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FINAL REPORT

Texas Wetlands Status and Trends Online GIS Viewer

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Introduction

Coastal wetlands enhance water quality, provide flood protection, buffer against erosive storm surges, present unique recreational opportunities and provide high-quality habitat for fish and shellfish production and migratory waterfowl. Coastal wetland and aquatic habitats are essential components of inland and barrier island environments along the Texas coast. These valuable resources are highly productive biologically and chemically and are part of an ecosystem in which a variety of flora and fauna depend. Scientific investigations of wetland distribution and abundance is needed to effectively manage the habitats and guide mitigation/restoration projects.

The University of Texas at Austin, Bureau of Economic Geology (Bureau) has undertaken coast-wide studies of the status and trends of wetlands and aquatic habitats along the Texas portion of the Gulf of Mexico. Based on these studies, the BEG produced a series of GIS datasets and reports designed to determine the status and historical trends of wetlands and associated aquatic habitats. These datasets are vital tools for coastal scientists, managers, planners, and decision makers. The Bureau developed a user-friendly, interactive, web-based display of GIS-based maps of historical and current Texas wetland types, boundaries, and distribution. The new interface and website allow users to view and analyze the datasets. Project reports and wetland status data are also available. An educational resource was developed to allow students to analyze the status and trends of wetlands at Powderhorn Ranch and Mustang Island State Park. These resources (interactive map display and educational activity) are included on the updated wetlands website (<http://www.beg.utexas.edu/research/programs/coastal/wetlands/trends>). The educational activity is also included on the Texas High School Coastal Monitoring Program (THSCMP) web site (<http://www.beg.utexas.edu/thscmp-resources>).

Create Interactive Texas Wetlands Map

The Bureau of Economic Geology has created an interactive map display for presenting the status of Texas coastal wetland habitats from the 1950's, 1979, and 2000's (Fig. 1). Wetlands were mapped in accordance with the classification by

Cowardin et al. (1979), in which wetlands are classified by system (marine, estuarine, riverine, palustrine, lacustrine), subsystem (reflective of hydrologic conditions), and class (descriptive of vegetation and substrate). Maps for 1979 and the 2000's were additionally classified by subclass (subdivisions of vegetated classes only), water regime, and special modifiers. The wetland classifications presented in the application are based on the US Fish and Wildlife Service's National Wetlands Inventory (NWI; https://www.fws.gov/wetlands/documents/NWI_Wetlands_and_Deepwater_Map_Code_Diagram.pdf). Each habitat is classified based upon a series of letter and number codes that relate to Cowardin definitions. Users can toggle between the data sets and retrieve general information for each habitat area including extent (acres and hectares) and classification of habitat by clicking on the area of interest. The full description tab will return National Wetlands Inventory definitions for the wetland code as well as a link to the Bureau's Status and Trend Report for mapped region. Direct link to the interactive map can be found here: <https://coastal.beg.utexas.edu/wetlandsmap/>. The interactive map can also be accessed from the Bureau's wetland website (<http://www.beg.utexas.edu/research/programs/coastal/wetlands/trends>).

The wetlands were mapped based upon the vegetation, hydrology, and geography at the time imagery was acquired. Ground features may have changed since the imagery acquisition date. These datasets represent the extent, approximate boundary location, and type of wetland at time of imagery collection. As the trends reports demonstrate, habitat boundaries and type may change through time.

The habitat viewer application consists of an ArcGIS Server map service and a client-side application written primarily in Javascript, which presents data from the map service to the user. On the server side, data from each time period (2000's, 1970's, and 1950's) are stored in a Microsoft SQL Server database configured using ESRI's Enterprise Geodatabase schema, with each time period having its own dedicated table. Additional tables representing relevant reports and the NWI classification information are also used. These data are then served out to the internet using ArcGIS Server over secure HTTP via the ArcGIS Server REST API. The client-side application

consists of an application written primarily in Javascript, and making use of the AngularJS Model-View-Controller (MVC) library, Angular Material user interface library, and the ArcGIS API for Javascript. The interactive map is provided by the ArcGIS API, and the remaining portion of the user interface is implemented using Angular and Angular Material, which implement the business logic and user interface elements, such as buttons and the side panel, respectively.

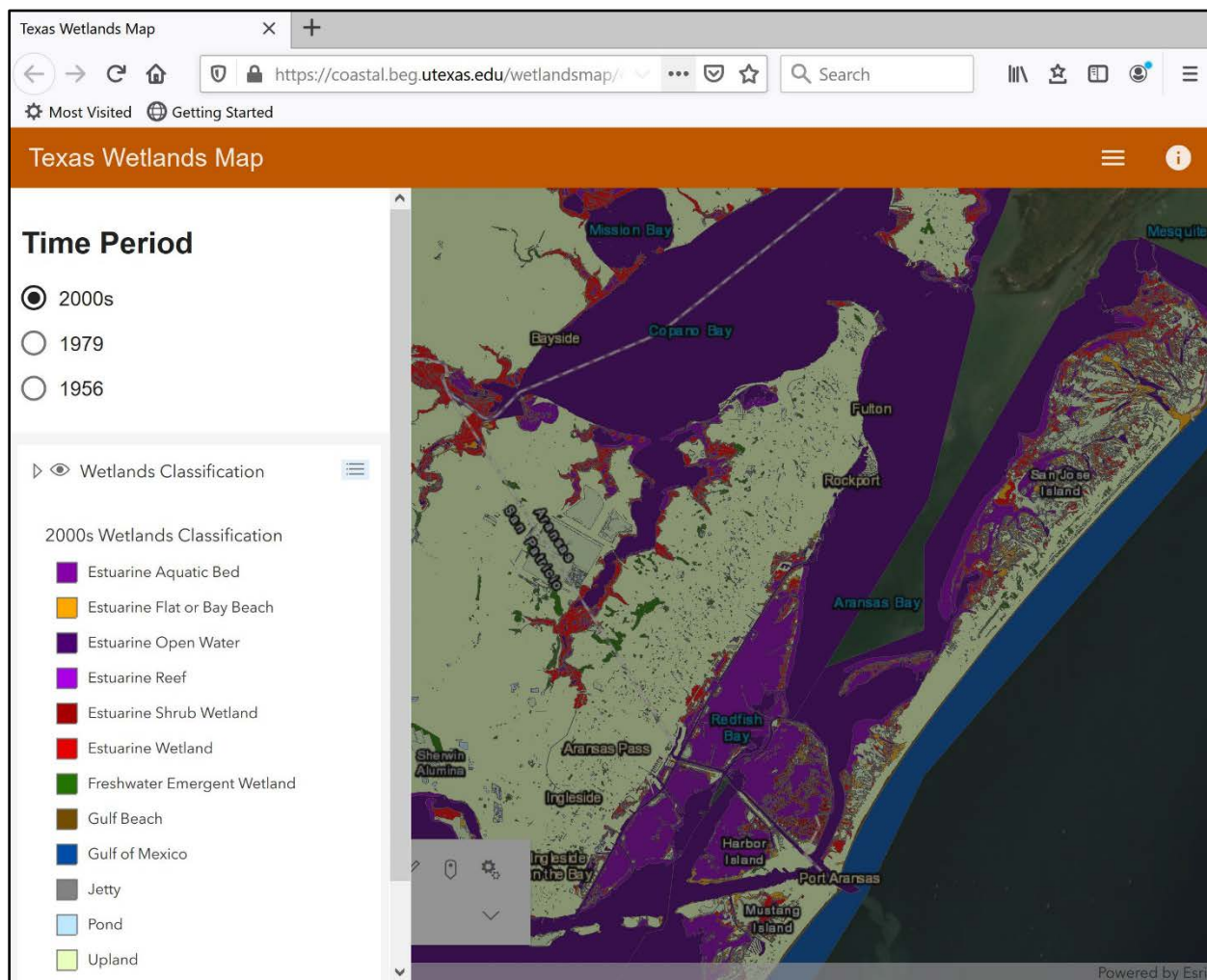


Figure 1. Display of interactive Texas wetlands map (<https://coastal.beg.utexas.edu/wetlandsmap/>).

