*
		29 — 9	*others collected-*
		29 — 9	*Sisyrinchium exile*
		29 — 9	*Hymenocallis caroliniana*
		29 — 9	*Physostegia intermedia*
Trinity River		29 — 10	
	GHAB 7451 8	29 — 10	*Taxodium distichum*
		29 — 10	*Salix nigra*
		29 — 10	*Celtis laevigata*
		29 — 10	*Cephalanthus occidentalis*
		29 — 10	*Ulmus crassifolia*
		29 — 10	*Sapium sebiferum*
		29 — 10	*Sabal minor*
		29 — 10	*Carya sp.*
		29 — 10	*Sesbania sp.*
	In water	29 — 10	*Eichhornia crassipes*
		29 — 10	*Lemna sp.*
		29 — 10	*Alternanthera philoxeroides*
	Edge of forested area	29 — 10	*Paspalum lividum*
		29 — 10	*Cyperus articulatus*
		29 — 10	*Panicum dichotomiflorum*
		29 — 10	*Polygonum sp.*
		29 — 10	*Rhynchospora sp.*
Tributary near	GHAB 7446 8	31 — 1	*Salix nigra along stream*
	River Terrace Park	31 — 1	*Pinus sp.*
		31 — 1	*Quercus nigra*
		31 — 1	*Quercus phellos*
		31 — 1	*Ulmus crassifolia*
		31 — 1	*Celtis laevigata*
		31 — 1	*Liquidambar styraciflua*
		31 — 1	*Ilex vomitoria*
	GHAB 7446 3	31 — 2	*Typha sp.*
	dead trees include	31 — 2	*Taxodium distichum*
	GHEF 7495 1	31 — 3	*Phragmites australis*
		31 — 3	*Spartina alterniflora*
		31 — 3	*Iva frutescens*
		31 — 3	*Eleocharis sp.*
		31 — 3	*Bacopa monnieri*
		31 — 3	*Spartina patens*
		31 — 3	*Sesbania sp.*
		31 — 3	*Solidago sp.*
		31 — 3	*Aster sp.*
		31 — 3	*Sesuvium portulacastrum*
		31 — 3	*Cynodon dactylon*
		31 — 3	*Borrichia frutescens*
		31 — 3	*Andropogon glomeratus*
		31 — 3	*Ambrosia sp.*
		31 — 3	*Baccharis halimifolia*

General Location	Site Number on Photo (Aerial photo + location No.) General descriptions	Site number Quad No.	Site No.	Prevalent Species
	shrubs/forest	31	3	*Tamarix gallica*
		31	3	*Ulmus crassifolia*
		31	3	*Salix nigra*
		31	3	*Celtis laevigata*
	GHAB 7446 6	31	4	
	Park water body	31	4	*Taxodium distichum*
	Margin of water	31	4	*Bacopa monnieri*
	Sandy Lake	31	4	*Spartina patens*
		31	4	*Bacopa monnieri*
		31	4	*Sesuvium sp. ?*
		31	4	*Paspalum vaginatum*
		31	4	*Cynodon dactylon*
	shrubs/forest	31	4	*Salix nigra*
	No bald cypress	31	4	*Quercus nigra*
		31	4	*Celtis laevigata*
		31	4	*Sapium sebiferum*
	GHAB 7446 1d	31	5	*Scirpus californicus*
		31	5	*Eleocharis sp.*
		31	5	*Typha sp.*
		31	5	*Alternanthera philoxeroides*
	GHAB 7446 1c	31	6	*Ulmus crassifolia*
	forested area toward river	31	6	*Celtis laevigata*
		31	6	*Sabal minor*
		31	6	*Sapium sebiferum*
		31	6	*Ilex vomitoria*
		31	6	*Liquidambar styraciflua*
		31	6	*Quercus nigra*
		31	6	*Quercus phellos*
		31	6	*Salix nigra*
		31	6	*Carya aquatica*
		31	6	*Pinus sp.*
		31	6	*Taxodium distichum*
	GHAB 7446 1b	31	7	*Typha sp.*
		31	7	*Polygonum hydropiperoides-collected*
		31	7	*Alternanthera philoxeroides*
		31	7	*Cyperus articulatus*
		31	7	*Aster subulatus-collected*
		31	7	*Solidago sempervirens-collected*
		31	7	*Panicum dichotomiflorum*
	scrub/shrubs fringing marsh	31	7	*Quercus virginiana*
		31	7	*Ulmus crassifolia*
		31	7	*Sapium sebiferum*
	GHEF 7496 2	31	8	*Spartina alterniflora*
		31	8	*Phragmites australis*
		31	8	*Iva frutescens*
		31	8	*Colocasia antiquorum*
		31	8	*Typha sp.*
		31	8	*Eleocharis sp.*
		31	8	*Solidago sp.*
		31	8	*Sesbania sp.*
		31	8	*Salix nigra*
		31	8	*Celtis laevigata*
		31	8	*Ilex vomitoria*
		31	8	*Sapium sebiferum*

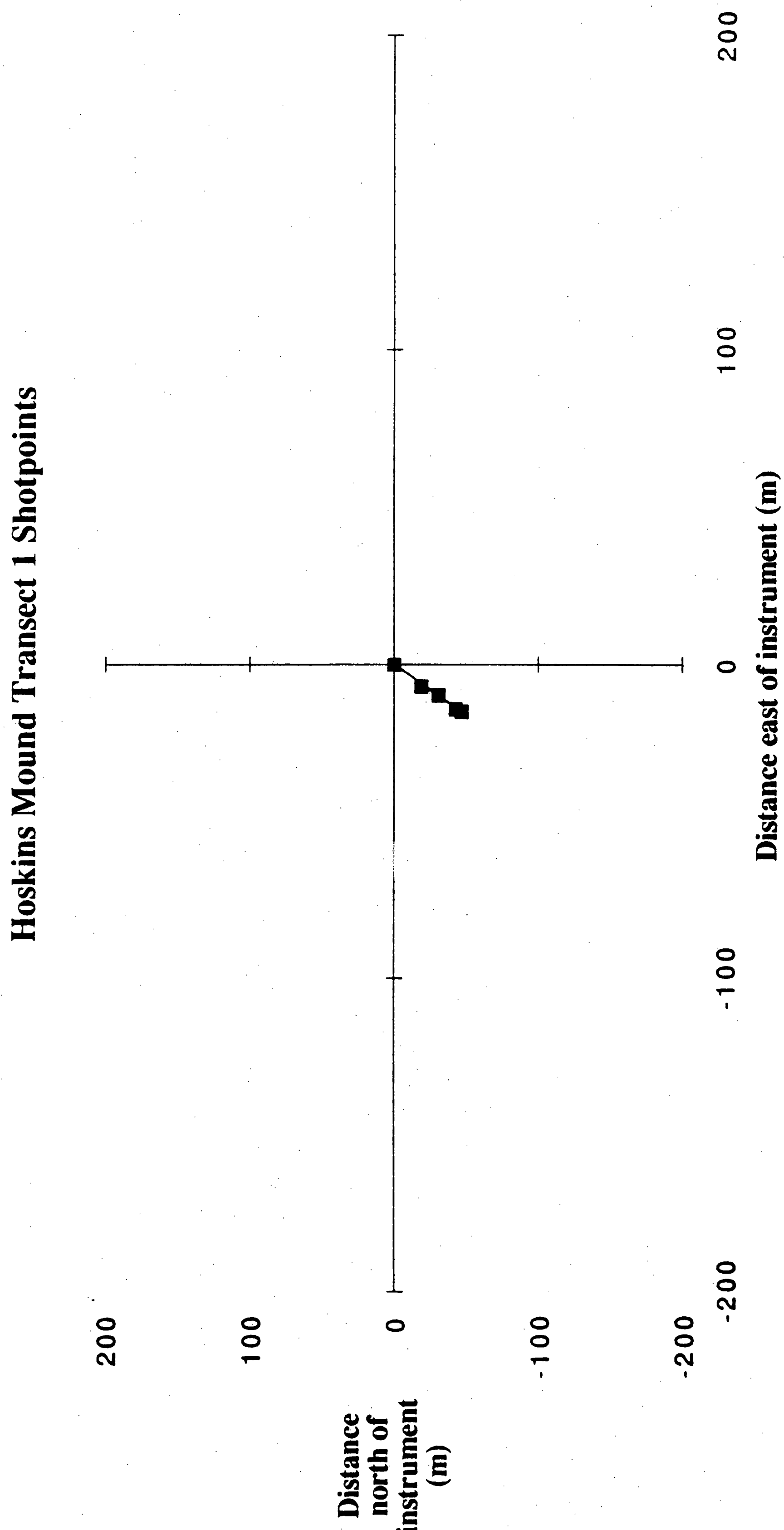
General Location	Site Number on Photo (Aerial photo + location No.) General descriptions	Site number Quad No. — Site No.	Prevalent Species
San Jacinto River	GHAB 7446 1a	31 — 9	*Typha sp.*
	GHAB 7446 5	31 — 10	*Iva frutescens dominant*
		31 — 10	*Spartina spartinae*
		31 — 10	*Eleocharis parvula ?*
		31 — 10	*Spartina patens*
		31 — 10	*Aster sp.*
		31 — 10	*Sesuvium portulacastrum*
		31 — 10	*Paspalum vaginatum*
	In ditch across frontage rd.	31 — 10	*Scirpus maritimus*
	" " " " "	31 — 10	*Typha sp.*
	Shrubs/forest	31 — 10	*Pinus sp.*
		31 — 10	*Ulmus crassifolia*
		31 — 10	*Ilex vomitoria*
		31 — 10	*Liquidambar styraciflua*
		31 — 10	*Sapium sebiferum*

Appendix C

Galveston Bay Elevation Transect: Site No. 7-1

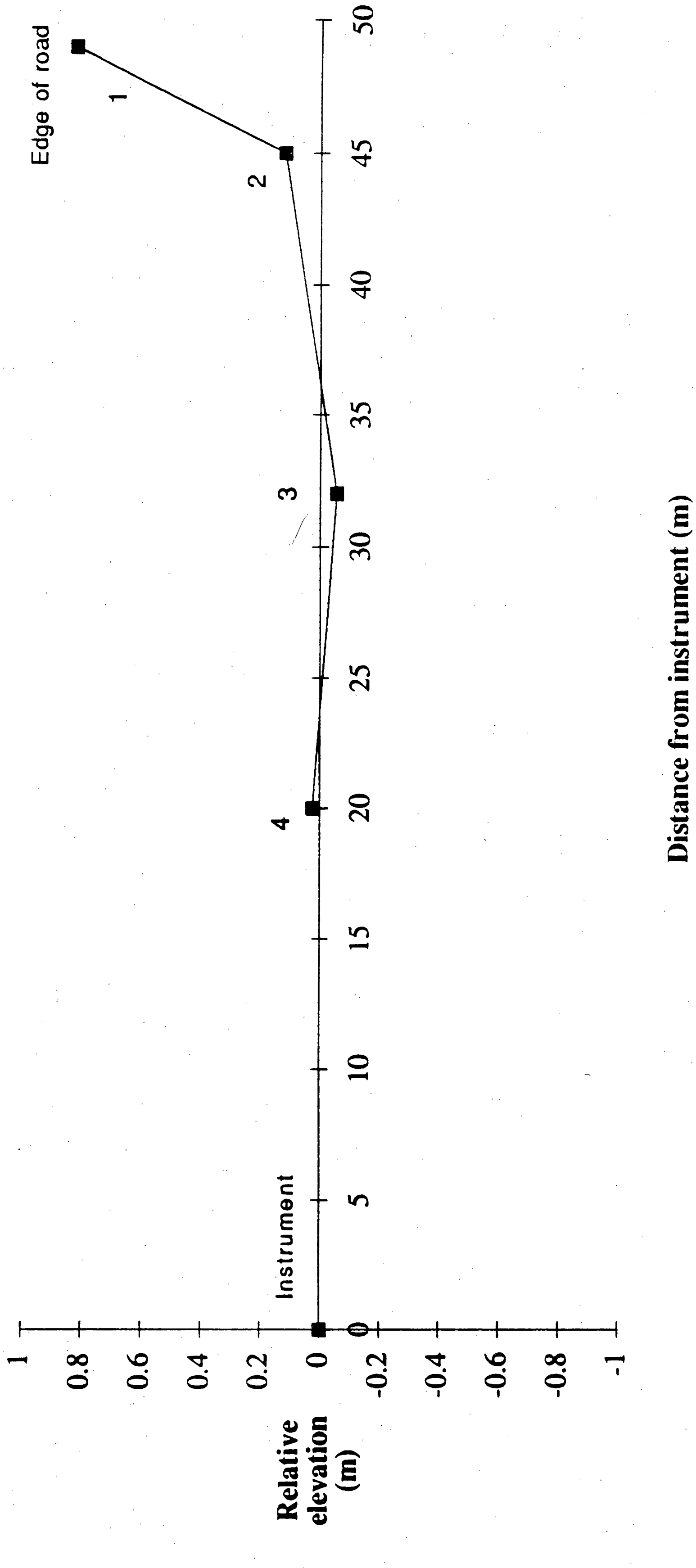
Hoskins Mound Transect 1
11/14/90
Instrument height (m): 1.470
Ground elevation (m): 0.000

Shot	Bearing °	'	"	Height (m)	Top (m)	Bottom (m)	Decimal Bearing (°)	Distance (m)	Relative Elevation (m)	X (m)	Y (m)	Line Distance (m)
0	0	0	0	1.470	1.470	1.470	0.000	0	0.000	0.0	0.0	0.0
4	200	58	10	1.445	1.540	1.340	200.969	20	0.025	-7.2	-18.7	20.0
3	198	11	52	1.525	1.690	1.370	198.198	32	-0.055	-10.0	-30.4	32.0
2	198	44	40	1.350	1.575	#N/A	198.744	45	0.120	-14.5	-42.6	45.0
1	198	4	40	0.650	0.895	#N/A	198.078	49	0.820	-15.2	-46.6	49.0


Hoskins Mound Transect 1 Shotpoints
200
100
0
-100
-200
Distance north of instrument (m)
-200
-100
0
100
200
Distance east of instrument (m)

Site No. 7-1

Hoskins Mound Transect 1



Hoskins Mound Transect 1: Site No. 7-1

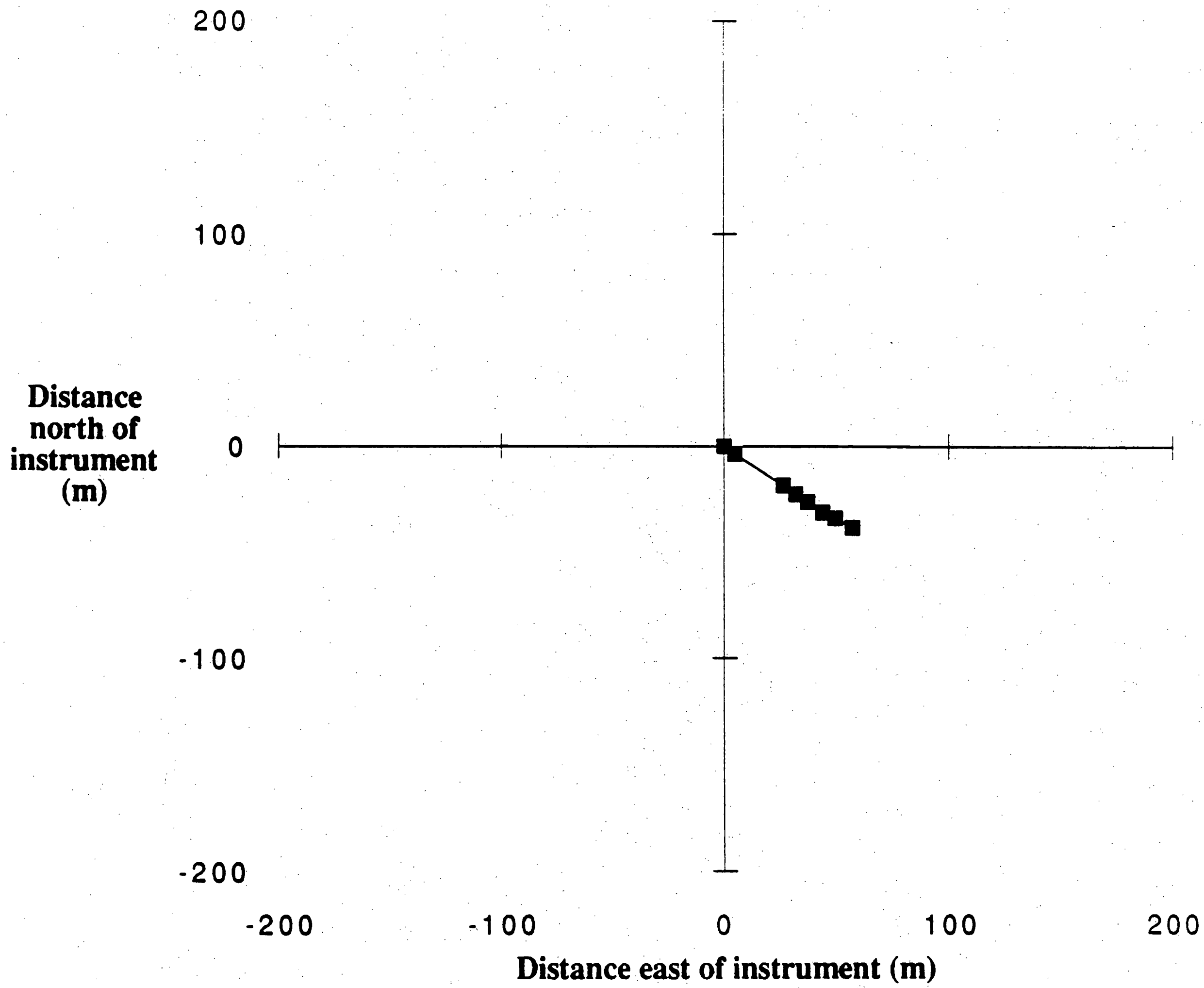
Station No.	
1	Edge of gravel road
2	*Juncus roemerianus*, *Spartina patens*, *Polygonum* sp., *Cyperus* sp., others
2-4	*Juncus roemerianus*
4-Instru.	*Spartina spartinae* (90%), *Spartina patens* (10%)
Instru.	*Spartina spartinae*

Galveston Bay Elevation Transect: Site No. 7-1

Hoskins Mound Transect 2
11/14/90
Instrument height (m): 1.470
Ground elevation (m): 0.000

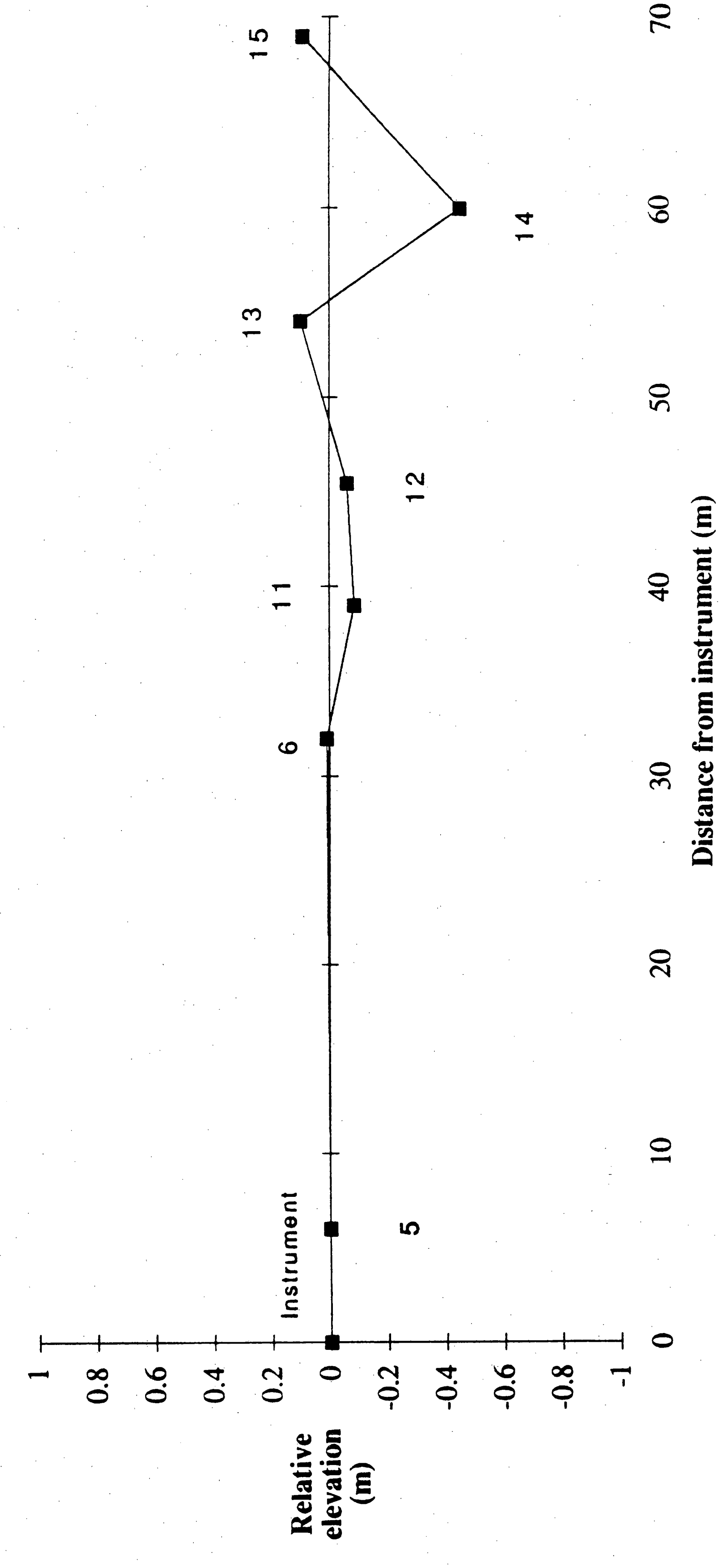
Shot	Bearing °	'	"	Height (m)	Top (m)	Bottom (m)	Decimal Bearing (°)	Distance (m)	Relative Elevation (m)	X (m)	Y (m)	Line Distance (m)
0	0	0	0	1.470	1.470	1.470	0.00	0	0.000	0.0	0.0	0.0
5	127	19	50	1.470	1.505	1.445	127.33	6	0.000	4.8	-3.6	6.0
6	124	56	20	1.460	1.620	1.300	124.94	32	0.010	26.2	-18.3	32.0
11	125	19	20	1.555	1.750	1.360	125.32	39	-0.085	31.8	-22.5	39.0
12	125	10	50	1.530	1.755	1.300	125.18	45	-0.060	37.2	-26.2	45.5
13	125	32	40	1.370	1.640	#N/A	125.54	54	0.100	43.9	-31.4	54.0
14	124	28	0	1.920	2.220	#N/A	124.47	60	-0.450	49.5	-34.0	60.0
15	123	52	40	1.375	1.720	#N/A	123.88	69	0.095	57.3	-38.5	69.0

Hoskins Mound Transect 2 Shotpoints



Site No. 7-1

Hoskins Mound Transect 2



APPENDIX C (cont.)

Hoskins Mound Transect 2: Site No. 7-1

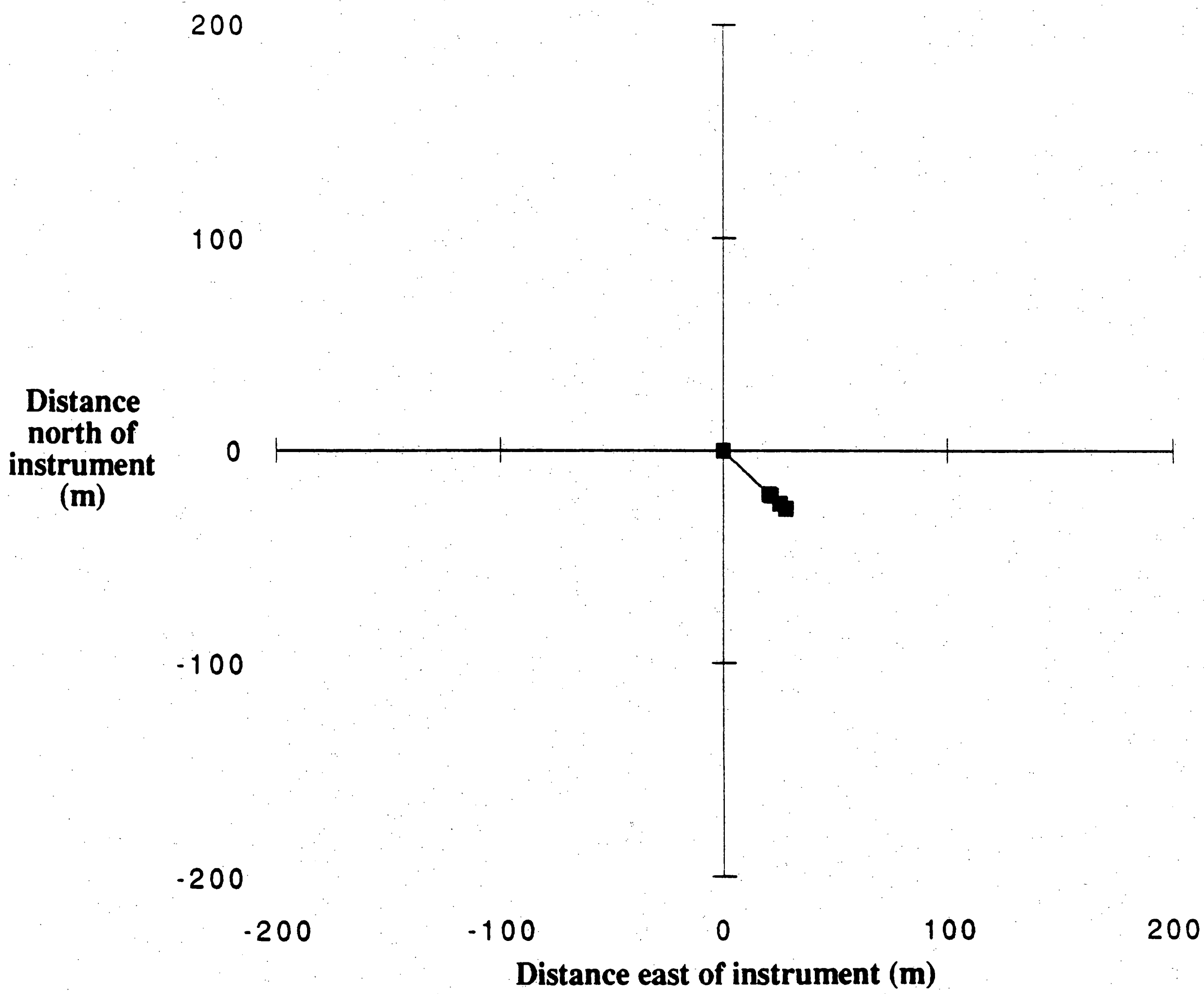
Station No.	
Instru. to 5	*Spartina spartinae*
5 to 6	*Juncus roemerianus*
6	*Spartina spartinae*, *Spartina patens*, *Setaria* sp., *Juncus roemerianus*, *Andropogon glomeratus*, *Solidago* sp.
11	*Juncus roemerianus*
12	*Spartina spartinae*, *Andropogon glomeratus*, *Fimbristylis castanea*, *Aster* sp., *Borrichia,* annuals
13	*Juncus roemerianus*, *Andropogon glomeratus*, *Paspalum laeve*, *Setaria* sp.
14	*Typha* sp.
15	*Spartina spartinae*, *Spartina patens*, *Eleocharis* sp., *Setaria* sp., *Fimbristylis castanea*, *Andropogon glomeratus*, *Solidago* sp.

