



HURRICANES HARVEY AND IRMA

Rapid Assessment Report



This rapid assessment provides a detailed early look at the impacts of hurricanes Harvey and Irma to the critical bird and wildlife habitats of the affected areas in Texas and Florida. Early recovery projects are included, as well as recommendations for overall resiliency priorities for the natural and built landscapes of the states’ coasts.

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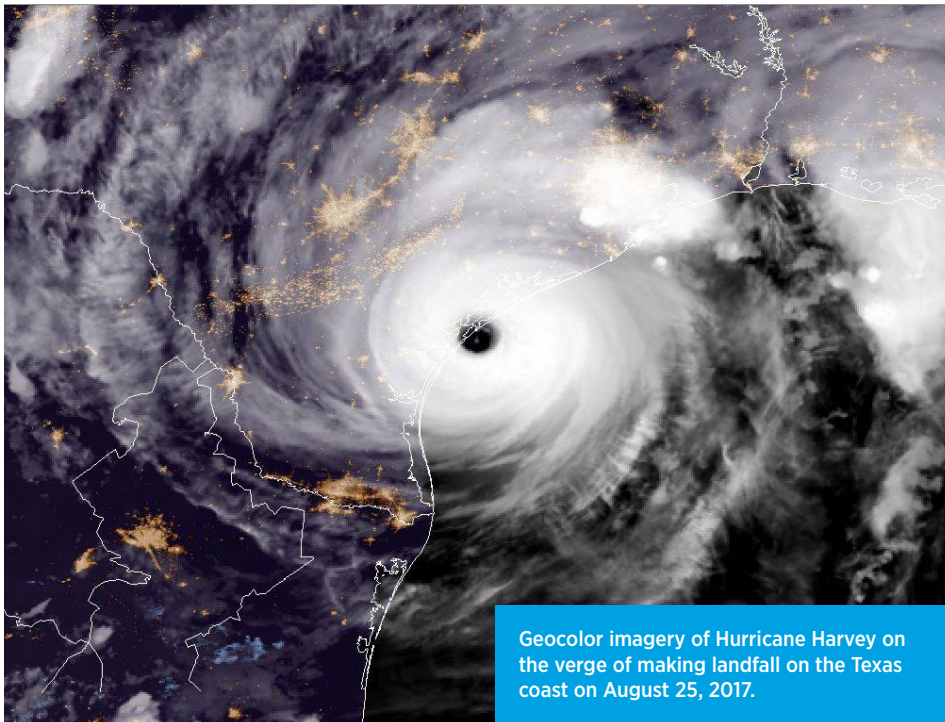
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Cover: Houses on Florida’s Vilano Beach built for the ocean view are now too close for comfort. A sea wall protected some parts of the beach from Hurricane Irma, but not all.

Photo: Andrew Moore



ANGELO GARBALDI/SHUTTERSTOCK



Geocolor imagery of Hurricane Harvey on the verge of making landfall on the Texas coast on August 25, 2017.

CIRA

Introduction

Hurricanes have been a part of our lives in many coastal areas for as long as we have historical records. For birds and other wildlife, hurricanes serve to rework our coastal habitats, destroying some areas while often providing sand and sediment to actually build others. However, as we have continued to develop and live in coastal areas, the destructive forces of hurricanes challenge the resilience of our coastal communities and the essential habitats upon which resident and migratory birds depend for their existence. Climate change has further increased the destructive nature of hurricanes; sea levels are rising; waters are warmer, thus fueling more intense hurricanes in ways that we haven't witnessed in the previous century.

The summer of 2017 was unprecedented in recorded history, with three major hurricanes, Harvey, Irma, and Maria, hitting the Gulf Coast states, multiple Caribbean islands and Dominica in a single season. The long-term impact of these storms on

critical island, wetland, and coastal forest habitats is still unfolding, as are efforts to maintain community resilience in their aftermath. Audubon has been providing coastal stewardship in all five of our Gulf States, Mexico, and several Caribbean islands for years. We are uniquely qualified to assess the impacts of the hurricanes on birds, wildlife, and coastal communities, and to provide leadership to inform long-term recovery on a local, regional, and Gulf-wide level.

This rapid assessment provides a detailed early look at the impacts of hurricanes Harvey and Irma to the critical bird and wildlife habitats of the affected areas in Texas and Florida. (An assessment of the impacts of Maria was not yet possible at the time of this report.) Early recovery projects are included, as well as recommendations for overall resiliency priorities for the natural and built landscapes of the states' coasts.

