NATIONAL WILDLIFE FEDERATION

CLIMATE RESILIENT GALVESTON

Understanding Climate Vulnerabilities and Adaptation Strategies to Build Resilience

Galveston Island is no stranger to extreme weather events. From the Great Storm of 1900, which still holds the record for the deadliest storm in the U.S., to Hurricane Ike in 2008, which damaged more than three-quarters of the island's buildings, Galvestonians have rebuilt and recovered after countless turbulent storms and floods. Through it all, the island has maintained a vibrant identity and sustained a unique economy through historic preservation and adaptation efforts. But climate change will continue to make the island and its communities even more vulnerable to natural disasters.

The low-lying island is particularly vulnerable to sea level rise, as well as high-tide flooding during rainstorms. Warmer water and atmospheric temperatures will threaten delicate ecosystems that support migrating birds, oysters and turtles; stronger storms or prolonged droughts fueled by climate change may alter the flow of watersheds into Galveston Bay, impacting its salinity and nutrient levels.

To equip local leaders with the best available climate science and policy solutions, the National Wildlife Federation presents "Climate Resilient Galveston: Understanding Climate Vulnerabilities and Adaptation Strategies to Build Resilience." Comprehensive adaptation strategies, community engagement, and policy adjustments are essential to ensure the island's long-term resilience and sustainability. Nature-based solutions can help Galvestonians create long term and resilient solutions to face the climate crisis.

Key Terms

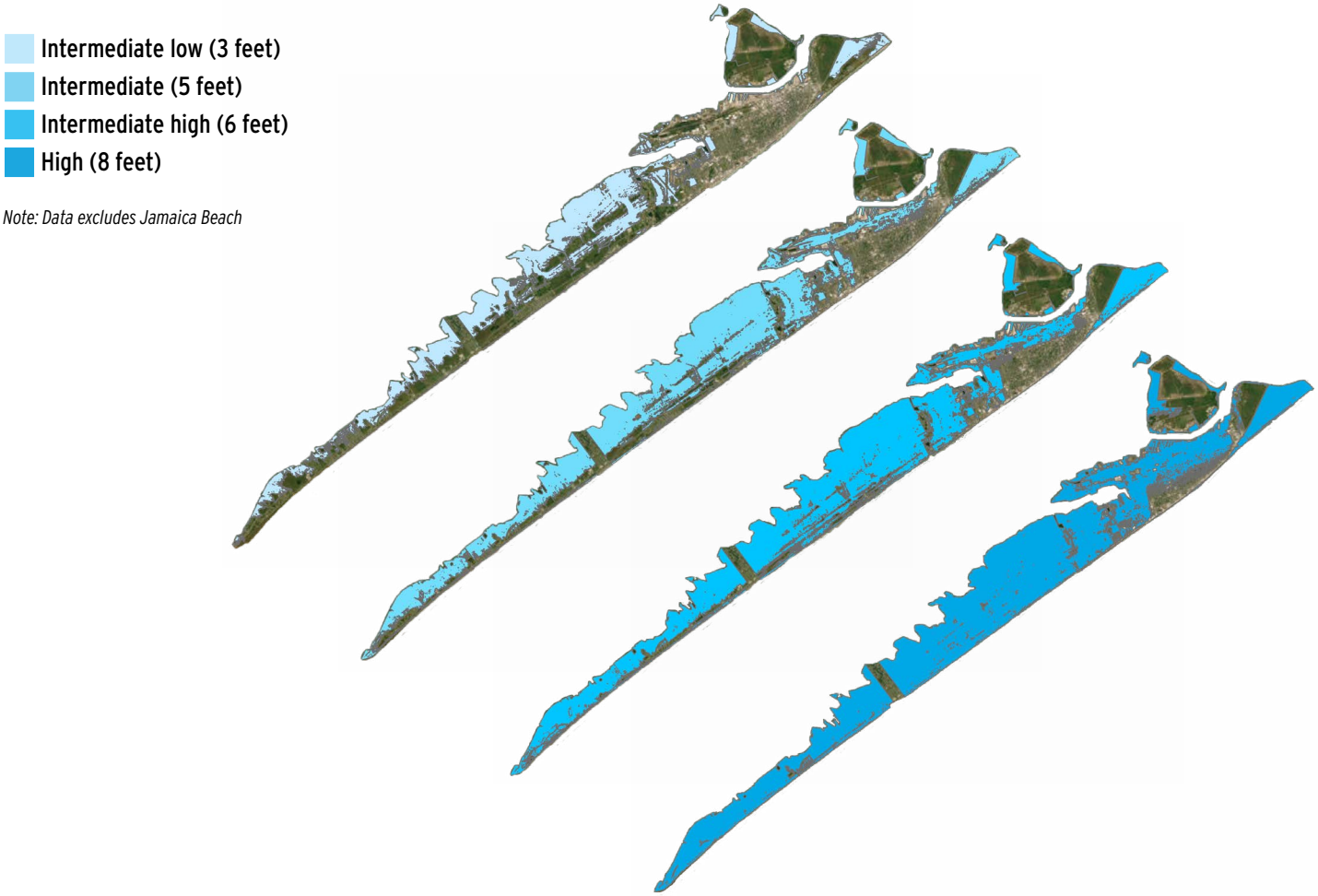
ADAPTATION: Measures and actions to prepare for and adjust to the the current or projected impacts of climate change.

