

THE GREEN COAST: COMBINING TEXAS' VALUES, ECONOMY, AND ECOLOGY TO CREATE A RESILIENT COAST

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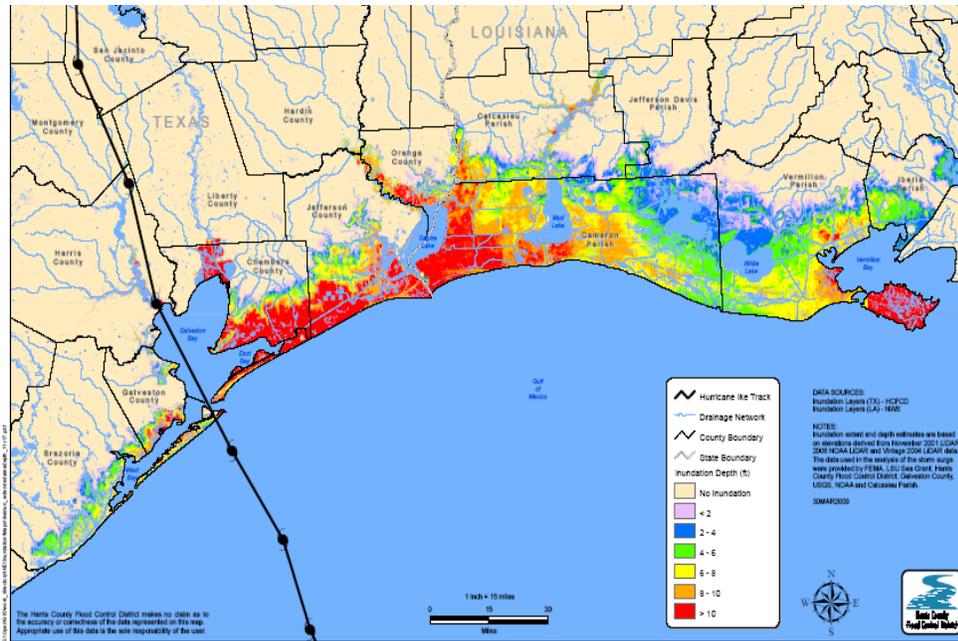
“The Green Coast: Combining Texas’ Values, Economy, and Ecology
to Create A Resilient Coast”

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The Green Coast: Combining Texas' Values, Economy, and Ecology to Create a Resilient Coast

When Hurricane Ike hit the Texas coast in 2008, the Greater Houston region dodged a bullet. To be sure, there was massive destruction to the east on the Bolivar Peninsula, to the south in Galveston, and to Galveston Bay communities such as Bacliff and Shoreacres. However, the bulk of our region escaped major damage thanks to the last-minute jog in Ike's path that took it up the middle of Galveston Bay, sending the worst surge into the wetlands and coastal prairies of Chambers and Jefferson counties, as shown in Figure 1.

Figure 1. Hurricane Ike Inundation Depth



Note: The areas flooded by Hurricane Ike extended far to the east of Galveston Bay, inundating coastal lands 15-20 miles inland.

Source: Harris County Flood Control District.

After Ike, the Severe Storm Prevention, Education, and Evacuation from Disaster (SSPEED) Center at Rice University was funded by the Houston Endowment to study and learn from Hurricane Ike and to propose solutions to reduce damage in the future. Over the intervening 10 years, much has been learned about reducing damage from hurricane surge. Perhaps more importantly, these new approaches do not simply address hurricane surge. They also produce economic benefits locally, enhance quality of life, support ecosystem integrity, rejuvenate the rural economy, and address sea level rise. These projects also offer customizable and adaptable models for coastal communities across the U.S. to address challenges presented by sea level rise and stronger and more frequent storms.

One early realization about Ike that strongly influenced the SSPEED Center's work was that the hundreds of thousands of acres of open space inundated by saltwater surge, as far as 20 miles inland, recovered relatively quickly, at little cost to the taxpayer and with no reported loss of human life. It offered a stark contrast with the devastation—human, social, and

economic—experienced on the Bolivar Peninsula and in Galveston, Bacliff, Shoreacres, and elsewhere. Based on this observation, the SSPEED Center team pursued strategies that would incentivize keeping marshes, coastal prairies and coastal bottomlands in their natural state so that the impact of future surges could be accommodated with minimal damage. In short, strategies for keeping coastal open spaces open were designed and are in the process of being implemented.

Another realization from Ike was that if its path had been slightly further south, and the worst of the surge had gone up toward the Houston Ship Channel, several hundred thousand residents would have been at risk, countless lives would have been lost, and Galveston Bay would have been home to an ecological disaster the likes of which the U.S. has not previously seen. Additionally, the impact to the industrial complex responsible for 25% of Texas' GDP and 20% of the U.S. refining capacity would have resulted in massive economic losses. So strategies for structural alternatives to protect the 2.2 million barrels of refining capacity, the several hundred petrochemical plants, and the 800,000 people living on the developed west side of Galveston Bay were also pursued.

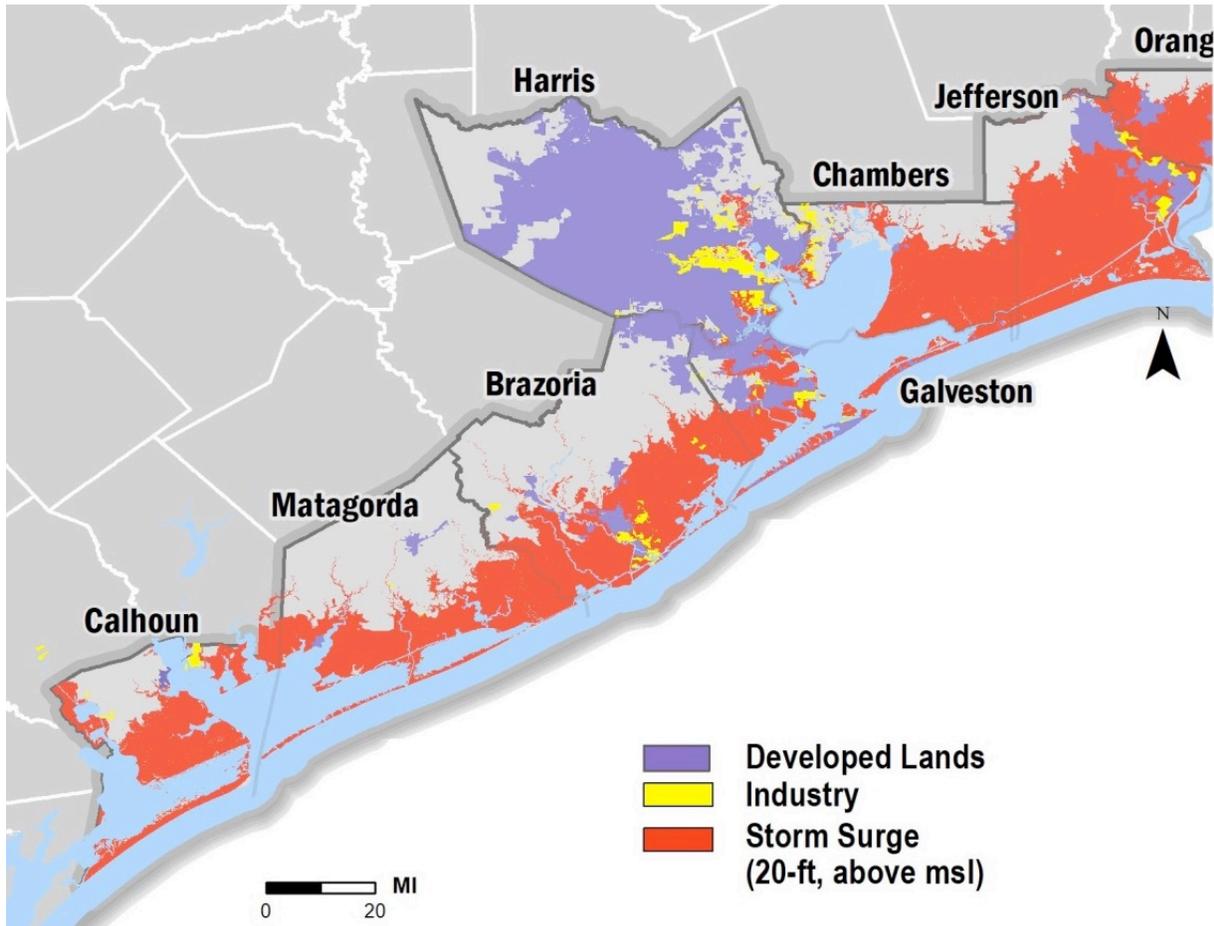
These early realizations shaped proposals that integrate economic development and nature to address our region's flood problems, along with structural solutions that serve multiple purposes. Further, these projects not only reduce damage from flooding, they also generate and reinforce other key aspects of long-term coastal resilience such as producing local and regional economic benefits, ecosystem integrity, enhanced quality of life, and rural economic rejuvenation. They are in various stages of implementation and include the proposed Lone Star Coastal National Recreation Area (LSCNRA), the Texas Coastal Exchange (TCX), and the Galveston Bay Park Plan (GBPP). Taken together along with the ongoing work of the U.S. Army Corps of Engineers (USACE) and the Texas General Land Office, these projects offer a vision for a vibrant and resilient future for the upper Texas Gulf Coast, whatever the weather may bring.

In the sections that follow, these structural and nonstructural concepts are presented. First, the nonstructural alternatives—the proposed Lone Star Coastal National Recreation Area and the Texas Coastal Exchange—are set out, with their focus on creating economic benefits around nature. Then, the structural alternative—the Galveston Bay Park Plan, which combines flood protection and industrial navigation expansion with environmental enhancement, recreation, and an outstanding quality of life amenity—is discussed, as is the USACE's plan for the coastal barrier and coastal restoration.