Educational Resource Development

An educational activity was developed that uses wetland status data from two areas in the Texas coastal bend (Tremblay and Calnan, 2010; White, *et al.*, 2006). The activity

can be used in biology, environmental science, environmental systems, aquatic science, marine science, geology, and geography classrooms. Students examine two properties owned by Texas Parks and Wildlife Department to determine how wetland habitats have changed through time (1950's, 1970s, and 2000s). Both are located on the central Texas coast but in different geologic settings (barrier island and inland). Powderhorn Ranch is located on the southwestern shoreline of Matagorda Bay in Calhoun County. Mustang Island State Park is located on a barrier island near Corpus Christi, Texas in Nueces County. Students use the wetland and aquatic habitats status data from Powderhorn Ranch and Mustang Island State Park to answer questions about trends in habitat change between time periods (Fig. 2). Graphics were created including 3D column graphs; maps of wetland distribution through time; estuarine wetland, freshwater wetland, and tidal flat comparison bar graphs; and distribution tables for each location to help the students visualize the change in habitats through time. All data provided in the activity comes from Bureau status and trends reports (Tremblay and Calnan, 2010; White, *et al.*, 2006). A PDF of the activity is available through both the Bureau's wetland and Texas High School Coastal Monitoring web sites (<http://www.beg.utexas.edu/research/programs/coastal/wetlands/trends> and <http://www.beg.utexas.edu/thscmp-resources>). The activity is included as Appendix A.

Questions

1. Complete the table below by calculating the percentage of land coverage for each Powderhorn Ranch habitat (including uplands) during 1956, 1979, and 2008.

Habitat	1956		1979		2008	
	acres	%	acres	%	acres	%
Estuarine wetland	1,434		2,004		1,520	
Freshwater wetland	1,906		3,578		3,697	
Fresh OW	132		68		70	
Tidal flats	697		273		326	
Uplands	13,819		12,039		12,253	
Totals	17,989		17,963		17,866	

Figure 2. Example question from educational exercise.

Website Update

The Bureau's Status and Trends of Wetlands website

(<http://www.beg.utexas.edu/research/programs/coastal/wetlands/trends>) has been updated to include information regarding the mapping of Texas coastal habitats in the 1950's, 1979, and 2000's; project sponsor acknowledgements; and access to the wetland habitat viewer and educational resource (Fig. 3). With the update, webpages were created for each of the Bureau's wetland status and trends study areas:

- Beaumont-Port Arthur
- Brownsville-Harlingen
- Coastal Bend
- Corpus Christi and Aransas Bays
- Freeport & San Antonio Bay
- Matagorda Bay
- Matagorda Peninsula and Island
- Sargent-Quintana & Southern Padre Island
- Strandplain-Chenier & Padre Island National Seashore
- Upper Coast (Galveston I, Follets I, & Bolivar Peninsula)

Each page includes a summary of the 2000's habitat status and 1950's-2000's wetland trends for each project area (including a table and figures). The status and trends report and 2000's status data can be downloaded from the individual webpages.



Figure 3. Updated status and trends website (<http://www.beg.utexas.edu/research/programs/coastal/wetlands/trends>).

Resources

- Cowardin, L.M., Carter, V., Golet, F.C., and LaRoe, E.T., 1979. *Classification of Wetlands and Deepwater Habitats of the United States*. Washington, D.C.: United States Department of Interior, Fish and Wildlife Service, 131p.
- Tremblay, T.A., and Calnan, T. R., 2010. *Status and Trends of Inland Wetland and Aquatic Habitats, Matagorda Bay Area*. Austin, Texas: The University of Texas at Austin, *Bureau of Economic Geology Final Report Prepared for Texas General Land Office and National Oceanic and Atmospheric Administration Under Contract 09-046*, 71p.
<http://www.beg.utexas.edu/research/programs/coastal/wetlands/matagorda-bay>
- White, W.A., Tremblay, T.A., Waldinger, R. L., and Calnan, T.R., 2006. *Status and Trends of Wetland and Aquatic Habitats on Texas Barrier Islands, Coastal Bend*. Austin, Texas: The University of Texas at Austin, *Bureau of Economic Geology Final Report Prepared for Texas General Land Office and National Oceanic and Atmospheric Administration Under Contract 05-041*, 65p.
<http://www.beg.utexas.edu/research/programs/coastal/wetlands/coastal-bend>

Appendix A

The educational resources that was developed using Bureau wetland status and trend data can be found on the following pages.

Status and Trends of Wetlands in Texas Coastal Parks



Background Information.

Coastal wetlands enhance water quality, provide flood protection, buffer against erosive storm surges, present unique recreational opportunities and provide high-quality habitat for fish and shellfish production and migratory waterfowl. Coastal wetland and aquatic habitats are essential components of inland and barrier island environments along the Texas coast. These valuable resources are highly productive biologically and chemically and are part of an ecosystem in which a variety of flora and fauna depend. Scientific investigations of wetland distribution and abundance is needed to effectively manage the habitats and guide mitigation/restoration projects. The University of Texas at Austin, Bureau of Economic Geology (Bureau) has undertaken coast-wide studies of the status and trends of wetlands and aquatic habitats along the Texas portion of the Gulf of Mexico. For background information about the Bureau's wetland mapping program, please visit the status and trends website