Galveston Bay Elevation Transect: Site No. 7-1

Hoskins Mound Transect 3
11/14/90
Instrument height (m): 1.470
Ground elevation (m): 0.000

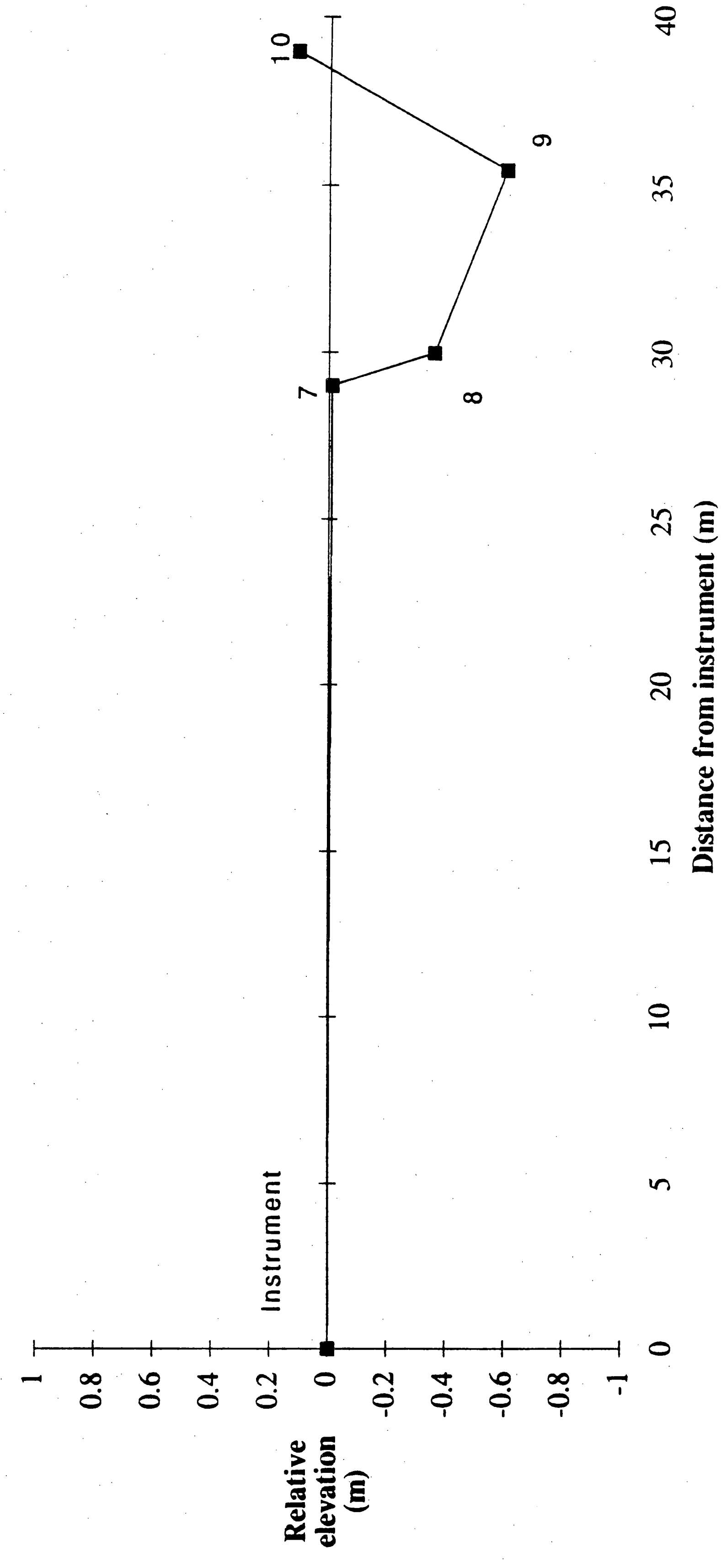
Shot	Bearing °	'	"	Height (m)	Top (m)	Bottom (m)	Decimal Bearing (°)	Distance (m)	Relative Elevation (m)	X (m)	Y (m)	Line Distance (m)
0	0	0	0	1.470	1.470	1.470	0.00	0	0.000	0.0	0.0	0.0
7	135	3	30	1.480	1.625	1.335	135.06	29	-0.010	20.5	-20.5	29.0
8	134	57	50	1.830	1.980	1.680	134.96	30	-0.360	21.2	-21.2	30.0
9	135	6	10	2.080	2.260	1.905	135.10	35	-0.610	25.1	-25.1	35.5
10	134	45	40	1.360	1.555	1.165	134.76	39	0.110	27.7	-27.5	39.0

Hoskins Mound Transect 3 Shotpoints



Site No. 7-1

Hoskins Mound Transect 3



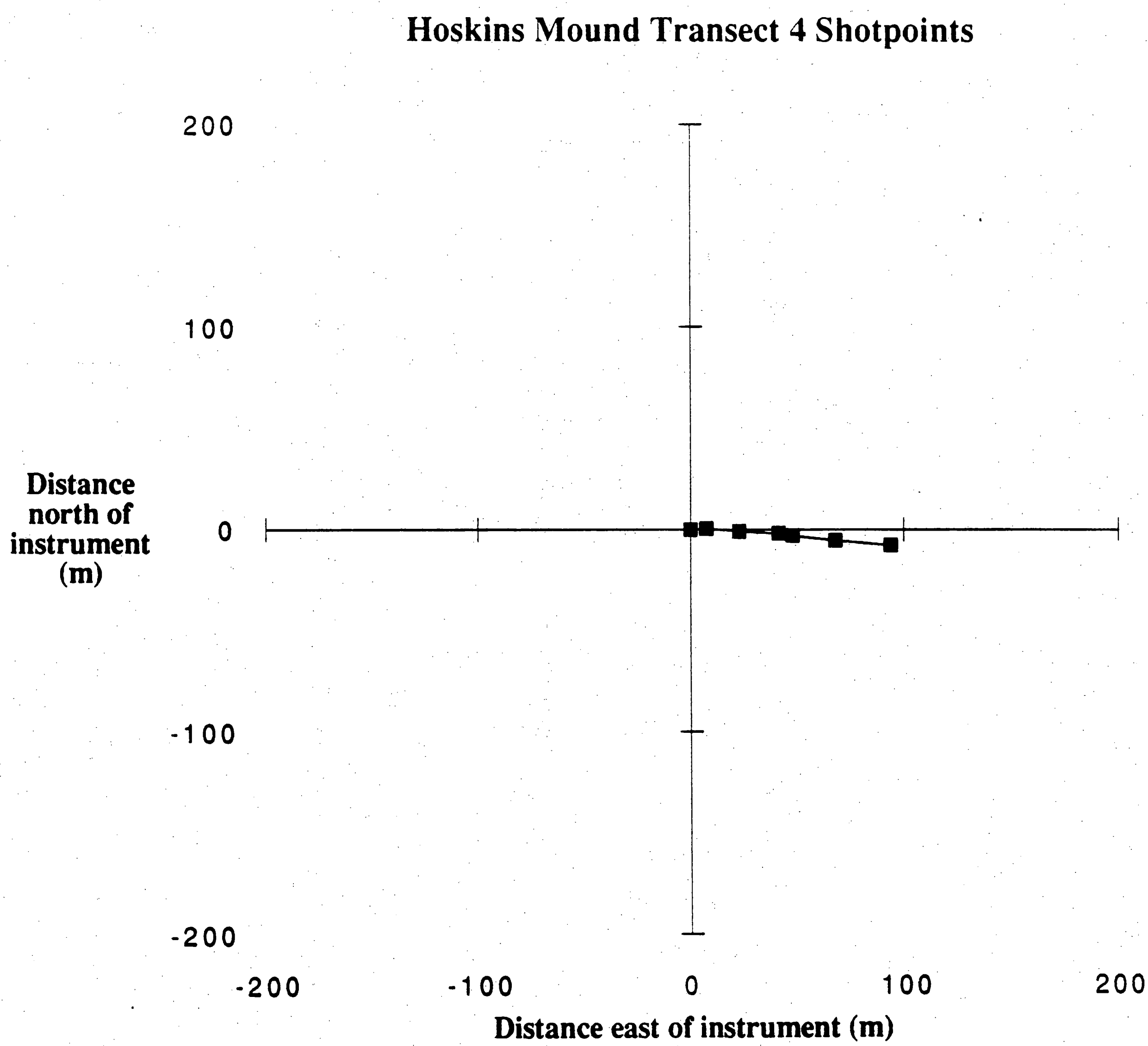
Hoskins Mound Transect 3: Site No. 7-1

Station No.	
Instru. to 7	*Juncus roemerianus*
7	*Spartina patens*, *Spartina spartinae*, *Setaria* sp., *Andropogon glomeratus*, *Juncus roemerianus*, *Solidago* sp.
8	*Typha* sp. (Water)
9	*Typha* sp. (Water)
10	*Spartina spartinae*, *Spartina patens*, *Andropogon glomeratus*, *Setaria* sp., *Juncus roemerianus*, *Polygonum* sp.

Galveston Bay Elevation Transect: Site No. 7-1

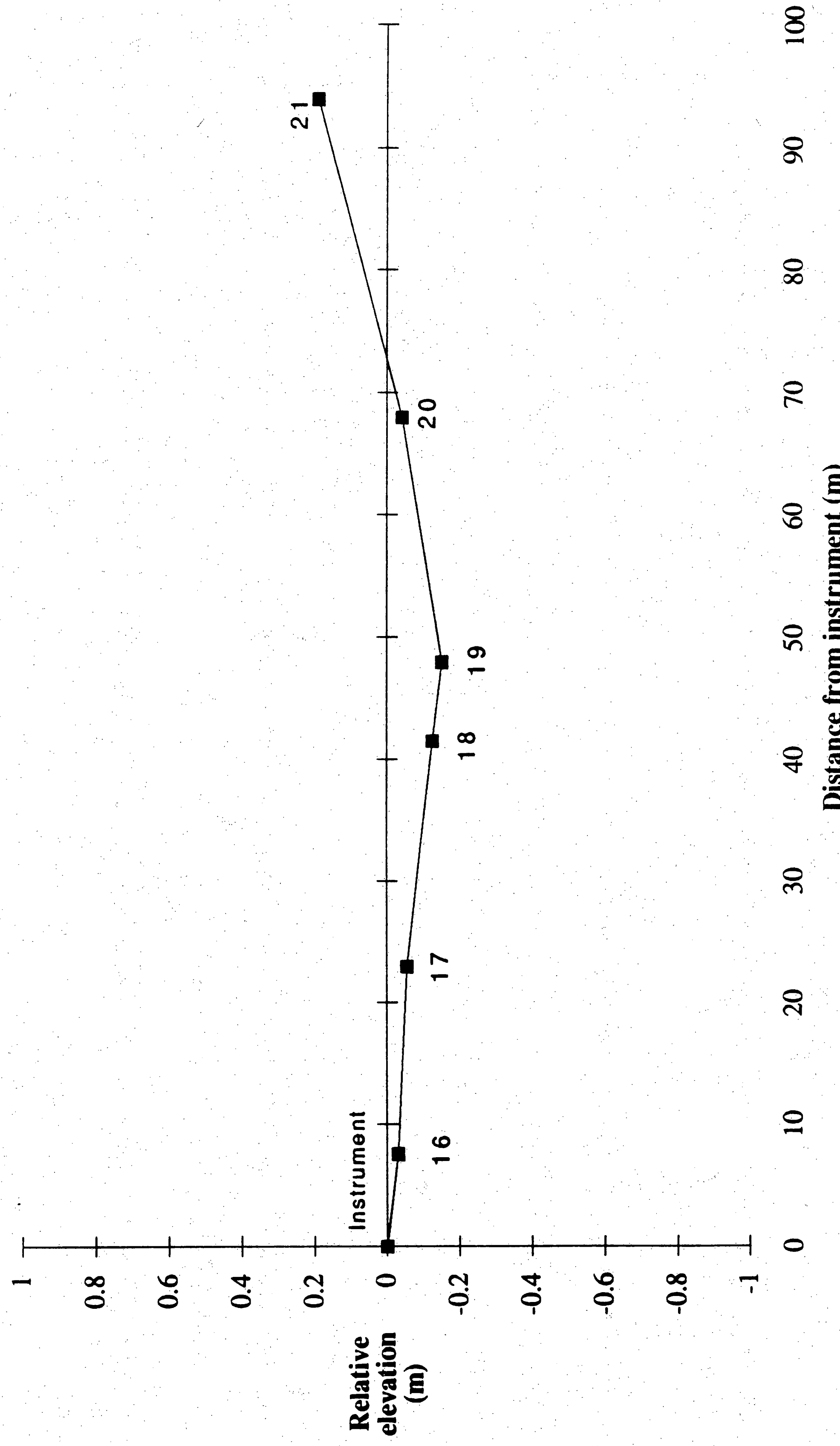
Hoskins Mound Transect 4
11/14/90
Instrument height (m): 1.470
Ground elevation (m): 0.000

Shot	Bearing °	'	"	Height (m)	Top (m)	Bottom (m)	Decimal Bearing (°)	Distance (m)	Relative Elevation (m)	X (m)	Y (m)	Line Distance (m)
0	0	0	0	1.470	1.470	1.470	0.00	0	0.000	0.0	0.0	0.0
16	87	21	40	1.500	1.538	1.462	87.36	8	-0.030	7.6	0.3	7.6
17	92	39	50	1.525	1.640	1.410	92.66	23	-0.055	23.0	-1.1	23.0
18	92	46	20	1.595	1.805	1.390	92.77	42	-0.125	41.5	-2.0	41.5
19	93	34	0	1.620	1.860	1.375	93.57	48	-0.150	47.9	-3.0	48.0
20	94	27	30	1.510	1.850	1.170	94.46	68	-0.040	67.8	-5.3	68.0
21	94	43	30	1.280	1.750	0.810	94.73	94	0.190	93.7	-7.7	94.0


Hoskins Mound Transect 4 Shotpoints
200
100
0
-100
-200
Distance north of instrument (m)
-200
-100
0
100
200
Distance east of instrument (m)

Site No. 7-1

Hoskins Mound Transect 4



Hoskins Mound Transect 4: Site No. 7-1

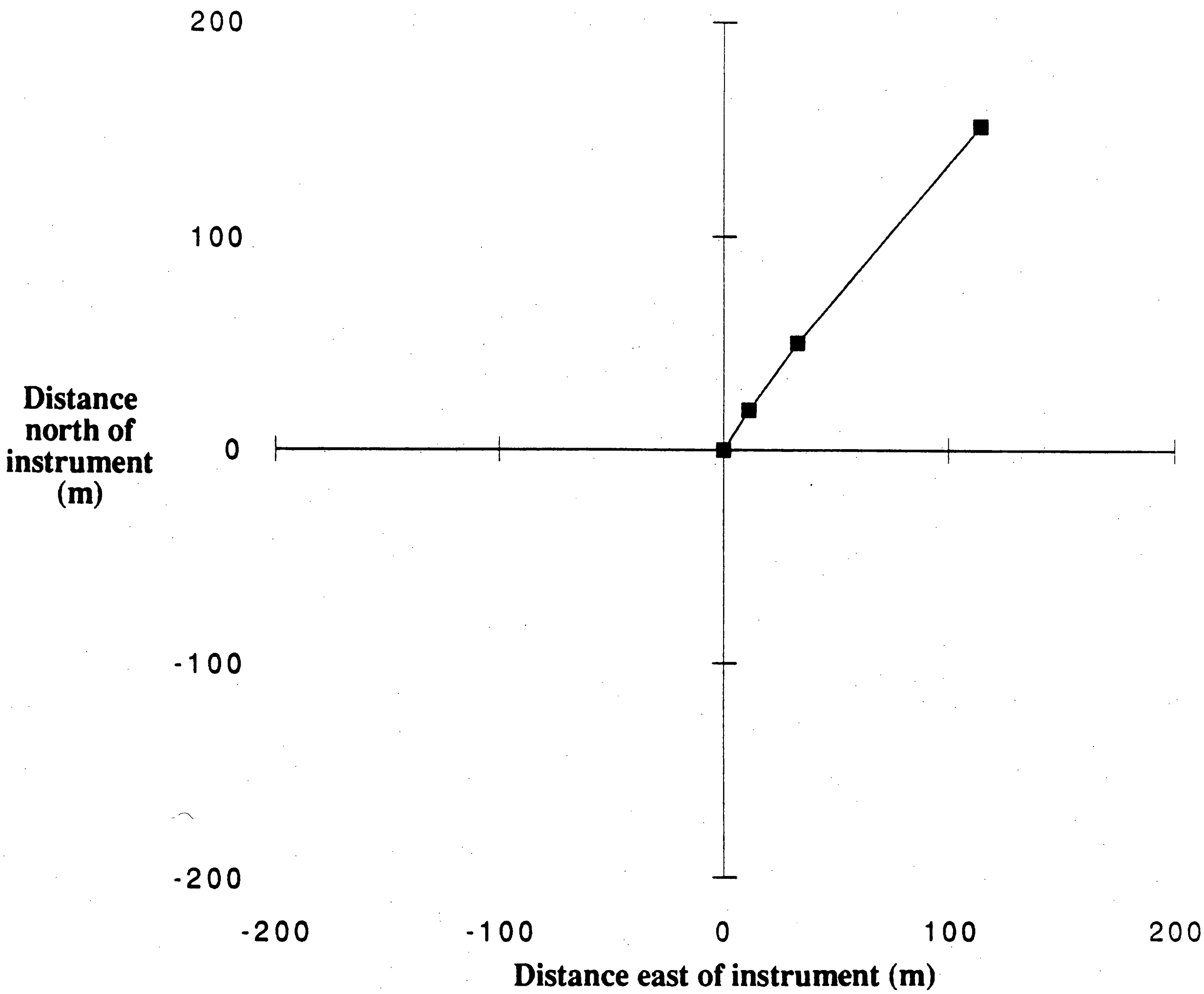
Station No.	
Instru.	*Spartina spartinae*
16 to 17	*Juncus roemerianus*
17 to 18	Barren flats, *Spartina patens* patches, *Eleocharis* sp., *Paspalum vaginatum*
18	*Paspalum vaginatum*, *Spartina patens* patches
19	Edge of *Spartina patens* patch
19 to 20	Mixtures of vegetation and barren flat
20	*Spartina spartinae* (short), scattered *Salicornia* sp., *Lymonium nashii*, *Fimbristylis castanea*, *Panicum* sp., *Cyperus articulatus*, algae mats
21	Prairie assemblage, *Spartina spartinae*, *Setaria* sp., *Aristida* sp., *Solidago* sp., *Andropogon glomeratus*, short *Distichlis spicata*, *Paspalum vaginatum*

Galveston Bay Elevation Transect: Site No. 7-1

Hoskins Mound Transect 5
11/14/90
Instrument height (m): 1.470
Ground elevation (m): 0.000

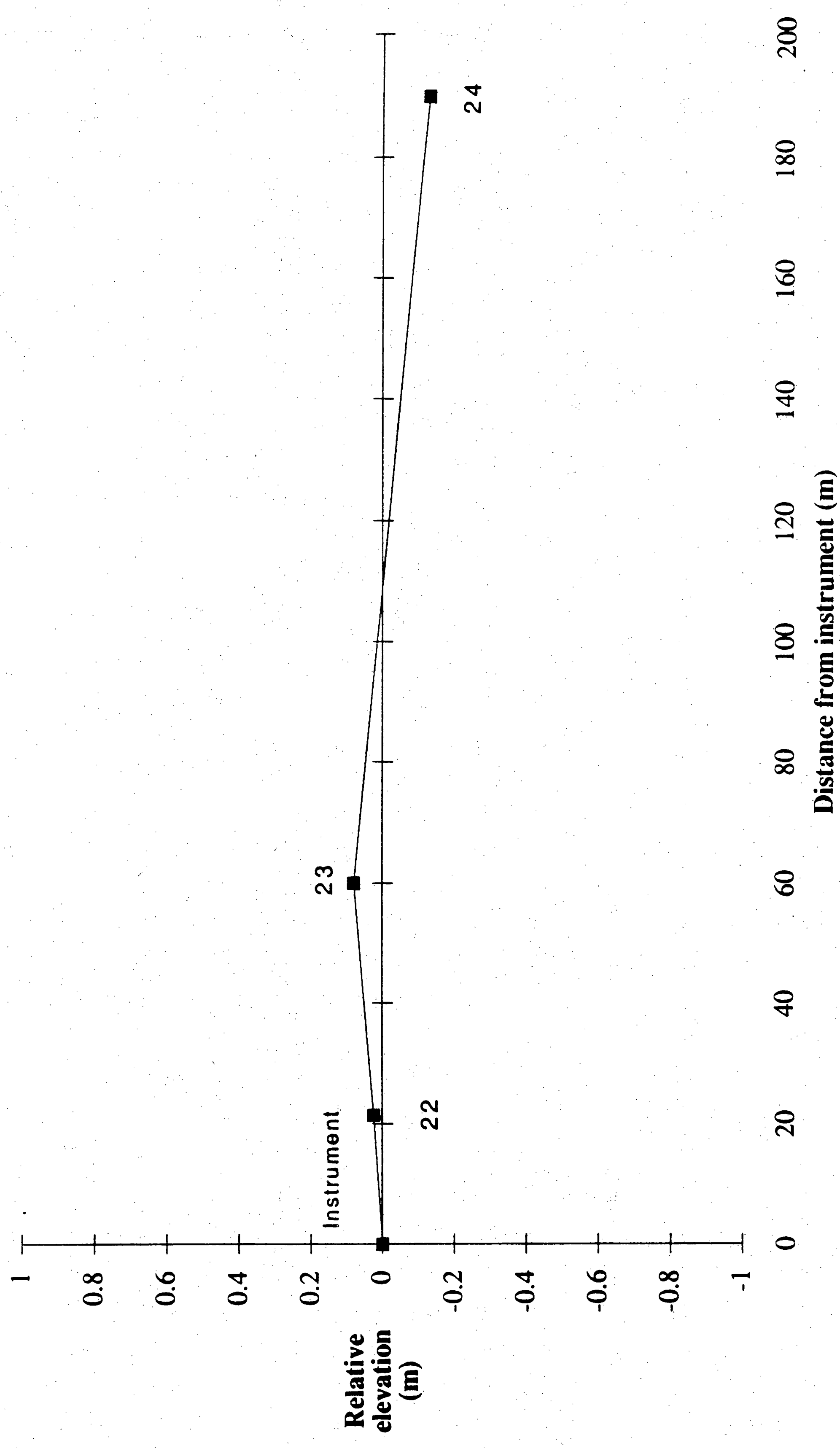
Shot	Bearing °	Bearing '	Bearing "	Height (m)	Top (m)	Bottom (m)	Decimal Bearing (°)	Distance (m)	Relative Elevation (m)	X (m)	Y (m)	Line Distance (m)
0	0	0	0	1.470	1.470	1.470	0.00	0	0.000	0.0	0.0	0.0
22	30	44	10	1.445	1.555	1.340	30.74	21	0.025	11.0	18.5	21.5
23	32	56	20	1.390	1.690	1.090	32.94	60	0.080	32.6	50.4	60.0
24	36	47	20	1.600	2.550	#N/A	36.79	190	-0.130	113.8	152.2	190.0