I. The Non-Structural Alternatives

As can be seen from Figure 2, much of the upper Texas coast is undeveloped. If the undeveloped low-lying land can be maintained in its undeveloped state, then the natural coastal systems that are surge tolerant can receive and dissipate the most damaging flooding. Figure 2 also shows the 20-foot elevation contour, which represents the demarcation of the reasonable worst-case surge threat for extensive damage.

Figure 2. Coastal High Risk Surge Area With Developed Lands and Industrial Areas



Note: Developed areas of the Texas coast are illustrated in purple, with industrial areas shown in yellow. The area shown in red is the undeveloped land that is 20 feet or lower in elevation, making it prone to surge flooding.

Source: Graphic by Christina Walsh, from *A Texan Plan for the Texas Coast*.

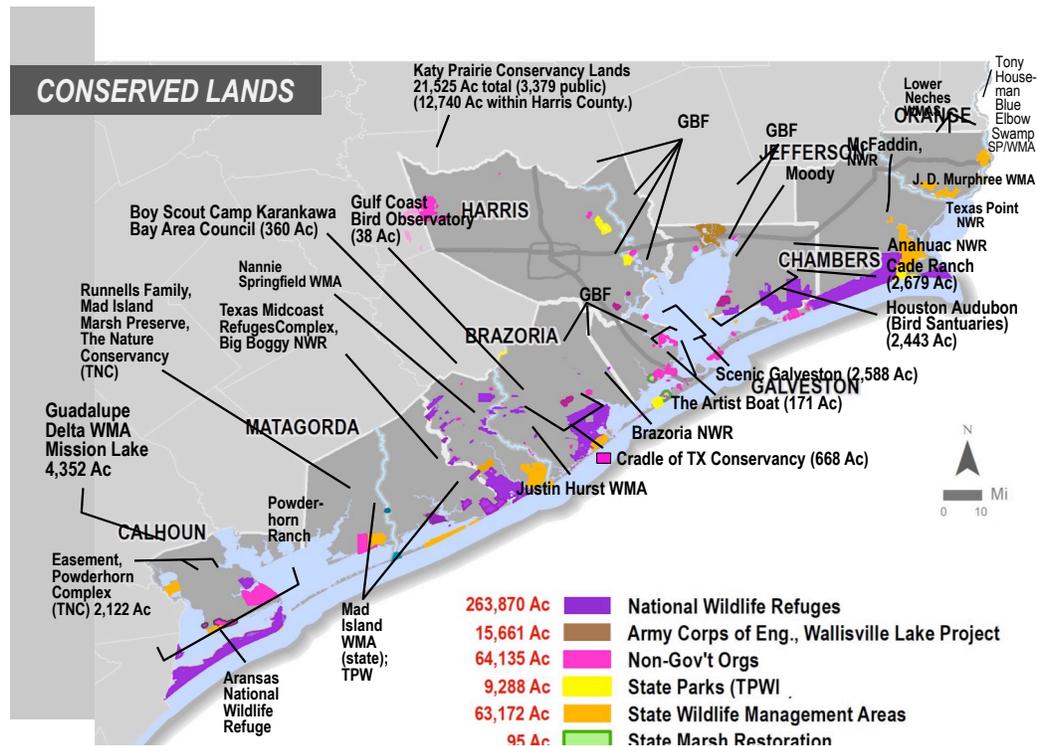
Given prevailing sentiments on the Texas coast, the project team did not consider regulation a viable nonstructural flood solution. Instead, the project team focused on ways to generate economic benefits from the undeveloped lands across the region and developed two major nonstructural concepts. The proposed Lone Star Coastal National Recreation Area, or LSCNRA, was created for existing protected lands, and the Texas Coastal Exchange, or TCX, was developed for privately owned lands.

A. Proposed Lone Star Coastal National Recreation Area

The proposed Lone Star Coastal National Recreation Area is an effort to establish a new model of a National Park Unit—one tailored to Texas sensibilities—along the upper Texas Gulf coast, which requires passage of federal legislation. Conceived at nonprofit Houston Wilderness, then developed at SSPEED, the proposed LSCNRA was then carried forward for implementation by the National Parks Conservation Association, and is now in the hands of the Lone Star Coastal Alliance, a local 501(c)(3) established to support the LSCNRA. Each of these organizations has played a critical role in getting the project where it is today, as has Houston Endowment through their generous funding to each of these organizations along the way.

In 2010, the SSPEED Center team set out to discover the best way to leverage the approximately 300,000 acres of coastal lands that have already been preserved for their outstanding ecological value. Traditionally, these lands have been managed for wildlife rather than recreation. However, not only do these existing protected lands form the core of a strip of coastal “open space” to receive flood waters, they can perform that function while supporting a robust economic sector underpinned by nature-based tourism. In this relatively small region, diverse and abundant animal and plant species populate diverse habitat types. These include barrier beaches, coastal estuaries, bays, marshes, riverine hardwood bottomlands, piney woods, and coastal prairies. This diversity in habitat also makes for a diversity of recreation—birding, hunting, fishing, biking, paddling, and boating to name a few. Our region is in the heart of the central flyway for neotropical songbird migration, and is the home to a large colonial water bird population, a major hawk migration, the second most productive estuary in the nation with Galveston Bay, and five species of sea turtles. Amazingly, this resource abundance may be better known in Britain and the European Union than in our own backyard. The region’s protected land areas are shown in Figure 3.

Figure 3. Ownership of Protected Lands in the Upper Texas Coast

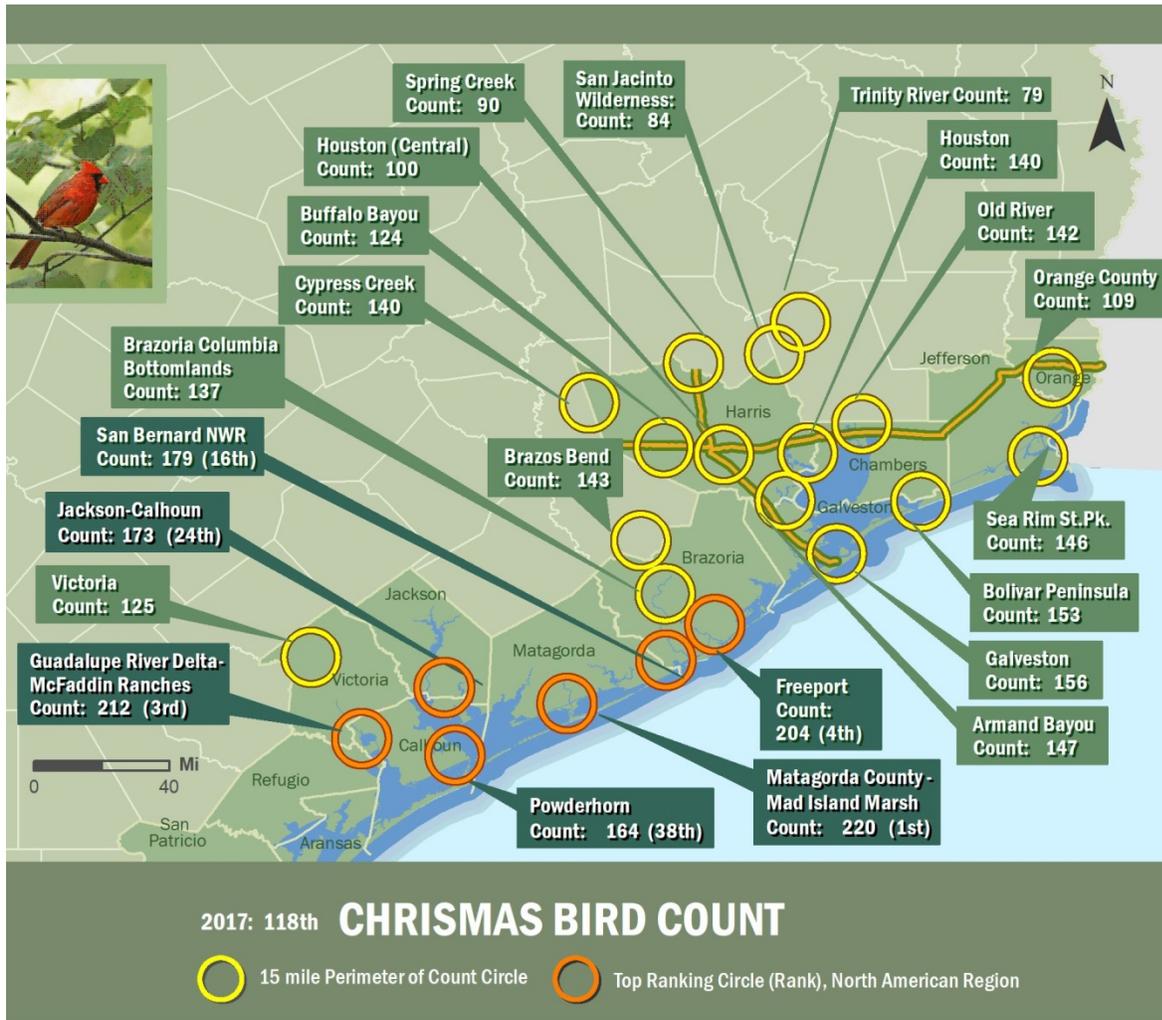


Source: A Texan Plan for the Texas Coast.
(Protected /Conserved land data from state agencies at noted in the book).