NATURE-BASED SOLUTIONS: Projects that conserve or restore or mimic natural ecosystems, such as healthy wetlands, floodplains, and forests. These solutions can play an important role in community climate adaptation, while also providing economic, social, and environmental benefits for local communities.

Sea Level Rise

The upper Texas Coast is particularly vulnerable to sea level rise due to simultaneous local land subsidence caused by oil, gas, and groundwater extraction. As a result, sea level rise in Galveston is higher than the average along the rest of the coast, with the island seeing a 2.18 foot increase over the last century. This rate of change has accelerated in the last ten years, with a recent analysis suggesting an extraordinary rate of sea level rise: 8 inches in 14 years since 2010 (Washington Post, 2024). In the extreme scenarios outlined above, if sea levels rise without any adaptation, coastal flooding will be more severe, and beaches and community assets will erode. Eventually, both wetlands and dry land may be submerged, making the island uninhabitable for residents and wildlife.

Inundation Caused by Sea Level Rise (2100 Scenarios)



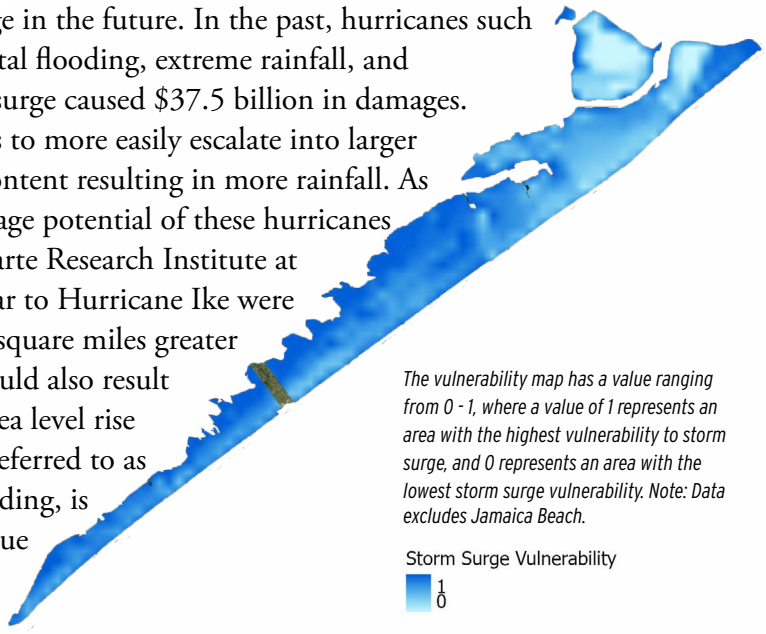
Note: Data excludes Jamaica Beach

Extreme Temperature and Rainfall

In Galveston, extreme temperatures on the hottest days of the year are projected to increase by 2 to 21°F by 2100, according to the Climate Explorer tool created by the National Environmental Modeling and Analysis Center (NEMAC) through statistical climate downscaling. An increase in extreme precipitation is likely. Historically, Galveston averaged 2 intense rainstorms per year. Annual counts of intense rainstorms—those that drop two or more inches in one day—vary significantly and are projected to have between a 2% decrease and a 14% increase based on the global greenhouse gas emissions scenarios.