Hoskins Mound Transect 5 Shotpoints



Site No. 7-1

Hoskins Mound Transect 5



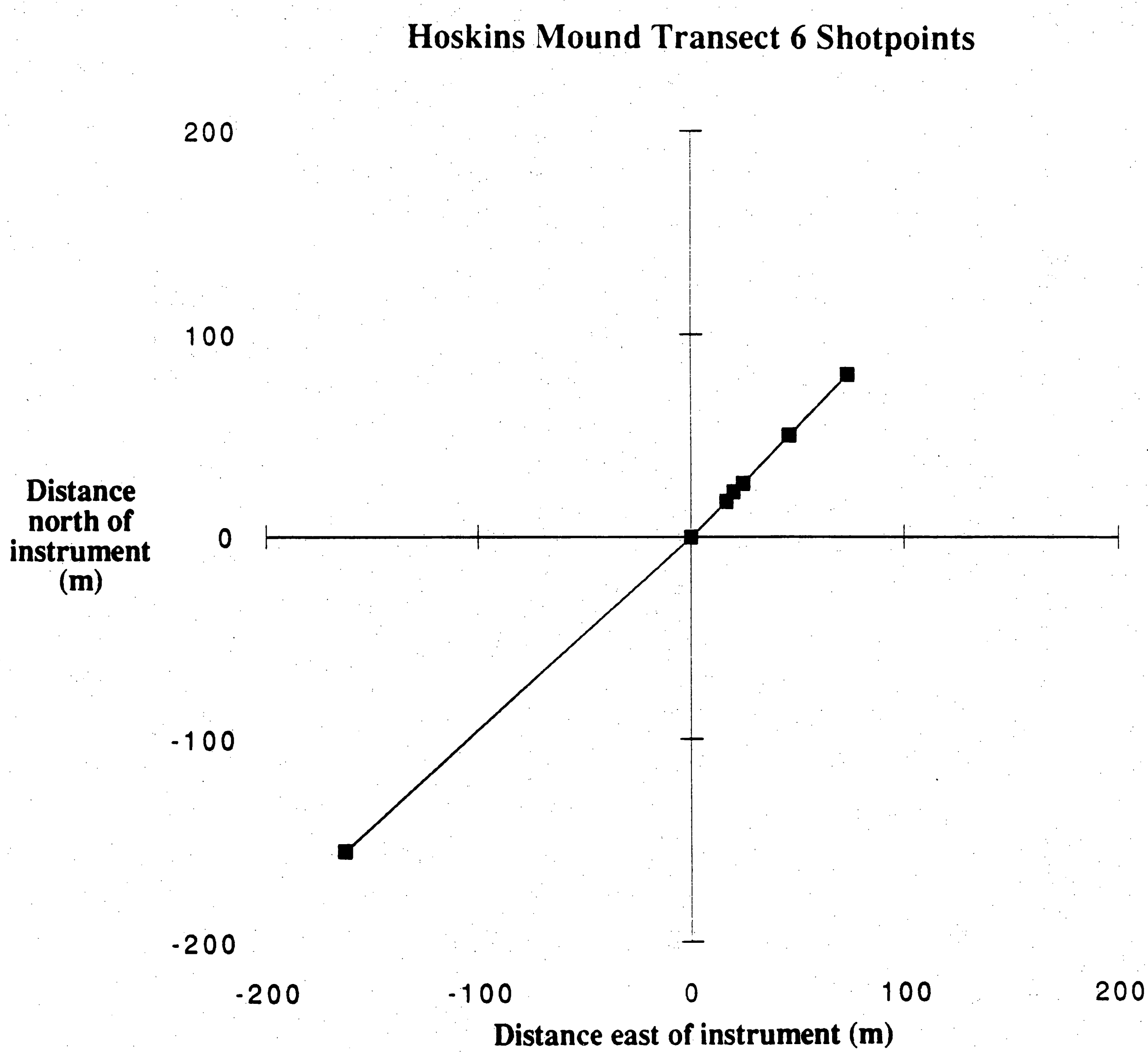
Hoskins Mound Transect 5: Site No. 7-1

Station No. Instru.	
22	Edge of tall *Spartina spartinae* (dominant)—*Juncus roemerianus* mix, Into short *Spartina spartinae—Spartina patens* assemblage, scattered *Cyperus articulatus*, *Fimbristylis castanea*, *Suaeda* sp., *Borrichia frutescens*, composites
23	Edge of prairie, short *Spartina spartinae*, *Spartina patens*, *Fimbristylis castanea*, *Panicum* sp., *Borrichia frutescens*, *Andropogon glomeratus*, *Aristida* sp., *Setaria* sp., *Aster* sp., composites, barren spots along trails
24	Edge of Prairie, short *Spartina spartinae*, *Distichlis spicata*, scattered *Fimbristylis castanea*, *Panicum* sp., *Borrichia frutescens*, (Damp soils in lows)

Galveston Bay Elevation Transect: Site No. 7-1

Hoskins Mound Transect 6
11/14/90
Instrument height (m): 1.560 (same location as T5, shot 24)
Ground elevation (m): -0.040 (relative to instrument position 1)

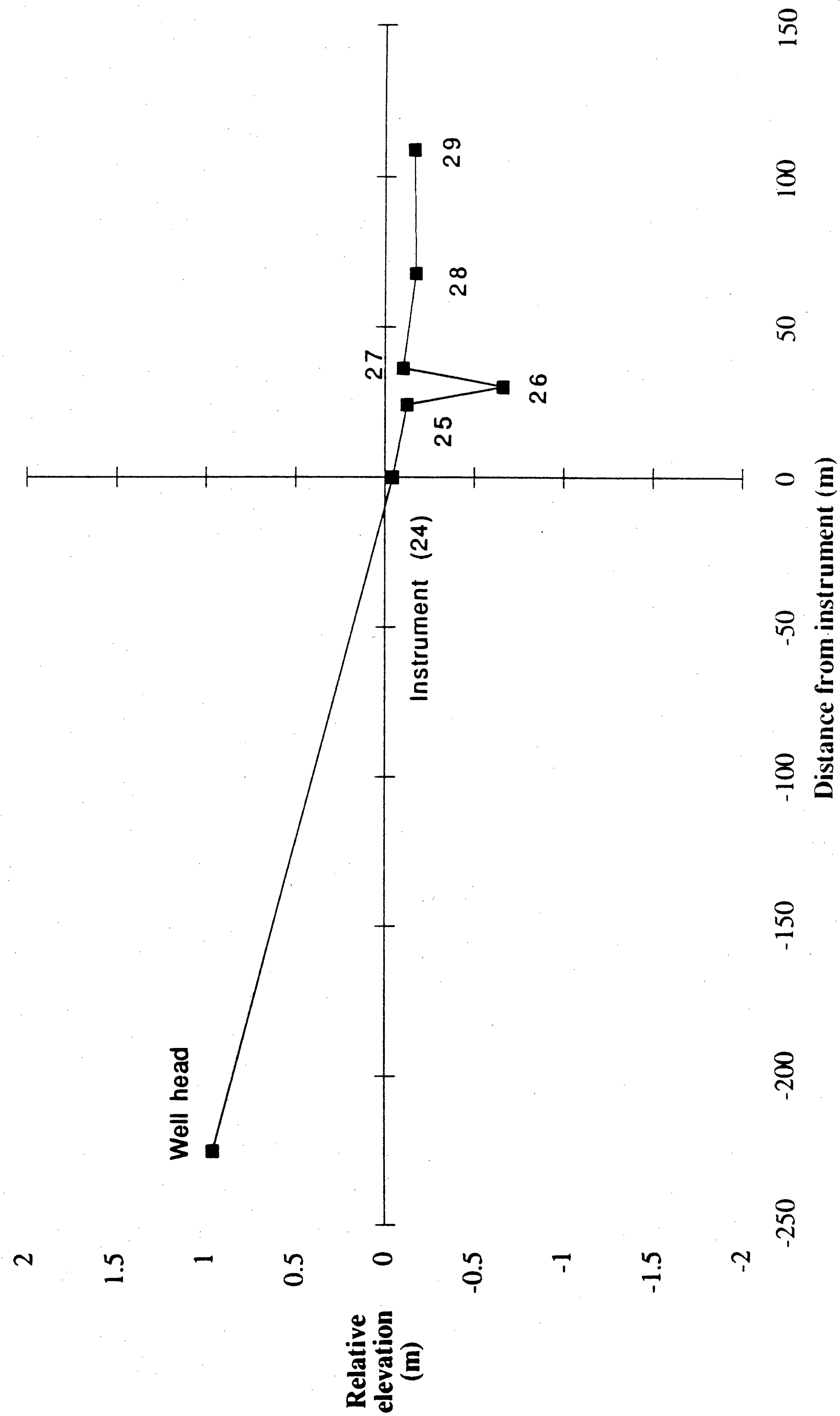
Shot	Bearing °	Bearing '	Bearing "	Height (m)	Top (m)	Bottom (m)	Decimal Bearing (°)	Distance (m)	Relative Elevation (IP1, m)	X (m)	Y (m)	Line Distance (m)
30	226	25	20	0.560	1.685	#N/A	226.42	225	0.960	-163.0	-155.1	-225
0	0	0	0	1.560	1.560	1.560	0.00	0	-0.040	0.0	0.0	0
25	43	53	50	1.640	1.760	1.520	43.90	24	-0.120	16.6	17.3	24
26	42	15	30	2.180	2.330	2.030	42.26	30	-0.660	20.2	22.2	30
27	43	6	20	1.620	1.800	1.440	43.11	36	-0.100	24.6	26.3	36
28	42	45	0	1.690	2.030	1.350	42.75	68	-0.170	46.2	49.9	68
29	42	41	20	1.680	2.220	1.130	42.69	109	-0.160	73.9	80.1	109


Hoskins Mound Transect 6 Shotpoints
200
100
0
-100
-200
Distance north of instrument (m)
-200
-100
0
100
200
Distance east of instrument (m)

APPENDIX C (cont.)

Site No. 7-1

Hoskins Mound Transect 6



Hoskins Mound Transect 6: Site No. 7-1

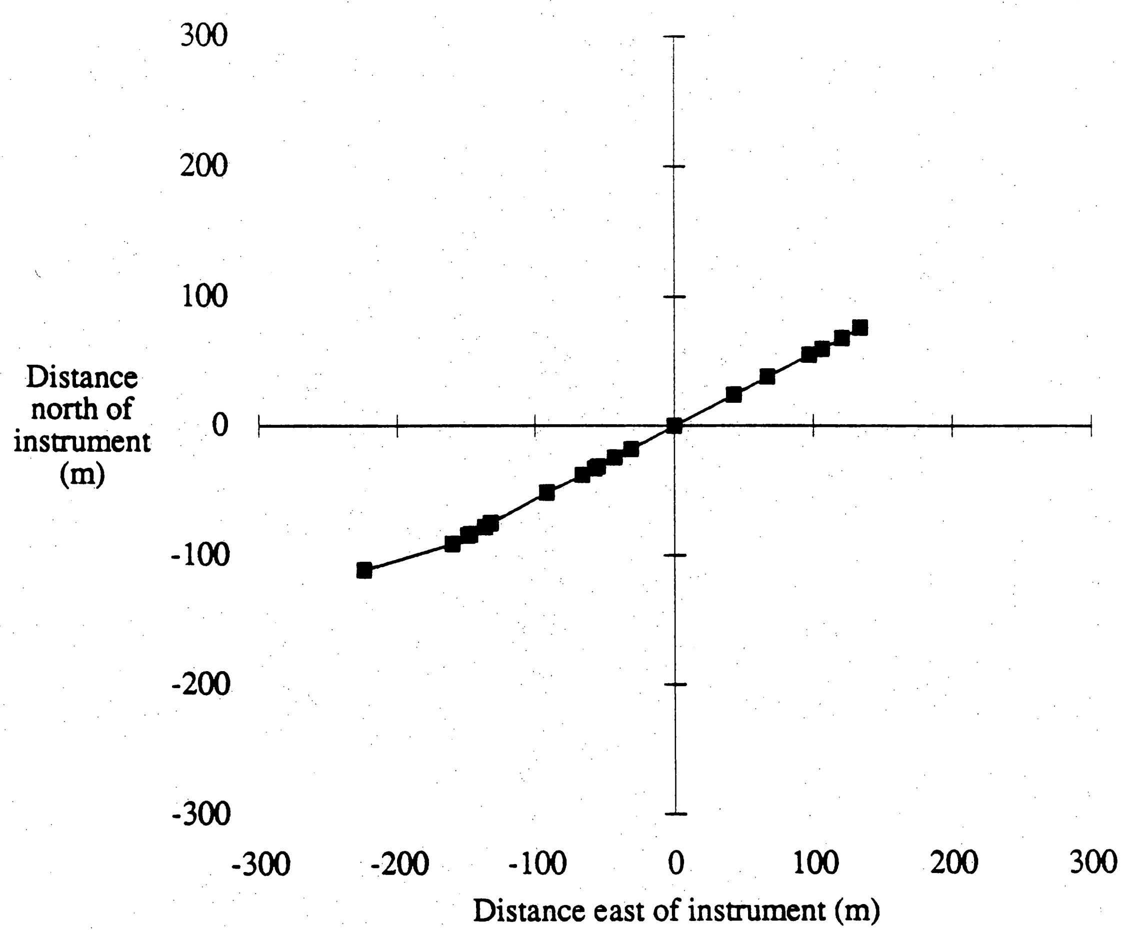
Station No. Instru.	
24	Edge of Prairie, short *Spartina spartinae*, *Distichlis spicata*, scattered *Fimbristylis castanea*, *Panicum* sp., *Borrichia frutescens*, (Damp soils in lows)
25	Short *Spartina spartinae*, *Spartina patens*, *Setaria* sp., *Andropogon glomeratus*, *Solidago* sp.
26	Typha sp. (Water 30 cm)
27	Short *Spartina spartinae*, *Spartina patens*, *Setaria* sp., *Andropogon glomeratus*, *Solidago* sp.
28	Tall *Spartina spartinae*—*Spartina patens*, *Fimbristylis castanea*, some *Juncus roemerianus*
29	Channel assemblage, tall *Spartina patens* (up to 75-90%)—*Juncus roemerianus* (up to 50–60% locally), *Cyperus articulatus*

Galveston Bay Elevation Transect: Site No. 3-2

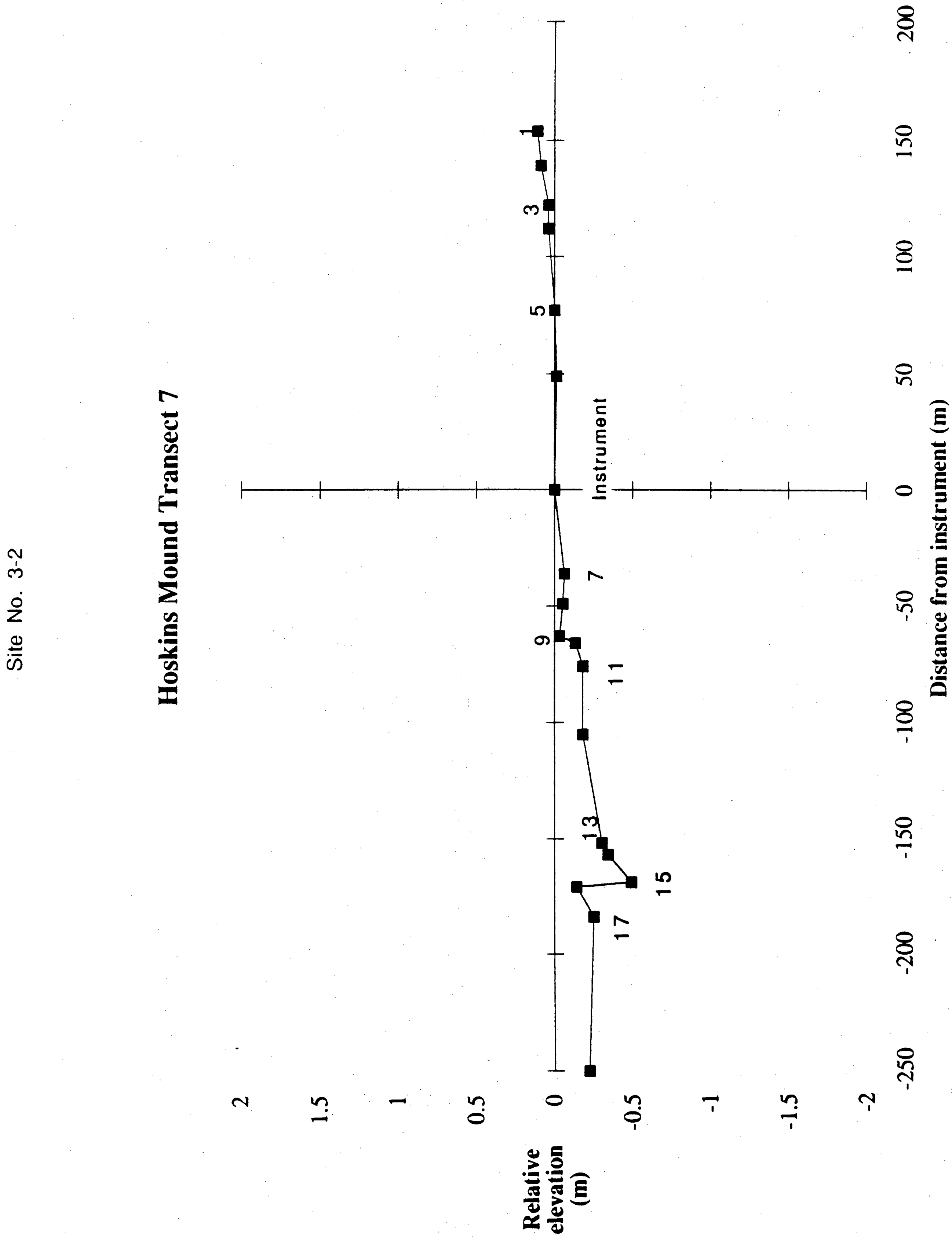
Hoskins Mound Transect 7
12/12/90
Instrument height (m): 1.560
Ground elevation (m): 0.000 (relative to instrument position)

Shot	Bearing °	'	"	Height (m)	Top (m)	Bottom (m)	Decimal Bearing (°)	Distance (m)	Relative Elevation (IP1, m)	X (m)	Y (m)	Line Distance (m)
1	60	18	50	1.450	2.220	#N/A	60.31	154	0.110	133.8	76.3	154
2	60	30	40	1.470	2.170	0.780	60.51	139	0.090	121.0	68.4	139
3	60	48	0	1.520	2.140	0.920	60.80	122	0.040	106.5	59.5	122
4	60	22	10	1.520	2.090	0.970	60.37	112	0.040	97.4	55.4	112
5	60	22	0	1.560	1.950	1.180	60.37	77	0.000	66.9	38.1	77
6	60	32	10	1.570	1.810	1.320	60.54	49	-0.010	42.7	24.1	49
0				1.560	#N/A	#N/A	0.00	#N/A	0.000	0.0	0.0	0
7	239	51	40	1.620	1.800	1.440	239.86	36	-0.060	-31.1	-18.1	-36
8	240	6	30	1.610	1.850	1.360	240.11	49	-0.050	-42.5	-24.4	-49
9	240	5	20	1.590	1.900	1.270	240.09	63	-0.030	-54.6	-31.4	-63
10	239	59	0	1.690	2.020	1.360	239.98	66	-0.130	-57.1	-33.0	-66
11	239	59	50	1.740	2.120	1.360	240.00	76	-0.180	-65.8	-38.0	-76
12	240	32	20	1.740	2.270	1.220	240.54	105	-0.180	-91.4	-51.6	-105
13	240	26	10	1.860	2.620	1.100	240.44	152	-0.300	-132.2	-75.0	-152
14	240	16	50	1.900	2.690	1.120	240.28	157	-0.340	-136.3	-77.8	-157
15	240	25	50	2.050	2.900	1.210	240.43	169	-0.490	-147.0	-83.4	-169
16	240	22	30	1.700	2.560	0.850	240.38	171	-0.140	-148.6	-84.5	-171
17	240	22	30	1.810	2.730	0.890	240.38	184	-0.250	-159.9	-91.0	-184
18	243	34	10	1.780	3.030	#N/A	243.57	250	-0.220	-223.9	-111.3	-250

Hoskins Mound Transect 7 Shotpoints



APPENDIX C (cont.)



Hoskins Mound Transect 7: Site No. 3-2

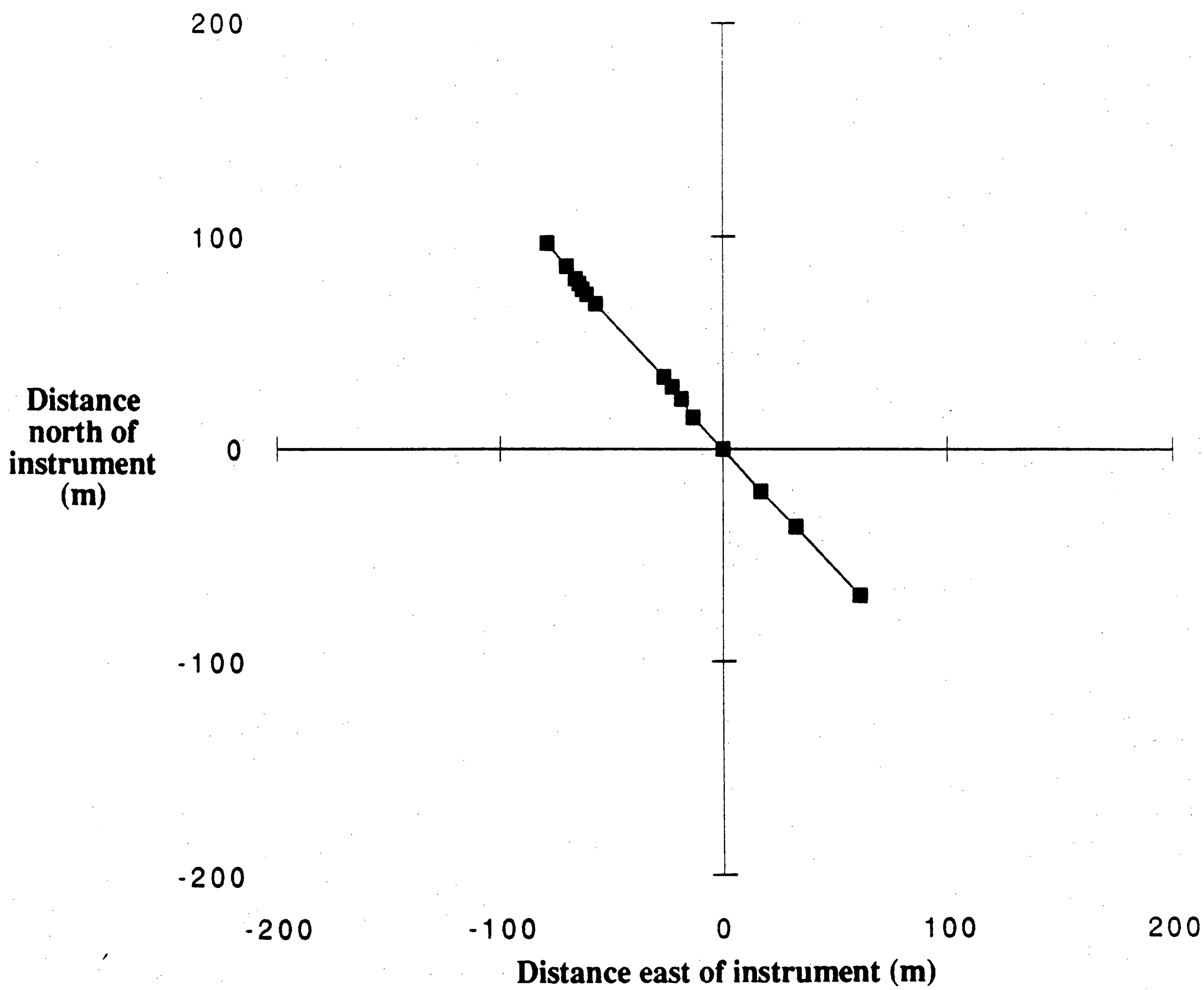
Station No.	
1	*Spartina spartinae, Spartina patens, Distichlis spicata* Scattered *Borrichia frutescens, Iva frutescens, Cyperus articulatus, Cyperus* sp.
2	Barren flat, scattered *Salicornia bigelovii*
3	*Distichlis spicata—Spartina patens—Spartina spartinae*
4	*Spartina patens* dominant, *Distichlis spicata* abundant, scattered *Spartina spartinae, Aster tenuifolius, Borrichia frutescens*
5	*Distichlis spicata—Spartina spartinae—Spartina patens*
6	*Spartina spartinae* dominant, some *Distichlis, Spartina patens,* scattered *Salicornia*
Instru.	*Spartina spartinae—Distichlis spicata,* scattered *Salicornia, Aster tenuifolius, Lymonium*
7	Edge of *Distichlis spicata—Spartina spartinae* zone, beginning of *Monanthochloe littoralis*
8	Edge of *Monanthochloe* dominance, beginning of *Spartina spartinae - Distichlis* zone
9	*Spartina spartinae* on rim of flat
10	Flat with *Monanthochloe,* scattered *Distichlis, Salicornia* spp., algal mat
11	*Distichlis spicata*
12	*Distichlis spicata,* scattered *Aster tenuifolius* and *Salicornia*
13	Edge of *Spartina alterniflora,* some *Distichlis*
14	Tidal channel, standing water, *Ruppia maritima*
15	Center of tidal channel (0.5 to 1 m wide) water 9 cm deep
16	*Spartina patens* dominant (margin of channel)
17	*Spartina patens* (tall and healthy), scattered *Juncus roemerianus, Distichlis spicata, Aster tenuifolius*
18	*Spartina patens—Distichlis spicata* zone, scattered *Scirpus maritimus, Juncus roemerianus* *Iva frutescens* abundant toward channel to SW (about 25 m)

Galveston Bay Elevation Transect: Site No. 3-3

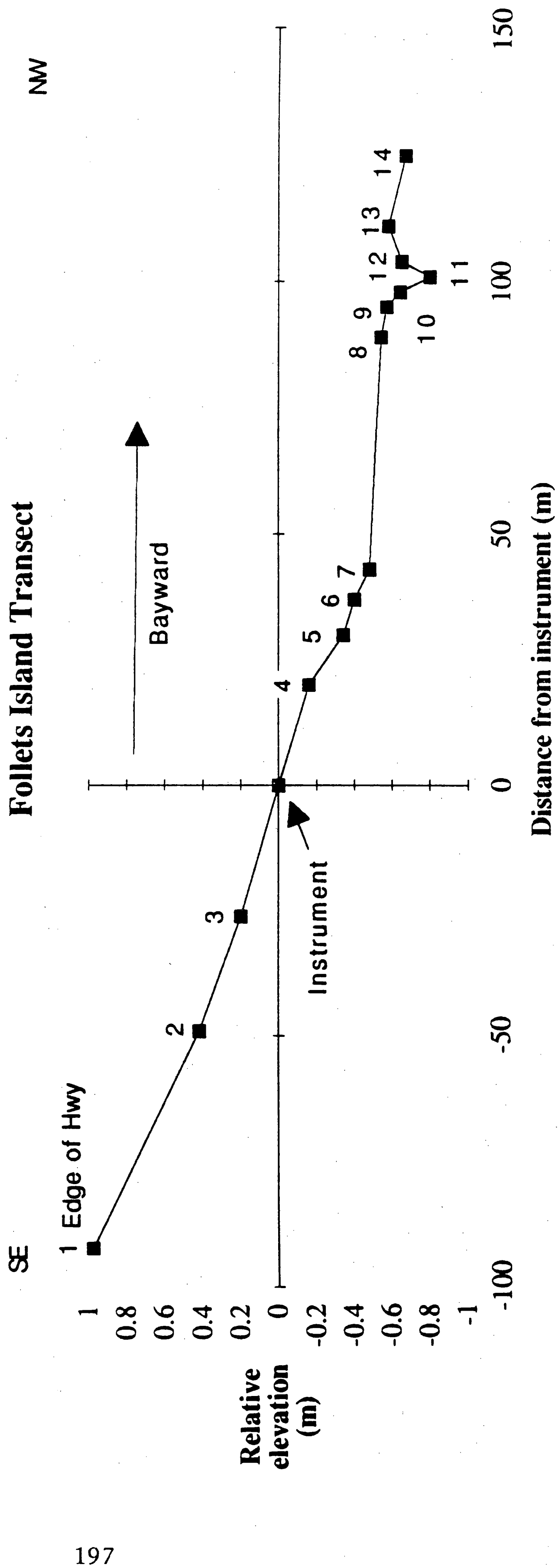
Follets Island Transect 1
11/14/90
Instrument height (m): 1.530
Ground elevation (m): 0.000 (relative to instrument position)