Outdoor recreation has the potential to be a powerful economic engine. According to the Outdoor Industry Association 2017 Recreation Report¹ outdoor recreation generated \$887 billion in direct and indirect economic activity, along with 7.6 million jobs. It was estimated that about 47 million birders were in the United States in 2011, and birds account for about \$40 billion in economic activity, including about \$14 billion in trip-related expenditures, generating 660,000 jobs with about \$31 billion in income. About 4.3 million birders annually bird in Texas. And the Texas coast has fabulous birding. As seen in Figure 4, the reported numbers for at least two Christmas bird counts along the Texas coast were among the highest totals in the United States, and this is a regular occurrence. In 2010, notwithstanding our first-rate assets—including but not limited to birding—our region was receiving little to no nature-based tourism, so our project team focused on the most effective way to expand this sector.

¹ See “The Outdoor Recreation Economy” at https://outdoorindustry.org/wp-content/uploads/2017/04/OIA_RecEconomy_FINAL_Single.pdf.

Figure 4. Reported Christmas Bird Count by Number of Species Recorded



Note: Counts shown in orange are among the top counts in the United States.

Source: Graphic by Christina Walsh, from *A Texan Plan for the Texas Coast*.

In looking for a model that would best facilitate the development of this recreational sector, the SSPEED Center team identified a type of national park unit called a “national recreation area.” Given negative sentiment in the region about involving the federal government, the potential of affiliating with the National Park Service (NPS) was studied carefully before being considered a legitimate option. However, we ultimately decided to involve NPS because they are *the* gold standard for nature-based, historic, and cultural tourism—domestically and worldwide. Equally important, the national recreation area model is flexible and could be shaped to align with Texas sensibilities.

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Though it was considered, at the time there was no way a state or local branding effort could compete with NPS. The NPS website has more than 800 million unique visits each year, and over 350 million visitors to the 417 National Park units each year. Tourists that seek out and visit National Park units are extremely desirable: they stay longer, spend more, seek out local culture and local businesses, leave the place better than they found it, and travel year-round. Additionally, a national park unit is an excellent quality of life indicator, drawing talent and business to the region. It would allow voluntary coordination and cooperation across sectors and agencies, and would make the region competitive for national philanthropic and private sector funding that is currently out of reach due to the lack of an integrated “landscape vision,” offering financial leverage and access to funding resources to support development of this sector and to coastal resilience more generally. In short, it would create a whole that is vastly greater than the sum of the parts.

Toward ground-truthing and developing the LSCNRA, the team got buy-in from the NGO and local, county, state, and federal agency landowners in the region, and garnered leadership – including former Secretary of State James A. Baker, III, and leading Houston businessman and national park advocate John L. Nau III. A conservative economic study was conducted in 2011 and updated in 2017 titled “Opportunity Knocks” that revealed that the LSCNRA after its 10th year could be responsible for bringing in 1.5 million visitors annually, generating over \$140 million increase in local sales, creating nearly 3,500 new local jobs, supporting a 2% increase in private employment, and developing 9% more jobs in the tourism industry. In short, the LSCNRA offered a major economic development opportunity to the coastal community without creating the vulnerability to storms often connected with coastal development.

The development of the LSCNRA proposal was based upon an existing, flexible NPS model. Many people think of Big Bend, Grand Canyon, Yosemite, and other large swaths of federally owned land when they think of a national park unit. Among the key differences of the LSCNRA model: it is a locally governed public-private partnership in which the National Park Service is one seat at the table; it is a “network” of individually owned and managed sites in which participation by site owners is voluntary; the NPS’ ownership is limited in the legislation to specific parcels from specific, willing landowners who have raised their hand for consideration; NPS lands can only be acquired through donation, purchase with donated funds, or property exchange, so no taxpayer dollars will be used to acquire land; and—very importantly— the LSCNRA does not introduce any new regulations and is specifically prohibited from doing so in the proposed legislation.

In 2012 and 2013, the coalition began drafting legislation to propose to the congressional members in the region to establish the LSCNRA. That legislation has evolved significantly over the years through rounds of input from stakeholders and local, state, and federal elected officials, and consultation with NPS. From the beginning, the development of the proposed LSCNRA has been driven by our local grassroots with the help and guidance of our local grass tops.

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Of distinction, the legislation also includes unique savings provisions: state and local jurisdictions will not be altered as a consequence of the NPS designation, and federal jurisdiction will not be enlarged (specifically, the legislation mentions the Clean Air Act and Endangered Species Act); private property rights are specifically protected and “incompatible use” cannot be invoked; it states specifically that designation does not impede and is not inconsistent with federally authorized or permitted channels, storm surge protection, flood control devices, and oil and gas pipelines and projects; and hunting, fishing, off-road vehicles, and personal watercraft are protected where allowed by law.

While skepticism about bringing another federal agency to the region has been hard to overcome, the Lone Star Coastal Alliance and LSCNRA Coalition remain committed to getting legislation passed to establish a national park unit along the upper Texas Gulf coast, and firmly believe that it is a matter of “when,” and not “if,” it will happen.

The good news is that since the advent of the LSCNRA proposal in 2011, a number of factors have emerged that support the development of the surge-resilient economic sector as envisioned while the coalition continues to pursue the LSCNRA legislation.

One factor is that technology, social media, and process have come light years, and non-NPS affiliated regional tourism brand identity efforts in widespread rural/industrial/urban regions like ours have shown significant, measurable benefits in a short period of time. Another factor is the coming of age of the millennial generation as travelers. They are “experiential travelers” who prefer to “go local,” patronize locally owned businesses, eat regional cuisine, and buy regional crafts. According to the ITB World Travel Trends Report 2016/ 2017 and PhoCusWright Travel Market Research they seek authentic travel experiences, care about the protection and preservation of the places they visit, and will spend more money and time if their spending decisions help to protect and preserve. And, international travelers tend toward this profile as well. *This is the traveler profile we sought with NPS designation*, and they are responding to opportunities like the ones we have in our region.

In order to capitalize on these factors and the work that has gone into the LSCNRA to date, at the request of the stakeholders, the Lone Star Coastal Alliance, under the leadership of JP Bryan, is convening a regional collaboration on tourism and coastal resilience. In addition to the original LSCNRA coalition, the regional collaboration includes local convention and visitors bureaus (CVBs), chambers of commerce, recreation and tourism-related businesses, and other civic and nongovernmental organizations. The convergence of ideas and purpose evidenced during five regional stakeholder workshops along the coast in October 2019 was striking and suggests a solid foundation for successful collaboration. While this process is just beginning, the mission that emerged from the workshops launching the collaboration is to elevate and recognize our region for its unique cultural, historical and natural assets and experiences, to inspire tourists to visit in ways that enhance benefits to local economies and increase the value and importance of the natural and cultural heritage within Matagorda, Brazoria, Galveston and Jefferson counties, and, to support stewardship of these vital assets across the region.

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At the time of this writing, a strategic framework for advancing this collaborative initiative has identified six core areas of activity. Priority projects for 2020 will build a foundation for the initiative and catalyze progress in these core areas:

1. Common Ground: Vision, Brand, and Indicators

Build on and develop shared interests and common understandings to provide a solid underpinning for the regional initiative.

2. Marketing and Communications

Develop and implement a marketing and communications plan for the destination and, more broadly, for the regional collaboration.

3. Product Development

Create regional tourism products (e.g., itineraries, tour packages, and driving routes) that can be offered and marketed to potential visitors.

4. Interpretation and Wayfinding

Enhance interpretive and wayfinding resources to create and reinforce the Lone Star Coastal regional identity and help visitors navigate and understand the area.

5. Workforce and Local Business Development

Provide hospitality, interpretation, guiding, and other skills-development education programs. Inspire and support job creation, entrepreneurship, local businesses, and investment in our travel and tourism industry.

6. Organizational Development of the Alliance

Build capacity for the Lone Star Coastal Alliance to act as a convening organization and implementation partner for the Lone Star Coastal regional collaboration.

Catalytic projects will be driven by leadership, support, and resources from a range of involved stakeholders as well as from the Alliance. Working together on these tangible projects will help create the collaborative structure and inform a strategic plan that will drive the initiative beyond 2020.

B. Texas Coastal Exchange

Though driven by the same motivating factors of a nonregulatory approach to keeping open spaces open in a manner that produces economic benefits, the Texas Coastal Exchange (TCX) is quite different than the LSCNRA. It is a private sector concept derived from the fact that more than 95% of the land in the state is privately owned and 82% of that is in working lands, according to Texas Land Trends.² Texas working lands are also among the most rapidly fragmenting due to the pressures of urbanization and agricultural economics. These working lands also function as “open space” in that they provide various

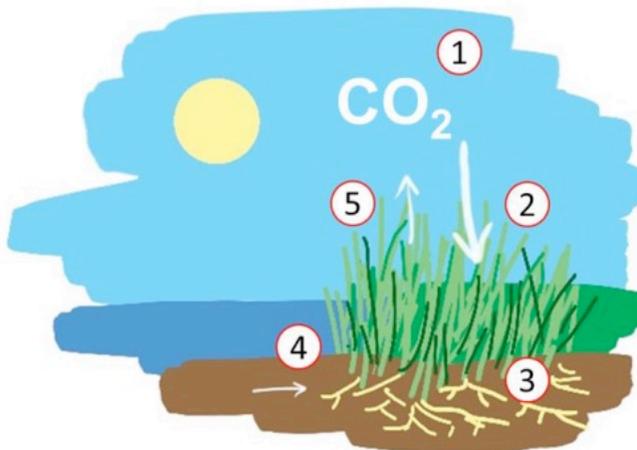
² Texas Land Trends 2019 Summary Report at https://issuu.com/tamu_nri/docs/texas_land_trends_-_5_year_report_f.

types of services that are of value to society—services for which the landowner has traditionally not been compensated. Among other things, they clean air and water, and provide wildlife habitat. Keeping them intact and in agricultural use serves a cost-effective surge damage risk reduction strategy as well.