Storm Surge and High Tide Flooding

Much of the island will also be susceptible to storm surge in the future. In the past, hurricanes such as Ike in 2008 and Rita in 2005 caused widespread coastal flooding, extreme rainfall, and dangerously high winds. Hurricane Ike's 15-foot storm surge caused $37.5 billion in damages. Warmer sea surface temperatures will allow small storms to more easily escalate into larger and stronger storms, and will cause a higher moisture content resulting in more rainfall. As storm surge combines with higher water levels, the damage potential of these hurricanes will further increase. In an analysis conducted by the Harte Research Institute at Texas A&M University-Corpus Christi, if a storm similar to Hurricane Ike were to hit Galveston in 2100, its storm surge would be 450 square miles greater than what the island experienced in 2008; the storm would also result in an additional 2.55 feet of storm surge height due to sea level rise and landscape changes. High tide flooding, sometimes referred to as nuisance flooding, sunny-day flooding, or king tide flooding, is occurring more frequently every year as sea levels continue to rise. This type of flooding is defined as the excess accumulation of ocean water at high tide that covers low-lying areas—anywhere from 1.75 to 2 feet above the daily average high tide—causing water to overflow onto streets or bubble up from storm drains. Galveston experienced 3-8 high tide flood days per decade between 2010 to 2020. Under intermediate-high scenarios and without any adaptation measures, high tide flood days may reach 209 annually by 2050.



The vulnerability map has a value ranging from 0 - 1, where a value of 1 represents an area with the highest vulnerability to storm surge, and 0 represents an area with the lowest storm surge vulnerability. Note: Data excludes Jamaica Beach.

What's at Risk?

A range of coastal habitats in Galveston provide hazard risk reduction through buffering storms, attenuating waves, and soaking and slowing runoff. They also provide community benefits such as improved air quality and outdoor recreation to Galvestonians. However, many of these ecologically significant areas are being impacted by development and land use changes. In the future, climate change-induced sea level rise and storm surge coupled with development pressures will lead to further loss of coastal habitats on the island. According to an analysis conducted by the Texas General Land Office, almost 13% of Galveston's land area is susceptible to convert into future open water due to sea level rise by 2100, under an intermediate-low scenario (TCRMP, 2023). Under an intermediate-high sea level rise scenario, nearly a quarter of the island is vulnerable to conversion into open water. About 17% of the existing coastal environment (such as freshwater wetlands, transitional wetlands, regularly flooded estuarine wetlands, tidal flats, and beach/foredune systems) is at risk of flooding and erosion under the intermediate-low sea level rise scenario, mainly along the bay shoreline where the largest wetland extent is located, and the strip of beaches and foredunes on the Gulf side.

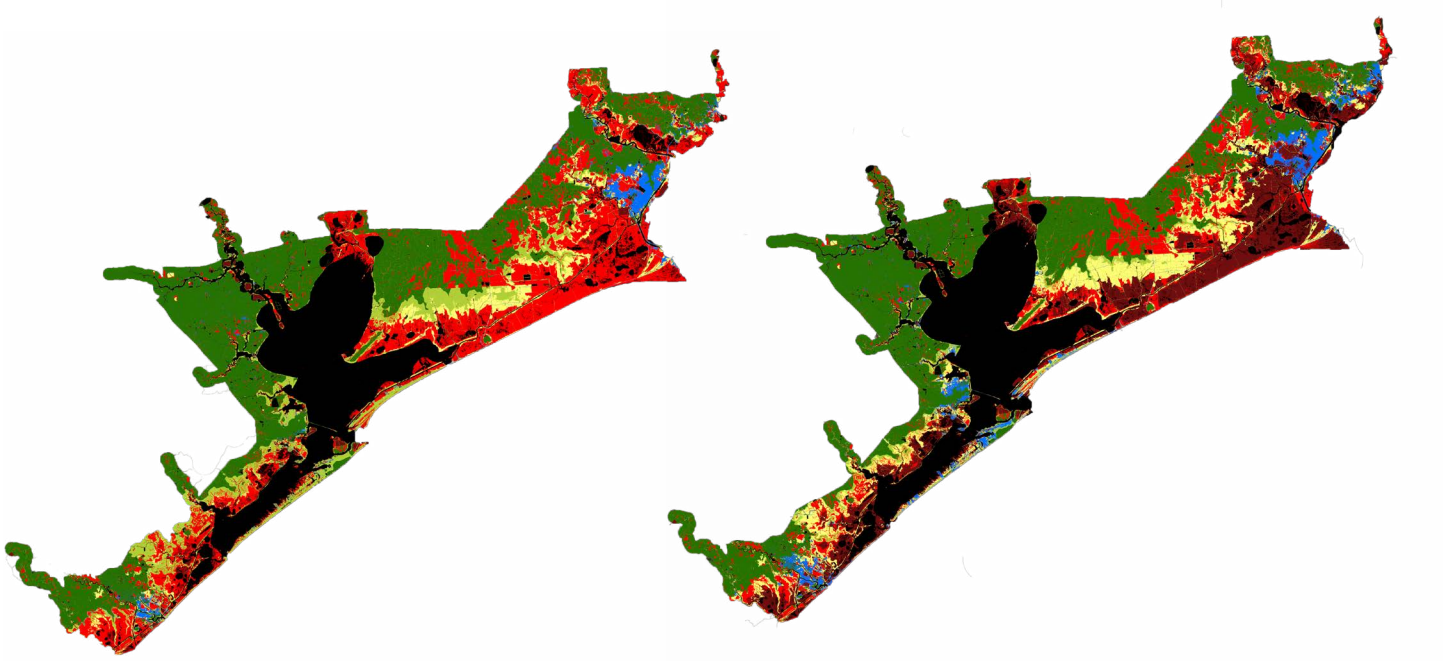
The loss of natural features will also mean the loss of the ecosystem services (benefits to human health, wellbeing, and environment that communities receive from nature) that they provide. Currently, wetlands around Galveston Bay can hold more than 300 million m^3 of water during a storm that generates a 1 m surge. They also store 29.21 million metric Tons C/ha of carbon dioxide. Losing these important systems poses the threat of cascading impacts, as carbon emissions may ultimately increase from inundated salt marshes or areas converted into open water (Guannel et al., 2014).