Shot	Bearing °	Bearing '	Bearing "	Height (m)	Top (m)	Bottom (m)	Decimal Bearing (°)	Distance (m)	Relative Elevation (m)	X (m)	Y (m)	Line Distance (m)
31	138	26	30	0.550	1.010	#N/A	138.44	92	0.980	61.0	-68.8	-92.0
32	138	20	40	1.110	1.360	0.870	138.34	49	0.420	32.6	-36.6	-49.0
33	140	19	50	1.330	1.460	1.200	140.33	26	0.200	16.6	-20.0	-26.0
0	0	0	0	1.530	1.530	1.530	0.00	0	0.000	0.0	0.0	0.0
34	317	42	10	1.690	1.790	1.590	317.70	20	-0.160	-13.5	14.8	20.0
35	320	52	0	1.870	2.020	1.720	320.87	30	-0.340	-18.9	23.3	30.0
36	321	35	50	1.930	2.120	1.750	321.60	37	-0.400	-23.0	29.0	37.0
37	321	42	0	2.010	2.220	1.790	321.70	43	-0.480	-26.7	33.7	43.0
38	319	50	20	2.070	2.510	1.620	319.84	89	-0.540	-57.4	68.0	89.0
39	319	41	40	2.100	2.570	1.620	319.69	95	-0.570	-61.5	72.4	95.0
40	319	46	40	2.170	2.660	1.680	319.78	98	-0.640	-63.3	74.8	98.0
41	320	15	40	2.330	2.830	1.820	320.26	101	-0.800	-64.6	77.7	101.0
42	320	16	30	2.180	2.700	1.660	320.28	104	-0.650	-66.5	80.0	104.0
43	320	47	0	2.110	2.670	1.560	320.78	111	-0.580	-70.2	86.0	111.0
44	320	51	10	2.200	2.820	1.570	320.85	125	-0.670	-78.9	96.9	125.0

Follets Island Transect 1 Shotpoints



Site No. 3-3


Follets Island Transect
SE
NW
Bayward
1 Edge of Hwy
2
3
4
5
6
7
8
9
10
11
12
13
14
Instrument
Relative elevation (m)
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-100
-50
0
50
100
150
Distance from instrument (m)

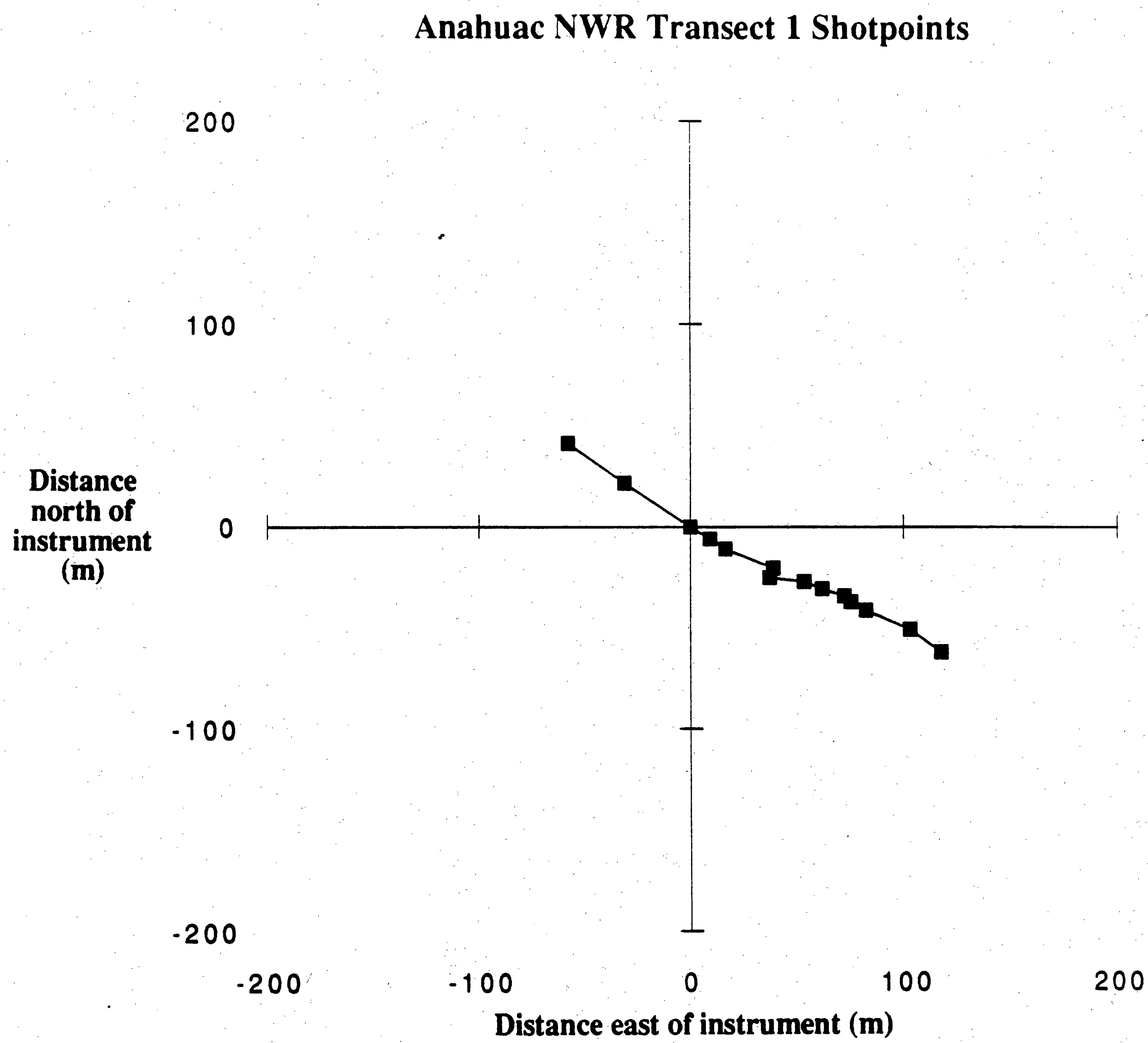
Follets Island Transect 1: Site No. 3-3

Station No.	
1	*Paspalum monostachyum, Spartina spartinae, Fimbristylis castanea, Andropogon glomeratus, Hydrocotyle bonariensis, Cyperus* sp.
2	Edge of *Iva frutescens, Paspalum monostachyum, Andropogon glomeratus, Fimbristylis castanea*, scattered *Hydrocotyle bonariensis*, composites
3	Middle of *Iva frutescens—Spartina patens* dominance, *Spartina spartinae* abundant, *Paspalum monostachyum, Andropogon glomeratus, Solidago* sp., *Scirpus americanus, Setaria* sp., *Borrichia frutescens*
Instru.	
4	Trailing edge of *Iva frutescens*, beginning of *Spartina patens* dominance with *Distichlis spicata* mix, scattered *Borrichia frutescens, Spatina spartinae*
5	Edge of *Spartina patens, Distichlis spicata* dominant (90%), scattered *Lymonium nashii, Salicornia* sp.
6	Leading edge of *Monanthochloe littoralis* dominance, gradation with *Distichlis spicata* zone about 1 m
7	Trailing edge of *Monanthochloe*, leading edge of algal flat
8	*Batis maritima*, trailing edge of algal flat
9	*Spartina alterniflora—Batis maritima*
10	Edge of water, *Spartina alterniflora* dominance, scattered *Distichlis spicata*
11	*Spartina alterniflora* (Water 17 cm)
12	*Spartina alterniflora—Distichlis spicata*
13	*Distichlis spicata*
14	*Spartina alterniflora* (90-95%), *Batis maritima* (5-10%)

Galveston Bay Elevation Transect: Site No. 18-9

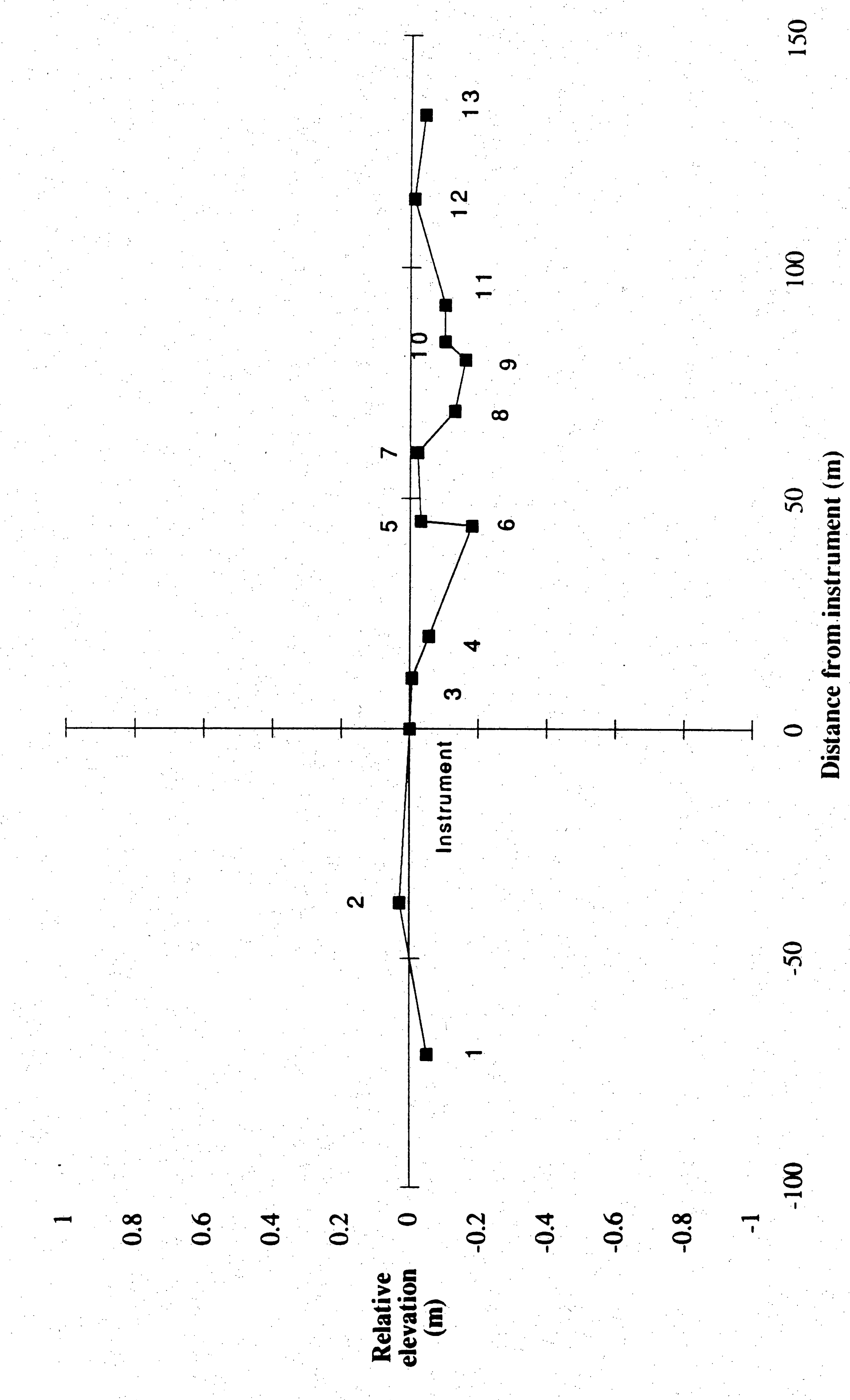
Anahuac Wildlife Refuge Transect 1
11/16/90
Instrument height (m): 1.620
Ground elevation (m): 0.000 (relative to instrument position)

Shot	Bearing °	'	"	Height (m)	Top (m)	Bottom (m)	Decimal Bearing (°)	Distance (m)	Relative Elevation (m)	X (m)	Y (m)	Line Distance (m)
45	305	16	10	1.670	2.020	1.310	305.27	71	-0.050	-58.0	41.0	-71.0
46	304	43	30	1.590	1.780	1.400	304.73	38	0.030	-31.2	21.6	-38.0
0	0	0	0	1.620	1.620	1.620	0.00	0	0.000	0.0	0.0	0.0
47	124	6	0	1.625	1.680	1.570	124.10	11	-0.005	9.1	-6.2	11.0
48	124	0	30	1.675	1.775	1.575	124.01	20	-0.055	16.6	-11.2	20.0
50	117	46	20	1.800	2.020	1.580	117.77	44	-0.180	38.9	-20.5	44.0
49	124	6	0	1.650	1.870	1.420	124.10	45	-0.030	37.3	-25.2	45.0
51	117	15	10	1.640	1.940	1.340	117.25	60	-0.020	53.3	-27.5	60.0
52	116	38	40	1.750	2.100	1.410	116.64	69	-0.130	61.7	-30.9	69.0
53	115	30	40	1.780	2.180	1.380	115.51	80	-0.160	72.2	-34.5	80.0
54	116	28	40	1.720	2.140	1.300	116.48	84	-0.100	75.2	-37.5	84.0
55	116	50	50	1.720	2.180	1.260	116.85	92	-0.100	82.1	-41.5	92.0
56	116	19	40	1.630	2.200	1.050	116.33	115	-0.010	103.1	-51.0	115.0
57	117	58	30	1.660	2.320	0.990	117.98	133	-0.040	117.5	-62.4	133.0


Anahuac NWR Transect 1 Shotpoints
200
100
0
-100
-200
Distance north of instrument (m)
-200
-100
0
100
200
Distance east of instrument (m)

Site No. 18-9

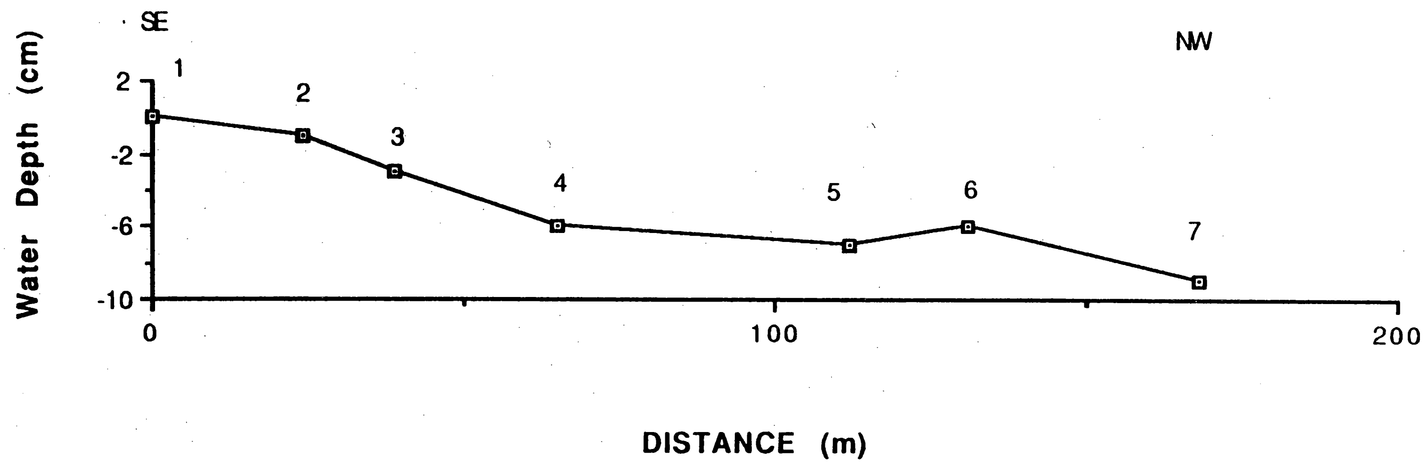
Anahuac NWR Transect 1



Anahuac NWR Transect 1: Site No. 18-9

Station No.	
1	*Spartina spartinae, Spartina patens, Distichlis spicata*, scattered *Aster* sp., *Borrichia frutescens, Iva frutescens* (Wet)
2	*Spartina spartinae* (Damp Soil)
Instru.	*Spartina spartinae*, some *Iva frutescens*
3	*Spartina patens—Distichlis spicata* dominance, *Paspalum vaginatum*, trailing edge of *Spartina spartinae*, scattered *Aster* sp., *Setaria, Cyperus* sp.
4	*Paspalum vaginatum*, (Water 1-2 cm)
5	Leading edge of *Scirpus olneyi*, trailing edge of *Paspalum vaginatum* and *Spartina patens*
6	*Scirpus olneyi* (Water 20 cm)
7	*Scirpus olneyi* (60%), *Spartina patens* (40%) (Water 4 cm)
8	*Scirpus olneyi, Spartina patens* (Water 6 cm)
9	*Scirpus olneyi* (90%), *Spartina patens, Echinochloa crusgalli, Bacopa monnieri* (Water 7 cm)
10	*Distichlis spicata* (tall), *Spartina patens*, scattered *Scirpus olneyi* (Water 2.5 cm)
11	Trailing edge of *Scirpus olneyi*, leading edge of *Distichlis spicata—Spartina patens* dominance, scattered *Echinochloa crusgalli, Spartina spartinae, Aster* sp.
12	*Spartina patens* dominance, abundant *Distichlis spicata*, scattered *Borrichia* and *Aster* sp. (Soil Damp)
13	*Spartina spartinae* dominance, *Spartina patens, Distichlis spicata, Aster* sp., *Borrichia frutescens, Cyperus articulatus, Echinochloa crusgalli* (Soil Damp)

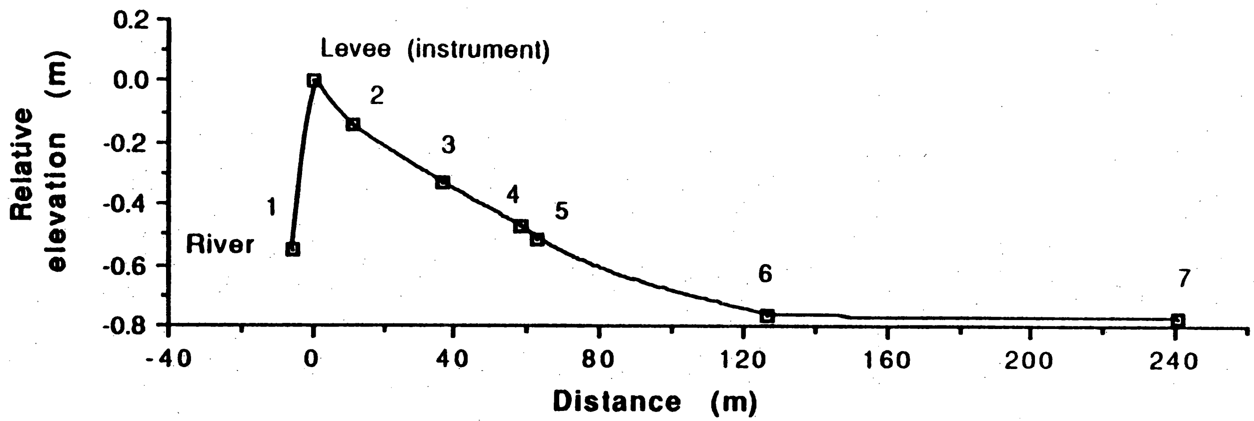
Inland From West Bay Transect: Site Nos. 10-1 to 10-3



Station No.	
1 to 2	*Distichlis spicata* (80%), *Spartina alterniflora* (15%), *Borrichia frutescens* (5%)
2 to 3	*Distichlis spicata* (60%), *Spartina alterniflor* (40%)
3 to 4	*Distichlis spicata* (99%)
4 to 5	*Spartina alterniflora* (65%), *Distichlis spicata* (35%)
5 to 6	*Spartina alterniflora* (70%), *Distichlis spicata* (20%), *Batis maritima* (10%)
6 to 7	*Spartina alterniflora* (99%)

other species noted in area: Scirpus maritimus, Saliconia sp., Juncus roemerianus

Trinity River Delta Transect: Site No. 28-2 to 6



Station No.	
1	River's edge; water level
Levee (instr.)	Upland assemblage: scattered trees and shrubs including *Salix nigra*, *Sapium sebiferum*; grasses include *Panicum repens* and *Phragmites australis*; forbs include *Iva annua*, *Physostegia intermedia*, others (from station 1 to 2)
2	Edge of tall grass assemblage including *Spartina patens*, *Setaria geniculata*, *Alternanthera philoxeroides*, *Cyperus articulatus*, *Lycium carolinianum*
3	Bayward edge of tall grass assemblage, beginning of assemblage of *Spartina patens*, *Paspalum vaginatum*? (no infloresence), *Polygonum hydropiperoides*, *Cyperus articulatus*, *Eleocharis sp.*, *Alternanthera philoxeroides*; water 0.5 cm deep
4	Continuation of assemblage noted above at station 3
5	Edge of dominant, tall *Eleocharis* sp. (90%) (0.8 m tall), *Polygonum hydropiperoides*, *Scirpus olneyi*, *Bacopa monnieri*, *Alternanthera philoxeriodes*
6	Center of tall *Eleocharis* sp. zone (see 5); water 3 to 8 cm deep
7	Beginning of less dense and shorter assemblage of *Bacopa monnieri* (60%) *Eleocharis* sp., *Polygonum hydropiperoides*, *Zizaniopsis miliacea*, *Crinum americanum*, *Paspalum vaginatum*?; water 3 to 8 cm deep

Appendix D

APPENDIX D. Mapped Habitats for 1989, 1979, 1950's.

MAPNAME		HABITAT (1989)	ACRES (1989)	HABITAT (1979)	ACRES (1979)	HABITAT (1950's)	ACRES (1950's)
ANAHUAC, TX (NE)		E1AB3L	115	E1AB6L	431	E1OW	3126
ANAHUAC, TX (NE)		E1UBL	1904	E1OWL	2868	E2EM	205
ANAHUAC, TX (NE)		E1UBLx	64	E1OWLx	55	E2FL	384
ANAHUAC, TX (NE)		E2AB5M	114	E2EM1N	2013	L1OW	6070
ANAHUAC, TX (NE)		E2EM1N/E2USN	33	E2EM1Nx	3	PEM	7152
ANAHUAC, TX (NE)		E2EM1N	243	E2EM1P	739	PFL	4
ANAHUAC, TX (NE)		E2EM1P	2558	E2FLN	483	PFO	845
ANAHUAC, TX (NE)		E2SS1P	13	E2FLP	62	PFO/PSS	19
ANAHUAC, TX (NE)		E2USM	1731	E2EM1N	170	POW	111
ANAHUAC, TX (NE)		E2USMx	0	L1OWHh	4954	PSS	1232
ANAHUAC, TX (NE)		E2USN	51	L1OWV	1038	PSS/PEM	54
ANAHUAC, TX (NE)		L1AB4Hh	27	L2AB6V	4	R1OW	237
ANAHUAC, TX (NE)		L1AB4Vx	5	L2FLY	60	R2OW	156
ANAHUAC, TX (NE)		L1UBH	47	L2OWH	47	U	21778
ANAHUAC, TX (NE)		L1UBHh	5	PAB7H	2		
ANAHUAC, TX (NE)		L1UBHx	22	PEM	52		
ANAHUAC, TX (NE)		L1UBV	876	PEM1C	782		
ANAHUAC, TX (NE)		L1UBVx	22	PEM1Cx	0		
ANAHUAC, TX (NE)		L2AB3V	197	PEM1F	55		
ANAHUAC, TX (NE)		L2AB4Hh	10	PEM1F/POWF	7		
ANAHUAC, TX (NE)		L2UBHh	4863	PEM1Fhx	31		
ANAHUAC, TX (NE)		L2UBT	97	PEM1Fx	1		
ANAHUAC, TX (NE)		L2USAh	23	PEM1R	1906		
ANAHUAC, TX (NE)		L2USAx	1	PEM1S	52		
ANAHUAC, TX (NE)		L2USCh	63	PEM1T	766		
ANAHUAC, TX (NE)		PAB4Hh	0	PEM1Y	54		
ANAHUAC, TX (NE)		PAB4Hx	10	PFLY	24		
ANAHUAC, TX (NE)		PEM1A	105	PFO5F	1		
ANAHUAC, TX (NE)		PEM1Ad	3	PFO6A	164		
ANAHUAC, TX (NE)		PEM1C	984	PFO6C	67		
ANAHUAC, TX (NE)		PEM1Ch	482	PFO6Chx	5		
ANAHUAC, TX (NE)		PEM1F	365	PFO6R	909		
ANAHUAC, TX (NE)		PEM1Fh	422	PFO6S	103		
ANAHUAC, TX (NE)		PEM1Fx	1	PFO6T	331		
ANAHUAC, TX (NE)		PEM1R	144	PFO6Y	17		
ANAHUAC, TX (NE)		PEM1S	5	POWF	12		
ANAHUAC, TX (NE)		PEM1T	851	POWFhx	24		
ANAHUAC, TX (NE)		PEM1Vx	3	POWFx	10		
ANAHUAC, TX (NE)		PFO1/2A	7	POWH	35		
ANAHUAC, TX (NE)		PFO1/2C	3	POWHh	2		
ANAHUAC, TX (NE)		PFO1/2R	397	POWHhx	121		
ANAHUAC, TX (NE)		PFO1A	228	POWHx	19		
ANAHUAC, TX (NE)		PFO1Ah	33	POWT	141		
ANAHUAC, TX (NE)		PFO1As	18	POWTh	2		
ANAHUAC, TX (NE)		PFO1C	152	POWThx	0		
ANAHUAC, TX (NE)		PFO1R	145	POWV	43		
ANAHUAC, TX (NE)		PFO1S	181	POWVx	1		
ANAHUAC, TX (NE)		PFO1Ss	42	PSS6A	180		
ANAHUAC, TX (NE)		PFO2Fh	1	PSS6F	2		
ANAHUAC, TX (NE)		PFO2T	1109	PSS6R	38		
ANAHUAC, TX (NE)		PFO2V	2	PSS6T	84		
ANAHUAC, TX (NE)		PSS1A	9	PSS6V	2		
ANAHUAC, TX (NE)		PSS1Ax	1	PSS6Y	18		
ANAHUAC, TX (NE)		PSS1C	8	R1OWV	490		
ANAHUAC, TX (NE)		PSS1Ch	44	R2OWH	57		
ANAHUAC, TX (NE)		PSS1R	32	R2OWHx	21		
ANAHUAC, TX (NE)		PSS1S	2	UA	4224		
ANAHUAC, TX (NE)		PSS1Ss	25	UAr	2304		
ANAHUAC, TX (NE)		PUBFh	0	UB	12		
ANAHUAC, TX (NE)		PUBFx	11	UBs	15		
ANAHUAC, TX (NE)		PUBH	3	UF6	2178		
ANAHUAC, TX (NE)		PUBHh	5	UF8	9362		
ANAHUAC, TX (NE)		PUBHx	107	UU	3606		
ANAHUAC, TX (NE)		PUBKHx	12	UUb	107		
ANAHUAC, TX (NE)		PUBT	68				
ANAHUAC, TX (NE)		PUBV	13				
ANAHUAC, TX (NE)		PUBVx	6				
ANAHUAC, TX (NE)		PUSA	1				
ANAHUAC, TX (NE)		PUSAx	8				
ANAHUAC, TX (NE)		R1UBT	58				
ANAHUAC, TX (NE)		R1UBV	384				
ANAHUAC, TX (NE)		R1UBVx	1				
ANAHUAC, TX (NE)		R1USR	1				
ANAHUAC, TX (NE)		R2UBH	39				
ANAHUAC, TX (NE)		UA	2105				