The basic idea of the TCX is to create a voluntary private sector financial system to generate a new stream of revenue for coastal landowners that compensates them for the positive functions of their ecological systems. In making these working lands more economically productive for the landowners in their current state, the goal is to keep them intact by reducing the pressure to develop or otherwise convert them in a manner that eliminates the benefits they provide to society.

A coastal saltwater wetland illustrates the kind of services society receives for free from coastal landowners. This wetland provides the nursery area for brown and white shrimp, blue crabs, and flounder, along with many other species. It removes pollutants such as nutrients from the water. It absorbs high-energy waves, protecting adjacent shorelines. And it takes carbon dioxide from the atmosphere and deposits it in the soil of the marsh. This service of carbon dioxide removal and carbon storage is shown in Figure 5.

Figure 5. The Cycling of Carbon Dioxide into a Coastal Marsh



Source: Graphic by Azure Bevington for the Texas Coastal Exchange.

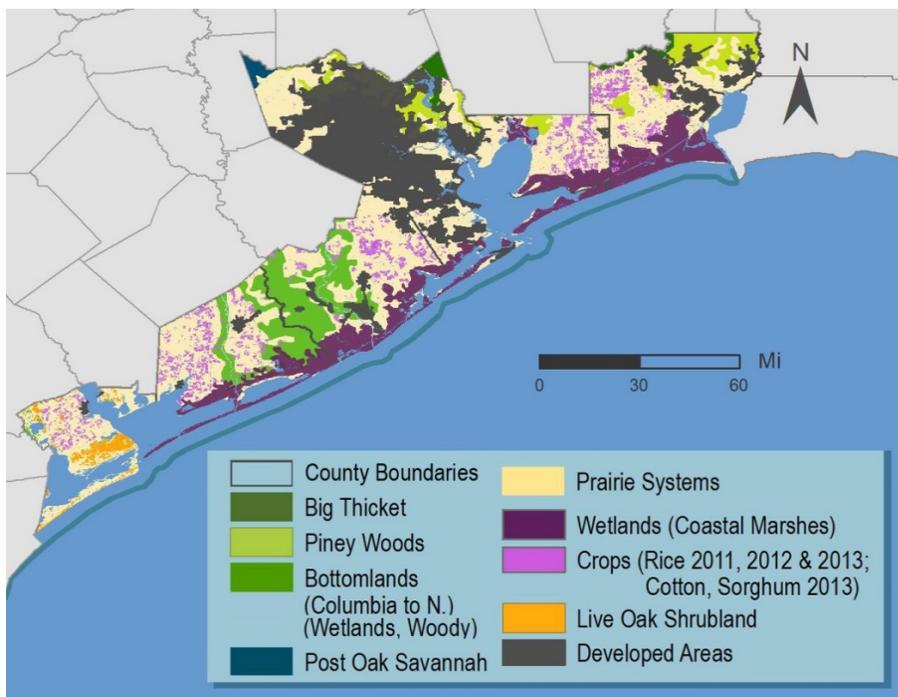
As shown in Figure 5, there are several distinct steps involved in the removal of carbon dioxide from the atmosphere. First, there is substantial carbon dioxide in the atmosphere. Second, that CO_2 is removed from the atmosphere by the plant. Third, that CO_2 is used by the plant to produce leaves, stems, and roots through photosynthesis. Fourth, dead roots remain in the soil because their decomposition is slowed due to tidal flooding by seawater, leading to high rates of carbon deposition. And fifth, some of the CO_2 returns to the atmosphere due to plant and microbial respiration, but the majority of it remains stored in

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the soil. Given that global concentrations of carbon dioxide are higher than at any time in human history, that this atmospheric carbon dioxide is linked to climate change, and that many individuals and communities are looking for ways to remove it from the atmosphere, this is a valuable service to society. Paying for it ensures the service will continue.

Marshes are not the only coastal ecosystems that perform useful environmental services to humans. Bottomland forests also store carbon dioxide in trees and coastal prairies store CO₂ in the soil due to the extensive root systems of prairie grasses. Similarly, forests and prairies can capture and store floodwater and, in some circumstances, can enhance both surface and groundwater supplies. And along the coast, both of these systems are very important for migrating and nesting songbirds. A map showing the ecosystems of the Texas coast is shown in Figure 6. Again, these are very beneficial services to society at large which have traditionally not been compensated.

Figure 6. Major Ecological Systems of the Upper Texas Coast



Source: Image by Christina Walsh, derived from *A Texan Plan for the Texas Coast*.

Driven by carbon emitters concerned about climate change and eager to offset their footprints locally, the Texas Coastal Exchange focused on payments to landowners to support their storage of carbon dioxide. Each individual, corporation, church, and foundation has a carbon footprint. A carbon footprint is the amount of carbon dioxide generated on a yearly basis by daily activities such as living in a home, running an office, heating and cooling living and work spaces, lighting homes and businesses, driving cars and trucks, and flying on vacations and for business, to name a few. Recognizing that avoiding or mitigating the amount of carbon put in the atmosphere is the best place to start in

lowering carbon emissions, the TCX first encourages consideration of the ways in which a carbon footprint can be reduced. After that, the TCX offers the opportunity to offset what remains in the soil or forest of a coastal landowner. A simplified guide to the carbon footprint is shown in Figures 7 and 8. For an excellent carbon footprint website, visit www.footprintapp.org.

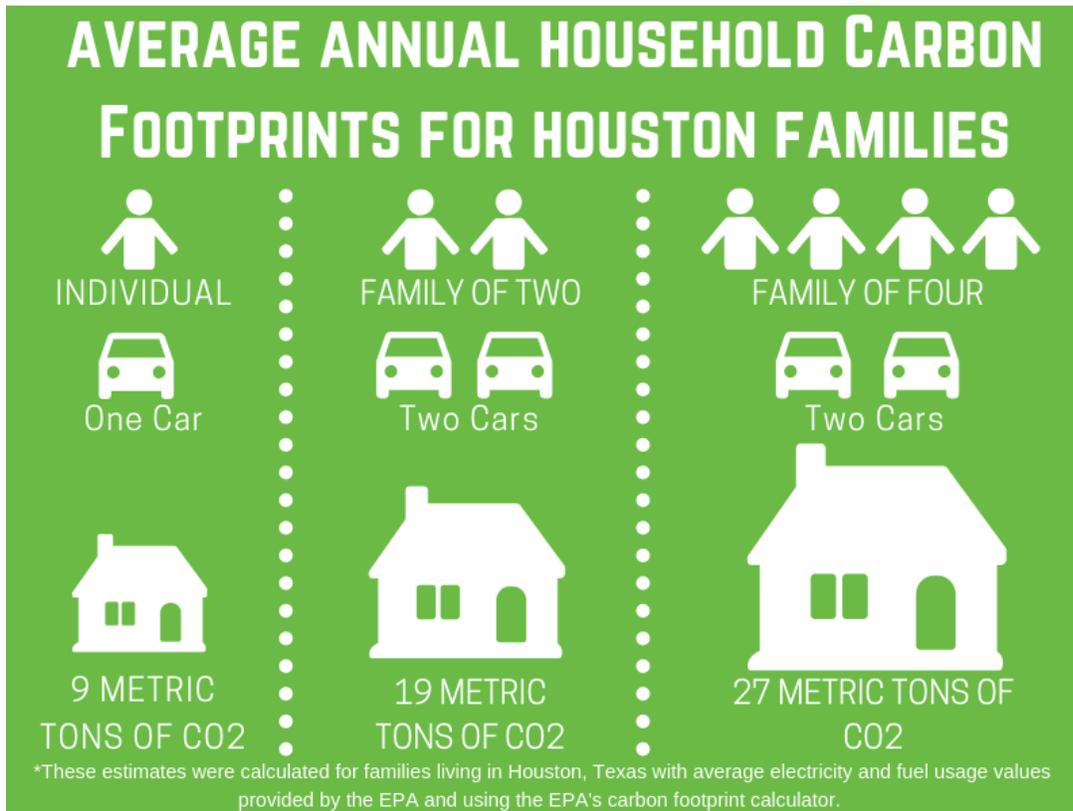
Figure 7. Carbon Footprint Minimization Strategies

10 WAYS TO REDUCE YOUR CARBON FOOTPRINT

- 1 REDUCE WASTE**
Purchase items with less packaging, or bring your own containers to the grocery store and shop in the bulk section. Re-use spray bottles and other items. Use a wash cloth to clean instead of a paper towel. And don't forget to recycle!
- 2 EAT YOUR VEGETABLES AND BUY LOCAL**
By eating local, vegetarian, or organic foods, you will reduce your carbon footprint and improve your health. Eating less meat and substituting chicken for beef will also lessen your environmental impact.
- 3 DRIVE LESS**
Riding your bike, walking, carpooling, or taking the bus to work are all great ways to reduce your carbon footprint and your stress levels at the same time.
- 4 TURN OFF AND UNPLUG**
Turn off and/or unplug your lights, TV, computer, and other electronics and appliances when you are not using them. The planet (and your wallet) will thank you.
- 5 USE RENEWABLE ENERGY**
While installing solar panels on your home is a great way to use renewable energy, it can be expensive. Thankfully, you can also purchase solar or wind power from your local energy provider.
- 6 BE ENERGY EFFICIENT**
Purchasing energy efficient appliances, replacing the light bulbs in your home with LEDs, and turning your thermostat up in summer and down in winter are some ways to reduce your energy use.
- 7 PLANT A NATIVE GARDEN**
By growing native plants, you will not need to use expensive chemical fertilizers or herbicides. These yards also require less water and maintenance than traditional lawns. You will be saying goodbye to your lawnmower and hello to butterflies in no time.
- 8 VISIT A THRIFT SHOP**
Try out your local thrift shop the next time you are in need of yard furniture or clothing. You never know what you might find!
- 9 LIVE IN A SMALL HOME**
Smaller homes require less energy and they are easier to maintain. That way you can spend less time vacuuming and more time saving the world.
- 10 PURCHASE LOW CARBON GOODS**
Many brands are taking steps to reduce the carbon footprints of their supply chains and products. These include Patagonia, Coola and PrAna, among others.