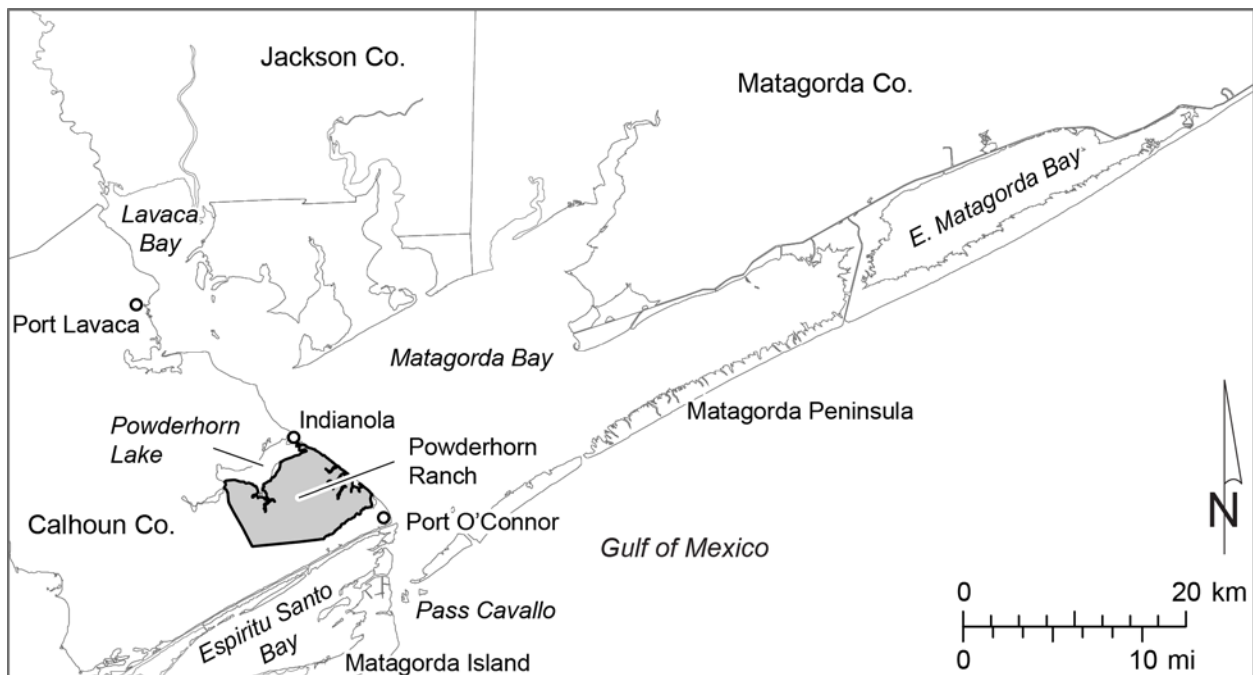
<http://www.beg.utexas.edu/research/programs/coastal/wetlands/trends>.

We are going to examine two properties owned by Texas Parks and Wildlife Department to examine how wetland habitats have changed through time (1950's, 1970s, and 2000s). Both are located on the central Texas coast but in different geologic

settings. Powderhorn Ranch is located on the southwestern shoreline of Matagorda Bay. Mustang Island State Park is located on a barrier island near Corpus Christi, Texas.

Powderhorn Ranch

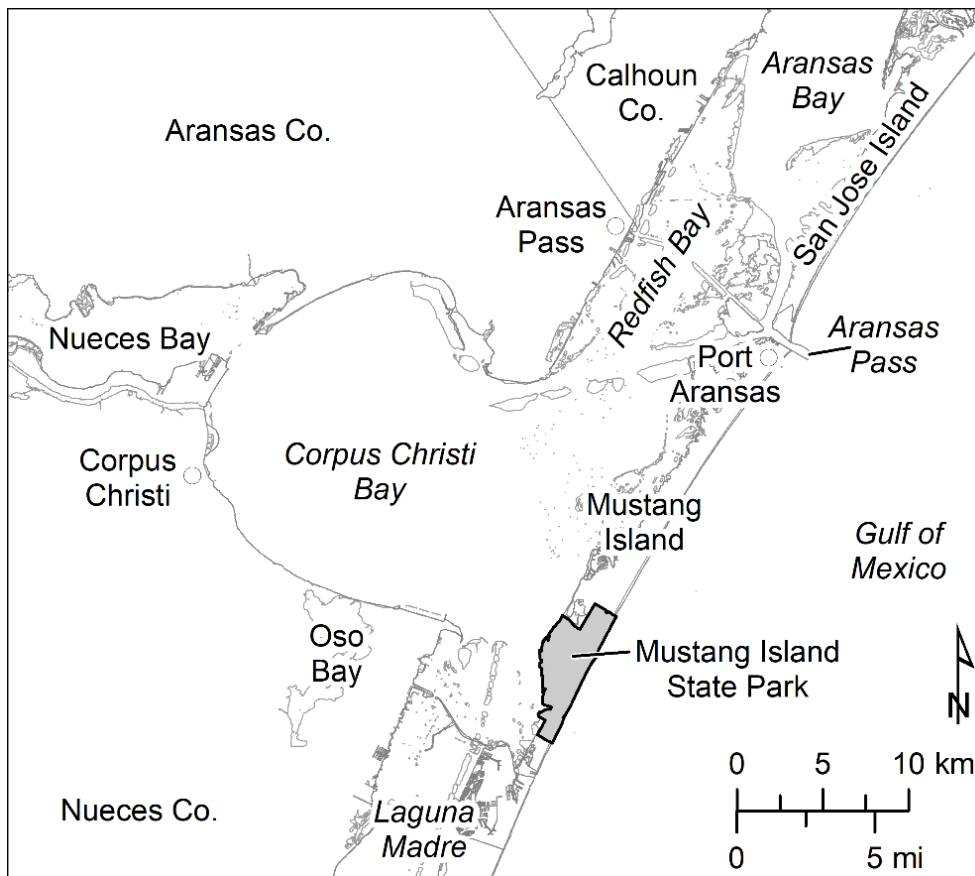
Powderhorn Ranch, located along Matagorda Bay and Powderhorn Lake in Calhoun County, is a 17,351-acre property that has been purchased for the state of Texas through a partnership among the Texas Parks and Wildlife Foundation, The Nature Conservancy (TNC), Texas Parks and Wildlife Department (TPWD), and The Conservation Fund. The environmental and conservation significance of Powderhorn Ranch is immense. It is one of the largest remaining tracts of native coastal prairie and is destined to become a state park and wildlife management area. It encompasses diverse coastal environments that include more than 12 miles of bay frontage, tallgrass prairies, fresh and saltwater wetlands, and live oak woodlands established on a Pleistocene barrier island complex (<http://www.beg.utexas.edu/prga-geology>). According to TNC, the ranch offers year-round habitat for shorebirds, wading birds, and waterfowl and critical fall-out areas for migrating birds. <http://www.beg.utexas.edu/prga-overview>



Map of the Matagorda Bay system showing the location of Powderhorn Ranch.

Mustang Island State Park

Mustang Island State Park in Nueces County, stretches from the Gulf of Mexico shoreline across Mustang Island to the waters of Corpus Christi Bay. Mustang Island was named for the wild horses that roamed the island for hundreds of years. Texas Parks and Wildlife Department bought 3,954 acres on Mustang Island in 1972 from private owners and opened Mustang Island State Park to the public in 1979. The unique and fragile barrier island ecosystem including plants, animals, birds, and sea turtles, are protected within the park's borders. Visitors can enjoy the Gulf of Mexico beach, fish in the bay, or enjoy bird watching at Mustang Island State Park. Mustang Island is an 18-mile-long barrier island, part of a chain which run along the Texas Gulf Coast. Barrier islands are long, narrow islands parallel to the coast built up by the deposition of sand. These islands protect the bay and mainland from waves, wind, tides, and storms of the Gulf of Mexico.



Map of the Corpus Christi area showing the location of Mustang Island State Park.