MAPNAME		HABITAT (1989)	ACRES (1989)	HABITAT (1979)	ACRES (1979)	HABITAT (1950's)	ACRES (1950's)
ANAHUAC, TX (NE)		UAr	2335				
ANAHUAC, TX (NE)		UB	27				
ANAHUAC, TX (NE)		UBs	7				
ANAHUAC, TX (NE)		UF6	206				
ANAHUAC, TX (NE)		UF7	1775				
ANAHUAC, TX (NE)		UF8	9302				
ANAHUAC, TX (NE)		UR	2591				
ANAHUAC, TX (NE)		USS	669				
ANAHUAC, TX (NE)		USSs	1				
ANAHUAC, TX (NE)		UU	2715				
ANAHUAC, TX (NE)		UUo	17				
BACLIFF, TX (NE)		E1UBL	38469	E1OWL	38551	E1OW	38586
BACLIFF, TX (NE)		E1UBLx	39	E1OWLx	26	E2EM	145
BACLIFF, TX (NE)		E2EM1Ps/E2SS1Ps	156	E2EM1N	10	E2FL	161
BACLIFF, TX (NE)		E2EM1Ns	43	E2EM1N/E2FLN	49	PEM	70
BACLIFF, TX (NE)		E2EM1P	18	E2EM1P	37	POW	3
BACLIFF, TX (NE)		E2EM1Ps	11	E2FL6N	79	U	2507
BACLIFF, TX (NE)		E2USM	94	E2FLN	130		
BACLIFF, TX (NE)		E2USMs	7	E2FLP	37		
BACLIFF, TX (NE)		E2USN	3	PEM1A	17		
BACLIFF, TX (NE)		E2USNs	79	PEM1C	6		
BACLIFF, TX (NE)		E2USP	23	PEM1Y	16		
BACLIFF, TX (NE)		E2USPs	4	POWF	1		
BACLIFF, TX (NE)		L1UBHh	0	POWFhx	2		
BACLIFF, TX (NE)		PEM1C	24	POWHhx	4		
BACLIFF, TX (NE)		PEM1Cx	0	PSS6C	0		
BACLIFF, TX (NE)		PSS1/3C	4	PSS6F	1		
BACLIFF, TX (NE)		PSS1A	72	PSS6Y	9		
BACLIFF, TX (NE)		PSS1C	16	R1OWV	0		
BACLIFF, TX (NE)		PSS3C	24	UA	894		
BACLIFF, TX (NE)		PUBHx	6	UBs	28		
BACLIFF, TX (NE)		UA	193	UF6	131		
BACLIFF, TX (NE)		UF6	61	UU	1446		
BACLIFF, TX (NE)		UF8	128				
BACLIFF, TX (NE)		UR	361				
BACLIFF, TX (NE)		URs	21				
BACLIFF, TX (NE)		USS	206				
BACLIFF, TX (NE)		UU	1411				
CAPLEN, TX (SE)		E1UBL	1464	E1OWL	1710	E1OW	1450
CAPLEN, TX (SE)		E1UBLx	393	E1OWLh	1	E2EM	847
CAPLEN, TX (SE)		E2EM1N	855	E1OWLx	37	E2EM/E2FL	1394
CAPLEN, TX (SE)		E2EM1P	992	E2EM1N	940	E2FL	212
CAPLEN, TX (SE)		E2USM	18	E2EM1P	894	M1OW	35032
CAPLEN, TX (SE)		E2USN	120	E2EM1P/E2FLP	23	M2BB	206
CAPLEN, TX (SE)		E2USP	56	E2FLN	194	PEM	91
CAPLEN, TX (SE)		L2UBFh	101	E2FLP	5	PFL	8
CAPLEN, TX (SE)		M1UBL	34981	M1OWL	35040	POW	4
CAPLEN, TX (SE)		M2USN	126	M2BBP	178	U	2278
CAPLEN, TX (SE)		M2USP	101	PEM1C	13		
CAPLEN, TX (SE)		PEM1Chs	73	PEM1F	0		
CAPLEN, TX (SE)		PEM1Fh	1	PEM1Y	30		
CAPLEN, TX (SE)		PSS1R	1	PEM1YH	7		
CAPLEN, TX (SE)		PUBH	0	POWF	3		
CAPLEN, TX (SE)		PUBHh	15	POWFhx	6		
CAPLEN, TX (SE)		PUBHx	12	POWFx	4		
CAPLEN, TX (SE)		UA	225	POWG	3		
CAPLEN, TX (SE)		UB	1	POWGHx	0		
CAPLEN, TX (SE)		UF6	13	UA	1813		
CAPLEN, TX (SE)		UR	1017	UU	542		
CAPLEN, TX (SE)		URs	44	UUo	65		
CAPLEN, TX (SE)		USS	87				
CAPLEN, TX (SE)		USSs	122				
CAPLEN, TX (SE)		UU	688				
CAPLEN, TX (SE)		UUo	3				
CHRISTMAS POINT, TX (SW)		E1AB3L	386	E1AB6L	3	E1AB	293
CHRISTMAS POINT, TX (SW)		E1UBL	15045	E1OWL	16442	E1OW	15454
CHRISTMAS POINT, TX (SW)		E1UBLx	577	E1OWLx	20	E2BB	23
CHRISTMAS POINT, TX (SW)		E2AB3KMh	109	E2EM1N	6966	E2EM	6955
CHRISTMAS POINT, TX (SW)		E2EM1P/E2USP	556	E2EM1N/E2FLN	204	E2EM/E2FL	5644
CHRISTMAS POINT, TX (SW)		E2EM1N/E2USN	410	E2EM1P	3302	E2FL	1091
CHRISTMAS POINT, TX (SW)		E2EM1P/E2USPs	54	E2EM1P/E2FLP	903	E2SB	56
CHRISTMAS POINT, TX (SW)		E2EM1N	7631	E2FLN	351	L2AB/L2OW	83

MAPNAME		HABITAT (1989)	ACRES (1989)	HABITAT (1979)	ACRES (1979)	HABITAT (1950's)	ACRES (1950's)
CHRISTMAS POINT, TX (SW)		E2EM1Ns	7	E2FLP	44	M1OW	8843
CHRISTMAS POINT, TX (SW)		E2EM1P	2486	E2SS1N	17	M2BB	176
CHRISTMAS POINT, TX (SW)		E2EM1Ps	0	L1OWHh	57	PEM	260
CHRISTMAS POINT, TX (SW)		E2EM1Px	3	L2AB7Hh/L2OWHh	45	PFL	25
CHRISTMAS POINT, TX (SW)		E2EM2N/E2USN	10	M1OWL	8969	PSS	4
CHRISTMAS POINT, TX (SW)		E2SS1P	28	M2BBP	172	U	2767
CHRISTMAS POINT, TX (SW)		E2SS1Ps	5	PEM1F	2		
CHRISTMAS POINT, TX (SW)		E2USN/E2EM1N	2	PEM1Y	278		
CHRISTMAS POINT, TX (SW)		E2USP/E2EM1P	236	POWF	4		
CHRISTMAS POINT, TX (SW)		E2USP/E2SS1P	17	POWH	20		
CHRISTMAS POINT, TX (SW)		E2USM	666	POWHh	6		
CHRISTMAS POINT, TX (SW)		E2USN	72	UA	3598		
CHRISTMAS POINT, TX (SW)		E2USP	70	UBd	16		
CHRISTMAS POINT, TX (SW)		E2USPs	3	UBs	45		
CHRISTMAS POINT, TX (SW)		L1UBFx	0	UNLABELED	45		
CHRISTMAS POINT, TX (SW)		L2AB3Hh	85	UU	144		
CHRISTMAS POINT, TX (SW)		L2USAhs	44	UUo	33		
CHRISTMAS POINT, TX (SW)		L2USChs	76				
CHRISTMAS POINT, TX (SW)		M1UBL	8997				
CHRISTMAS POINT, TX (SW)		M2USN	100				
CHRISTMAS POINT, TX (SW)		M2USP	123				
CHRISTMAS POINT, TX (SW)		PEM1C	68				
CHRISTMAS POINT, TX (SW)		PEM1F	16				
CHRISTMAS POINT, TX (SW)		PEM1Fh	5				
CHRISTMAS POINT, TX (SW)		PEM1Fhx	9				
CHRISTMAS POINT, TX (SW)		PEM1R	38				
CHRISTMAS POINT, TX (SW)		PEM1T	0				
CHRISTMAS POINT, TX (SW)		PSS1Ah	3				
CHRISTMAS POINT, TX (SW)		PUBF	1				
CHRISTMAS POINT, TX (SW)		PUBH	2				
CHRISTMAS POINT, TX (SW)		PUBHx	1				
CHRISTMAS POINT, TX (SW)		PUSA/PEM1A	2				
CHRISTMAS POINT, TX (SW)		PUSAh	6				
CHRISTMAS POINT, TX (SW)		UAr	17				
CHRISTMAS POINT, TX (SW)		UB	2				
CHRISTMAS POINT, TX (SW)		UBd	0				
CHRISTMAS POINT, TX (SW)		UBs	22				
CHRISTMAS POINT, TX (SW)		UR	2911				
CHRISTMAS POINT, TX (SW)		URs	392				
CHRISTMAS POINT, TX (SW)		USS	79				
CHRISTMAS POINT, TX (SW)		USSs	160				
CHRISTMAS POINT, TX (SW)		UU	145				
CHRISTMAS POINT, TX (SW)		UUo	4				
CHRISTMAS POINT, TX (SW)		UUs	3				
COVE, TX (NE)		E1AB3L	14	E1OWL	4941	E1OW	5353
COVE, TX (NE)		E1UBL	4154	E1OWLx	4	E2AB	188
COVE, TX (NE)		E1UBLx	40	E2EM1N	1007	E2EM	1349
COVE, TX (NE)		E2AB5M	337	E2EM1P	1369	E2EM/E2FL	15
COVE, TX (NE)		E2EM1N	140	E2FLN	54	E2FL	1371
COVE, TX (NE)		E2EM1P	3066	E2FLP	15	L1OW	937
COVE, TX (NE)		E2SBM	2	E2FLM	32	L2OW	26
COVE, TX (NE)		E2SS1P	9	L1OWHh	3124	PEM	7689
COVE, TX (NE)		E2USM	675	L1OWHhx	143	PEM/PFL	321
COVE, TX (NE)		E2USMx	3	L1OWV	1178	PEM/PSS	385
COVE, TX (NE)		E2USN	55	L2AB5Fh	9	PFL	354
COVE, TX (NE)		E2USP	4	L2FLV	257	PFO	398
COVE, TX (NE)		L1UBKHh	2595	L2FLYh	269	PFO/PSS	6
COVE, TX (NE)		L1UBKHx	38	L2OWFh	41	POW	64
COVE, TX (NE)		L1UBV	1124	PAB4Hh	1	PSS	1750
COVE, TX (NE)		L1UBVx	70	PAB5F	8	PSS/PEM	122
COVE, TX (NE)		L2UBT	299	PAB6F	11	R1OW	218
COVE, TX (NE)		PAB3H	1	PEM1A	8	R2OW	417
COVE, TX (NE)		PAB4Hh	8	PEM1C	89	U	20409
COVE, TX (NE)		PAB4Hx	0	PEM1Ch	89		
COVE, TX (NE)		PAB4V	12	PEM1F	34		
COVE, TX (NE)		PEM1A	11	PEM1F/POWF	44		
COVE, TX (NE)		PEM1C	53	PEM1Fh	768		
COVE, TX (NE)		PEM1Ch	213	PEM1Fhx	4		
COVE, TX (NE)		PEM1F	3	PEM1Fhx/POWFhx	11		
COVE, TX (NE)		PEM1Fh	115	PEM1Fx	4		
COVE, TX (NE)		PEM1Fx	1	PEM1Hhx	3		
COVE, TX (NE)		PEM1KAh	145	PEM1R	2402		
COVE, TX (NE)		PEM1R	707	PEM1S	92		

MAPNAME		HABITAT (1989)	ACRES (1989)	HABITAT (1979)	ACRES (1979)	HABITAT (1950's)	ACRES (1950's)
COVE, TX (NE)		PEM1S	12	PEM1T	1461		
COVE, TX (NE)		PEM1T	3119	PEM1Y	8		
COVE, TX (NE)		PEM1Vx	2	PEM1Yh	1		
COVE, TX (NE)		PFO1/2C	589	PEMFh	2		
COVE, TX (NE)		PFO1/2R	135	PFO1A	19		
COVE, TX (NE)		PFO1A	128	PFO6A	132		
COVE, TX (NE)		PFO1Ax	35	PFO6C	272		
COVE, TX (NE)		PFO1C	6	PFO6Chx	1		
COVE, TX (NE)		PFO1R	884	PFO6F	79		
COVE, TX (NE)		PFO1S	52	PFO6R	418		
COVE, TX (NE)		PFO1Ss	11	PFO6S	383		
COVE, TX (NE)		PFO2T	47	PFO6Y	1		
COVE, TX (NE)		PSS1Ax	3	POWF	18		
COVE, TX (NE)		PSS1C	0	POWFhx	8		
COVE, TX (NE)		PSS1F	1	POWFx	5		
COVE, TX (NE)		PSS1R	132	POWG	3		
COVE, TX (NE)		PUBF	0	POWGh	10		
COVE, TX (NE)		PUBFx	19	POWGhx	19		
COVE, TX (NE)		PUBH	1	POWGx	1		
COVE, TX (NE)		PUBHh	24	POWH	21		
COVE, TX (NE)		PUBHx	64	POWHh	3		
COVE, TX (NE)		PUBT	309	POWHhx	57		
COVE, TX (NE)		PUBV	44	POWHx	9		
COVE, TX (NE)		R1UBT	133	POWT	89		
COVE, TX (NE)		R1UBTx	4	POWThx	1		
COVE, TX (NE)		R1UBV	1475	POWV	1		
COVE, TX (NE)		R1UBVx	6	PSS1C	7		
COVE, TX (NE)		R1USS	0	PSS6C	20		
COVE, TX (NE)		R2UBH	48	PSS6CHx	1		
COVE, TX (NE)		UA	1618	PSS6F/PEM1F	1		
COVE, TX (NE)		UAr	8019	PSS6R	435		
COVE, TX (NE)		UBx	50	PSS6S	21		
COVE, TX (NE)		UF6	57	PSS6Y	14		
COVE, TX (NE)		UF8	2577	R1AB5T	4		
COVE, TX (NE)		UR	2520	R1FLV	17		
COVE, TX (NE)		URs	162	R1OWV	1692		
COVE, TX (NE)		USS	3272	R1OWVx	18		
COVE, TX (NE)		USSs	49	R2OWH	47		
COVE, TX (NE)		UU	1831	R2OWHhx	7		
COVE, TX (NE)		UUo	31	UA	11868		
COVE, TX (NE)				UAr	3496		
COVE, TX (NE)				UB	50		
COVE, TX (NE)				UBs	4		
COVE, TX (NE)				UF6	404		
COVE, TX (NE)				UF8	2440		
COVE, TX (NE)				UU	1741		
COVE, TX (NE)				UUo	47		
DICKINSON, TX (SW)		E1UBL	129	E1OWL	180	E2EM	9
DICKINSON, TX (SW)		E1UBLx	1	E2EM1N	27	E2FL	1
DICKINSON, TX (SW)		E2EM1N	42	E2EM1P	54	PEM	707
DICKINSON, TX (SW)		E2EM1P	17	E2FLN	4	PFL	15
DICKINSON, TX (SW)		E2SS1P	5	L1OWHh	21	PFO	14
DICKINSON, TX (SW)		E2USM	92	L1OWHx	120	POW	75
DICKINSON, TX (SW)		L1UBHx	182	PAB4G	1	PSS	8
DICKINSON, TX (SW)		PAB4Hx	0	PEM1A	104	R1OW	155
DICKINSON, TX (SW)		PEM1A	39	PEM1C	50	R2FL	3
DICKINSON, TX (SW)		PEM1C	20	PEM1F	63	R2OW	95
DICKINSON, TX (SW)		PEM1F	11	PEM1Fh	1	U	40440
DICKINSON, TX (SW)		PEM1Fh	0	PEM1Hx/POWHx	3		
DICKINSON, TX (SW)		PEM1Fx	1	PEM1Y	104		
DICKINSON, TX (SW)		PFO1A	17	PFO6Y/PSS6Y	12		
DICKINSON, TX (SW)		PFO2/1A	2	PFO6A	4		
DICKINSON, TX (SW)		PSS1/2C	50	POWF	26		
DICKINSON, TX (SW)		PSS1A	182	POWFH	3		
DICKINSON, TX (SW)		PSS1C	34	POWFHx	6		
DICKINSON, TX (SW)		PSS2/1C	34	POWFx	17		
DICKINSON, TX (SW)		PUBF	1	POWG	11		
DICKINSON, TX (SW)		PUBFx	2	POWGh	35		
DICKINSON, TX (SW)		PUBHh	2	POWGhx	17		
DICKINSON, TX (SW)		PUBHx	157	POWGx	11		
DICKINSON, TX (SW)		PUSAx	20	POWH	0		
DICKINSON, TX (SW)		R1UBV	9	POWHh	1		
DICKINSON, TX (SW)		R1UBVx	4	POWHhx	23		
DICKINSON, TX (SW)		R2UBHx	4	PSS1A	9		

MAPNAME		HABITAT (1989)	ACRES (1989)	HABITAT (1979)	ACRES (1979)	HABITAT (1950's)	ACRES (1950's)
DICKINSON, TX (SW)		UA	8207	PSS1Y	26		
DICKINSON, TX (SW)		UAr	5363	PSS6A/PEM1A	15		
DICKINSON, TX (SW)		UB	128	PSS6C	5		
DICKINSON, TX (SW)		UBx	53	PSS6C/PEM1C	14		
DICKINSON, TX (SW)		UF6	53	PSS6F	0		
DICKINSON, TX (SW)		UF7	12	PSS6F/PEM1F	1		
DICKINSON, TX (SW)		UF8	1243	PSS6Hx/POWHx	1		
DICKINSON, TX (SW)		UR	5615	PSS6Y	13		
DICKINSON, TX (SW)		USS	8121	PSS6Y/PEM1Y	6		
DICKINSON, TX (SW)		USSs	12	R1OWV	14		
DICKINSON, TX (SW)		UU	11658	UA	20403		
DICKINSON, TX (SW)		UUo	3	UAr	4559		
DICKINSON, TX (SW)				UB	24		
DICKINSON, TX (SW)				UF6	801		
DICKINSON, TX (SW)				UF8	179		
DICKINSON, TX (SW)				UU	14226		
DICKINSON, TX (SW)				UUo	335		
FLAKE, TX (SE)		E1UBL	15986	E1AB6L	10	E1OW	16120
FLAKE, TX (SE)		E1UBLx	655	E1OWL	16741	E2BB	8
FLAKE, TX (SE)		E2EM1Ps/E2USPs	40	E1OWLh	1	E2EM	1789
FLAKE, TX (SE)		E2EM1N	1947	E1OWLx	22	E2EM/E2FL	2184
FLAKE, TX (SE)		E2EM1Ns	4	E2EM1N	1862	E2FL	521
FLAKE, TX (SE)		E2EM1P	1581	E2EM1P	2244	M1OW	13392
FLAKE, TX (SE)		E2EM1Ps	3	E2FLN	126	M2BB	500
FLAKE, TX (SE)		E2SS1P	1		0	PEM	1030
FLAKE, TX (SE)		E2USPs/E2EM1Ps	7	E2FLP	176	POW	27
FLAKE, TX (SE)		E2USMs	63	E2FLPh	13	PSS	40
FLAKE, TX (SE)		E2USN	171	M1OWL	13252	U	5912
FLAKE, TX (SE)		E2USNs	2	M2BBP	286		
FLAKE, TX (SE)		E2USP	84	PAB4F	3		
FLAKE, TX (SE)		E2USPs	4	PEM1F	8		
FLAKE, TX (SE)		L2UBFh	82	PEM1Y	344		
FLAKE, TX (SE)		L2USCh	24	POWF	19		
FLAKE, TX (SE)		M1UBL	13157	POWFh	5		
FLAKE, TX (SE)		M2AB5M	0	POWFhx	1		
FLAKE, TX (SE)		M2USN	230	POWFx	14		
FLAKE, TX (SE)		M2USP	137	POWG	1		
FLAKE, TX (SE)		PAB4H	1	POWGh	3		
FLAKE, TX (SE)		PEM1A	152	POWHh	19		
FLAKE, TX (SE)		PEM1Ah	55	POWHhx	1		
FLAKE, TX (SE)		PEM1C	75	POWHx	2		
FLAKE, TX (SE)		PEM1Ch	18	UA	5015		
FLAKE, TX (SE)		PEM1Cx	7	UBs	76		
FLAKE, TX (SE)		PEM1F	10	UF6	19		
FLAKE, TX (SE)		PEM1Fh	5	UU	1258		
FLAKE, TX (SE)		PEM1Fx	3				
FLAKE, TX (SE)		PSS1A	10				
FLAKE, TX (SE)		PSS1Ah	66				
FLAKE, TX (SE)		PSS1C	26				
FLAKE, TX (SE)		PUBF	0				
FLAKE, TX (SE)		PUBH	15				
FLAKE, TX (SE)		PUBHh	26				
FLAKE, TX (SE)		PUBHx	63				
FLAKE, TX (SE)		PUSAh	15				
FLAKE, TX (SE)		UA	862				
FLAKE, TX (SE)		UBs	20				
FLAKE, TX (SE)		UF6	75				
FLAKE, TX (SE)		UR	3092				
FLAKE, TX (SE)		URs	429				
FLAKE, TX (SE)		USS	915				
FLAKE, TX (SE)		USSs	23				
FLAKE, TX (SE)		UU	1361				
FLAKE, TX (SE)		UUo	17				
FROZEN POINT, TX (NE)		E1UBL	16519	E1AB5LHx	5	E1OW	15594
FROZEN POINT, TX (NE)		E1UBLx	102	E1OWL	15479	E2EM	16919
FROZEN POINT, TX (NE)		E2EM1N/E2USN	58	E1OWLHx	74	E2EM/E2FL	234
FROZEN POINT, TX (NE)		E2EM1N	1566	E1OWLx	325	E2FL	901
FROZEN POINT, TX (NE)		E2EM1P	13412	E2AB5M	10	L1OW	217
FROZEN POINT, TX (NE)		E2SS1P	3	E2EM1N	5076	L2AB	34
FROZEN POINT, TX (NE)		E2SS3P	9	E2EM1N/E2FLN	907	M1OW	108
FROZEN POINT, TX (NE)		E2USN/E2EM1N	44	E2EM1Nhx	12	M2BB2	14
FROZEN POINT, TX (NE)		E2USM	423	E2EM1P	9728	PEM	37
FROZEN POINT, TX (NE)		E2USN	477	E2EM1P/E2FLP	37	POW	14

MAPNAME		HABITAT (1989)	ACRES (1989)	HABITAT (1979)	ACRES (1979)	HABITAT (1950's)	ACRES (1950's)
FROZEN POINT, TX (NE)		E2USP	25	E2EM1Px	2	PSS	7
FROZEN POINT, TX (NE)		L1UBHh	163	E2FLN	1488	R2OW	16
FROZEN POINT, TX (NE)		L2UBFhs	63	E2FLP	54	U	7379
FROZEN POINT, TX (NE)		L2USAhs	17	L1OWHhx	18		
FROZEN POINT, TX (NE)		L2USChs	77	L2AB2Hhx	123		
FROZEN POINT, TX (NE)		M1UBL	130	L2FLCh	38		
FROZEN POINT, TX (NE)		M2USN	15	M2BBP	23		
FROZEN POINT, TX (NE)		M2USP	14	PAB6FHx/POWFHx	6		
FROZEN POINT, TX (NE)		PEM1C	478	PAB7Fh	4		
FROZEN POINT, TX (NE)		PEM1Ch	15	PEM1C	195		
FROZEN POINT, TX (NE)		PEM1F	19	PEM1Ch	38		
FROZEN POINT, TX (NE)		PEM1Fh	278	PEM1Chx	25		
FROZEN POINT, TX (NE)		PEM1Fhs	20	PEM1F	36		
FROZEN POINT, TX (NE)		PEM1Fx	0	PEM1Fh	3		
FROZEN POINT, TX (NE)		PEM1KCh	759	PEM1Fx	3		
FROZEN POINT, TX (NE)		PEM1KFh	1324	PEM1Y	963		
FROZEN POINT, TX (NE)		PSS1C	1	PEM1Yhx	2		
FROZEN POINT, TX (NE)		PSS3Chs	90	PEM1Yx	1		
FROZEN POINT, TX (NE)		PUBF	11	POWF	76		
FROZEN POINT, TX (NE)		PUBH	7	POWFh	35		
FROZEN POINT, TX (NE)		PUBHh	9	POWFhx	2		
FROZEN POINT, TX (NE)		PUBHx	4	POWFx	5		
FROZEN POINT, TX (NE)		PUBKFh	63	POWHhx	1		
FROZEN POINT, TX (NE)		PUBKFx	9	POWHx	0		
FROZEN POINT, TX (NE)		PUBKHx	0	UA	4113		
FROZEN POINT, TX (NE)		R1UBVx	8	UAr	2409		
FROZEN POINT, TX (NE)		UAr	1294	UBs	41		
FROZEN POINT, TX (NE)		UBs	63	UU	111		
FROZEN POINT, TX (NE)		UF6	5	UUo	0		
FROZEN POINT, TX (NE)		UF6s	1				
FROZEN POINT, TX (NE)		UR	3459				
FROZEN POINT, TX (NE)		URs	18				
FROZEN POINT, TX (NE)		USS	201				
FROZEN POINT, TX (NE)		USSs	58				
FROZEN POINT, TX (NE)		UU	146				
FROZEN POINT, TX (NE)		UUo	3				
GALVESTON, TX (SE)		E1UBL	18110	E1OWL	18482	E1OW	18890
GALVESTON, TX (SE)		E1UBLx	242	E1OWLh	3	E2BB	127
GALVESTON, TX (SE)		E2EM1N	500	E1OWLx	66	E2EM	1795
GALVESTON, TX (SE)		E2EM1P	478	E2BBP	4	E2EM/E2FL	622
GALVESTON, TX (SE)		E2SS1P	40	E2EM1N	309	E2FL	430
GALVESTON, TX (SE)		E2USM	39	E2EM1N/E2FLN	21	E2FL/E2EM	18
GALVESTON, TX (SE)		E2USN	105	E2EM1P	663	L1OW	53
GALVESTON, TX (SE)		E2USNs	2	E2FLN	178	L2OW	28
GALVESTON, TX (SE)		E2USP	191	E2FLP	203	M1OW	8778
GALVESTON, TX (SE)		E2USPs	42	E2FLPh	105	M2BB	225
GALVESTON, TX (SE)		L1UBHx	27	L2FLYh	923	PEM	432
GALVESTON, TX (SE)		L2UBFhs	158	L2OWFh	105	PEM/PFL	15
GALVESTON, TX (SE)		L2UBKFh	86	M1OWL	8688	POW	16
GALVESTON, TX (SE)		L2UBKFhs	65	M2BBP	163	U	10144
GALVESTON, TX (SE)		L2USCh	15	PEM1A	9		
GALVESTON, TX (SE)		L2USChs	5	PEM1C	26		
GALVESTON, TX (SE)		L2USKAh	29	PEM1Cd	88		
GALVESTON, TX (SE)		L2USKAhs	983	PEM1F	1		
GALVESTON, TX (SE)		L2USKCh	16	PEM1Y	253		
GALVESTON, TX (SE)		M1UBL	8734	PEM1Yh	380		
GALVESTON, TX (SE)		M2USN	75	PEM1Yh/PFLYh	111		
GALVESTON, TX (SE)		M2USP	34	PFLY	10		
GALVESTON, TX (SE)		PEM1A	1	PFO6A	1		
GALVESTON, TX (SE)		PEM1Ahs	8	POWF	6		
GALVESTON, TX (SE)		PEM1C	80	POWFh	65		
GALVESTON, TX (SE)		PEM1Ch	16	POWFx	3		
GALVESTON, TX (SE)		PEM1F	5	POWG	14		
GALVESTON, TX (SE)		PEM1Fh	7	POWGhx	1		
GALVESTON, TX (SE)		PEM1Fx	2	POWH	2		
GALVESTON, TX (SE)		PEM1KAhs	553	POWHh	9		
GALVESTON, TX (SE)		PEM1KChs	15	POWHhx	1		
GALVESTON, TX (SE)		PSS2A	1	POWHx	20		
GALVESTON, TX (SE)		PSS2KAhs	4	PSS6Y	1		
GALVESTON, TX (SE)		PUBH	13	PSS6Y/PEM1Y	2		
GALVESTON, TX (SE)		PUBHh	39	UA	2265		
GALVESTON, TX (SE)		PUBHx	68	UBs	32		
GALVESTON, TX (SE)		PUSCx	3	UU	8339		
GALVESTON, TX (SE)		UA	20	UUo	21		