Source: Texas Coastal Exchange website, <https://www.texascoastalexchange.org/calculating-your-carbon-footprint.html>.

Figure 8. Calculating Your Carbon Footprint



Source: Texas Coastal Exchange website, <https://www.texascoastalexchange.org/calculating-your-carbon-footprint.html>.

Because the TCX is a nonprofit organization, it is not offering to sell carbon storage but is instead arranging for carbon storage by making grants to landowners who commit to leaving ecological systems that store carbon intact for a period of 10 years. The donation of money for carbon storage also happens to protect the additional ecological functions of the wetland, bottomland hardwoods, or prairie. The amount of the donation is set by the tons of carbon dioxide that the donor seeks to store. Initially, the TCX is requesting that those wishing to store their carbon footprint donate \$20 per ton of carbon dioxide to be stored. In turn, the TCX will make a grant to the landowner in the amount of \$17 per ton stored, leaving an administrative fee of \$3 per ton. That price will vary in the future with carbon pricing trends.

To ensure transparency, accountability, and accurate counting, there is a substantial infrastructure behind this donation and grant system. The land of each potential grantee is evaluated to determine the storage capacity of the ecosystems within that property. TCX employs a chief scientist, Azure Bevington, who reviews published literature and makes a conservative estimate of the tons of carbon dioxide removed per acre of the various ecosystems.

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In calculating the carbon storage capacity of different ecosystems, TCX started with saltwater wetlands due to the proven and extensive body of published literature on carbon sequestration rates, and given Bevington's expertise on the subject matter. Next, TCX will be evaluating the CO₂ storage capacities of into hardwood forests due to the existence of proven and extensive methodologies for estimating timber sequestration rates. The prairie ecosystem represents a greater challenge due to variability of plant types, rainfall, soil types and management processes and will not be added until late 2020. All calculations of carbon storage are supported by GIS imagery, including the national wetland inventory, lidar elevation imagery, aerial photographic interpretation, and, where necessary, field evaluation.

In order to be accepted into the TCX grants program, a landowner must first submit a letter of intent identifying the property that s/he wishes to enroll, then complete a formal application. This application, when accepted by TCX, becomes a binding contract between TCX and the grantee. As a condition of the grant agreement, the landowner agrees to maintain the land in an undeveloped state for 10 years. Grants can be made sequentially for many years, but each grant carries with it a 10-year commitment, leading it to be termed a "rolling 10-year commitment." In this manner, a balance between adaptability of service and long-term protection is reached.

The most notable feature of the TCX is that it is setting up a system to compensate landowners for the functions of the ecological system maintained on their property. The TCX is implementing what has been termed a "circular economy"—a system where wastes are recycled and reused, in this case in accord with natural ecological cycles. As such, it is stimulating long-term, ecologically beneficial decisions that make economic sense for the landowner. For example, if coastal wetlands are producing revenue, coastal landowners may be inclined to allow them to move inland with our rising sea level rather than building berms to block the rising water. In this way, the TCX is incentivizing landowners to allow the marsh—along with estuarine, surge reduction, and other beneficial functions—to expand as the sea level rises, as well as to maintain their native bottomland hardwoods and native prairies in their natural state.

The TCX not only allows but encourages "stacking" of ecological services, meaning that a landowner can receive a carbon-based grant and also lease the land for hunting or bird-watching, run cattle, and even receive payments for flood storage if an entity such as the Federal Emergency Management Agency were so inclined. Additionally, the TCX allows anyone to participate, regardless of when the ecological system started functioning. The TCX recognizes private property rights and treats carbon removal as environmental engineering by the landowner. If carbon is removed and stored in any year, the landowner may qualify for grant support.

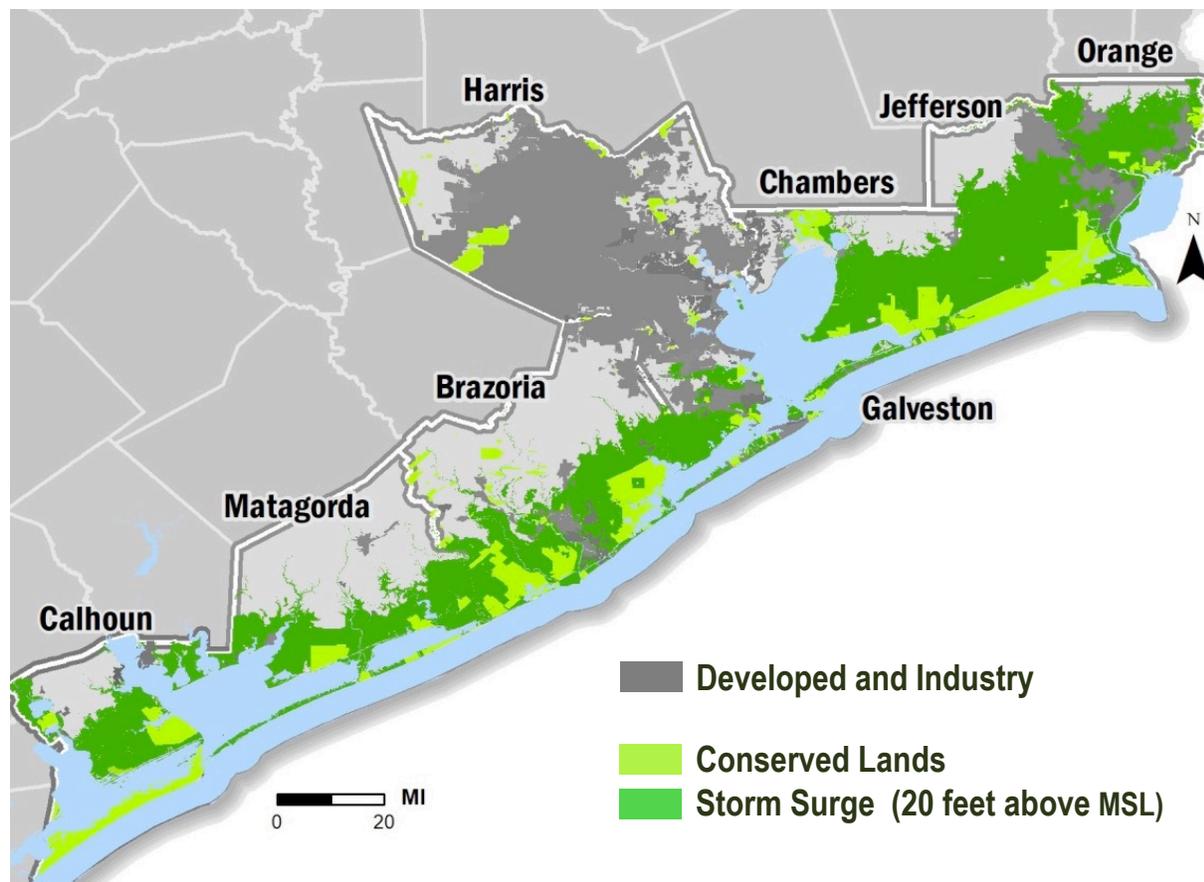
The TCX has just begun operation. As of September 1, 2019, the inventory of carbon storage is just over 13,000 tons. We anticipate that carbon footprint donations will increase as the end of the year approaches and tax deductions are sought, perhaps even becoming a

popular holiday gift item. By making a donation to the TCX, individuals not only offset their own carbon footprint, but also support the long-term economic, social, and environmental resilience of the upper Texas coast and help reduce damages due to hurricane surge flooding. More information about how to make a difference can be found on the TCX website: www.texascoastalexchange.org.

C. The Non-Structural Fabric of the Green Coast

When the lands that are part of the regional collaboration underpinning the proposed LSCNRA are combined with the 2 million low-lying, privately owned acres targeted by the TCX, the impact of this non-structural approach can be appreciated, as shown in Figure 9. The areas shown in light green are the existing conserved lands of the proposed LSCNRA, and the dark green are potential grantees for the TCX as it expands from coastal marshes into bottomland hardwoods and coastal prairies. In both cases, economic systems based on nature lie at the center of these non-structural surge damage reduction strategies.