Wetland Habitats



Estuarine Wetlands: Low-lying, vegetated, poorly drained, coastal areas that transition between open estuarine water and uplands (land not under the influence of fresh or salt water). Vegetation in estuarine wetlands are saltwater tolerant as they are intermittently or permanently flooded with waters from the nearby estuary. An estuary is a partially enclosed coastal body of water that receives freshwater from rivers and streams and saltwater from an ocean (ex. Matagorda and Corpus Christi Bays).



Tidal Flats: Unvegetated areas that are alternately submerged or exposed by the changing tides. Occasionally the surface can be covered by algal mats (dark areas in picture above). Tidal flats that are covered and exposed in response to wind-driven waters rather than astronomical tides are called wind tidal flats.



Freshwater Wetlands: Wetlands associated with freshwater (ponds, lakes, or rivers). Areas can be permanently flooded to occasionally flooded.



Aquatic Bed: Habitats dominated by plants that grow on or below the surface of the water (seagrass). They can occur in nearshore areas in estuaries, along coastlines, and in rivers, ponds, and lakes.



Gulf Beach: Gently sloping deposit of sediment along a shore that is influenced by wind, waves, and tides. In Texas, the Gulf of Mexico shoreline is bordered by sandy beaches. Dunes are the mounds or ridges at the back edge of the beach that are usually vegetated. The vegetation helps to hold the sand in place. Dunes provide protection to the environments behind them from high water and waves.

Uplands: This is an area above normal water level. The vegetation is prairie grasses, oak mottes, invasive salt cedar, and other shrub bushes and grasses. The upland environment is where people build homes, roads, and other structures.

Additional Wetland Educational Links

Powderhorn Ranch Wetlands Status and Trends: <http://www.beg.utexas.edu/prga-wetlands>

Texas Coastal Wetlands: <https://texaswetlands.org/>

What is a wetland? National Ocean Service:
<https://oceanservice.noaa.gov/facts/wetland.html>

Coastal Wetlands: Too Valuable to Lose, NOAA Fisheries:
<https://www.fisheries.noaa.gov/national/habitat-conservation/coastal-wetlands-too-valuable-lose>

Wetland Benefits, NOAA Office for Coastal Management:
<https://coast.noaa.gov/states/fast-facts/wetland-benefits.html>

References

Tremblay, T.A., and Calnan, T. R., 2010. *Status and Trends of Inland Wetland and Aquatic Habitats, Matagorda Bay Area*. Austin, Texas: The University of Texas at Austin, Bureau of Economic Geology Final Report Prepared for Texas General Land Office and National Oceanic and Atmospheric Administration Under Contract 09-046, 71p.

<http://www.beg.utexas.edu/research/programs/coastal/wetlands/matagorda-bay>

White, W.A., Tremblay, T.A., Waldinger, R. L., and Calnan, T.R., 2006. *Status and Trends of Wetland and Aquatic Habitats on Texas Barrier Islands, Coastal Bend*. Austin, Texas: The University of Texas at Austin, Bureau of Economic Geology Final Report Prepared for Texas General Land Office and National Oceanic and Atmospheric Administration Under Contract 05-041, 65p.

<http://www.beg.utexas.edu/research/programs/coastal/wetlands/coastal-bend>

Riggio, R. R., Bomar, G. W., and Larkin, T. J., 1987. *Texas drought: its recent history (1931-1985)*. Austin, Texas: Texas Water Commission, LP 87-04, 74 p.

https://www.edwardsaquifer.org/wp-content/uploads/2019/02/1987_Riggio-et-al_TexasDrought.pdf

Instructions

Use the wetland and aquatic habitats status data provided for Powderhorn Ranch (Calhoun County, Texas) and Mustang Island State Park (Nueces County, Texas) to answer questions about trends in habitat change between time periods. Several graphics (3D column graph, distribution maps, and bar graph) and a table for each location have been provided to help you visualize the change in habitats through time.

Questions

1. Complete the table below by calculating the percentage of land coverage for each Powderhorn Ranch habitat (including uplands) during 1956, 1979, and 2008.

Habitat	1956		1979		2008	
	acres	%	acres	%	acres	%
Estuarine wetland	1,434		2,004		1,520	
Freshwater wetland	1,906		3,578		3,697	
Fresh OW	132		68		70	
Tidal flats	697		273		326	
Uplands	13,819		12,039		12,253	
Totals	17,989		17,963		17,866	

2. Look at the Powderhorn Ranch tables (above and Table 1 below) and Figures 1-3. During the following time periods did estuarine wetlands, freshwater wetlands, and tidal flats increase or decrease in coverage?

Time Period	Estuarine Wetlands	Freshwater Wetlands	Tidal Flats
1956 to 1979			
1979 to 2008			
1956 to 2008			

3. Which habitat (estuarine wetlands, freshwater wetlands, or tidal flats) is the most abundant habitat 1956? Does it remain the most abundant in 1979 and 2008? If not, which habitat is the primary habitat during those years?

4. Now look at the Mustang Island State Park data. Complete the table below by calculating the percentage of land coverage for each MISP habitat (including uplands) during 1956, 1979, and 2004.

Habitat	1956		1979		2004	
	acres	%	acres	%	acres	%
Gulf beach	297		228		150	
Estuarine wetland	275		434		471	
Palustrine wetland	39		163		73	
Fresh OW	4		6		2	
Tidal Flats	1,825		349		629	
Uplands	1,777		2,659		2,621	
Totals	4,217		3,840		3,945	

5. Look at the Mustang Island State Park tables (immediately above and Table 2 below) and Figures 4-6. During the following time periods did estuarine wetlands, freshwater wetlands, and tidal flats increase or decrease in coverage?

Time Period	Estuarine Wetlands	Freshwater Wetlands	Tidal Flats
1956 to 1979			
1979 to 2004			
1956 to 2004			

9. Look at the changes along the Powderhorn Ranch bay shoreline (Matagorda Bay) through time. What might the emergence and expansion of aquatic beds (seagrasses) tell you about sea level along the Texas coast?

10. How do you think changes in climate and sea level rise will impact wetland habitats in these two areas over the next 10 years? 50 years? 100 years?

11. Both Powderhorn Ranch and Mustang Island State Park are in a segment of the central Texas coast called the Coastal Bend. Use the Interactive Wetlands Map to view different areas of the Texas coast. Pick locations the upper coast (northeast of the Colorado River) or the lower coast (Padre Island) and compare how distribution of wetlands compares with the locations you examined above. If you look at inland areas compare with Powderhorn Ranch. If you look at areas on a barrier island, compare with Mustang Island State Park.
<https://coastal.beg.utexas.edu/wetlandsmap/#/>
*Note: Galveston and Follets Islands and Bolivar Peninsula on the upper Texas coast only have 2000s status data. All other areas have status data from the 1950s and 1970s.

Powderhorn Ranch Data

Table 1. Total area of major habitats in 1956, 1979, and 2008.