MAPNAME		HABITAT (1989)	ACRES (1989)	HABITAT (1979)	ACRES (1979)	HABITAT (1950's)	ACRES (1950's)
GALVESTON, TX (SE)		UBd	60				
GALVESTON, TX (SE)		UR	2069				
GALVESTON, TX (SE)		URd	18				
GALVESTON, TX (SE)		URs	39				
GALVESTON, TX (SE)		USS	459				
GALVESTON, TX (SE)		UU	7985				
GALVESTON, TX (SE)		UUo	127				
GALVESTON SOUTH, TX (SE)		E1UBLx	4	E1OWL	6	E2EM	9
GALVESTON SOUTH, TX (SE)		E2EM1P	1	M1OWL	41254	M1OW	41233
GALVESTON SOUTH, TX (SE)		M1UBL	41287	M2BBP	7	M2BB	43
GALVESTON SOUTH, TX (SE)		M2USN	7	PEM1C	10	PEM	35
GALVESTON SOUTH, TX (SE)		M2USP	6	PEM1Y	22	POW	6
GALVESTON SOUTH, TX (SE)		PEM1C	3	POWF	1	U	297
GALVESTON SOUTH, TX (SE)		PEM1Fx	2	POWG	4		
GALVESTON SOUTH, TX (SE)		PSS1C	3	POWGx	10		
GALVESTON SOUTH, TX (SE)		PUBH	1	POWx	9		
GALVESTON SOUTH, TX (SE)		PUBHx	26	PSS6C	3		
GALVESTON SOUTH, TX (SE)		UR	182	UA	289		
GALVESTON SOUTH, TX (SE)		USS	6	UU	6		
GALVESTON SOUTH, TX (SE)		UU	92				
HIGH ISLAND, TX (NE)		E1UBL	2545	E1OWL	2513	E1OW	2452
HIGH ISLAND, TX (NE)		E1UBLx	509	E1OWLh	16	E2AB	32
HIGH ISLAND, TX (NE)		E2EM1N	492	E1OWLhx	148	E2EM	21966
HIGH ISLAND, TX (NE)		E2EM1P	20050	E1OWLx	32	E2FL	852
HIGH ISLAND, TX (NE)		E2SS1P	18	E2EM1N	6461	E2OW	0
HIGH ISLAND, TX (NE)		E2USM	242	E2EM1Nx/E2FLNx	15	L1OW	120
HIGH ISLAND, TX (NE)		E2USN	301	E2EM1P	12387	M1OW	9796
HIGH ISLAND, TX (NE)		E2USP	5			M2BB	176
HIGH ISLAND, TX (NE)		L2AB3KHh	341	E2FL6P	64	PAB	5
HIGH ISLAND, TX (NE)		L2USAhs	149	E2FLM	10	PEM	21
HIGH ISLAND, TX (NE)		L2USChs	11	E2FLN	1169	PFL	5
HIGH ISLAND, TX (NE)		M1UBL	9894	E2FLP	414	POW	30
HIGH ISLAND, TX (NE)		M2USN	92	E2SS3P	141	PSS	1
HIGH ISLAND, TX (NE)		M2USP	108	L2AB7Hh	323	U	6016
HIGH ISLAND, TX (NE)		PEM1A	75	M1OWL	9811		
HIGH ISLAND, TX (NE)		PEM1C	415	M2BBP	208		
HIGH ISLAND, TX (NE)		PEM1Ch	2	PAB5F	6		
HIGH ISLAND, TX (NE)		PEM1Cx	3	PEM1A	24		
HIGH ISLAND, TX (NE)		PEM1F	221	PEM1C	1441		
HIGH ISLAND, TX (NE)		PEM1Fh	87	PEM1F	14		
HIGH ISLAND, TX (NE)		PEM1R	1117	PEM1FH/POWFh	3		
HIGH ISLAND, TX (NE)		PEM1T	72	PEM1Fhx	7		
HIGH ISLAND, TX (NE)		PSS1Ch	19	PEM1Y	3155		
HIGH ISLAND, TX (NE)		PSS1R	2	POWF	285		
HIGH ISLAND, TX (NE)		PUBF	1	POWFhx	58		
HIGH ISLAND, TX (NE)		PUBFx	8	POWHhx	7		
HIGH ISLAND, TX (NE)		PUBH	13	POWHx	7		
HIGH ISLAND, TX (NE)		PUBHh	2	PSS1A	6		
HIGH ISLAND, TX (NE)		PUBHx	24	PSS6Ch	22		
HIGH ISLAND, TX (NE)		PUBKFh	10	PSS6F/PEM1F	1		
HIGH ISLAND, TX (NE)		UAr	17	UA	1838		
HIGH ISLAND, TX (NE)		UF6	82	UBs	3		
HIGH ISLAND, TX (NE)		UR	2683	UF6	24		
HIGH ISLAND, TX (NE)		URs	477	UU	686		
HIGH ISLAND, TX (NE)		USS	213	UUo	107		
HIGH ISLAND, TX (NE)		USSs	16	UUoA	49		
HIGH ISLAND, TX (NE)		UU	1071				
HIGH ISLAND, TX (NE)		UUo	69				
HIGHLANDS, TX (NW)		E1UBL	4951	E1OWL	5344	E1OW	2761
HIGHLANDS, TX (NW)		E1UBLx	157	E1OWLx	314	E2EM	338
HIGHLANDS, TX (NW)		E2EM1N/E2USN	7	E2EM1N	18	E2EM/E2FL	1152
HIGHLANDS, TX (NW)		E2EM1N	57	E2EM1N/E2FLN	1	E2FL	624
HIGHLANDS, TX (NW)		E2EM1P	136	E2EM1P	188	L1OW	36
HIGHLANDS, TX (NW)		E2SS1P/E2EM1P	19	E2FLM	1	L2FL	5
HIGHLANDS, TX (NW)		E2USN/E2EM1N	1	E2FLN	14	L2OW	423
HIGHLANDS, TX (NW)		E2USM	359	L1OWFx	72	PEM	263
HIGHLANDS, TX (NW)		E2USN	83	L1OWHh	452	PEM/PSS	3
HIGHLANDS, TX (NW)		E2USP	184	L1OWHhx	187	PFL	93
HIGHLANDS, TX (NW)		L1UBHh	436	L1OWV	266	PFO	123
HIGHLANDS, TX (NW)		L1UBHx	238	L2FLV	4	PFO/PEM	11
HIGHLANDS, TX (NW)		L1UBKHh	189	L2FLYhs	132	POW	184
HIGHLANDS, TX (NW)		L1UBV	19	PAB5V	12	PSS	13

MAPNAME		HABITAT (1989)	ACRES (1989)	HABITAT (1979)	ACRES (1979)	HABITAT (1950's)	ACRES (1950's)
HIGHLANDS, TX (NW)		L1UBVx	240	PAB6H	53	R1OW	271
HIGHLANDS, TX (NW)		L2USCh	42	PAB7Hhxs	26	R2FL	3
HIGHLANDS, TX (NW)		L2USChs	684	PEM1A	5	R2OW	23
HIGHLANDS, TX (NW)		L2USKCx	32	PEM1C	2	R4SB	2
HIGHLANDS, TX (NW)		L2USR	57	PEM1Cx	0	U	35043
HIGHLANDS, TX (NW)		PAB4Hx	0	PEM1F	1		
HIGHLANDS, TX (NW)		PEM1A	11	PEM1Fh	21		
HIGHLANDS, TX (NW)		PEM1C	4	PEM1Fhx	2		
HIGHLANDS, TX (NW)		PEM1Ch	70	PEM1T	193		
HIGHLANDS, TX (NW)		PEM1Cx	7	PEM1X	11		
HIGHLANDS, TX (NW)		PEM1F	33	PEM1Y	318		
HIGHLANDS, TX (NW)		PEM1Fh	2	PEM1Yx	26		
HIGHLANDS, TX (NW)		PEM1Fx	15	PFLY	15		
HIGHLANDS, TX (NW)		PEM1R	7	PFLYX	18		
HIGHLANDS, TX (NW)		PEM1S	1	PFO6A	27		
HIGHLANDS, TX (NW)		PEM1T	175	PFO6C	13		
HIGHLANDS, TX (NW)		PFO1/2C	68	PFO6F	19		
HIGHLANDS, TX (NW)		PFO1/2F	3	PFO6R	3		
HIGHLANDS, TX (NW)		PFO1A	53	PFO6Y	56		
HIGHLANDS, TX (NW)		PFO1C	61	PFO6Y/PSS6Y	11		
HIGHLANDS, TX (NW)		PFO1R	21	POWF	14		
HIGHLANDS, TX (NW)		PFO1S	169	POWFh	3		
HIGHLANDS, TX (NW)		PFO2/1C	10	POWFhx	81		
HIGHLANDS, TX (NW)		PFO2/1F	21	POWFx	44		
HIGHLANDS, TX (NW)		PFO2F	3	POWGhx	2		
HIGHLANDS, TX (NW)		PFO2Gh	23	POWh	49		
HIGHLANDS, TX (NW)		PFO2T	2	POWHh	2		
HIGHLANDS, TX (NW)		PSS1/2C	7	POWHhx	159		
HIGHLANDS, TX (NW)		PSS1A	268	POWHV	1		
HIGHLANDS, TX (NW)		PSS1Ah	6	POWThx	232		
HIGHLANDS, TX (NW)		PSS1C	9	POWT	5		
HIGHLANDS, TX (NW)		PSS1Cx	20	PSS6C/PEM1C	3		
HIGHLANDS, TX (NW)		PSS1R	49	PSS6Ch	28		
HIGHLANDS, TX (NW)		PSS1S	61	PSS6F	1		
HIGHLANDS, TX (NW)		PUBf	2	PSS6R	7		
HIGHLANDS, TX (NW)		PUBFx	40	PSS6Y	36		
HIGHLANDS, TX (NW)		PUBH	14	R1FLR	2		
HIGHLANDS, TX (NW)		PUBHh	7	R1OWV	337		
HIGHLANDS, TX (NW)		PUBHx	265	R2OWHhx	61		
HIGHLANDS, TX (NW)		PUBKHx	11	R2OWHx	93		
HIGHLANDS, TX (NW)		PUBVx	2	UA	13530		
HIGHLANDS, TX (NW)		PUSR	43	UAr	173		
HIGHLANDS, TX (NW)		R1UBV	310	UB	316		
HIGHLANDS, TX (NW)		R1USR	5	UBs	444		
HIGHLANDS, TX (NW)		R2UBHx	61	UF6	6052		
HIGHLANDS, TX (NW)		UA	4558	UU	10632		
HIGHLANDS, TX (NW)		UAr	2378	UUo	1247		
HIGHLANDS, TX (NW)		UB	94				
HIGHLANDS, TX (NW)		UBs	51				
HIGHLANDS, TX (NW)		UBx	35				
HIGHLANDS, TX (NW)		UF6	172				
HIGHLANDS, TX (NW)		UF7	4				
HIGHLANDS, TX (NW)		UF8	5361				
HIGHLANDS, TX (NW)		UR	1913				
HIGHLANDS, TX (NW)		USS	1909				
HIGHLANDS, TX (NW)		USSs	130				
HIGHLANDS, TX (NW)		UU	12687				
HIGHLANDS, TX (NW)		UUo	2309				
HITCHCOCK, TX (SW)		E1UBL	485	E1OWL	942	E1OW	362
HITCHCOCK, TX (SW)		E1UBLx	136	E1OWLh	3	E2EM	3426
HITCHCOCK, TX (SW)		E2EM1N/E2USN	616	E1OWLx	154	E2EM/E2FL	669
HITCHCOCK, TX (SW)		E2EM1N	1104	E2EM1N	2083	E2FL	115
HITCHCOCK, TX (SW)		E2EM1P	2162	E2EM1P	1635		0
HITCHCOCK, TX (SW)		E2USN/E2EM1N	53	E2FLM	4	PEM	4176
HITCHCOCK, TX (SW)		E2USM	783	E2FLN	413		0
HITCHCOCK, TX (SW)		E2USN	23	E2FLP	26	PEM/POW	1
HITCHCOCK, TX (SW)		PAB4H	1	PAB6Fx	2	PFL	17
HITCHCOCK, TX (SW)		PAB4Hx	2	PEM1A	57	PFO	2
HITCHCOCK, TX (SW)		PEM1A	61	PEM1C	154	POW	24
HITCHCOCK, TX (SW)		PEM1C	128	PEM1F	19	PSS	1
HITCHCOCK, TX (SW)		PEM1F	21	PEM1F/POWF	1	R1OW	0
HITCHCOCK, TX (SW)		PEM1R	19	PEM1Fx	0	R2OW	104
HITCHCOCK, TX (SW)		PEM1S	8	PEM1J	1	U	32674
HITCHCOCK, TX (SW)		PEM1T	14	PEM1R	22		

MAPNAME		HABITAT (1989)	ACRES (1989)	HABITAT (1979)	ACRES (1979)	HABITAT (1950's)	ACRES (1950's)
HITCHCOCK, TX (SW)		PFO1A	140	PEM1S	1		
HITCHCOCK, TX (SW)		PFO2/PFO1A	2	PEM1T	1		
HITCHCOCK, TX (SW)		PSS1A	103	PEM1Y	80		
HITCHCOCK, TX (SW)		PSS1S	17	PFO6A	97		
HITCHCOCK, TX (SW)		PUBF	0	PFO6C	38		
HITCHCOCK, TX (SW)		PUBFh	8	POWF	10		
HITCHCOCK, TX (SW)		PUBFx	0	POWFhx	11		
HITCHCOCK, TX (SW)		PUBH	4	POWFx	45		
HITCHCOCK, TX (SW)		PUBHh	1	POWG	2		
HITCHCOCK, TX (SW)		PUBHx	62	POWGhx	3		
HITCHCOCK, TX (SW)		PUSAx	25	POWHhx	8		
HITCHCOCK, TX (SW)		R1UBV	31	POWHx	16		
HITCHCOCK, TX (SW)		R1UBVx	30	PSS6C	4		
HITCHCOCK, TX (SW)		UA	7064	PSS6C/PEM1C	5		
HITCHCOCK, TX (SW)		UAr	10011	PSS6F	1		
HITCHCOCK, TX (SW)		UB	83	PSS6F/PEM1F	9		
HITCHCOCK, TX (SW)		UF6	49	PSS6S/PEM1S	2		
HITCHCOCK, TX (SW)		UF8	288	PSS6Y	7		
HITCHCOCK, TX (SW)		UR	9518	PSS6Y/PEM1Y	25		
HITCHCOCK, TX (SW)		USS	3087	R1OWV	46		
HITCHCOCK, TX (SW)		USSs	12	R2OWHx	32		
HITCHCOCK, TX (SW)		UU	5386	UA	6426		
HITCHCOCK, TX (SW)		UUo	28	UAr	20515		
HITCHCOCK, TX (SW)				UB	78		
HITCHCOCK, TX (SW)				UBs	121		
HITCHCOCK, TX (SW)				UF6	59		
HITCHCOCK, TX (SW)				UU	8358		
HITCHCOCK, TX (SW)				UUo	45		
HITCHCOCK, TX (SW)				UUs	22		
HOSKINS MOUND, TX (SW)		E1AB3L	125	E1OWL	8564	E1OW	7510
HOSKINS MOUND, TX (SW)		E1UBL	8245	E2EM1N	1818	E2BB	6
HOSKINS MOUND, TX (SW)		E1UBLx	123	E2EM1N/E2FLN	62	E2EM	6127
HOSKINS MOUND, TX (SW)		E2EM1N/E2USN	238	E2EM1P	3854	E2EM/E2FL	386
HOSKINS MOUND, TX (SW)		E2EM1P/E2USP	528	E2EM1P/E2FLP	43	E2FL	885
HOSKINS MOUND, TX (SW)		E2EM1P/E2USPs	5	E2FLN	48	L1OW	409
HOSKINS MOUND, TX (SW)		E2EM1N	1893	L1OWHx	241	PEM	5798
HOSKINS MOUND, TX (SW)		E2EM1Ns	1	L2ABHx	9	PEM/PFL	114
HOSKINS MOUND, TX (SW)		E2EM1P	4331	PAB6Hh	23		0
HOSKINS MOUND, TX (SW)		E2EM1Ps	4	PEM1A	10	PFL	17
HOSKINS MOUND, TX (SW)		E2SS1P	10	PEM1C	95	POW	51
HOSKINS MOUND, TX (SW)		E2USM	100	PEM1F	23	PSS	33
HOSKINS MOUND, TX (SW)		E2USN	28	PEM1F/POWF	47	PSS/PEM	19
HOSKINS MOUND, TX (SW)		E2USP	12	PEM1Fh/POWFh	46	R1OW	76
HOSKINS MOUND, TX (SW)		E2USPs	6	PEM1Fx	85	R4SB	0
HOSKINS MOUND, TX (SW)		L1UBFx	29	PEM1R	28	U	20192
HOSKINS MOUND, TX (SW)		L1UBHh	194	PEM1T	32		
HOSKINS MOUND, TX (SW)		L1UBHx	191	PEM1Y	2971		
HOSKINS MOUND, TX (SW)		L2UBFh	132	PEM1Yh	36		
HOSKINS MOUND, TX (SW)		L2USAh	23	PFLCx	16		
HOSKINS MOUND, TX (SW)		L2USAhs	120	PFO6A	22		
HOSKINS MOUND, TX (SW)		L2USCh	98	PFO6R	17		
HOSKINS MOUND, TX (SW)		L2USChs	53	PFO6S	18		
HOSKINS MOUND, TX (SW)		PEM1A	995	POWF	27		
HOSKINS MOUND, TX (SW)		PEM1Ah	15	POWFh	2		
HOSKINS MOUND, TX (SW)		PEM1Ax	2	POWFhx	13		
HOSKINS MOUND, TX (SW)		PEM1C	380	POWFx	69		
HOSKINS MOUND, TX (SW)		PEM1Ch	2	POWH	1		
HOSKINS MOUND, TX (SW)		PEM1Cx	13	POWHh	7		
HOSKINS MOUND, TX (SW)		PEM1F	229	POWHhx	162		
HOSKINS MOUND, TX (SW)		PEM1Fh	29	POWHx	23		
HOSKINS MOUND, TX (SW)		PEM1Fx	17	PSS1C/PEM1C	141		
HOSKINS MOUND, TX (SW)		PEM1R	26	PSS1F	9		
HOSKINS MOUND, TX (SW)		PFO1A	6	PSS6C/PEM1C	76		
HOSKINS MOUND, TX (SW)		PSS1A	19	PSS6R	9		
HOSKINS MOUND, TX (SW)		PSS1C	5	PSS6S	37		
HOSKINS MOUND, TX (SW)		PSS1R	24	PSS6T	18		
HOSKINS MOUND, TX (SW)		PSS1S	59	PSS6T/PEM1T	20		
HOSKINS MOUND, TX (SW)		PSS1T	12	PSS6Y	5		
HOSKINS MOUND, TX (SW)		PUBFh	13	R2OWHx	30		
HOSKINS MOUND, TX (SW)		PUBFx	15	UA	19222		
HOSKINS MOUND, TX (SW)		PUBH	0	UAr	2081		
HOSKINS MOUND, TX (SW)		PUBHh	32	UBs	2		
HOSKINS MOUND, TX (SW)		PUBHx	15	UU	893		
HOSKINS MOUND, TX (SW)		PUSA	4	UUo	683		

MAPNAME	HABITAT (1989)	ACRES (1989)	HABITAT (1979)	ACRES (1979)	HABITAT (1950's)	ACRES (1950's)
HOSKINS MOUND, TX (SW)	PUSAh	23				
HOSKINS MOUND, TX (SW)	PUSAhs	9				
HOSKINS MOUND, TX (SW)	PUSCh	8				
HOSKINS MOUND, TX (SW)	PUSCx	2				
HOSKINS MOUND, TX (SW)	R2UBHx	22				
HOSKINS MOUND, TX (SW)	UA	44				
HOSKINS MOUND, TX (SW)	UAr	6523				
HOSKINS MOUND, TX (SW)	UB	149				
HOSKINS MOUND, TX (SW)	UBs	20				
HOSKINS MOUND, TX (SW)	UF6	153				
HOSKINS MOUND, TX (SW)	UR	14008				
HOSKINS MOUND, TX (SW)	URs	136				
HOSKINS MOUND, TX (SW)	USS	842				
HOSKINS MOUND, TX (SW)	USSs	168				
HOSKINS MOUND, TX (SW)	UU	129				
HOSKINS MOUND, TX (SW)	UUo	993				
LA PORTE, TX (NW)	E1UBL	5712	E1OWL	5562		
LA PORTE, TX (NW)	E1UBLx	238	E1OWLx	531	E1AB	22
LA PORTE, TX (NW)	E2EM1N	24	E2EM1P	774	E1OW	4528
LA PORTE, TX (NW)	E2EM1P	83	E2FL6N	18	E2AB	223
LA PORTE, TX (NW)	E2USM	93	E2FL6Nx	3	E2EM	383
LA PORTE, TX (NW)	E2USN	91	E2FLN	273	E2EM/E2FL	393
LA PORTE, TX (NW)	E2USP	25	E2FLNx	24	E2FL	1818
LA PORTE, TX (NW)	L1AB6Hh	176	E2FLP	453	L2FL	9
LA PORTE, TX (NW)	L1UBHh	395	L1OWHhx	349	L2OW	8
LA PORTE, TX (NW)	L2USAhs	152	L2AB5Hhx	2	PAB	3
LA PORTE, TX (NW)	L2USChs	1207	PAB7Fhx	4	PEM	265
LA PORTE, TX (NW)	PAB3H	2	PEM1A	3	PEM/POW	8
LA PORTE, TX (NW)	PAB4Hx	2	PEM1C	13	PFL	58
LA PORTE, TX (NW)	PEM1C	13	PEM1F	11	POW	90
LA PORTE, TX (NW)	PEM1Ch	5	PEM1Fhx/POWFhx	2	PSS	2
LA PORTE, TX (NW)	PEM1F	5	PEM1Y	73	U	33612
LA PORTE, TX (NW)	PEM1Fx	2	PEM1Yx	0		
LA PORTE, TX (NW)	PSS1A	17	PFO6A	8		
LA PORTE, TX (NW)	PSS1Ax	9	PFO6x	5		
LA PORTE, TX (NW)	PUBFx	32	PFO6Y	33		
LA PORTE, TX (NW)	PUBH	28	POWF	12		
LA PORTE, TX (NW)	PUBHh	21	POWFhx	207		
LA PORTE, TX (NW)	PUBHx	72	POWFx	53		
LA PORTE, TX (NW)	PUBKFx	3	POWHh	6		
LA PORTE, TX (NW)	PUBKHx	159	POWHhx	74		
LA PORTE, TX (NW)	PUSAx	4	POWHx	39		
LA PORTE, TX (NW)	PUSKCx	3	POWKhx	1		
LA PORTE, TX (NW)	UA	4132	PSS6A	7		
LA PORTE, TX (NW)	UB	2	PSS6C	2		
LA PORTE, TX (NW)	UBs	123	PSS6Y	10		
LA PORTE, TX (NW)	UF6	18	PSS6Y/PEM1Y	25		
LA PORTE, TX (NW)	UF8	1992	R1OWVx	12		
LA PORTE, TX (NW)	UR	4946	R2OWH	3		
LA PORTE, TX (NW)	USS	3616	UA	14493		
LA PORTE, TX (NW)	USSs	334	UB	233		
LA PORTE, TX (NW)	UU	10575	UBs	245		
LA PORTE, TX (NW)	UUo	7114	UF6	1323		
LA PORTE, TX (NW)			UU	11776		
LA PORTE, TX (NW)			UUo	4770		
LAKE COMO, TX (SE)	E1UBL	7694	E1OWL	7906	E1AB	650
LAKE COMO, TX (SE)	E1UBLx	294	E1OWLx	177	E1OW	6691
LAKE COMO, TX (SE)	E2EM1N	766	E2EM1N	1290	E2EM	1971
LAKE COMO, TX (SE)	E2EM1P	840	E2EM1P	877	E2EM/E2FL	138
LAKE COMO, TX (SE)	E2EM1Px	0	E2FLN	450	E2FL	443
LAKE COMO, TX (SE)	E2SS1P	17	E2FLP	206	E2RF	4
LAKE COMO, TX (SE)	E2SS2P	26	E2FLPh	29	L2OW	82
LAKE COMO, TX (SE)	E2USN/E2EM1N	909	E2SS6C	13	M1OW	25090
LAKE COMO, TX (SE)	E2USM	36	E2SS6P	3	M2BB	312
LAKE COMO, TX (SE)	E2USN	47	M1OWL	25235	PEM	632
LAKE COMO, TX (SE)	E2USP	141	M2BBP	205	POW	131
LAKE COMO, TX (SE)	M1UBL	25290	PEM1A	11	PSS	43
LAKE COMO, TX (SE)	M2USN	146	PEM1C	6	U	5437
LAKE COMO, TX (SE)	M2USP	122	PEM1F	15		
LAKE COMO, TX (SE)	PEM1A	26	PEM1Fh	1		
LAKE COMO, TX (SE)	PEM1C	59	PEM1Y	82		
LAKE COMO, TX (SE)	PEM1F	14	POWF	10		
LAKE COMO, TX (SE)	PSS1A	5	POWFh	10		