+ Priority Actions

While final assessments are still underway, non-governmental organizations and government agencies have begun working to mitigate the negative impacts from the storms. Objectives of the response are as follows:

- Restore critical waterbird nesting islands and beaches to support bird habitat and protect communities;
- Restore or establish coastal barrier islands to protect communities from future storm surges and establish critical wildlife habitat;
- Restore shorelines and habitats suffering from storm-related erosion, using natural infrastructure techniques such as living shorelines and native plant restoration;
- Establish a voluntary buy-out program that reconnects floodplains to river systems, addresses future headwater threats, and saves taxpayer funds;
- Replace infrastructure important for erosion control, management activities, and nesting;
- Enhance stewardship capacity on islands and beaches to protect nesting habitat;
- Rapidly assess effects from the storm on the upcoming avian breeding season; and
- Using science, engineering, and stakeholder processes, work with communities to design a future more resilient to storms and storm surge while also enhancing wildlife habitat.

Recovery efforts must focus on near- and long-term solutions that will restore critical coastal habitats impacted by the storm and make the Gulf Coast resilient to future storms. The tables that accompany this report outline recommended projects to be implemented by NGOs, government agencies, and universities.

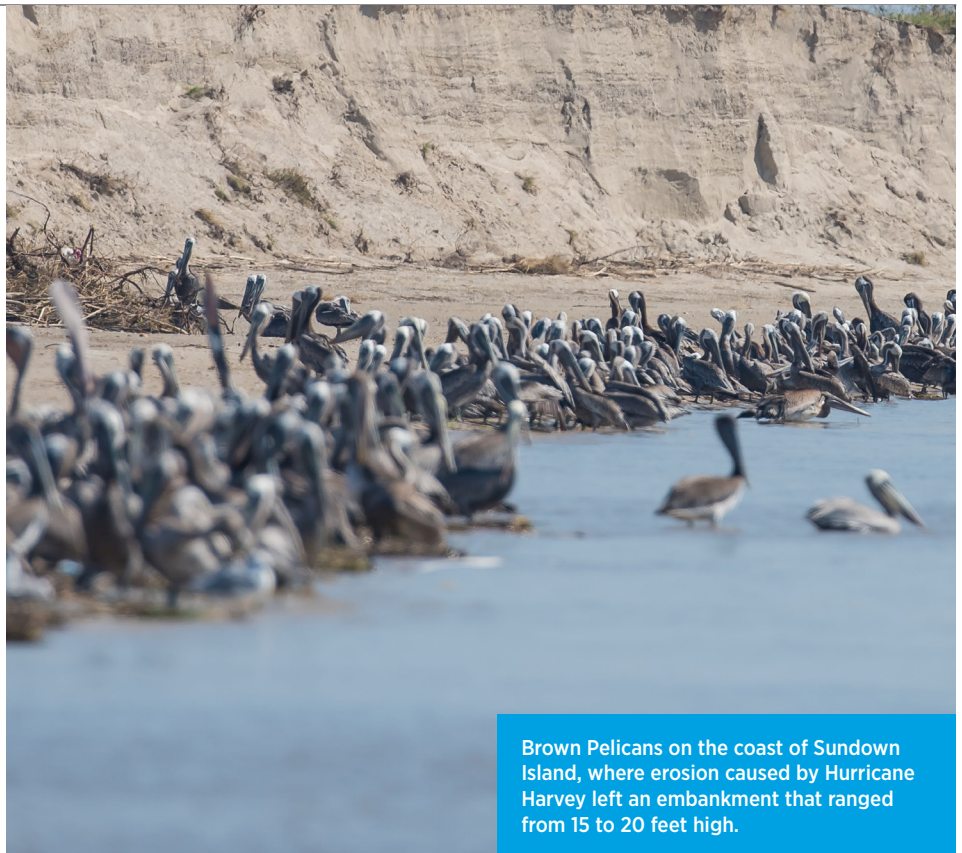
HARVEY

Overview

Hurricane Harvey was actually two storms in one. It was a powerful hurricane as the first Category 4 storm to make landfall in the United States since Hurricane Charley in 2004. The central coast of Texas was pounded by its immense force, and the inland areas were equally impacted by strong winds and heavy rains. In addition to the impacts to people, there were also severe habitat impacts for birds and wildlife in this region. Harvey then went back out to sea and became an expansive and slow-moving tropical storm that crippled the upper coast with devastating flooding, racking up a potential economic impact of nearly \$100 billion.

Habitats and natural areas were heavily affected by this flooding, the storm surge, and the continued winds of the storm. Particularly hard-hit were colonial waterbirds and shorebirds, including Brown Pelicans, Black Skimmers, herons, egrets, terns, plovers, and other coastal birds, as well as upland birds such as the Attwater Prairie Chicken. Death and injury to these birds is a part of any hurricane or tropical storm; however, Harvey battered our coastal ecosystems for many days in several different ways, creating larger conservation challenges than usual.