Figure 9. The Combined Area of the Proposed LSCNRA and the TCX Focal Region

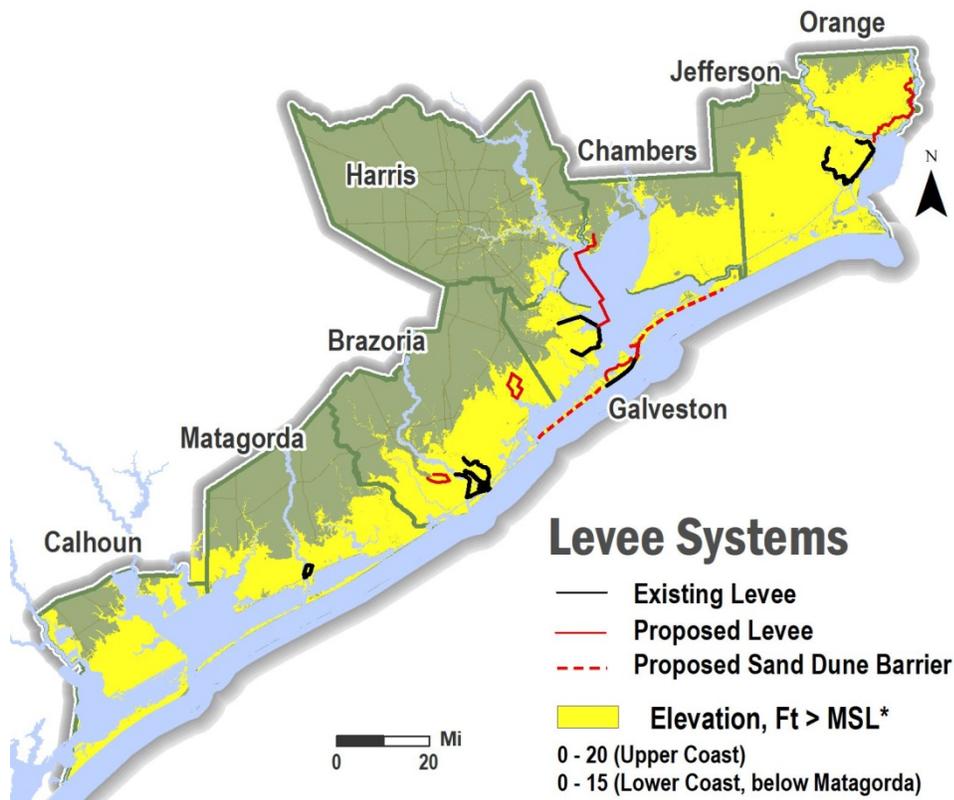


Source: Graphic by Christina Walsh.

II. Coastal Structural Protection Becoming Greener

Various structural alternatives have been constructed in the Houston-Galveston region over the years. After the storm of 1900 demolished most of the city, Galveston built a 17-foot sea wall that has served it well over the years. In the early 1960s, the Corps of Engineers built the Texas City levee, which surrounds the industrial and residential areas of the city and extends across Interstate 45 on the south and to Dickinson Bayou on the north, with protection varying from 17 to 20 feet of elevation. Similar levees have been built around the industrial complex and residential community in Port Arthur in Jefferson County adjacent to Sabine Lake, and in Freeport-Lake Jackson in Brazoria County. A map of the existing protection system is depicted by the black lines in Figure 10.

Figure 10. Map of Existing and Proposed Levee/Barrier Systems



Source: Graphic by Christina Walsh, from *A Texan Plan for the Texas Coast*.

Several major structural projects have been proposed to improve flood and surge protection for the region. A major levee has been authorized for construction by the Army Corps of Engineers to protect the Adams Bayou industrial area in Orange County. This project was funded with congressional appropriations from HR 1892 and is currently being implemented. Other proposed structural projects include the the Army Corps of Engineers' Coastal Barrier Project for Galveston, Chambers and Harris counties, and the SSPEED Center's Galveston Bay Park Plan to protect the developed western shoreline of Galveston Bay. It is important to note that on August 23, 2019, the Army Corps of Engineers, the Texas General Land Office, and the SSPEED Center issued a joint statement of compatibility regarding these two projects. They are now being pursued at the same time, but the coastal barrier is proposed to be a federal project built with federal and state funding, while the Galveston Bay Park Plan is proposed to be built by local governmental authorities under permits issued by the Corps and funded by local and private sources of capital. These are discussed sequentially below.

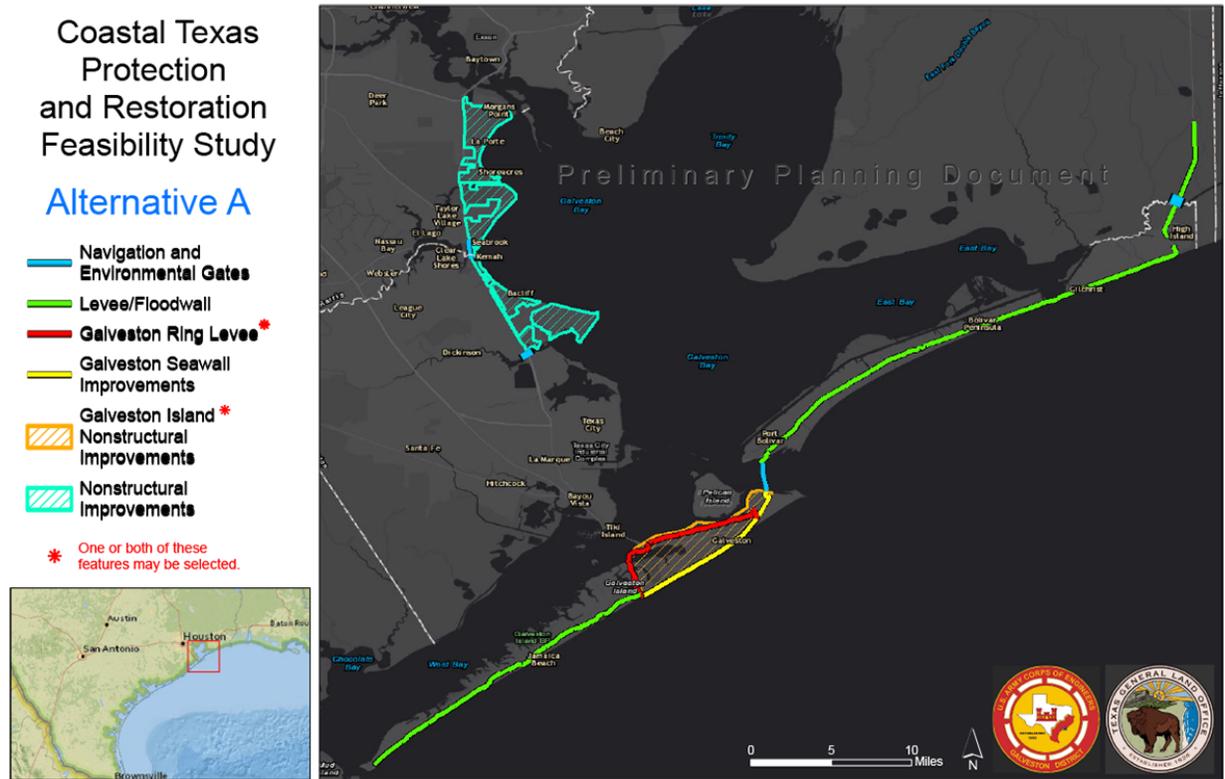
A. The Coastal Barrier

The Army Corps of Engineers' Coastal Texas Protection and Restoration System—i.e., the Coastal Barrier Project—originated with Dr. William Merrell of Texas A&M University at Galveston, who rode out Hurricane Ike in a historic building in downtown Galveston. After that experience, Dr. Merrell proposed building what he termed the “Ike Dike,” a coastal barrier that would be a first line of defense for the coast. That concept was endorsed by the Gulf Coast Community Protection and Recovery District, a six-county special governmental district formed by the Texas Legislature after Ike to develop protection plans. This concept then matriculated to the Corps and emerged as Proposed Alternative A—the Coastal Barrier—in the Corps/GLO Coastal Texas Protection and Restoration System analysis project that went to out on public notice in fall 2018.

The original project proposed in fall 2018 is being changed by the Corps in response to public comments and feedback received from the review of the draft environmental impact statement (DEIS). The original proposal included a 17-foot earthen levee along the Bolivar Peninsula as well as along the west end of Galveston Island from the end of the sea wall to San Luis Pass. As a result of public comments, that proposal has been modified to a proposed strengthening of the sand dune system on the Bolivar Peninsula and the west end of Galveston Island, a proposal that if implemented would be ecologically beneficial as sand dunes lost in Ike and/or due to erosion are restored.

Similarly, a two-mile-long gate structure proposed to cross Bolivar Roads—the pass between Galveston and the Bolivar Peninsula—is being redesigned to cause less constriction of tidal ebb and flow into the bay system, an important issue for long-term bay health. This redesigned gate structure and its potential impacts are scheduled to be released publicly in the second half of 2020. Other elements of the coastal barrier include a backside levee around the city of Galveston and levee structures within Clear Lake and Dickinson Bayou to address residual surge remaining in Galveston Bay even with restriction of storm surge from entering the bay. The original proposal for the Coastal Barrier is shown in Figure 11.

Figure 11. The Proposed Coastal Barrier Project



Note: The proposed levee along the shoreline shown in green is now proposed to be a sand dune structure. The two-mile-long gate structure is shown as the blue line between the yellow sea wall and the green line along the Bolivar Peninsula.

Source: Army Corps of Engineers and the Texas General Land Office.

There are also environmental restoration and enhancement components of the Corps/GLO Coastal Texas Protection and Restoration System beyond the proposed structures. This work includes beach and dune restoration on the Bolivar Peninsula, the west end of Galveston Island, and Follets Island in Brazoria County, and nourishment of marshes and protection of shorelines along the Gulf Intracoastal Waterway (GIWW) from High Island to Bastrop Bay and along the GIWW adjacent to East Matagorda Bay. Additional environmental restoration work is also proposed for Lavaca Bay and along the Powderhorn Lake shoreline on the southern end of Matagorda Bay. The locations of these shoreline protection structures are shown in Figure 12.