MAPNAME		HABITAT (1989)	ACRES (1989)	HABITAT (1979)	ACRES (1979)	HABITAT (1950's)	ACRES (1950's)
LAKE COMO, TX (SE)		PSS1C	4	POWFx	1		
LAKE COMO, TX (SE)		PSS2A	6	POWG	9		
LAKE COMO, TX (SE)		PSS1Ah	3	POWGh	15		
LAKE COMO, TX (SE)		PSS2C	23	POWGhx	0		
LAKE COMO, TX (SE)		PUBH	22	POWH	16		
LAKE COMO, TX (SE)		PUBHx	44	POWHh	22		
LAKE COMO, TX (SE)		UA	156	PSS1A	2		
LAKE COMO, TX (SE)		UF6	44	PSS6C	16		
LAKE COMO, TX (SE)		UF8	6	U	5		
LAKE COMO, TX (SE)		UR	2966	UA	3841		
LAKE COMO, TX (SE)		USS	236	UF6	33		
LAKE COMO, TX (SE)		UU	1679	UU	1140		
LAKE* COMO, TX (SE)		UUo	4				
LAKE STEPHENSON, TX (NE)		E1UBL	18399	E1OWL	19196	E1OW	17869
LAKE STEPHENSON, TX (NE)		E1UBLx	20	E1OWLh	293	E2EM	8439
LAKE STEPHENSON, TX (NE)		E2AB5M	35	E1OWLhx	6	E2EM/E2FL	191
LAKE STEPHENSON, TX (NE)		E2EM1N	214	E1OWLx	16	E2FL	195
LAKE STEPHENSON, TX (NE)		E2EM1P	9474	E2AB2N	33	E2FL	1091
LAKE STEPHENSON, TX (NE)		E2SS1P	1	E2AB5N	3	E2SS	1
LAKE STEPHENSON, TX (NE)		E2USM	950	E2EM1N	5416	PAB	13
LAKE STEPHENSON, TX (NE)		E2USN	136	E2EM1Nhx	2	PEM	877
LAKE STEPHENSON, TX (NE)		E2USP	1	E2EM1P	6899	PEM/POW	2
LAKE STEPHENSON, TX (NE)		L1UBHh	355	E2EM1Px	0		0
LAKE STEPHENSON, TX (NE)		L2AB3Hh	42	E2EM5N	69	POW	93
LAKE STEPHENSON, TX (NE)		PAB3H	22	E2FLM	2	PSS	1
LAKE STEPHENSON, TX (NE)		PEM1A	76	E2FLN	329	PSS/PEM	12
LAKE STEPHENSON, TX (NE)		PEM1C	123	E2FLP	358	R4SB	25
LAKE STEPHENSON, TX (NE)		PEM1F	28	L1OWHh	91	U	12662
LAKE STEPHENSON, TX (NE)		PEM1Fh	21	L2AB7Hh	41		
LAKE STEPHENSON, TX (NE)		PEM1R	4	PAB5F	41		
LAKE STEPHENSON, TX (NE)		PEM1S	12	PAB7F	4		
LAKE STEPHENSON, TX (NE)		PFO2F	1	PEM1C	73		
LAKE STEPHENSON, TX (NE)		PSS1A	40	PEM1F	63		
LAKE STEPHENSON, TX (NE)		PSS1C	25	PEM1Fhx	3		
LAKE STEPHENSON, TX (NE)		PSS1F	6	PEM1Y	652		
LAKE STEPHENSON, TX (NE)		PUBH	9	PEM1Yh	16		
LAKE STEPHENSON, TX (NE)		PUBHx	4	PEM1Yhx	0		
LAKE STEPHENSON, TX (NE)		UA	52	PFO2F	2		
LAKE STEPHENSON, TX (NE)		UAr	720	POWF	4		
LAKE STEPHENSON, TX (NE)		UF6	17	POWFhx	20		
LAKE STEPHENSON, TX (NE)		UF7	84	POWH	5		
LAKE STEPHENSON, TX (NE)		UF8	99	POWHh	6		
LAKE STEPHENSON, TX (NE)		UR	10138	POWHhx	18		
LAKE STEPHENSON, TX (NE)		URs	16	PSS6A	26		
LAKE STEPHENSON, TX (NE)		USS	287	PSS6C	9		
LAKE STEPHENSON, TX (NE)		UU	37	PSS6S	5		
LAKE STEPHENSON, TX (NE)		UUo	18	UA	6927		
LAKE STEPHENSON, TX (NE)				UAr	538		
LAKE STEPHENSON, TX (NE)				UF6	177		
LAKE STEPHENSON, TX (NE)				UU	101		
LAKE STEPHENSON, TX (NE)				UUo	19		
LEAGUE CITY, TX (NW)		E1UBL	4831	E1OWL	5264	E1AB	27
LEAGUE CITY, TX (NW)		E1UBLx	601	E1OWLx	291	E1OW	3460
LEAGUE CITY, TX (NW)		E2EM1N	21	E2EM1N	11	E2EM	959
LEAGUE CITY, TX (NW)		E2EM1P	268	E2EM1P	229	E2FL	171
LEAGUE CITY, TX (NW)		E2SS1P/E2EM1P	11	E2FLN	5	L1OW	45
LEAGUE CITY, TX (NW)		E2SS1P	24	L1OWHx	32	PEM	998
LEAGUE CITY, TX (NW)		E2USM	264	PAB6F	0	PFL	76
LEAGUE CITY, TX (NW)		E2USN	7	PAB6FHx	20	PFO	26
LEAGUE CITY, TX (NW)		L1UBHx	70	PEM1A	67	POW	54
LEAGUE CITY, TX (NW)		PAB4Hx	0	PEM1C	34	PSS	13
LEAGUE CITY, TX (NW)		PEM1A	53	PEM1F	59	R1OW	140
LEAGUE CITY, TX (NW)		PEM1C	59	PEM1Fx	1	R2OW	32
LEAGUE CITY, TX (NW)		PEM1F	12	PEM1T	17	U	35470
LEAGUE CITY, TX (NW)		PEM1Fh	3	PEM1Y	130		
LEAGUE CITY, TX (NW)		PEM1Fx	7	PEM1Yx	5		
LEAGUE CITY, TX (NW)		PEM1R	5	PFO6A	20		
LEAGUE CITY, TX (NW)		PEM1S	7	PFO6C	21		
LEAGUE CITY, TX (NW)		PEM1T	14	PFO6Y	14		
LEAGUE CITY, TX (NW)		PFO1/2C	2	POWF	17		
LEAGUE CITY, TX (NW)		PFO1A	14	POWFHx	4		
LEAGUE CITY, TX (NW)		PFO1S	6	POWFx	115		
LEAGUE CITY, TX (NW)		PSS1A	79	POWHhx	28		

MAPNAME		HABITAT (1989)	ACRES (1989)	HABITAT (1979)	ACRES (1979)	HABITAT (1950's)	ACRES (1950's)
LEAGUE CITY, TX (NW)		PSS1C	1	POWHx	9		
LEAGUE CITY, TX (NW)		PSS1S	2	PSS6A	2		
LEAGUE CITY, TX (NW)		PUBF	0	PSS6A/PEM1A	3		
LEAGUE CITY, TX (NW)		PUBFx	2	PSS6C	15		
LEAGUE CITY, TX (NW)		PUBH	1	PSS6F	6		
LEAGUE CITY, TX (NW)		PUBHh	20	PSS6Y	14		
LEAGUE CITY, TX (NW)		PUBHx	179	PSS6Y/PEM1Y	0		
LEAGUE CITY, TX (NW)		PUBKHx	8	R1OWV	117		
LEAGUE CITY, TX (NW)		PUBVx	3	R1OWVx	48		
LEAGUE CITY, TX (NW)		R1UBV	47	R2FLC	18		
LEAGUE CITY, TX (NW)		R1UBVx	10	R2OWH	15		
LEAGUE CITY, TX (NW)		R1USR	8	R2OWHx	31		
LEAGUE CITY, TX (NW)		R2UBHx	30	UA	15367		
LEAGUE CITY, TX (NW)		UA	3386	UB	20		
LEAGUE CITY, TX (NW)		UB	35	UBs	37		
LEAGUE CITY, TX (NW)		UBs	9	UF6	3534		
LEAGUE CITY, TX (NW)		UF6	81	UU	14954		
LEAGUE CITY, TX (NW)		UF7	58	UUo	905		
LEAGUE CITY, TX (NW)		UF8	4700				
LEAGUE CITY, TX (NW)		UR	5782				
LEAGUE CITY, TX (NW)		URs	9				
LEAGUE CITY, TX (NW)		USS	5514				
LEAGUE CITY, TX (NW)		USSs	5				
LEAGUE CITY, TX (NW)		UU	13871				
LEAGUE CITY, TX (NW)		UUo	1360				
MONT BELVIEU, TX (NE)		E1UBL	54	E1OWL	65	PEM	456
MONT BELVIEU, TX (NE)		E1UBLx	3	E2EM1P	25	PFL	0
MONT BELVIEU, TX (NE)		E2EM1P	27	L1OWHhx	56	PFO	2
MONT BELVIEU, TX (NE)		E2SS1P	3	L2AB6Hhx	300	POW	131
MONT BELVIEU, TX (NE)		L1UBHh	17	L2OWHhx	25	PSS	12
MONT BELVIEU, TX (NE)		L1UBKHh	28	PAB7Hhx	1	R1OW	131
MONT BELVIEU, TX (NE)		L2AB3Hh	231	PEM1C	45	R2OW	83
MONT BELVIEU, TX (NE)		PAB3H	3	PEM1Chx	1	R4SB	3
MONT BELVIEU, TX (NE)		PAB4Hx	3	PEM1Cx	39	U	40555
MONT BELVIEU, TX (NE)		PEM1A	7	PEM1F	21		
MONT BELVIEU, TX (NE)		PEM1C	3	PEM1F/POWF	3		
MONT BELVIEU, TX (NE)		PEM1Cx	31	PEM1Fhx	9		
MONT BELVIEU, TX (NE)		PEM1F	5	PEM1R	28		
MONT BELVIEU, TX (NE)		PEM1Fh	9	PEM1Y	17		
MONT BELVIEU, TX (NE)		PEM1Fx	5	PEM1Yh	1		
MONT BELVIEU, TX (NE)		PEM1R	2	PFLY	3		
MONT BELVIEU, TX (NE)		PEM1S	3	PFLYhx	10		
MONT BELVIEU, TX (NE)		PFO1A	1	PFO6A	5		
MONT BELVIEU, TX (NE)		PFO1C	10	PFO6C	47		
MONT BELVIEU, TX (NE)		PFO1F	3	PFO6Cd	3		
MONT BELVIEU, TX (NE)		PFO1R	1	PFO6R	6		
MONT BELVIEU, TX (NE)		PSS1C	18	PFO6Y	3		
MONT BELVIEU, TX (NE)		PSS1F	1	PFOHx	1		
MONT BELVIEU, TX (NE)		PSS1S	1	POWF	11		
MONT BELVIEU, TX (NE)		PUBFx	12	POWFhx	55		
MONT BELVIEU, TX (NE)		PUBH	30	POWFx	16		
MONT BELVIEU, TX (NE)		PUBHh	3	POWGhx	17		
MONT BELVIEU, TX (NE)		PUBHx	91	POWGx	1		
MONT BELVIEU, TX (NE)		PUBKFh	12	POWH	32		
MONT BELVIEU, TX (NE)		PUBKHh	145	POWHh	8		
MONT BELVIEU, TX (NE)		PUBKHx	79	POWHhx	251		
MONT BELVIEU, TX (NE)		R1UBV	50	POWHx	6		
MONT BELVIEU, TX (NE)		R2UBHx	3	POWT	0		
MONT BELVIEU, TX (NE)		UA	3762	PSS6A	20		
MONT BELVIEU, TX (NE)		UAr	7723	PSS6C	23		
MONT BELVIEU, TX (NE)		UB	6	PSS6Cx	2		
MONT BELVIEU, TX (NE)		UBx	10	PSS6F	38		
MONT BELVIEU, TX (NE)		UF6	24	PSS6R	2		
MONT BELVIEU, TX (NE)		UF7	773	PSS6Y	7		
MONT BELVIEU, TX (NE)		UF8	4794	R1OWV	67		
MONT BELVIEU, TX (NE)		UR	7572	R2OWHhx	135		
MONT BELVIEU, TX (NE)		USS	4527	UA	19819		
MONT BELVIEU, TX (NE)		UU	8408	UAr	3332		
MONT BELVIEU, TX (NE)		UUo	2883	UF6	56		
MONT BELVIEU, TX (NE)				UF7	4955		
MONT BELVIEU, TX (NE)				UF8	73		
MONT BELVIEU, TX (NE)				UU	8207		
MONT BELVIEU, TX (NE)				UUo	3532		

MAPNAME	HABITAT (1989)	ACRES (1989)	HABITAT (1979)	ACRES (1979)	HABITAT (1950's)	ACRES (1950's)
MORGANS POINT, TX (NE)	E1UBL	17570	E1OWL	18384	E1OW	16789
MORGANS POINT, TX (NE)	E1UBLx	131	E1OWLh	3	E2EM	1159
MORGANS POINT, TX (NE)	E2EM1Ps/E2SS1Ps	73	E1OWLx	216	E2EM/E2FL	487
MORGANS POINT, TX (NE)	E2EM1M/E2USM	2	E2EM1N	545	E2FL	1439
MORGANS POINT, TX (NE)	E2EM1N/E2USN	4	E2EM1N/E2FLN	19	PEM	242
MORGANS POINT, TX (NE)	E2EM1N	160	E2EM1P	208	PFL	52
MORGANS POINT, TX (NE)	E2EM1Ns	276	E2EM1Ph	37	POW	62
MORGANS POINT, TX (NE)	E2EM1P	564	E2FLN	320	PSS	18
MORGANS POINT, TX (NE)	E2EM1Ps	464	E2FLM	5	R1OW	56
MORGANS POINT, TX (NE)	E2SS1P	70			R2OW	51
MORGANS POINT, TX (NE)	E2SS1Ps	30	E2FLNx	1	U	21068
MORGANS POINT, TX (NE)	E2USM	418	E2FLP	68		
MORGANS POINT, TX (NE)	E2USMs	157	L1OWHhx	45		
MORGANS POINT, TX (NE)	E2USN	169	L2FLYH	37		
MORGANS POINT, TX (NE)	E2USNs	73	L2OWFh	2		
MORGANS POINT, TX (NE)	E2USP	8	PEM1A	20		
MORGANS POINT, TX (NE)	E2USPs	45	PEM1AH	22		
MORGANS POINT, TX (NE)	L1UBKHh	41	PEM1C	34		
MORGANS POINT, TX (NE)	L2USAh	1	PEM1Ch	48		
MORGANS POINT, TX (NE)	L2USAhs	96	PEM1Cx	21		
MORGANS POINT, TX (NE)	L2USCh	43	PEM1F	7		
MORGANS POINT, TX (NE)	PAB3H	1	PEM1Fh	7		
MORGANS POINT, TX (NE)	PAB3Hx	3	PEM1Fhx	1		
MORGANS POINT, TX (NE)	PEM1A	5	PEM1Fx	12		
MORGANS POINT, TX (NE)	PEM1Ax	4	PEM1Y	58		
MORGANS POINT, TX (NE)	PEM1C	32	PEM1Y/PFLY	71		
MORGANS POINT, TX (NE)	PEM1Ch	123	PEM1YH	34		
MORGANS POINT, TX (NE)	PEM1F	2	PEM1Yx	1		
MORGANS POINT, TX (NE)	PEM1Fh	2	PFLY	4		
MORGANS POINT, TX (NE)	PEM1Fx	0	PFO6C	335		
MORGANS POINT, TX (NE)	PEM1T	11	PFO6F/POWF	1		
MORGANS POINT, TX (NE)	PFO1C	41	PFO6Fhx	24		
MORGANS POINT, TX (NE)	PSS1C	9	POWF	12		
MORGANS POINT, TX (NE)	PSS1F	0	POWFh	11		
MORGANS POINT, TX (NE)	PSS1R	16	POWFhx	29		
MORGANS POINT, TX (NE)	PUBF	1	POWFx	4		
MORGANS POINT, TX (NE)	PUBFh	0	POWH	3		
MORGANS POINT, TX (NE)	PUBFx	0	POWHhx	90		
MORGANS POINT, TX (NE)	PUBH	2	POWHx	1		
MORGANS POINT, TX (NE)	PUBHh	7	PSS6A	5		
MORGANS POINT, TX (NE)	PUBHx	35	PSS6C	66		
MORGANS POINT, TX (NE)	PUBKHh	32	PSS6F	1		
MORGANS POINT, TX (NE)	PUBKHx	13	PSS6F/POWF	3		
MORGANS POINT, TX (NE)	PUSA	40	PSS6R	18		
MORGANS POINT, TX (NE)	PUSAx	8	PSS6Y	3		
MORGANS POINT, TX (NE)	PUSChs	11	PSS6Y/PEM1Y	3		
MORGANS POINT, TX (NE)	UA	4304	R4SBC	2		
MORGANS POINT, TX (NE)	UAr	80	R4SBChx	3		
MORGANS POINT, TX (NE)	UB	147	U	4		
MORGANS POINT, TX (NE)	UF6	107	UA	10490		
MORGANS POINT, TX (NE)	UF7	64	UAr	245		
MORGANS POINT, TX (NE)	UF8	2677	UBs	31		
MORGANS POINT, TX (NE)	UR	1194	UF6	2065		
MORGANS POINT, TX (NE)	URs	6	UU	6502		
MORGANS POINT, TX (NE)	USS	5606	UUo	530		
MORGANS POINT, TX (NE)	UU	5994	UUo/A	460		
MORGANS POINT, TX (NE)	UUo	451	UUo/F6	251		
OAK ISLAND, TX (NE)	E1AB3L	181	E1AB6L	80	E1OW	17722
OAK ISLAND, TX (NE)	E1UBL	16188	E1OWL	17885	E2EM	60
OAK ISLAND, TX (NE)	E1UBLx	148	E1OWLx	22	E2FL	194
OAK ISLAND, TX (NE)	E2AB5M	86	E2EM1N	120	E2RS	2
OAK ISLAND, TX (NE)	E2EM1N	76	E2EM1P	122	PEM	824
OAK ISLAND, TX (NE)	E2EM1P	169	E2FLN	77	PEM/POW	91
OAK ISLAND, TX (NE)	E2SS1P	11	E2FLP	1	PFL	3
OAK ISLAND, TX (NE)	E2USM	1411	L1OWHh	117	PFO	50
OAK ISLAND, TX (NE)	E2USN	72	PAB5F	2	PFO/PEM	7
OAK ISLAND, TX (NE)	E2USP	1	PAB7Hhx	2	POW	43
OAK ISLAND, TX (NE)	L1UBHh	3	PEM1A	33	PSS	0
OAK ISLAND, TX (NE)	PEM1A	32	PEM1C	125	PSS/PEM	5
OAK ISLAND, TX (NE)	PEM1C	266	PEM1Cx	14	R1OW	133
OAK ISLAND, TX (NE)	PEM1Ch	0	PEM1F	40	R2OW	55
OAK ISLAND, TX (NE)	PEM1Cx	2	PEM1FHx	1	U	22232
OAK ISLAND, TX (NE)	PEM1F	9	PEM1R	27		
OAK ISLAND, TX (NE)	PEM1Fx	1	PEM1Y	918		

MAPNAME		HABITAT (1989)	ACRES (1989)	HABITAT (1979)	ACRES (1979)	HABITAT (1950's)	ACRES (1950's)
OAK ISLAND, TX (NE)		PEM1R	81	PEM1Yhx	1		
OAK ISLAND, TX (NE)		PEM1T	3	PFO6A	22		
OAK ISLAND, TX (NE)		PFO1A	2	PFO6C	50		
OAK ISLAND, TX (NE)		PSS1A	31	PFO6R	3		
OAK ISLAND, TX (NE)		PSS1C	22	POWF	4		
OAK ISLAND, TX (NE)		PUB4Hh	0	POWFh	3		
OAK ISLAND, TX (NE)		PUBF	0	POWFhx	17		
OAK ISLAND, TX (NE)		PUBH	7	POWFx	0		
OAK ISLAND, TX (NE)		PUBHh	0	POWHhx	13		
OAK ISLAND, TX (NE)		PUBHx	16	POWHx	2		
OAK ISLAND, TX (NE)		PUBKHx	9	POWT	1		
OAK ISLAND, TX (NE)		PUBVx	1	PSS6C	33		
OAK ISLAND, TX (NE)		R1UBV	31	R1OWV	31		
OAK ISLAND, TX (NE)		UA	4887	UA	11357		
OAK ISLAND, TX (NE)		UAr	8062	UAr	6226		
OAK ISLAND, TX (NE)		UF6	445	UF6	2826		
OAK ISLAND, TX (NE)		UF7	385	UU	1233		
OAK ISLAND, TX (NE)		UF8	2418	UUo	12		
OAK ISLAND, TX (NE)		UR	5109				
OAK ISLAND, TX (NE)		USS	541				
OAK ISLAND, TX (NE)		UU	701				
OAK ISLAND, TX (NE)		UUo	7				
OYSTER BAYOU, TX (NE)		E1UBL	40	E1OWLHx	13	E1OW	27
OYSTER BAYOU, TX (NE)		E2EM1P	476	E2EM1N	35	E2EM	442
OYSTER BAYOU, TX (NE)		L2AB3Hh	41	E2EM1P	508	E2FL	38
OYSTER BAYOU, TX (NE)		L2UBHh	23	E2FLN	43	L1OW	61
OYSTER BAYOU, TX (NE)		PAB4H	1	L2AB7Hhx	164	PEM	2015
OYSTER BAYOU, TX (NE)		PAB4V	1	PAB7Hhx	2	PFO	74
OYSTER BAYOU, TX (NE)		PEM1A	84	PEM1A	15	POW	16
OYSTER BAYOU, TX (NE)		PEM1C	124	PEM1C	1082	PSS	21
OYSTER BAYOU, TX (NE)		PEM1Ch	57	PEM1F	107	R2OW	192
OYSTER BAYOU, TX (NE)		PEM1F	17	PEM1FHx	4	R42B	2
OYSTER BAYOU, TX (NE)		PEM1Fh	30	PEM1FHx/POWFHx	1	U	38534
OYSTER BAYOU, TX (NE)		PEM1Fx	2	PEM1Fx	2		
OYSTER BAYOU, TX (NE)		PEM1T	5	PEM1Y	725		
OYSTER BAYOU, TX (NE)		PFO1A	52	PEM1YHx	1		
OYSTER BAYOU, TX (NE)		PFO1C	3	PEM1Yx	1		
OYSTER BAYOU, TX (NE)		PSS1A	1	PFO6A	650		
OYSTER BAYOU, TX (NE)		PSS1C	4	PFO6C	296		
OYSTER BAYOU, TX (NE)		PUBF	3	POWF	23		
OYSTER BAYOU, TX (NE)		PUBFx	0	POWFHx	6		
OYSTER BAYOU, TX (NE)		PUBH	6	POWFx	1		
OYSTER BAYOU, TX (NE)		PUBHh	12	POWHhx	28		
OYSTER BAYOU, TX (NE)		PUBHx	5	POWHx	1		
OYSTER BAYOU, TX (NE)		PUBKFx	1	PSS6A	134		
OYSTER BAYOU, TX (NE)		R1UBV	59	PSS6C	71		
OYSTER BAYOU, TX (NE)		R1UBVx	15	PSS6F	1		
OYSTER BAYOU, TX (NE)		R2UBH	1	PSS6Y	2		
OYSTER BAYOU, TX (NE)		UA	1932	R1AB5V	1		
OYSTER BAYOU, TX (NE)		UAr	24032	R1AB5VHx	4		
OYSTER BAYOU, TX (NE)		UF6	1049	R1AB7VHx	3		
OYSTER BAYOU, TX (NE)		UF7	228	R1OWVHx	50		
OYSTER BAYOU, TX (NE)		UF8	1744	UA	12707		
OYSTER BAYOU, TX (NE)		UR	10915	UAr	20828		
OYSTER BAYOU, TX (NE)		USS	401	UF6	1865		
OYSTER BAYOU, TX (NE)		UU	31	UU	39		
OYSTER BAYOU, TX (NE)		UUo	20	UUo/A	598		
OYSTER BAYOU, TX (NE)				UUo/Ar	1404		
OYSTER CREEK, TX (SW)		E1UBL	1646	E1OWL	1315	E1OW	1094
OYSTER CREEK, TX (SW)		E1UBLx	65	E2EM1N	835	E2EM	3051
OYSTER CREEK, TX (SW)		E2EM1P/E2USP	48	E2EM1N/E2FLN	72	E2EM/E2FL	378
OYSTER CREEK, TX (SW)		E2EM1N	780	E2EM1P	5069	E2FL	111
OYSTER CREEK, TX (SW)		E2EM1P	5886	E2FLM	26	L1OW	368
OYSTER CREEK, TX (SW)		E2USN/E2EM1N	2	E2FLN	76	L2AB	32
OYSTER CREEK, TX (SW)		E2USP/E2EM1P	5	L1OWF	43	L2AB/L2OW	149
OYSTER CREEK, TX (SW)		E2USM	3	L1OWFh	37	L2FL	17
OYSTER CREEK, TX (SW)		E2USP	1	L1OWH	28		0
OYSTER CREEK, TX (SW)		L1UBGh	20	L1OWHh	296	PAB/POW	25
OYSTER CREEK, TX (SW)		L1UBHh	26	L1OWHx	6	PEM	8872
OYSTER CREEK, TX (SW)		L1UBHx	27	L2AB5H/L2OWH	20	PEM/PFL	3
OYSTER CREEK, TX (SW)		L2AB3H	187	L2AB7F	4	PFL	58
OYSTER CREEK, TX (SW)		L2AB3Hh	225	L2AB7Fh/L2OWFh	16	PFO	454
OYSTER CREEK, TX (SW)		L2AB4H	45	L2AB7H	19	POW	86