“ Habitats and natural areas were heavily affected by the flooding, the storm surge, and the continued winds of the storm. Particularly hard-hit were colonial waterbirds and shorebirds. ”



Brown Pelicans on the coast of Sundown Island, where erosion caused by Hurricane Harvey left an embankment that ranged from 15 to 20 feet high.

PEGGY WILKINSON

Background

The Texas coast stretches over 367 miles, and much of it has long suffered from severe erosion, lack of freshwater inflows, and pollution. This rich eco-region is the wintering grounds and stopover sites for more than 98% of the long-distance migratory bird species in North America. More than 60 species of coastal birds depend on Texas' marshes, shorelines, and islands. Many of these species are found throughout the Gulf Coast, feeding and nesting in pockets of viable habitat interspersed amongst our coastal communities. Coastal birds rely on this network of habitat sites, moving in response to changes in predators, prey availability, nesting substrate, and human disturbance. Substantial loss of habitat in the Gulf has hindered the ability of coastal birds to adapt to changes in their nesting and feeding habitats, making them

highly vulnerable to unpredictable events, like oil spills and hurricanes. It is critical to maintain existing—and create additional—habitat to afford coastal birds the capacity to adapt to this ever-changing environment.

Birds and other wildlife are important to the economy and vitality of the Texas Gulf Coast. Rockport, where Hurricane Harvey made landfall, is a community fueled by ecotourism, with people flocking to the small town from throughout the country to see coastal and migratory birds. Overall, coastal and migratory birds attract 3.2 million birders to the Texas coast annually. In 2013, Texas coastal tourism generated more than \$5 billion and supported 72,417 jobs. State and local tax revenue was estimated at nearly \$820 million.

Habitat Impacts

Beaches

Texas has an expansive beach and barrier island system. Barrier islands have distinct landforms that are characterized by their sediment type and location on the island. The beach side faces the sea and receives the full force of the wind, tide, and currents, whereas the shoreward side of the main body of the island is the back-barrier. The back-barrier region consists of a protected shoreline and bay or lagoon, which is more influenced by tides than waves. Additionally, during storms, water may rush over the island carrying beach and dune sand and deposit the sand in the bay, helping to create important habitat types that include salt marsh, sea grass, and mudflats. These muddy and/or sandy sediments are rich with organic matter, helping to support a large diversity of plant and animal life.



Eroded beach on Aransas Bay



These before and after photos from Sundown Island demonstrate just how dramatic Harvey's impact on the landscape could be.

H.M. ARNOLD

Beach and barrier islands are critically important to beach-nesting birds and migrating shorebirds. Beach-nesting birds include solitary nesting species, like the Wilson's Plover, Snowy Plover, Eastern Willet, American Oystercatcher, and Common Nighthawk, as well as colonial-nesting seabirds like the terns and skimmers.

Initial assessments conducted by researchers with Harte Research Institute and The Texas General Land Office describe shoreline retreat to varying degrees northeast of where the eye crossed the shoreline. Additionally, back-barrier regions endured further erosion as Hurricane Harvey crossed back over the same barrier islands as it returned out to the Gulf prior to making landfall again closer to Galveston. Studies of beach profiles off the mainland and on barrier islands—both beach and back-barrier sides—to determine the actual degree of erosion and accretion Harvey caused will be essential in determining impacts to multiple species including beach-nesting and migrating shorebirds.

Rookery Islands

Prior to the extensive Gulf Intracoastal Waterway (GIWW) dredging projects of the early 1900s, colonial waterbirds depended on natural rookery islands. Few natural islands remain due to changes in hydrology and erosion rates. However, when the GIWW was completed in the mid-20th century, dredged material heaped along its sides formed new islands that became replacement rookeries for waterbirds. In recent decades these GIWW dredge spoil islands have been eroding as a result of limited natural processes encouraging natural beach building. Today, those that remain are experiencing severe erosion. National Audubon Society leases hundreds of these islands from the Texas General Land office to protect them for waterbirds for years to come.

Hurricane Harvey reduced the size of key nesting islands, which may negatively impact colonial waterbirds. Such waterbirds, like Brown Pelicans, Roseate Spoonbills, and Reddish Egrets, nest in large mixed-species groups, which affords them protection from predators. Each species nests in a different habitat type, such as Great Blue Herons in large shrubs

and trees, Reddish Egrets in low vegetation, Least Terns on bare ground, and Brown Pelicans in any of these habitats, depending on availability. The complete scouring of vegetation seen on many of the islands, especially of shrubby plants, will impact long-legged wading birds like Reddish Egret, Tricolored Heron, Roseate Spoonbill, and Great Blue Heron. Loss of bare ground will affect ground nesters like Piping Plovers and Black Skimmers. And Brown Pelicans will flourish, outcompeting and thus threatening other coastal bird species.