Habitat	1956		1979		2008	
	ha	acres	ha	acres	ha	acres
Estuarine wetland	580	1,434	811	2,004	615	1,520
Freshwater wetland	771	1,906	1,448	3,578	1,496	3,697
Fresh OW	53	132	27	68	28	70
Tidal flats	282	697	111	273	132	326
Uplands	5,291	13,819	4,872	12,039	4,959	12,253

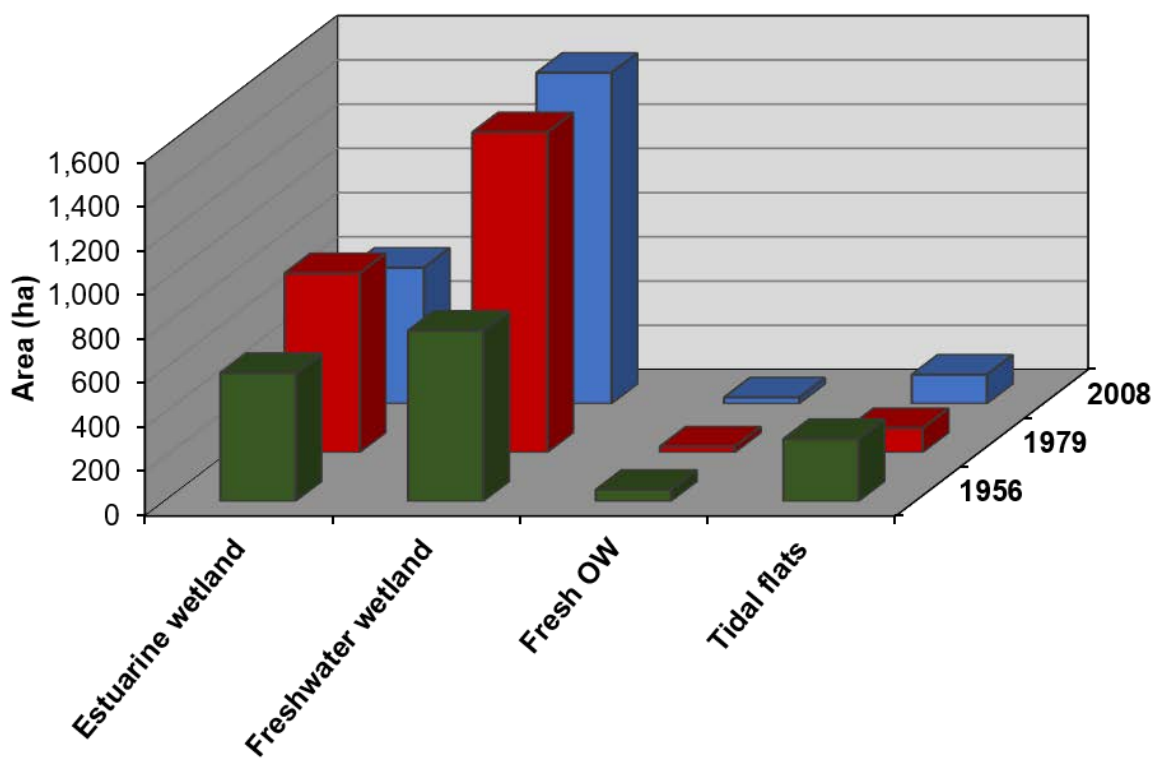


Figure 1. Distribution of major habitats at Powderhorn Ranch in 1956, 1979, and 2008. Fresh OW (open water) includes ponds and lakes. Algal flats are included with tidal flats.

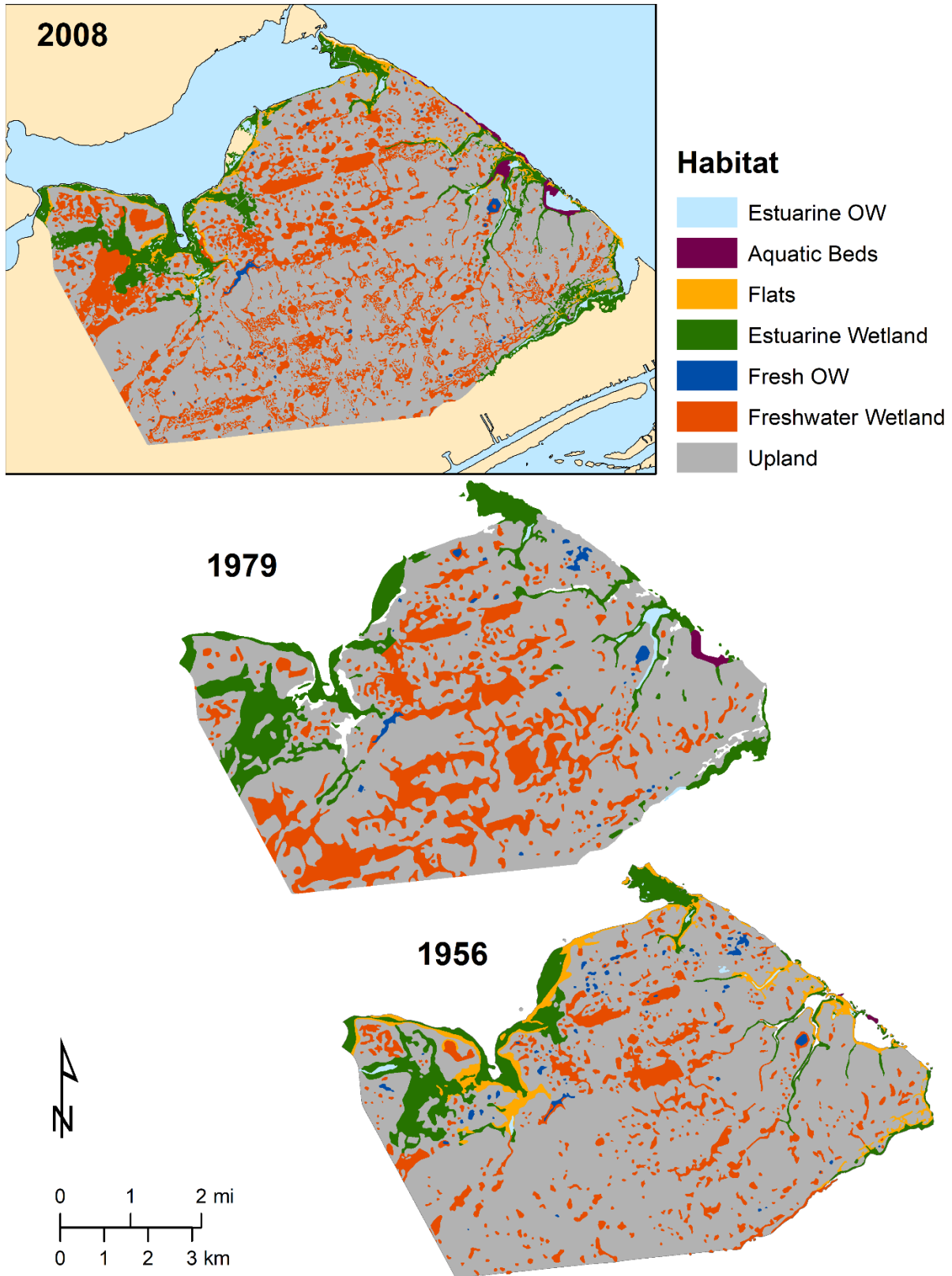


Figure 2. Maps showing distribution of major wetland and aquatic habitats in 2008, 1979, and 1956 within the Powderhorn Ranch Boundary.