Extreme weather events can have long-lasting impacts on Galveston Bay's health. According to the Galveston Bay Report Card, the bay is susceptible to alternating between extreme high and low flow events (a measure of how much water is flowing through the bay's two major riversheds, bringing changes in salinity, sediments and nutrient

Geohazards Maps

Developed by Harte Research Institute at TAMUCC

Left: Intermediate-low scenario, 2100
Right: Intermediate-high scenario, 2100



levels). The bay experienced more high flow events between 2015 and 2020, likely affected by Hurricane Harvey's extreme rain; it experienced more low flow events between 2009 and 2014 due to the corresponding severe drought. As the climate continues to change, these extreme events such as hurricanes and drought will continue to intensify. For instance, increasing annual temperature will contribute to longer and prolonged droughts.

Droughts and hurricanes have devastated oyster populations in the bay (GBF and HARC, 2023). Oyster mortality rates increased from 11% before Hurricane Harvey to 48% post Harvey; the storm's extreme rainfall significantly lowered the salinity of Galveston Bay (Du et al. 2021). In the future, climate change may exacerbate many stressors on fish populations, including changes in ocean pH and salinity and an increase in water temperature. Galveston Bay's winter water temperature has increased more than 10% in the last 15 years causing the loss of plants and marine life in these systems that moved upwards into new areas. Additionally, several critical species such as larval and juvenile blue crabs, brown shrimp, southern flounder and red drum are found in Galveston Bay. Stocks are declining due to overfishing, loss of habitat and water pollution– threatening the vitality of the commercial fishing industry, which is a major component of the island's economy (TCRMP, 2023).

The island is home to a variety of mammals (rabbits, raccoons, river otters), reptiles (rattlesnakes, cottonmouth, American alligator, king snakes, alligator snapping turtles), and birds (Roseate spoonbill, tri-colored heron, brown pelican) that depend on high-quality breeding and nesting habitats to thrive. Loss of coastal habitats will cause cascading impacts to the wildlife that thrive in these systems. Several studies conducted in the Galveston Bay Estuary found a link between a decline in wetland area and declining waterbird populations, including wetlands found on rookery islands (USFWS, 2021). An increase in the sand temperature on beaches also disrupts the breeding balance for sea turtles, leading to more female eggs at higher temperatures (Patrício et al., 2021).

Sea level rise will result in the inundation of critical facilities and infrastructure along the coast. According to

Climate Central's Risk Finder Tool which combines data from over ten federal agencies, roads, hospitals, and homes are at-risk in Galveston under intermediate low, intermediate and intermediate high sea level rise scenarios by 2100.