MAPNAME		HABITAT (1989)	ACRES (1989)	HABITAT (1979)	ACRES (1979)	HABITAT (1950's)	ACRES (1950's)
OYSTER CREEK, TX (SW)		L2UBHh	121	L2AB7H/L2OWH	216	PSS	10
OYSTER CREEK, TX (SW)		L2UBKFhx	77	L2AB7Hh	9	R1OW	508
OYSTER CREEK, TX (SW)		L2UBKFx	54	L2AB7Hh/L2OWHh	7	U	26454
OYSTER CREEK, TX (SW)		PAB4H	7	L2OWF	33		
OYSTER CREEK, TX (SW)		PEM1A	881	L2OWH	98		
OYSTER CREEK, TX (SW)		PEM1Ad	244	PEM1A	35		
OYSTER CREEK, TX (SW)		PEM1C	970	PEM1Ad	638		
OYSTER CREEK, TX (SW)		PEM1F	480	PEM1C	524		
OYSTER CREEK, TX (SW)		PEM1Fh	4	PEM1F	449		
OYSTER CREEK, TX (SW)		PEM1Fx	0	PEM1Fh	3		
OYSTER CREEK, TX (SW)		PEM1H	6	PEM1Hh/POWHh	28		
OYSTER CREEK, TX (SW)		PEM1R	629	PEM1R	763		
OYSTER CREEK, TX (SW)		PEM1S	75	PEM1T	419		
OYSTER CREEK, TX (SW)		PEM1T	310	PEM1Y	2390		
OYSTER CREEK, TX (SW)		PFO1A	631	PEM1Yh	28		
OYSTER CREEK, TX (SW)		PFO1C	44	PFLCx	40		
OYSTER CREEK, TX (SW)		PSS1C	10	PFO6A	520		
OYSTER CREEK, TX (SW)		PSS1F	1	PFO6S	74		
OYSTER CREEK, TX (SW)		PUBF	0	PFO6Y	53		
OYSTER CREEK, TX (SW)		PUBFx	4	POWF	52		
OYSTER CREEK, TX (SW)		PUBH	17	POWFh	30		
OYSTER CREEK, TX (SW)		PUBHh	5	POWFhx	5		
OYSTER CREEK, TX (SW)		PUBHx	69	POWFx	87		
OYSTER CREEK, TX (SW)		PUBKHx	35	POWH	3		
OYSTER CREEK, TX (SW)		PUBV	3	POWHh	11		
OYSTER CREEK, TX (SW)		PUBVx	22	POWHhx	4		
OYSTER CREEK, TX (SW)		PUSCx	0	POWHx	1		
OYSTER CREEK, TX (SW)		R1UBV	34	PSS1A	3		
OYSTER CREEK, TX (SW)		R1UBVx	6	R1OWV	383		
OYSTER CREEK, TX (SW)		R2UBHx	18	UA	23719		
OYSTER CREEK, TX (SW)		UA	108	UAr	38		
OYSTER CREEK, TX (SW)		UAr	421	UF6	1306		
OYSTER CREEK, TX (SW)		UB	218	UU	864		
OYSTER CREEK, TX (SW)		UBs	9	UUo	996		
OYSTER CREEK, TX (SW)		UF6	688				
OYSTER CREEK, TX (SW)		UF8	1021				
OYSTER CREEK, TX (SW)		UR	23802				
OYSTER CREEK, TX (SW)		URs	22				
OYSTER CREEK, TX (SW)		USS	473				
OYSTER CREEK, TX (SW)		USSs	6				
OYSTER CREEK, TX (SW)		UU	1193				
OYSTER CREEK, TX (SW)		UUo	5				
PORT BOLIVAR, TX (SE)		E1UBL	40150	E1OWL	40368	E1OW	40203
PORT BOLIVAR, TX (SE)		E1UBLx	199	E2EM1N	66	E2EM	317
PORT BOLIVAR, TX (SE)		E2EM1N	54	E2EM1P	133	E2FL	124
PORT BOLIVAR, TX (SE)		E2EM1Ns	20	E2FLN	59	PEM	69
PORT BOLIVAR, TX (SE)		E2EM1P	87			POW	2
PORT BOLIVAR, TX (SE)		E2SS1P	11	E2FLP	1	U	809
PORT BOLIVAR, TX (SE)		E2USMs	29	PEM1F	1		
PORT BOLIVAR, TX (SE)		E2USN	11	POWHh	1		
PORT BOLIVAR, TX (SE)		E2USP	30	UA	521		
PORT BOLIVAR, TX (SE)		E2USPs	37	UU	374		
PORT BOLIVAR, TX (SE)		L2UBFh	14				
PORT BOLIVAR, TX (SE)		L2USCh	9				
PORT BOLIVAR, TX (SE)		L2USChs	0				
PORT BOLIVAR, TX (SE)		PEM1F	27				
PORT BOLIVAR, TX (SE)		PSS1Ah	61				
PORT BOLIVAR, TX (SE)		PSS1Ch	11				
PORT BOLIVAR, TX (SE)		PUBFx	1				
PORT BOLIVAR, TX (SE)		PUBH	1				
PORT BOLIVAR, TX (SE)		PUBHx	0				
PORT BOLIVAR, TX (SE)		PUSAh	3				
PORT BOLIVAR, TX (SE)		PUSCh	9				
PORT BOLIVAR, TX (SE)		UA	48				
PORT BOLIVAR, TX (SE)		UR	183				
PORT BOLIVAR, TX (SE)		URs	149				
PORT BOLIVAR, TX (SE)		USS	34				
PORT BOLIVAR, TX (SE)		UU	330				
PORT BOLIVAR, TX (SE)		UUo	15				
SAN LUIS PASS, TX (SW)		E1UBL	2042	E1OWL	2112	E1AB	90
SAN LUIS PASS, TX (SW)		E2EM1N/E2USN	21	E2BBP	5	E1OW	2027
SAN LUIS PASS, TX (SW)		E2EM1P/E2USP	122	E2EM1N	76	E2EM	6
SAN LUIS PASS, TX (SW)		E2EM1N	105	E2EM1N/E2FLN	69	E2EM/E2FL	1450

MAPNAME		HABITAT (1989)	ACRES (1989)	HABITAT (1979)	ACRES (1979)	HABITAT (1950's)	ACRES (1950's)
SAN LUIS PASS, TX (SW)		E2EM1P	49	E2EM1P	169	E2FL	196
SAN LUIS PASS, TX (SW)		E2USP/E2EM1P	21	E2EM1P/E2FLP	47	M1OW	37502
SAN LUIS PASS, TX (SW)		E2USM	64	E2FLN	119	M2BB	200
SAN LUIS PASS, TX (SW)		E2USN	45	E2FLP	32	PEM	12
SAN LUIS PASS, TX (SW)		E2USP	49	M1OWL	37854	U	190
SAN LUIS PASS, TX (SW)		M1UBL	37850	M2BBP	101		
SAN LUIS PASS, TX (SW)		M2USN	62	PEM1C	1		
SAN LUIS PASS, TX (SW)		M2USP	93	PEM1Y	44		
SAN LUIS PASS, TX (SW)		PEM1C	2	POWFh	2		
SAN LUIS PASS, TX (SW)		PEM1F	0	POWHh	2		
SAN LUIS PASS, TX (SW)		PSS2As	1	UA	953		
SAN LUIS PASS, TX (SW)		PUBH	2	UBd	7		
SAN LUIS PASS, TX (SW)		PUBHx	2	UU	83		
SAN LUIS PASS, TX (SW)		PUSA	1				
SAN LUIS PASS, TX (SW)		UBd	13				
SAN LUIS PASS, TX (SW)		UR	698				
SAN LUIS PASS, TX (SW)		USS	229				
SAN LUIS PASS, TX (SW)		UU	206				
SEA ISLE, TX (SW)		E1AB3L	120	E1OWL	21404	E1AB	1446
SEA ISLE, TX (SW)		E1UBL	21044	E1OWLx	65	E1OW	19132
SEA ISLE, TX (SW)		E1UBLx	517	E2FLN	38	E2EM	8023
SEA ISLE, TX (SW)		E2AB3M	404	E2EM1N	2889	E2EM/E2FL	2432
SEA ISLE, TX (SW)		E2EM1N/E2USN	23	E2EM1N/E2FLN	36	E2FL	883
SEA ISLE, TX (SW)		E2EM1P/E2USP	77	E2EM1P	4076	M1OW	3232
SEA ISLE, TX (SW)		E2EM1N	1719	E2EM1P/E2FLP	33	M2BB	148
SEA ISLE, TX (SW)		E2EM1P	5673	E2FLM	11	PEM	817
SEA ISLE, TX (SW)		E2SS1P	18	E2FLN	698		0
SEA ISLE, TX (SW)		E2USN/E2EM1N	317	E2FLP	1	POW	4
SEA ISLE, TX (SW)		E2USP/E2EM1P	45	L1OWHh	177	R1OW	31
SEA ISLE, TX (SW)		E2USM	125	M1OWL	3340	U	5475
SEA ISLE, TX (SW)		E2USN	40	M2BBP	58		
SEA ISLE, TX (SW)		E2USP	128	PAB6Hh/POWHh	6		
SEA ISLE, TX (SW)		L1UBGh	222	PEM1C	169		
SEA ISLE, TX (SW)		L2USAh	111	PEM1F	3		
SEA ISLE, TX (SW)		L2USCh	91	PEM1J	1		
SEA ISLE, TX (SW)		M1UBL	3244	PEM1Y	229		
SEA ISLE, TX (SW)		M2USN	116	POWF	1		
SEA ISLE, TX (SW)		M2USP	61	POWFx	0		
SEA ISLE, TX (SW)		PEM1A	273	POWH	16		
SEA ISLE, TX (SW)		PEM1C	115	POWHh	4		
SEA ISLE, TX (SW)		PEM1F	2	POWHhx	4		
SEA ISLE, TX (SW)		PUBFx	0	UA	6347		
SEA ISLE, TX (SW)		PUBH	0	UAr	1490		
SEA ISLE, TX (SW)		PUBHh	7	UU	532		
SEA ISLE, TX (SW)		PUBHx	7				
SEA ISLE, TX (SW)		PUSAh	2				
SEA ISLE, TX (SW)		UAr	1624				
SEA ISLE, TX (SW)		UB	57				
SEA ISLE, TX (SW)		UBs	34				
SEA ISLE, TX (SW)		UF8	3				
SEA ISLE, TX (SW)		UR	4144				
SEA ISLE, TX (SW)		USS	165				
SEA ISLE, TX (SW)		USSs	305				
SEA ISLE, TX (SW)		UU	786				
SEA ISLE, TX (SW)		UUo	8				
SMITH POINT, TX (NE)		E1UBL	38776	E1OWL	39764	E1AB	14
SMITH POINT, TX (NE)		E1UBLx	3	E1OWLHx	1	E1OW	39454
SMITH POINT, TX (NE)		E2EM1N/E2USN	9	E1OWLx	2	E2EM	410
SMITH POINT, TX (NE)		E2EM1N	190	E2EM1N	218	E2FL	285
SMITH POINT, TX (NE)		E2EM1P	261	E2EM1Nhx	1	PAB	1
SMITH POINT, TX (NE)		E2SS1P	21	E2EM1P	268	PEM	45
SMITH POINT, TX (NE)		E2USM	1021	E2FLN	50	POW	3
SMITH POINT, TX (NE)		E2USN	25	E2FLP	33	U	1263
SMITH POINT, TX (NE)		E2USP	6	PAB5F	5		
SMITH POINT, TX (NE)		PAB3H	5	PAB7F	1		
SMITH POINT, TX (NE)		PEM1A	19	PEM1F	11		
SMITH POINT, TX (NE)		PEM1C	2	PEM1Y	77		
SMITH POINT, TX (NE)		PEM1F	6	POWF	6		
SMITH POINT, TX (NE)		PSS1C	3	POWFhx	2		
SMITH POINT, TX (NE)		PUBH	1	POWFx	1		
SMITH POINT, TX (NE)		PUBHx	2	POWHhx	2		
SMITH POINT, TX (NE)		UA	85	PSS6Y	32		
SMITH POINT, TX (NE)		UF8	55	UA	811		

MAPNAME		HABITAT (1989)	ACRES (1989)	HABITAT (1979)	ACRES (1979)	HABITAT (1950's)	ACRES (1950's)
SMITH POINT, TX (NE)		UR	712	UBs	8		
SMITH POINT, TX (NE)		USS	112	UF6	15		
SMITH POINT, TX (NE)		UU	153	UU	143		
SMITH POINT, TX (NE)		UUo	6	UUo	21		
TEXAS CITY, TX (SE)		E1AB3L	2	E1AB6L	84	E1OW	13775
TEXAS CITY, TX (SE)		E1AB3Lx	9	E1AB7L	4	E2EM	1888
TEXAS CITY, TX (SE)		E1UBL	12924	E1AB7Lx	2	E2EM/E2FL	11
TEXAS CITY, TX (SE)		E1UBLx	311	E1OWL	14188	E2FL	270
TEXAS CITY, TX (SE)		E2EM1N/E2USN	43	E1OWLx	379	E2SS	2
TEXAS CITY, TX (SE)		E2EM1N	537	E2EM1N	513	L1OW	888
TEXAS CITY, TX (SE)		E2EM1Ns	2	E2EM1P	828	PEM	2409
TEXAS CITY, TX (SE)		E2EM1P	392	E2EM1P/E2FLP	2	PFL	1
TEXAS CITY, TX (SE)		E2EM1Ps	0	E2FLN	28	POW	59
TEXAS CITY, TX (SE)		E2SS1P	28	E2FLP	23	R1OW	19
TEXAS CITY, TX (SE)		E2USM	1300	L1OWHhx	909	R2OW	25
TEXAS CITY, TX (SE)		E2USN	8	PAB56H	2	U	22177
TEXAS CITY, TX (SE)		E2USNs	7	PEM1A	24		
TEXAS CITY, TX (SE)		E2USP	32	PEM1C	134		
TEXAS CITY, TX (SE)		E2USPs	10	PEM1F	56		
TEXAS CITY, TX (SE)		L1UBHh	27	PEM1Y	184		
TEXAS CITY, TX (SE)		L1UBKHh	868	PEM1Yx	5		
TEXAS CITY, TX (SE)		L2UBFh	1	PFLHx	2		
TEXAS CITY, TX (SE)		L2USAhs	10	PFLYH	2		
TEXAS CITY, TX (SE)		L2USChs	7	PFO1A	3		
TEXAS CITY, TX (SE)		PAB4Hx	1	POWF	9		
TEXAS CITY, TX (SE)		PEM1A	104	POWFh	1		
TEXAS CITY, TX (SE)		PEM1Ax	1	POWFhx	1		
TEXAS CITY, TX (SE)		PEM1C	35	POWFx	1		
TEXAS CITY, TX (SE)		PEM1Ch	27	POWG	8		
TEXAS CITY, TX (SE)		PEM1Cx	1	POWGh	6		
TEXAS CITY, TX (SE)		PEM1F	5	POWGhx	2		
TEXAS CITY, TX (SE)		PEM1Fh	25	POWGx	4		
TEXAS CITY, TX (SE)		PEM1Fx	1	POWHh	20		
TEXAS CITY, TX (SE)		PEM1R	0	POWHhx	11		
TEXAS CITY, TX (SE)		PFO1R	10	POWHx	3		
TEXAS CITY, TX (SE)		PSS1/3A	5	PSS6C	2		
TEXAS CITY, TX (SE)		PSS1/3C	1	PSS6C/PEM1C	5		
TEXAS CITY, TX (SE)		PSS1A	0	R2OWHx	12		
TEXAS CITY, TX (SE)		PSS1C	8	UA	14356		
TEXAS CITY, TX (SE)		PUBF	2	UAr	877		
TEXAS CITY, TX (SE)		PUBFx	1	UU	8135		
TEXAS CITY, TX (SE)		PUBH	0	UUo	698		
TEXAS CITY, TX (SE)		PUBHh	3				
TEXAS CITY, TX (SE)		PUBHx	74				
TEXAS CITY, TX (SE)		PUBKHx	10				
TEXAS CITY, TX (SE)		PUSAx	4				
TEXAS CITY, TX (SE)		PUSKCx	13				
TEXAS CITY, TX (SE)		R1UBVx	49				
TEXAS CITY, TX (SE)		R2UBHx	14				
TEXAS CITY, TX (SE)		R2UBKHx	0				
TEXAS CITY, TX (SE)		R4SBFx	0				
TEXAS CITY, TX (SE)		UA	3184				
TEXAS CITY, TX (SE)		UAr	876				
TEXAS CITY, TX (SE)		UBs	24				
TEXAS CITY, TX (SE)		UF6	4				
TEXAS CITY, TX (SE)		UF8	4				
TEXAS CITY, TX (SE)		UR	9058				
TEXAS CITY, TX (SE)		URs	30				
TEXAS CITY, TX (SE)		USS	1443				
TEXAS CITY, TX (SE)		USSs	9				
TEXAS CITY, TX (SE)		UU	8750				
TEXAS CITY, TX (SE)		UUo	1232				
THE JETTIES, TX (SE)		E1UBL	4180	E1OWL	4332	E1OW	4201
THE JETTIES, TX (SE)		E1UBLx	3	E2EM1N	54	E2BB	60
THE JETTIES, TX (SE)		E2EM1N	213	E2EM1P	216	E2EM	90
THE JETTIES, TX (SE)		E2EM1P	89	E2FLN	239	E2EM/E2FL	399
THE JETTIES, TX (SE)		E2USN	102	E2FLP	93	E2FL	37
THE JETTIES, TX (SE)		E2USP	111	M1OWL	36243	M1OW	36347
THE JETTIES, TX (SE)		M1UBL	35956	M2BBP	94	M2BB	377
THE JETTIES, TX (SE)		M2AB5M	375	PEM1C	2	PEM	10
THE JETTIES, TX (SE)		M2USN	115	UA	236	U	52
THE JETTIES, TX (SE)		M2USP	73	UU	57		
THE JETTIES, TX (SE)		PUBHx	5				

MAPNAME		HABITAT (1989)	ACRES (1989)	HABITAT (1979)	ACRES (1979)	HABITAT (1950's)	ACRES (1950's)
THE JETTIES, TX (SE)		UBd	40				
THE JETTIES, TX (SE)		UR	215				
THE JETTIES, TX (SE)		URd	21				
THE JETTIES, TX (SE)		USS	10				
THE JETTIES, TX (SE)		UU	58				
UMBRELLA POINT, TX (NE)		E1UBL	36603	E1OWL	36792	E1OW	36576
UMBRELLA POINT, TX (NE)		E2EM1P	2	E2FLN	2	E2EM	1
UMBRELLA POINT, TX (NE)		E2USM	219	E2FLP	3	E2FL	216
UMBRELLA POINT, TX (NE)		E2USN	2	PEM1C	1	PEM	63
UMBRELLA POINT, TX (NE)		PEM1F	0	PEM1F	1	PFO	7
UMBRELLA POINT, TX (NE)		PEM1Fh	4	PEM1Fx	1	POW	2
UMBRELLA POINT, TX (NE)		PFO1C	13	PEM1Y	2	PSS	6
UMBRELLA POINT, TX (NE)		PUBFx	1	PEM1YH	3	U	4551
UMBRELLA POINT, TX (NE)		PUBH	0	PFO1A	7		
UMBRELLA POINT, TX (NE)		PUBHx	1	PFO6A	94		
UMBRELLA POINT, TX (NE)		PUSAh	3	PFO6C	44		
UMBRELLA POINT, TX (NE)		PUSCh	1	POWF	1		
UMBRELLA POINT, TX (NE)		UA	363	POWFHx	3		
UMBRELLA POINT, TX (NE)		UF6	73	POWFx	1		
UMBRELLA POINT, TX (NE)		UF8	233	POWHh	2		
UMBRELLA POINT, TX (NE)		UR	686	POWHhx	1		
UMBRELLA POINT, TX (NE)		USS	2580	PSS6C	0		
UMBRELLA POINT, TX (NE)		UU	634	UA	3447		
UMBRELLA POINT, TX (NE)				UF6	235		
UMBRELLA POINT, TX (NE)				UF8	131		
UMBRELLA POINT, TX (NE)				UU	608		
UMBRELLA POINT, TX (NE)				UUb	39		
VIRGINIA POINT, TX (SE)		E1AB3L	1	E1OWL	19038	E1OW	16404
VIRGINIA POINT, TX (SE)		E1AB5L	735	E1OWLx	717	E2AB	1
VIRGINIA POINT, TX (SE)		E1UBL	15749	E2AB2L	57	E2BB	3
VIRGINIA POINT, TX (SE)		E1UBLx	1019	E2BBP	11	E2EM	7663
VIRGINIA POINT, TX (SE)		E2EM1N	3126	E2EM1N	3179	E2EM/E2FL	2719
VIRGINIA POINT, TX (SE)		E2EM1Ns	8	E2EM1N/E2FLN	115	E2FL	561
VIRGINIA POINT, TX (SE)		E2EM1P	2372	E2EM1Nx	8	L1OW	17
VIRGINIA POINT, TX (SE)		E2EM1Px	1	E2EM1P	1538	L2OW	204
VIRGINIA POINT, TX (SE)		E2SS1P	74	E2EM1P/E2FLP	43	PEM	545
VIRGINIA POINT, TX (SE)		E2SS2P	5	E2FLN	1318	PFL	7
VIRGINIA POINT, TX (SE)		E2SS3P	19	E2FLP	118	POW	102
VIRGINIA POINT, TX (SE)		E2SS3Ps	5	E2FLPx	5	R1OW	0
VIRGINIA POINT, TX (SE)		E2USN/E2EM1N	81	E2SS3P	21	U	13346
VIRGINIA POINT, TX (SE)		E2USM	2348	E2SS6P	83		
VIRGINIA POINT, TX (SE)		E2USMs	126	L1OWGx	29		
VIRGINIA POINT, TX (SE)		E2USN	34	L1OWHh	131		
VIRGINIA POINT, TX (SE)		E2USNs	1	L2FLYH	166		
VIRGINIA POINT, TX (SE)		E2USP	112	L2OWFh	13		
VIRGINIA POINT, TX (SE)		E2USPs	26	L2OWHh	146		
VIRGINIA POINT, TX (SE)		L1AB4KHh	101	PEM1A	14		
VIRGINIA POINT, TX (SE)		L1UBHx	92	PEM1C	29		
VIRGINIA POINT, TX (SE)		L2UBFh	15	PEM1Ch	5		
VIRGINIA POINT, TX (SE)		L2UBFhs	34	PEM1F	50		
VIRGINIA POINT, TX (SE)		L2UBKFh	1	PEM1Fhx	2		
VIRGINIA POINT, TX (SE)		L2USAhs	78	PEM1Y	90		
VIRGINIA POINT, TX (SE)		L2USChs	141	PEM1Yh	33		
VIRGINIA POINT, TX (SE)		L2USKAh	67	PEM1hx	4		
VIRGINIA POINT, TX (SE)		L2USKCh	17	PFLY	21		
VIRGINIA POINT, TX (SE)		L2USKCx	1	PFLYH	20		
VIRGINIA POINT, TX (SE)		PEM1A	12	PFLYHx	8		
VIRGINIA POINT, TX (SE)		PEM1Ahs	67	PFO6A	9		
VIRGINIA POINT, TX (SE)		PEM1Ax	38	POWF	2		
VIRGINIA POINT, TX (SE)		PEM1C	54	POWFh	11		
VIRGINIA POINT, TX (SE)		PEM1Cx	15	POWFhx	3		
VIRGINIA POINT, TX (SE)		PEM1Fx	37	POWFx	46		
VIRGINIA POINT, TX (SE)		PSS1A	20	POWGhx	307		
VIRGINIA POINT, TX (SE)		PSS2A	7	POWGx	15		
VIRGINIA POINT, TX (SE)		PUBF	1	POWH	13		
VIRGINIA POINT, TX (SE)		PUBFx	35	POWHh	48		
VIRGINIA POINT, TX (SE)		PUBH	0	POWHhx	36		
VIRGINIA POINT, TX (SE)		PUBHx	181	PSS6A	1		
VIRGINIA POINT, TX (SE)		PUBKCx	4	PSS6C/PEM1C	6		
VIRGINIA POINT, TX (SE)		PUBKHh	121	UA	5043		
VIRGINIA POINT, TX (SE)		PUBKHx	43	UBs	351		
VIRGINIA POINT, TX (SE)		PUSAx	27	UBx	111		
VIRGINIA POINT, TX (SE)		PUSCx	22	UU	6078		

MAPNAME		HABITAT (1989)	ACRES (1989)	HABITAT (1979)	ACRES (1979)	HABITAT (1950's)	ACRES (1950's)
VIRGINIA POINT, TX (SE)		PUSKAh	5	UUo	2482		
VIRGINIA POINT, TX (SE)		PUSKCh	214				
VIRGINIA POINT, TX (SE)		PUSKCx	29		1286863		
VIRGINIA POINT, TX (SE)		PUSKHh	12				
VIRGINIA POINT, TX (SE)		UA	231				
VIRGINIA POINT, TX (SE)		UB	6				
VIRGINIA POINT, TX (SE)		UBs	61				
VIRGINIA POINT, TX (SE)		UBx	265				
VIRGINIA POINT, TX (SE)		UF8	12				
VIRGINIA POINT, TX (SE)		UR	4457				
VIRGINIA POINT, TX (SE)		URs	488				
VIRGINIA POINT, TX (SE)		USS	1196				
VIRGINIA POINT, TX (SE)		USSs	73				
VIRGINIA POINT, TX (SE)		UU	4941				
VIRGINIA POINT, TX (SE)		UUo	2512				
			1286885				