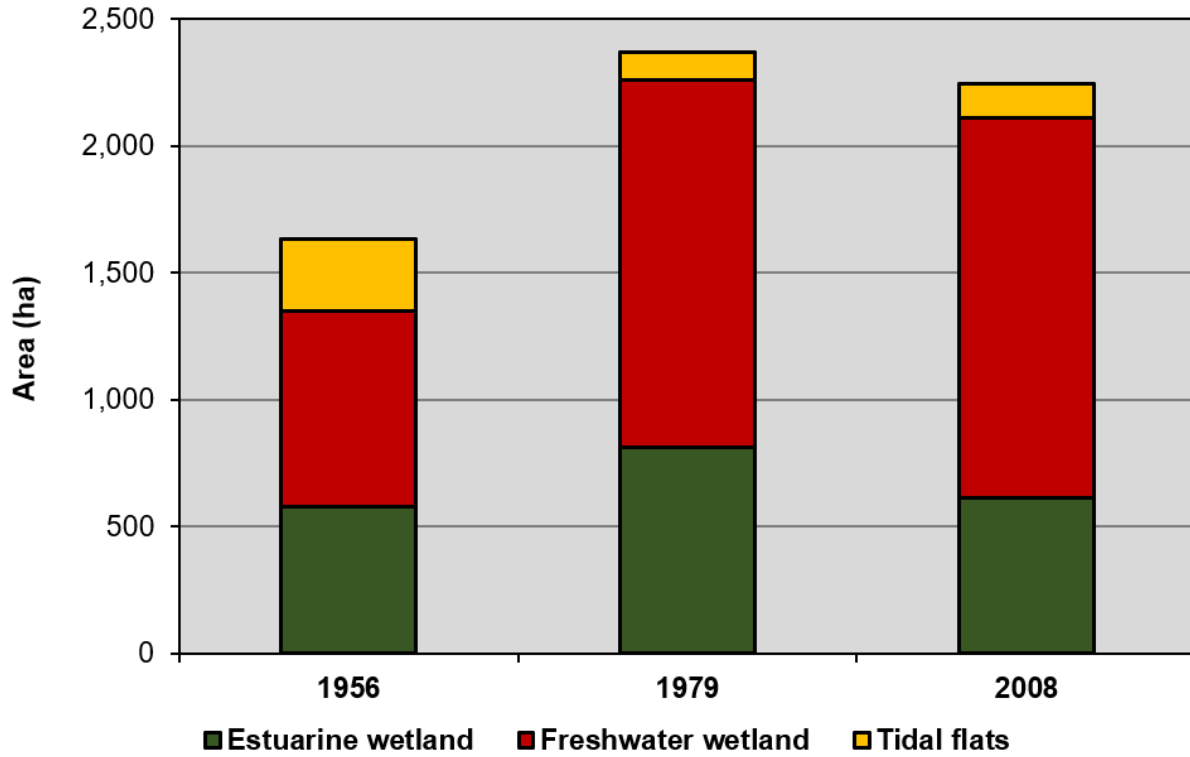


Figure 3. Distribution of estuarine wetlands, freshwater wetlands, and tidal flats in 1956, 1979, and 2008.

Mustang Island State Park Data

Table 2. Total area of major habitats in 1956, 1979, and 2004.

Habitat	1956		1979		2004	
	ha	acres	ha	acres	ha	acres
Gulf beach	120	297	92	228	61	150
Estuarine wetland	111	275	176	434	190	471
Palustrine wetland	16	39	66	163	29	73
Fresh OW	2	4	3	6	1	2
Tidal flats	739	1,825	141	349	255	629
Uplands	719	1,777	1,076	2,659	1,061	2,621

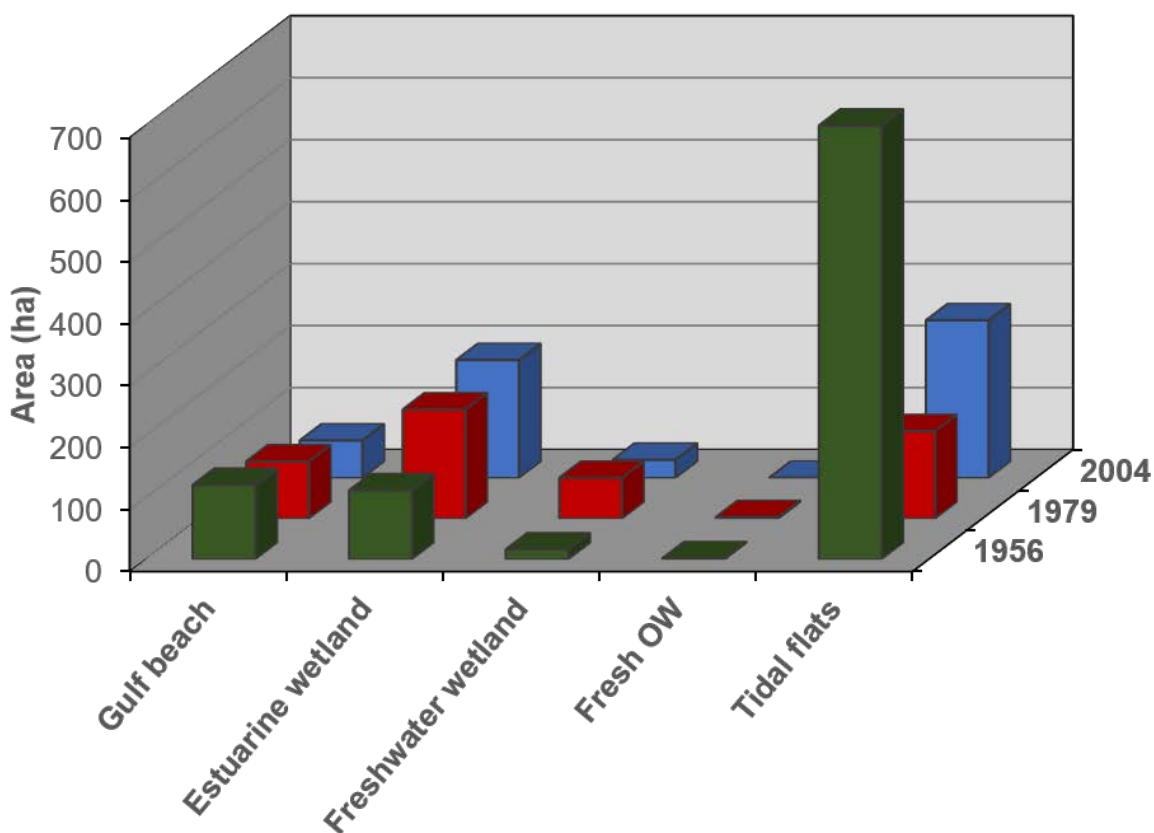


Figure 4. Distribution of major habitats at Mustang Island State Park in 1956, 1979, and 2004. Fresh OW (open water) includes ponds and lakes. Algal flats are included with tidal flats.