Figure 12. Environmental Restoration Projects Proposed for the Coast Barrier Project



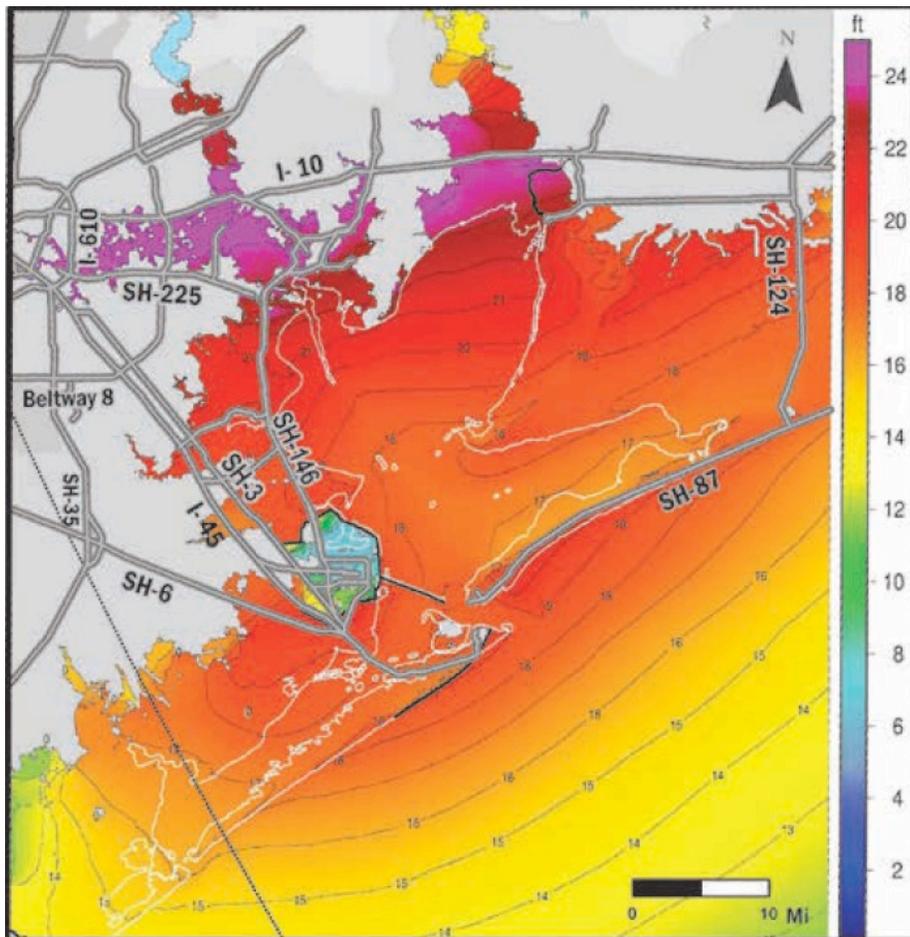
Source: Army Corps of Engineers and the Texas General Land Office.

With the proposed changes to the coastal levee and with the environmental restoration proposals, the Corps/GLO projects have the potential to make a major difference in reducing coastal erosion and wetland loss along the Texas coast as well as providing significant hurricane surge protection for the city of Galveston and Galveston Bay. It will not, however, eliminate surge flooding within Galveston Bay, as will be discussed in the next section. The total projected cost of the Coastal Texas Protection and Restoration System is approximately \$30 billion. The project was originally estimated to be completed by 2035.

B. Galveston Bay Park Plan

The Galveston Bay Park Plan was developed by the SSPEED Center at Rice based on computer modeling its researchers conducted regarding reasonable worst-case storms for the region. The SSPEED Center determined that a weak Category 4 storm hitting the southern end of Galveston Island would send 20 feet of water into the sea wall at Galveston and 25 feet of surge into the upper parts of Galveston Bay. The results of that storm, which can be seen in Figure 13, would be catastrophic, flooding 2.2 million barrels of refining capacity and 200-300 chemical plants along the Houston Ship Channel, the Bayport Industrial complex, and Texas City (because the levee is overtopped) to some extent. Over 800,000 people would be at risk.

Figure 13. Surge Depth from a Weak Category 4 Storm Striking the South End of Galveston Island



Source: Graphic by Christina Walsh based on modeling by the SSPEED Center.

The resulting damage to the Houston Ship Channel and the national and regional economies would be devastating. U.S. national security would be threatened. Significant loss of life is likely. Our regional economy would be indelibly changed. A 20-foot surge at the coast translates into a 24-foot surge up the Houston Ship Channel. According to Dr. Jamie Padgett of the Rice University Civil and Environmental Engineering Department, a 24-foot-surge up the ship channel would release over 90 million gallons of oil and hazardous substances due to storage tanks rising from their foundations and/or collapsing. That does not include damage from puncture by debris such as containers and timbers carried by the surge as well as leakage from process units that would be flooded. Quite simply, we are not prepared in any way for an event of this magnitude.

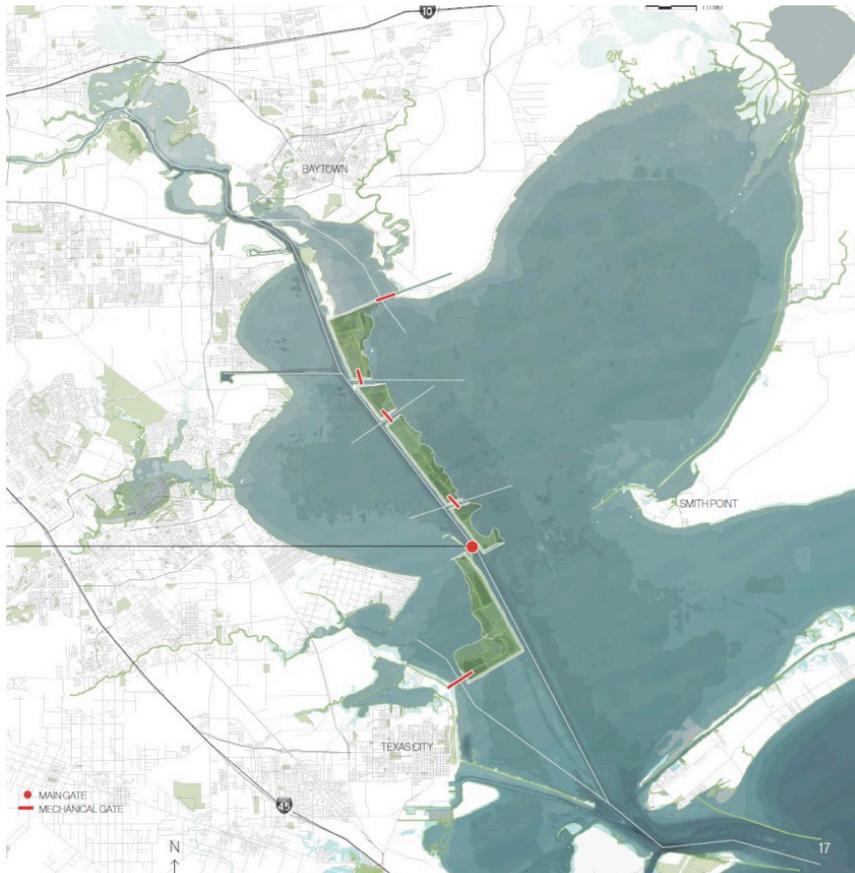
The Green Coast: Combining Texas' Values, Economy, and Ecology to Create a Resilient Coast

To address this storm, the SSPEED Center has proposed a levee project that runs from Houston Point in Chambers County on the north down the east side of the Houston Ship Channel to a point about equal to the narrows between Smith and Eagle Points where a navigation gate is proposed. At this point, the levee would extend to the western side of the channel, and proceed south then to the west to connect with the Texas City levee system. The park plan also proposes that the Texas City levee be raised from -17 feet to 25 feet.

A key element of the park plan is that the raw material to construct the levee—clay—would be provided by the proposed widening and deepening of the Houston Ship Channel. At present, the Army Corps of Engineers and the Port of Houston are proposing to widen the Houston Ship Channel to 700 feet; with the larger post-Panamax container vessels expected to enter the channel and increased oil export traffic, the need exists to further widen it for transport safety reasons to at least 850-900 feet. Although the dredge material from the 700-foot widening is already allocated to various disposal sites and beneficial use plans, the opportunity exists to utilize the virgin clay material from the further widening to build the levee along the channel edge.

The location of the levee, along with proposed locations for both the lateral small craft navigation gates and the ship channel navigation gate, is shown in Figure 14. So, in addition to providing flood protection (see Figure 15), the Galveston Bay Park Plan will enhance safety on the ship channel by widening the channel, then reusing the resource of clay soil for building material. It will also provide disposal capacity for future ship channel maintenance dredging which ultimately will be converted into saltwater wetlands.

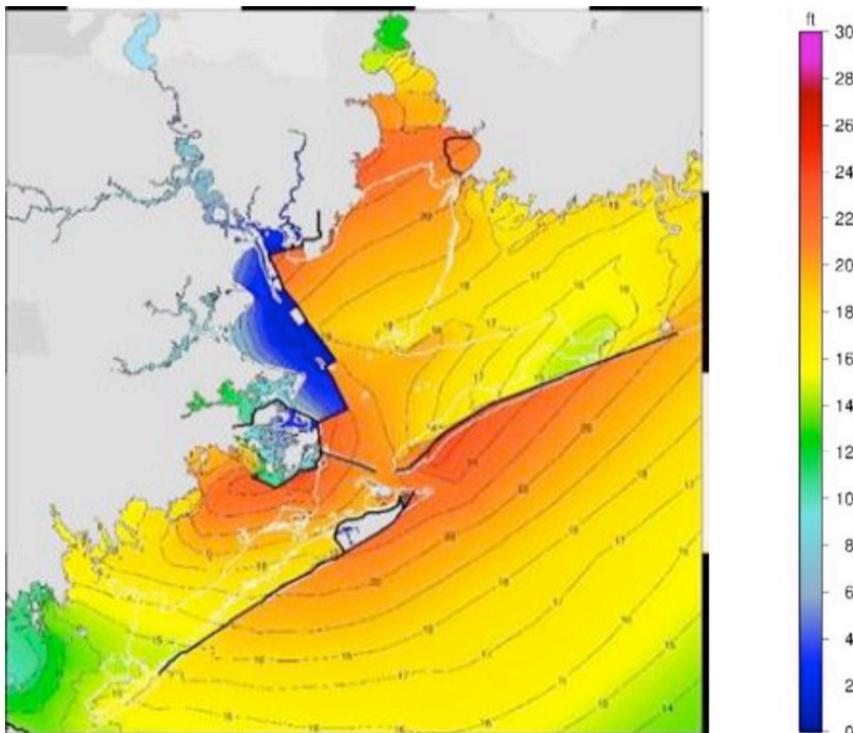
Figure 14. Proposed Location of the Galveston Bay Park Plan Levees



Note: The map depicts five small craft/circulation navigation gates and one major navigation gate (indicated by red circle).