Wind-battered islands and other nesting sites have lost sand and shell, lowering their elevations and thus putting nesting sites at greater risk to storm surge. Black Skimmers will often build nests on low-lying bare ground islands, only for their nests to be overwashed with a high tide or typical storm. These low-lying but otherwise suitable sites act like population sinks, attracting nesting birds but producing no fledglings. Geospatial data analysis is vital to ascertaining subtle changes to island elevations and size, which may have profound effects on nesting success.

“ Wind-battered islands and other nesting sites may now be lower in elevation, thus putting nesting sites at greater risk to storm surge. ”

Victoria Vazquez, coastal conservation program manager for Audubon Texas, right, and warden Dennis Jones, center, dig out a prickly pear cactus from the mound of shells left on the beach by Hurricane Harvey.



JULIA ROBINSON

Marshes

Coastal marsh is found along much of the Texas Gulf Coast and protects many vulnerable coastal areas against storm and current inundation and surge. Virtually everything in the estuarine environment is tied to coastal marsh. It provides food, nurseries for shrimp and fish, and nesting habitat for a suite of bird species, including wintering habitat for the endangered Whooping Crane. Studies have highlighted the value of well-functioning estuarine ecosystem and the magnitude of ecosystem services they provide to us and our economies.

Initial assessments from the central coast show that coastal marshes on the mainland and on peninsulas experienced some erosion, especially in the areas experiencing the greatest storm surge (i.e. Aransas National Wildlife Refuge). According to a USFWS early assessment

document, the refuge experienced 5-20 feet of erosion. (In a typical year, erosion at the refuge is measured in inches.) Barrier islands near Aransas, Mesquite, and San Antonio Bays experienced overwash from that same storm surge, fragmenting and in some cases completely removing coastal marsh habitats.

In areas where coastal marsh was inundated by storm surge, wrack lines full of potentially hazardous materials and other man-made debris were left behind and must be removed. Removal must be done in a sensitive manner, or it can be extremely damaging to marsh ecosystems. The best-practice removal protocols used at federal and state protected areas should be made available to the public and be used on private lands, possibly through existing state and federal landowner-assistance programs.

Monitoring of coastal marsh throughout



Uprooted trees on
Second Chain Island

the Harvey impacted area must also be a priority. Partner and volunteer observation in areas impacted by the storm indicates that, to date, coastal marshes not affected by erosion fared well during the storm and the associated flooding. This was to be expected: Many studies have demonstrated the capability of salt marshes to attenuate waves; much like mangroves on the coast of Florida, marshes dissipate wave energy and persist even when above-ground grass stalks are damaged.

Even so, studies should focus on marsh health well beyond the next year. Scientists have always thought marshes could withstand nutrient enrichment, such as the flow of nitrogen and phosphorus from fertilizers and septic systems; however, a recent study lead by Linda A. Deegan, a senior scientist at the Marine Biological Laboratory in Woods Hole, Massachusetts, showed that adding large amounts of nutrients to an estuary leads

to an initial burst of growth but eventually causes the marsh plants to collapse onto themselves, converting healthy systems into mud flats (Deegan, L.A et al, 2012). Excess fresh water full of nutrients and runoff is flowing into each bay system and being further distributed by the Gulf Intercoastal Waterway (GIWW). This flow of nutrients may cause unexpected marsh loss throughout the coast, impacting entire estuarine environments.

Estuary Waters

As Hurricane Harvey stalled over the coast of Texas, rainfall accumulated in the region, reaching record levels in just a few days. Rivers and bayous flooded, and in the weeks following

they carried fresh water, silt, and trash to the bays. This large influx of fresh water and silt will force fish and other marine life away from major parts of the bay systems in search of saltier water—a displacement of prey that may have significant impacts on coastal birds. At the time of the storm the nesting season had just ended, with lots of young, inexperienced birds foraging in the bays.

The effect of diminished food availability on these juvenile birds won't be discernable until the next nesting season. We are also concerned that excessive nutrients from runoff may create algal blooms in coastal waters, followed by low water oxygen and fish kills. Red tides and other toxic algal blooms may be of concern as well, and would impact not only fish-eating birds, but migratory shorebirds too.