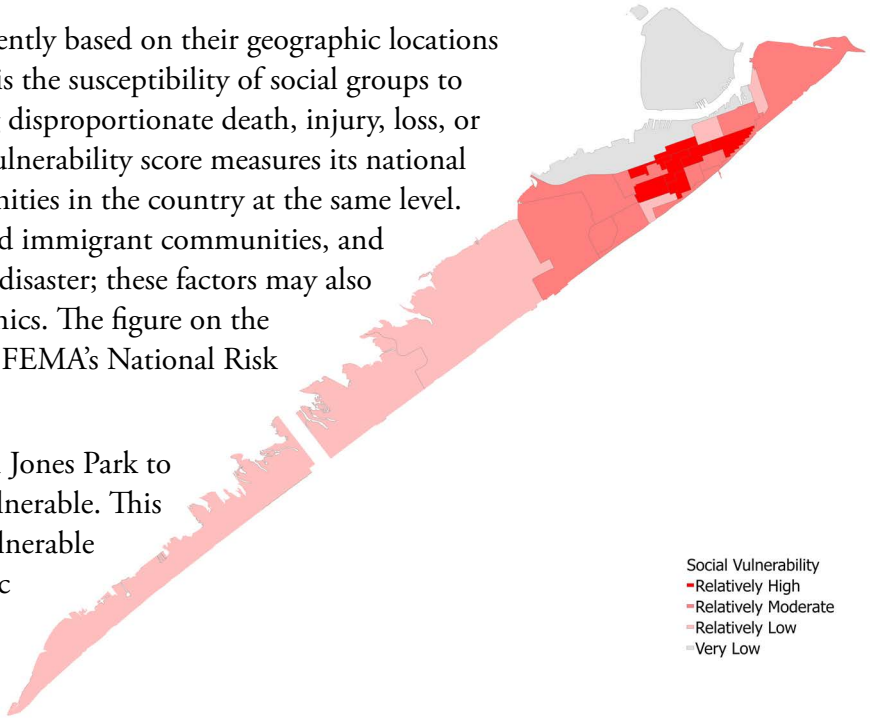
Under the low sea level rise scenario, only 7.4% of the Island's homes are at risk; that number increases nearly 10 fold to 71.8% under the high sea level rise scenario. A high increase in sea level rise will also lead to property damages totaling $5.133 billion. Hospitals in the area are not at-risk under the low and intermediate low sea level rise scenarios but become susceptible under the intermediate high and high scenarios. The absence of these critical facilities and the essential services they provide will have far-reaching consequences on Galveston's functioning and future existence.

Damage caused by Hurricane Ike in 2008 (United States Geological Survey / Karen L.M Morgan)

Social Vulnerability

Galvestonians will experience climate risks differently based on their geographic locations and socio-economic factors. Social vulnerability is the susceptibility of social groups to the adverse impacts of natural hazards, including disproportionate death, injury, loss, or disruption of livelihood. A community's social vulnerability score measures its national rank or percentile compared to all other communities in the country at the same level. For example, older adult populations, refugee and immigrant communities, and renters face different challenges during a natural disaster; these factors may also increase their risks compared to other demographics. The figure on the right displays levels of vulnerability according to FEMA's National Risk Index (NRI).

Communities on the east end of the island, from Jones Park to UT Medical Branch, were found to be highly vulnerable. This could be due to a higher than average socially vulnerable population in this area based on the demographic characteristics.



NATURE-BASED SOLUTIONS

Employing programs and adaptation strategies that protect natural resources and foster ecosystem and community resilience will help Galveston build a better approach for understanding and managing climate change. Nature based solutions also offer an opportunity to enhance wildlife habitat. Nature-based solutions pay particular attention to existing ecosystems which provide valuable resources and services. Wetlands provide protection from storm surge, and other habitats like seagrass meadows sequester and store carbon naturally.

Restoring these ecoystems can have compunding effects: for example, a Kemp's Ridley Turtle nest—one of the most endangered species of sea turtles—was found on Babe's Beach in Galveston, a renourished beach that historically has not been a preferred nesting site for turtles. The prevailing wisdom, however, is to build our way out of problems presented by climate change. Hard infrastructure projects—such as levees, sea walls, and drainage channels—tend to be the first solution that leaders gravitate towards. However, we know that recent extreme weather events have caused widespread failures among the nation's already stressed and deteriorating infrastructure. Additionally, there is a rising gap between the past climatic conditions most of these structures were designed to accommodate, and the conditions they eventually must confront.The number of billion-dollar climate and weather-related natural disasters has been increasing dramatically, with more than twice the number of such costly disasters occurring in the last two decades compared with the 40-year average.