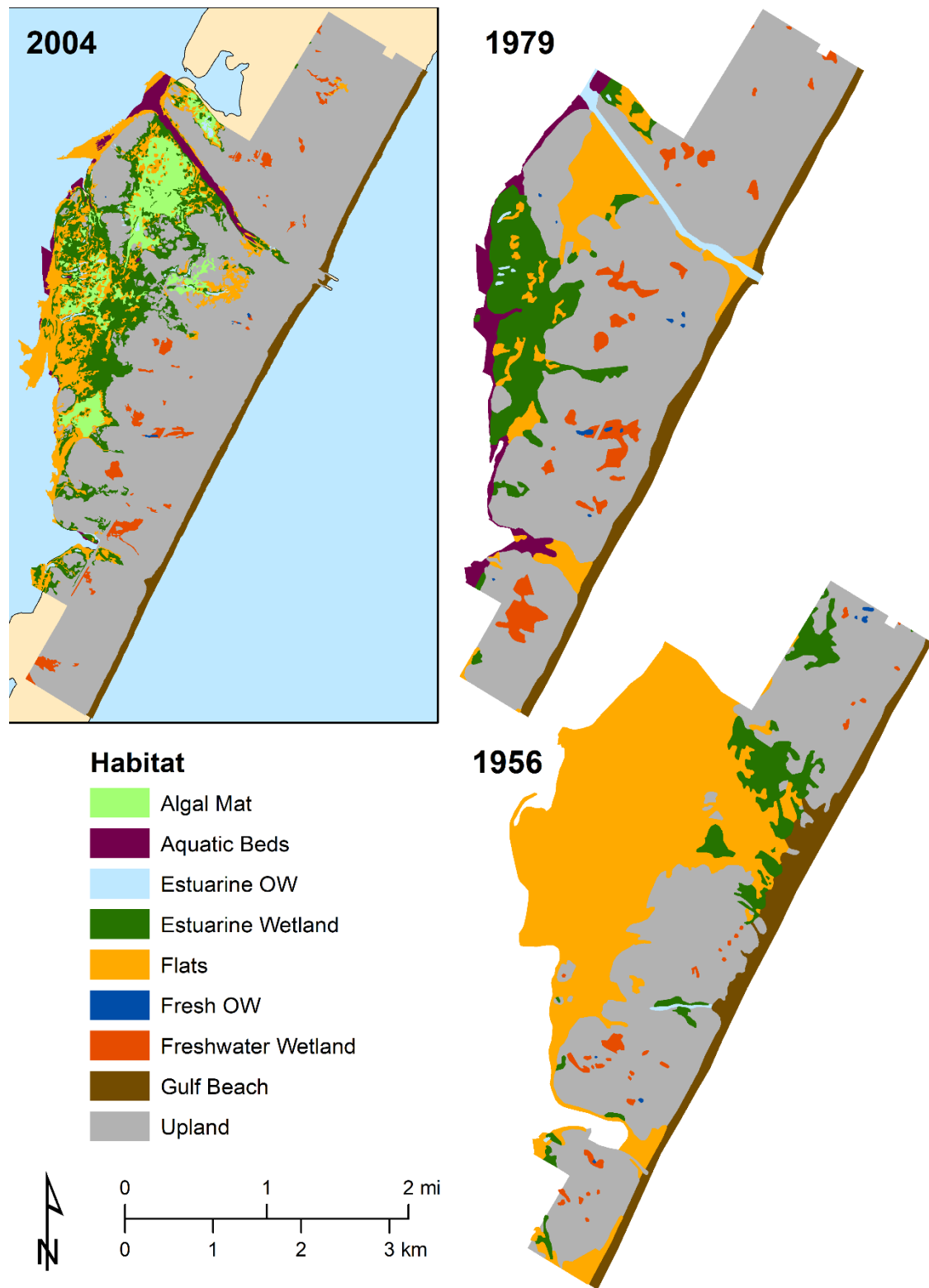


Figure 5. Maps showing distribution of major wetland and aquatic habitats in 2004, 1979, and 1956 within the Mustang Island State Park Boundary. Algal mats were mapped separately from tidal flats in 2004. They are combined in 1956 and 1979.

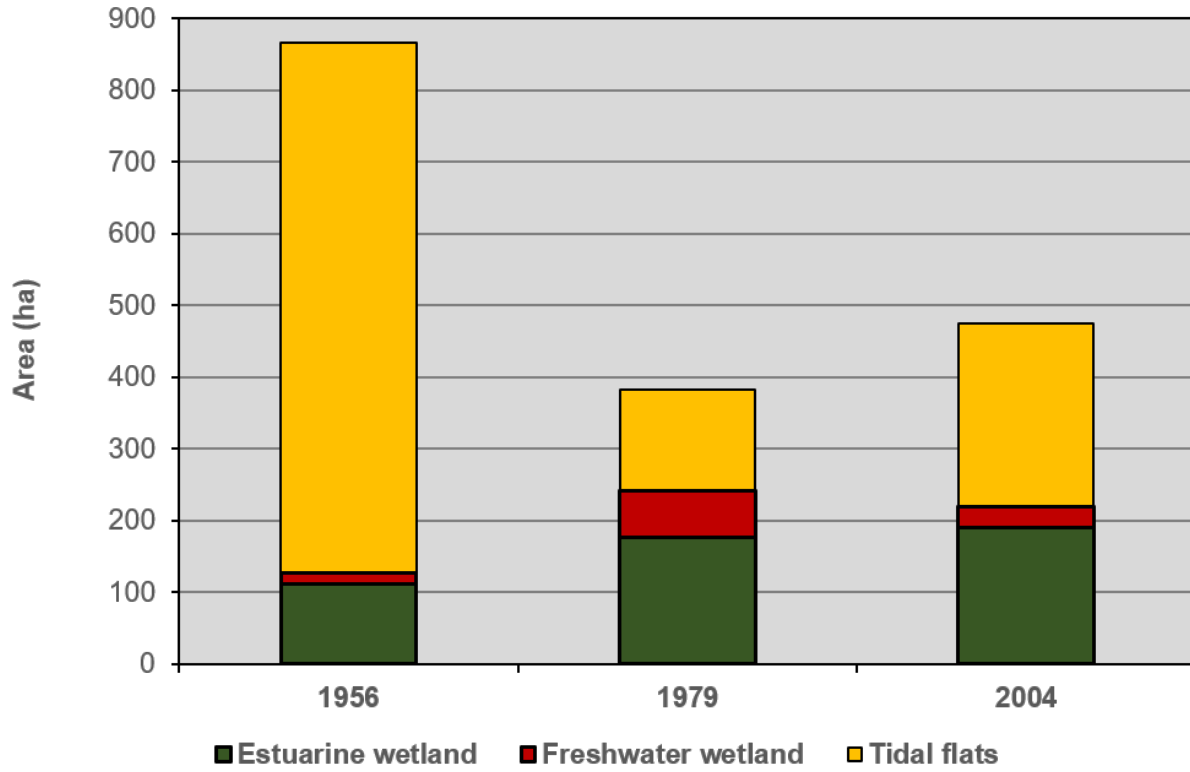


Figure 6. Distribution of estuarine wetlands, freshwater wetlands, and tidal flats in 1956, 1979, and 2008. Algal flats are included with tidal flats.