Carcasses of Great Blue Herons
found on Second Chain Island

Coastal Impacts by Region

Upper Coast

Galveston Bay experienced tropical storm force winds and two to five feet of storm surge. These conditions were not as severe as in the central coast, where Harvey made landfall as a Category 4 hurricane. Regardless, there were island and shoreline impacts that need to be addressed, as well as a larger environmental issue of extreme fresh water inundation to the bay as a result of strong and intensive pulses of fresh water inflow from flooded rivers and bayous. The resulting rapid decrease in salinity in the bay system has likely dramatically impacted oyster reefs and proximal fisheries critical for avian foraging.

Rookery islands in the upper coast of Texas are found primarily in the Galveston Bay area. The suite of islands hosts as many as 35,000 breeding pairs of colonial waterbirds annually. North Deer Island and Marker 52 Island experienced substantial overwash and deposition of sand and shell material onto plants near the shoreline. Some vegetation was partially uprooted. The extent of the effects are unclear and are still being investigated.

Central Coast

The central coast of Texas has more than 100 small dredge spoil islands that support nesting colonial waterbirds. Roughly half of the islands were severely impacted by Harvey, which caused erosion,

shifting shorelines, and destruction of nesting structures. Substantial vegetation loss occurred, further exacerbating the ongoing effects of erosion, and devastating important wildlife habitat.

Sundown Island (known locally as Chester's Island) in the Matagorda Ship Channel near Port O'Connor, Texas, hosts 17,000–20,000 pairs of nesting colonial waterbirds every year. Sundown Island experienced storm surge of four feet along with high winds, which caused erosion, especially on the more vegetated south and southeast sides, where the storm left an embankment 15 to 20 feet high. In total, the island lost seven acres, reducing its size to 76 acres. The wetlands on the southern end have been breached, with extremely strong flow going in and out during tide changes. Dead birds were found along the shoreline and interior, mostly Brown Pelicans. Additionally, an obvious and disturbing amount of plastic bags, bottles, chemical containers, and other trash was found, much of which was removed. Loss of nesting vegetation and area may have an impact on species composition and abundance during future nesting seasons.

Big Bayou Island experienced severe erosion, resulting in a substantial loss of bare ground habitat. This could affect bare-ground nesters, such as Black Skimmers and Least Terns. Second Chain and Third Chain Islands also experienced substantial erosion and shoreline shifting. Deadman's Island was practically wiped out, eliminating habitat for shrub and tree nesters that nested in the constructed platforms.

Harvey's destructive winds battered and displaced posted awareness signage on Second Chain and many other islands.



ELIZABETH SMITH

Audubon's recommendations for projects to repair damage resulting from Harvey, and making these habitats and species more resilient in the face of future storms:

Restoration of Damaged and Lost Habitat

Project	Impact	Action	Why	Status	Location	Cost
In-depth analysis of geospatial data to determine erosion & habitat change from pre- to post-Harvey	Erosion	Acquire LiDAR & aerial imagery, collect vegetation data for ground-truthing, conduct geospatial analysis.	Post-Harvey LiDAR and aerial imagery will illustrate the current island shorelines and elevations and allow us to compare them to past imagery and elevation data.	Audubon completed a study on "Predicted Waterbird Habitat Loss on Eroding Texas Rookery Islands" in 2016. The study included aerial imagery and LiDAR data ranging from 2004 - 2014.	Islands in Galveston, Matagorda, and Corpus Christi Bay systems	\$140,000
Assignment of future dredge material from nearby dredge maintenance projects to islands & shorelines	Erosion	Coordinate with USACE for placement of beneficial use material from September 2018 - January 2019.	The USACE regularly dredges shipping channels and ports to maintain safe ship traffic. It is most cost-effective to work with USACE to ensure material is placed where it is most needed.	Material last placed on Sundown Island in Matagorda Bay in January 2017.	Matagorda Bay and Corpus Christi Bay Systems	\$35,000
Replacement of lost nesting structures	Habitat loss	Plant native vegetation including fast-growing species of Acacia, Lantana, and Opuntia. Construct nesting platforms.	Certain bird species only nest in bushes or trees, therefore replacing lost plants is necessary to providing sufficient habitat for next year's nesting season. Since plants take time to grow, constructed nesting platforms will provide immediate habitat.	Thirty-eight tree seedlings were planted on Sundown Island in Matagorda Bay near Port O'Connor on November 10, 2017.	Matagorda and Corpus Christi Bay systems	\$50,000
Assessment of effects of Hurricane Harvey on colonial waterbird foraging habitat	Habitat loss	Train additional community members to become Audubon community scientists; schedule monitoring at additional marshes.	Nearby foraging, or feeding, sites are integral to successful nesting. Community scientists help biologists gather data, making the geographic extent of data collection much greater than it would be without community involvement.	Audubon community scientists currently monitor 148 foraging sites in 14 coastal counties.	Galveston, Matagorda, and Corpus Christi Bay systems	\$100,000