Nature-based solutions, however, face barriers due to the lack of equivalent familiarity. Community members and stakeholders may lack technical training on the topic and express concerns about the effectiveness of such projects, hindering public support. Combined with a lack of regulations in place, nature-based solutions are often harder to adopt and implement. We have identified the following four pillars to advance nature-based solutions.

Pillar 1: Identifying and Implementing On-the-Ground Projects

We recommend that local leaders prioritize projects that protect and restore natural habitats that provide crucial ecosystem services such as flood control and carbon storage. Such projects may include living shorelines, offshore oyster reefs, and barrier beach and dune restoration. We have specifically highlighted the following projects for their ecological and social benefits: living shorelines, oyster reef restoration, salt marsh restoration, and urban planning policies that facilitate habitat connectivity. To successfully implement such projects, we recommend identifying potential locations that can replicate projects that have already proven successful.

Pillar One	1.1 Use living shorelines to stabilize shoreline edges, where appropriate.
	1.2 Explore construction of offshore oyster reefs and beds to attenuate wave energy, reduce erosion, and improve water quality.
	1.3 Protect and restore barrier beaches and dunes through renourishment and revegetation.
	1.4 Restore degraded salt marshes and facilitate marsh migration.
	1.5 Consider opportunities to establish habitat connectivity on and around local project sites.
	1.6 Implement site-specific green infrastructure measures to mitigate stormwater runoff, reduce urban heat island effect, and improve water quality.
	1.7 Prioritize low-impact development (LID) practices and conserve land to increase open space.
	1.8 Sustain freshwater inflows.

Pillar 2: Building Community Capacity and Cohesion

Public support and buy-in are crucial components for the success of nature-based solutions. Leaders will need to engage communities and create outreach and educational opportunities to highlight the importance of these projects. We recommend that engagement and outreach are integrated early in the planning processes, ensuring that residents understand the ecological and social benefits that may be seen in their neighborhoods. We suggest that leaders and planners identify community champions to lead discussions on climate change and resilience planning; additionally we propose that city leaders and the philanthropic community create a liaison position to aid collaboration between these establishments.

Pillar Two	2.1 Develop strategies for enhanced outreach and education. 2.2 Empower grassroot champions to co-design nature-based projects. 2.3 Create a city-community liaison to align city leadership, non-profits, and philanthropic interests to enhance collaboration and coordination. 2.4 Coordinate with existing organizations to promote ecotourism.

Pillar 3: Climate Jobs and Training

Nature-based solutions can create employment opportunities in conservation and climate-related fields. We recommend initiatives that will encourage community science participation, as well as resilience training programs for city officials and project-based learning collaborations. These job training and creation programs can be supported through partnerships with educational institutions, environmental organizations, and existing federal programs. Informal training programs that promote backyard habitat development practices can also engage the public in conservation efforts.

Pillar Three	3.1 Support and develop opportunities for community science. 3.2 Launch a place-based resilience training program for city officials. 3.3 Implement project and place-based learning through existing collaborations and frameworks. 3.4 Encourage backyard habitat development practices.

Texas City Prairie Preserve (Courtesy of R.J. Hinkle for The Nature Conservancy in Texas)

Pillar 4: Fostering a Conducive Regulatory and Policy Landscape

The policy framework needed to support nature-based projects must be strengthened to ensure the long-term success of these strategies. Government agencies and philanthropic organizations must be aligned on priorities and responsibilities; collaboration between these entities will be key to ensuring a coordinated response to climate change. We highlight land conservation and use of financial incentives to remove priority infrastructure from high-risk floodplains and the revision of building codes to account for climate change impacts. Additionally, overarching regulations that strengthen wetland protections, create transferable development credits and initiate comprehensive water resources management can all guide responsible development.

Pillar Four	4.1 Conserve land and use financial incentives to remove infrastructure from floodplains. 4.2 Update building codes to account for climate change impacts. 4.3 Incorporate the best available science on the impacts of climate change in policies, regulations and programs. 4.4 Create local wetlands protection bylaws and regulations. 4.5 Designate areas requiring special protection in light of climate change (e.g., beaches, wetlands, priority habitat) and limit new development in these areas. 4.6 Use transferable development credits to reduce risky coastal development. 4.7 Implement comprehensive water resources management such as One Water. 4.8 Create incentives for integrating nature in development. 4.9 Increase collaboration among local, regional, and state entities.

Citations

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For a more detailed guide to these pillars, please access a fully copy of *Climate Resilient Galveston* at the following link. This report builds upon a similar assessment we conducted for the Texas Mid-Coast. Access a copy here.

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