Climate and Sea Level

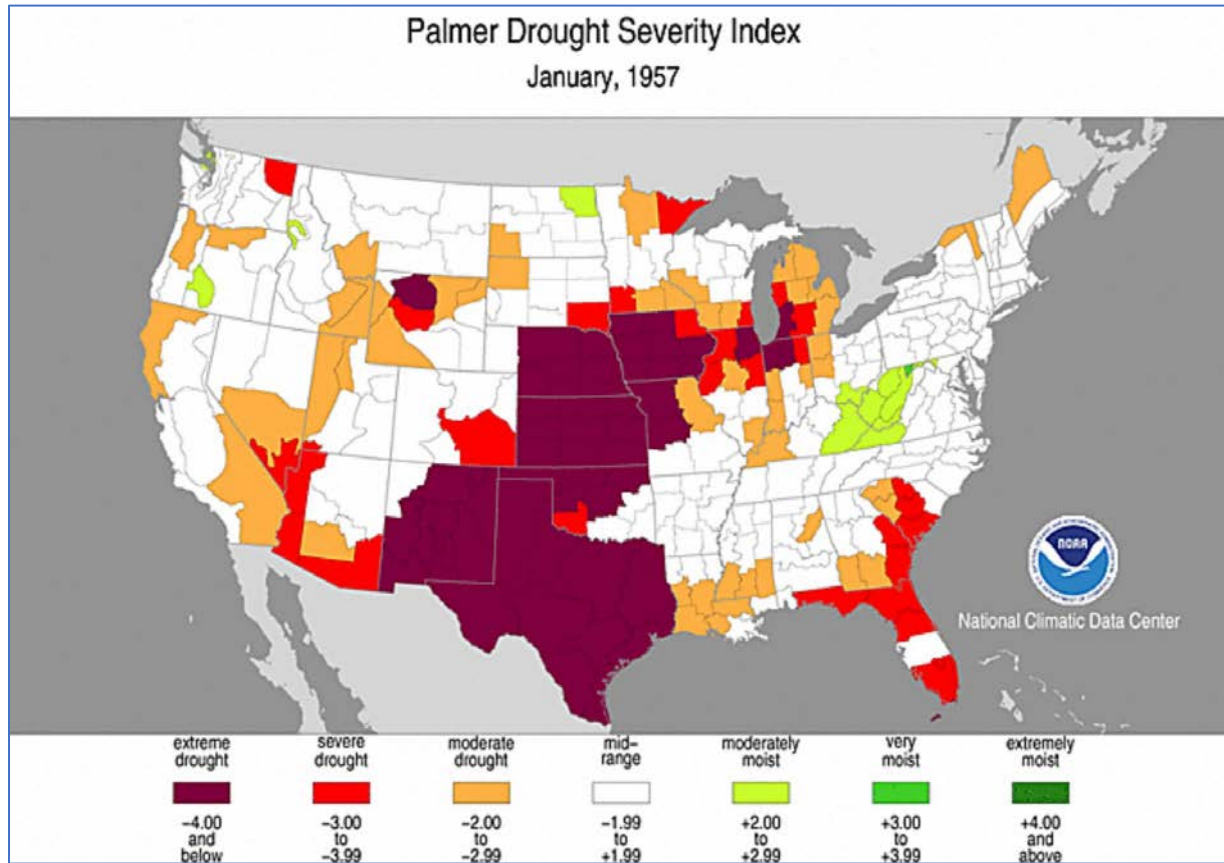


Figure 7. Drought severity index in January, 1957. Notice all of Texas is in extreme drought. Image from the National Climatic Data Center.

<https://www.ncdc.noaa.gov/temp-and-precip/drought/historical-palmers/>

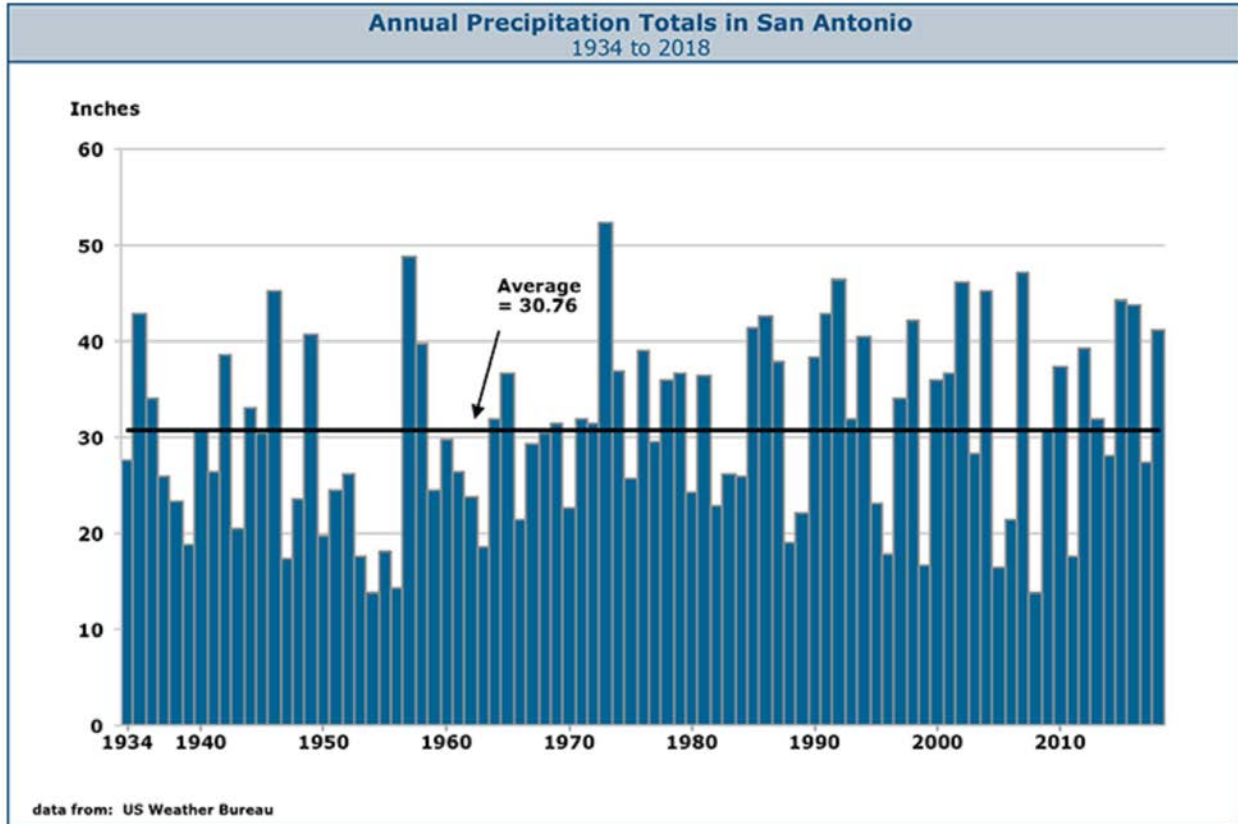


Figure 8. Annual precipitation totals in San Antonio, Texas from 1934 to 2019. Average precipitation is 30.76 inches per year. From 1950 to 1956, precipitation rates were well below average. Data is from the US Weather Bureau. Image is from the Edwards Aquifer Website (<https://www.edwardsaquifer.net/climate.html>)