Restoration of Damaged and Lost Habitat

Project	Impact	Action	Why	Status	Location	Cost
Trash and debris removal including special concern for chemical containers and other hazardous materials	Habitat degradation	Conduct island and beach clean-ups.	Birds can ingest or get entangled in trash, often resulting in death.	Trash and debris are picked up every year from September - January in preparation for the subsequent nesting season. Additional workdays may be necessary to collect the trash and debris washed onto the islands from Harvey.	Galveston, Matagorda, and Corpus Christi Bay systems	\$50,000
Assessment of effects of Hurricane Harvey on Whooping Crane populations in Texas	Habitat loss	Increase geographic extent and frequency of monitoring.	The landfall location of Hurricane Harvey coincides with the wintering habitat of the endangered Whooping Crane.	A workshop to train community scientists on the procedures for monitoring Whooping Cranes is scheduled for December 2017.	Aransas National Wildlife Refuge and nearby areas	\$20,000
Protect North Deer Island from further erosion	Erosion	Repair damaged groin, behind which the shoreline is eroding.	North Deer Island is one of the most productive rookery islands on the Texas coast.	Groins were installed on the north side of North Deer Island in 2008.	Galveston Bay	\$80,000
Restore Sundown Island	Erosion	Work with US Army Corps of Engineers to obtain beneficial use material at no charge. Hire contractor to move the applied material within the island to provide the most suitable bird habitat.	Sundown Island is one of the most productive rookery islands on the Texas coast.	One million cubic yards of beneficial use material was placed on Sundown Island in January 2017 at no charge.	Matagorda Bay	\$50,000
Protect Sundown Island from further erosion	Erosion	Purchase and installation of dredge material and installation of gray infrastructure to prevent erosion.	Sundown Island is one of the most productive rookery islands on the Texas coast.	Conceptual designs have been completed.	Matagorda Bay and Corpus Christi Bay Systems	\$5,000,000

Restoration of Damaged and Lost Habitat

Project	Impact	Action	Why	Status	Location	Cost
Assessment of effects of Hurricane Harvey on shorebird wintering and breeding populations	Erosion, shifting shorelines	Increase geographic extent of monitoring.	The threatened Piping Plover and many other shorebird species winter along the Texas coast.	A workshop to train community scientists on shorebird identification is scheduled for December 2017.	Galveston, Matagorda, and Corpus Christi Bay systems	\$20,000
STUDIES						
Assessment of green infrastructure opportunities that will replace gray infrastructure practices and support a buy-out program	Flood mitigation	Work with subject matter experts to identify green infrastructure projects to support comprehensive buy-out programs in the city, county, and throughout watersheds.	Harvey and other recent flood events are examples of the need to work with more progressive flood mitigation strategies that work with natural systems rather than alter them.		Greater Houston Area and other coastal communities	\$1,500,000
Evaluation of the ecological impacts of storm surge infrastructure project called Ike Dike or coastal spine	Altered hydrology and infrastructure damage in Galveston Bay region	Work closely with coastal spine project partners to review and assess ecological benefits of project and its ability to reduce impacts of storm surge on community and ecological infrastructure.	Major storm surge mitigation and hydrological changes can interfere with natural systems and cause unintended changes to coastal ecosystems.	Initial conversations are ongoing with project partners.	Sabine Pass, Galveston, West, and Matagorda Bay Systems	\$2,250,000
PREY						
Monitor fisheries	Altered freshwater inflow and salinity reduction	Increase monitoring frequency, if needed. Compare pre- and post-Harvey data.	Availability of prey is a key factor in bird survival.	Texas Parks and Wildlife Department has an ongoing fisheries monitoring program.	Galveston, Matagorda, and Corpus Christi Bay systems	\$300,000
DISTURBANCE						
Communication of importance of maintaining distance from nesting birds	Human disturbance	Install restricted access signs, provide informational brochures to recreational boaters, increase awareness through community-wide events.	Human disturbance can cause adults to flee the nest, leaving eggs and chicks vulnerable to predation and high temperatures.	Three signs lost or knocked over during Harvey were installed on Sundown Island on November 10, 2017.	Galveston, Matagorda, and Corpus Christi Bay systems	\$30,000
						Total
						\$9,625,000

IRMA

Overview

Shorebirds, seabirds, and long-legged wading birds depend on Florida's vast array of coastal habitats—sandy beaches, sand and mudflats, and mangrove islands—for year-round nesting, feeding, and resting. Wind and rain delivered by tropical weather systems are a fact of life for all of Florida's bird residents and visitors but their resilience in the face of these storms is compromised by continued coastal development, increasing human beach recreation, and coastal armoring with seawalls. In 2017, three tropical weather systems significantly impacted Florida's coastal nest success and habitat, the latter for years to come. Tropical Storm Cindy made landfall in Louisiana on June 22 but heavy rain and winds battered Florida Panhandle nests. Hurricane Harvey made landfall on August 25 in Texas and again on August 29 in Louisiana, with storm surge battering western Florida Panhandle beaches.