Source: Illustration by Rogers Partners for SSPEED Center.

Figure 15. Weak Category 4 Storm Hitting San Luis Pass with the Galveston Bay Plan in Place

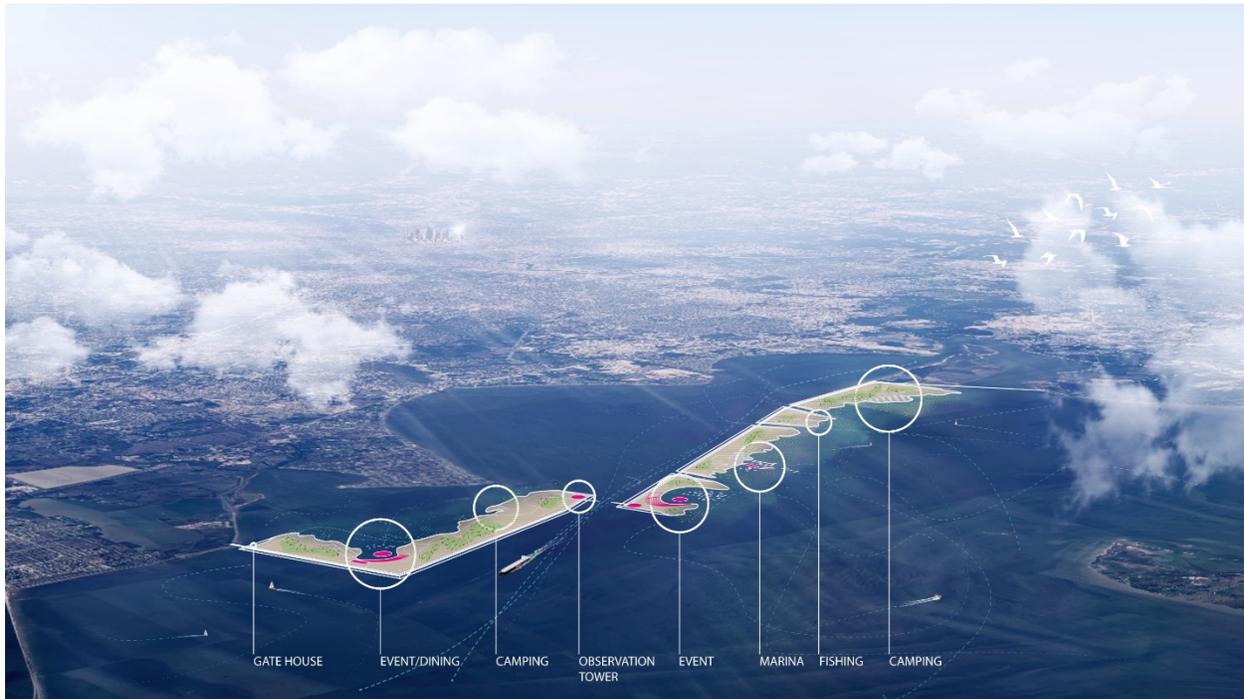


Source: Graphic by Christina Walsh based on modeling by the SSPEED Center.

Not only will the Galveston Bay Park Plan provide critical human and infrastructure protection, it will do so while providing an outstanding recreational and quality of life amenity for the region, as well as environmental benefits. Galveston Bay is very inaccessible to the general public. Much of the western shoreline of Harris and Galveston counties is privately owned. Only two major public access points exist along this shoreline—Sylvan Beach in Harris County, and the Texas City Dike in Galveston County. Many of the 6 million-plus citizens that live in our region are unfamiliar with Galveston Bay. That would change with the Galveston Bay Park Plan.

Under this plan, access for recreation to the general public is an intentional and desirable outcome. This recreational access would include fishing, birding, camping, and picnicking, along with providing a destination for recreational boaters. It would become a landmark for solving flood and navigation issues jointly while providing the public and the environmental system with daily benefits. A conceptual view of the park aspects is shown in Figure 16.

Figure 16. Potential Recreational Use of the Proposed Galveston Bay Park



Source: Illustration by Rogers Partners for SSPEED Center.

Under a recent compatibility agreement between the Army Corps of Engineers, the Texas General Land Office, and the SSPEED Center at Rice, it has been agreed that the GBPP will be implemented through permits issued by the Corps, while funding for construction will come from private and local governmental sources. The GBPP must still undergo environmental clearance, secure local sponsors, and identify funding sources for construction costs, initially estimated as ranging between \$3 and \$6 billion (and being carefully re-evaluated). At the writing of this publication, the Harris County Commissioners Court has authorized the county attorney to evaluate seeking a permit for this park, and the Port of Houston Authority has voted to investigate being of assistance in the implementation of the park plan. If a permit application were timely submitted and funding secured, the park plan could be constructed—putting protection in place—before 2030.

III. The Green Coast

When we started work at the SSPEED Center after Ike, an urban planner from the University of Houston College of Architecture named Tom Colbert was part of the team. He encouraged us to think broadly and creatively—to make a statement with our project that would not only solve our problem but solve it in a bold and meaningful way. To illustrate his view of the vision, he created the image in Figure 17.

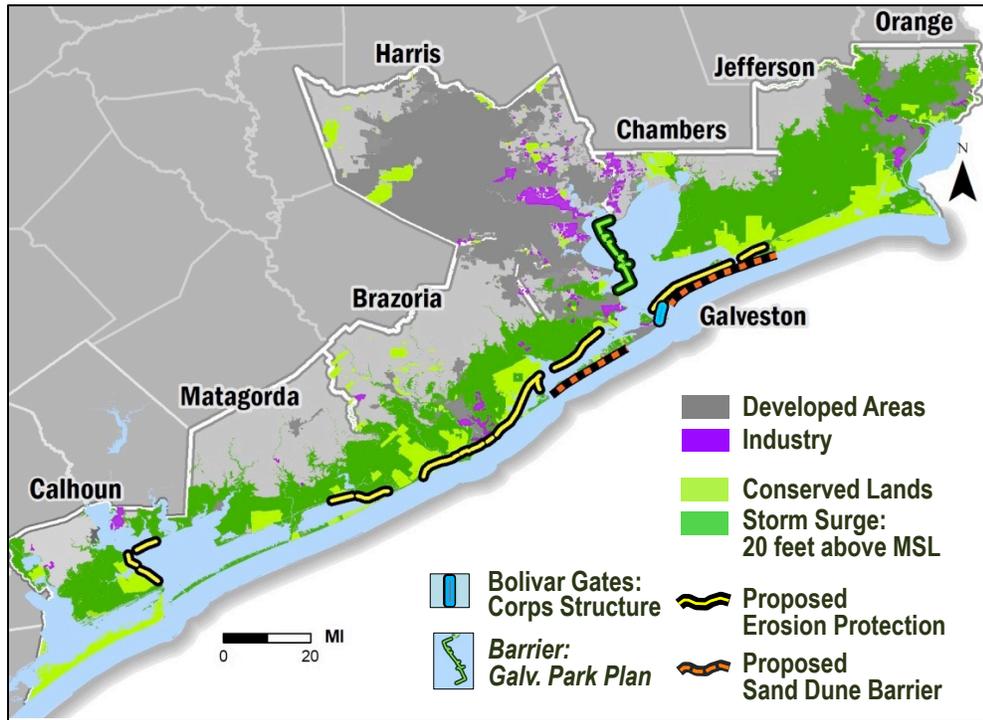
Figure 17. Tom Colbert's Vision of the Message to be Conveyed by a Successful Flood Damage Reduction Project



Source: Illustration by Tom Colbert for SSPEED Center.

The economic and ecological green coast described in this paper can be viewed as a metaphorical realization of this vision. The Statue of Liberty emerged from an oyster reef in New York Harbor. The LSCNRA, TCX, the Corps' coastal projects, and the park plan will emerge from the estuaries, marshes, and prairies of the Texas coast, embracing our diverse and intact ecological systems, which are notable and unique in the United States if not the world. The green coast stands for our values as Texans—a respect for private property and a belief in market systems and private sector solutions. It offers an adaptable and effective solution for the flooding problems that will define the 21st century along the coasts of the world. The collective effort of all of the proposals discussed in this paper is shown in Figure 18.

Figure 18. View of the Green Coast, including the LSCNRA, the TCX, the Coastal Barrier and restoration projects and the Galveston Bay Park Plan



Source: Graphic by Christina Walsh.

Tom Colbert is not among us to enjoy the arrival of the first stages of the green coast, as he succumbed to cancer in 2015. However, he would be proud of the projects that have evolved—projects inspired by his vision.