Most devastatingly, Hurricane Irma made landfall in the middle Florida Keys and again at Marco Island on September 10, pounding the interior Florida peninsula and both Gulf and Atlantic coasts as she passed northward through the state and into South Georgia. With peak wind gusts of 142 mph recorded in Naples, the center of the storm path passed approximately 2.5 miles west of Audubon's Corkscrew Swamp Sanctuary and continued across the state to exit in northeast Florida. Not only was this

storm powerful, it was also vast, causing impacts to the entire peninsula of Florida and its natural resources. From toppled tropical hardwood hammocks in the Keys to critically eroded beaches in Jacksonville, the natural-resource impacts from this storm were widespread and extensive.

Coastal Impacts

Audubon staff partnered with the Florida Fish and Wildlife Conservation Commission to rapidly assess visible impacts to 87 sites important to nesting and migratory shorebirds and seabirds and 24 important wading bird rookery sites throughout the Florida peninsula and the Florida Panhandle. Storms Cindy and Harvey caused Black Skimmer and Least Tern egg and chick mortality at six sites in the western Panhandle. Hurricane Irma made landfall at the end of the nesting season, causing major habitat impacts and some mortality to late-nesting wading birds in Southwest Florida. Of the 87 coastal beach sites assessed, 34% suffered harmful erosion, primarily in Collier, Lee, Nassau, Duval, and St. Johns counties. Of the wading bird rookery sites assessed, 62% suffered damage that may significantly affect tree-nesting birds primarily in Hillsborough, Pinellas, Manatee, and Collier counties.

Interestingly, because many beach-nesting species prefer open sandy areas with little vegetation, there were some sites that had storm impacts that improved the habitat by burying or salt-killing vegetation. Approximately 22% of assessed coastal beach sites saw some improvement in habitat condition because of this successional reset.

Saltmarsh habitats fared very well, performing the storm surge attenuation functions for which they are renowned. Cordgrass marshes were largely unimpacted, and effects to mangrove marshes were limited. Even in Florida Bay, where staff expected catastrophic torsion of mangroves comparable to that seen after Hurricane Wilma, trees showed only modest windburning, which will recover within a season.



Audubon worried for Florida's wintering shorebirds in the face of Irma. This Piping Plover from Nova Scotia was found safe in Northeast Florida two days post-storm.

PAT AND DORIS LEARY

“ Of the 87 coastal beach sites assessed, 34% suffered harmful erosion, primarily in Collier, Lee, Nassau, Duval, and St. Johns counties. Of the wading bird rookery sites assessed, 62% suffered damage that may significantly affect tree-nesting birds, primarily in Hillsborough, Pinellas, Manatee, and Collier counties. ”



Audubon has managed the Alafia Bank Sanctuary (owned by the Mosaic Company and Port Tampa Bay) for more than 50 years.

JOHN LONDON

The Richard T. Paul Alafia Bank Sanctuary and Critical Wildlife Area, located in eastern Tampa Bay, annually hosts up to 13,000 nesting pairs of 18 shorebird, seabird, and wading bird species. The Sanctuary hosts Florida's largest Roseate Spoonbill colony and one of the largest Reddish Egret colonies in the state. The shorelines and wading bird nesting trees protected by the existing breakwaters survived the storm with minimal impacts, while erosion and significant tree damage occurred only along the north shore of Sunken and Bird Islands where protective breakwater structures have not been installed.

More than 20 mature native trees used by nesting Brown Pelicans, Roseate Spoonbills, Reddish Egrets, and other large waders were uprooted along the shoreline and a 10-foot-high escarpment on a land bridge between the two islands, in addition to damaged limbs on interior trees. The Alafia Bank continues to experience rapid loss of critical habitat along the northern shoreline not protected by the offshore breakwaters. Events like Hurricane Irma exacerbate and accelerate this process and will continue to do so until we are able to complete the breakwater array, at an estimated cost of \$2.1 million.



Storm overwash cleared vegetation from Julia's Island—an improvement for Least Tern nesting—but it also reduced the island's elevation, leaving nesting birds more vulnerable to seasonally high tides and storm events.

AUDUBON FLORIDA

Julia's Island is a paddle or ferry ride from downtown St. Augustine in St. Johns County. The island was created by dredge spoil deposition, and for the past 5 years, Least Terns, Wilson's Plovers, and American Oystercatchers have nested on the island. Active nest sites were posted by St. Johns County Audubon members in partnership with Audubon Florida,

and in 2016 and 2017 bird stewards were transported by ferry to Julia's Island to chaperone active nests and educate the public about beach-nesting birds. Hurricane Matthew's waves overwashed the island in Fall 2016, and the island was again overwashed when Hurricane Irma passed through Florida in September 2017. On the bright side, new sand de-

posited onshore and vegetation killed by salt water provide beach habitat preferred by beach-pioneer species such as Least Tern. On the downside, overwash has reduced the height of the island so that beach-nesting birds are far more vulnerable to seasonal high tides and tropical weather systems in the future.

A Tale of Two CWAs



The Second Chance Critical Wildlife Area (CWA) is a U-shaped offshore shoal located south of Marco Island along Florida's Southwest Gulf Coast. The shoal has supported annual nesting of Least Terns, Black Skimmers, and Wilson's Plovers on a partially vegetated, elevated sand platform since it emerged from the Gulf less than 10 years ago. Nesting success improved dramatically following establishment of the CWA in 2016. As Hurricane Irma passed directly over the CWA, waves breached the U-shape of the shoal, dragging the elevated nesting area into the Gulf and leaving a tidal inlet unlikely to fill in quickly. On the north end of nearby Marco Island, the peninsular Big Marco Pass CWA was breached by waves at a narrow point but filled in quickly following Irma's passage. In contrast to offshore Second Chance, the northern two miles of the peninsula received loads of wave-driven new sand that covered sandspur grass and other thickly vegetated areas that hide predators from the view of nesting shorebirds. New sand deposits are a big win for Big Marco Pass CWA.

Audubon's recommendations for projects to repair damage resulting from Irma, and making these habitats and species more resilient in the face of future storms:

Restoration of Damaged and Lost Habitat

Project Name	Type	Location	Brief description	Amount (estimate)
Alafia Bank	Shoreline erosion protection	Tampa Bay	Install wave break along remainder of unprotected north shoreline.	\$2,100,000
Julia's Island	Restoration	St. Augustine, St. Johns County	Sand/spoil placement to increase height above sea level.	>\$500,000
Nassau/Amelia rakes	Restoration and erosion protection	Nassau County, Northeast Florida	Install bags of oyster shells around perimeter of existing rakes to trap sediment and decrease erosion.	>\$100,000
Florida Bay Islands	Replacement signage	Monroe County	Replacing lost signage protecting rookery islands such as Sandy Key.	\$25,000
Critical Wildlife Areas	State law enforcement funding	Monroe, Collier, Lee, Sarasota, Manatee, Hillsborough, Levy, Franklin, Nassau, Duval, St. Johns, Volusia counties.	Managing disturbance at new critical wildlife areas will require education of boaters about the new protections for these sites. Florida Fish and Wildlife Conservation Commission officers provide outreach and enforcement for these sites, but staffing levels have not kept pace with population growth and tourism growth in the last decade. Controlling disturbance at the sites where these birds nest is one hazard we are able to ameliorate, making uncontrollable tropical system impacts less catastrophic on a population level.	\$2,000,000
St. Joseph Sound rookery islands	Restoration	Intercoastal Waterway, Pinellas County	Breakwater protection of eroding rookery islands in Greater Tampa Bay.	\$1,000,000
				Total

\$5,725,000

Everglades

As the largest subtropical wetland ecosystem in North America, the Everglades acts as South Florida's first line of defense against storms like Hurricane Irma, and moderates the impacts of extreme weather, such as flooding and drought. Coastal and freshwater wetlands in the U.S. are estimated to provide \$23.3 billion per year in storm protection. Each

2.7 miles of wetlands reduce storm surge by a foot, and one acre of wetlands holds up to 1.5 million gallons of floodwaters.

According to the National Oceanic and Atmospheric Administration, the cost of natural disasters in the U.S. has exceeded \$1.2 trillion since 1980, not including hurricanes Harvey, Irma, and Maria. Recent storm events demonstrate the wisdom of proactively investing in infra-

structure like Everglades restoration projects that protect natural lands and provide water managers critical flexibility to reduce flood damage and risk throughout South Florida. In addition to the benefits for resiliency, the Everglades, including its national parks, national wildlife refuges, and other federal and state lands, serve as places of recreation, and are key economic drivers for Floridians.



Audubon Florida Director of Research Dr. Jerry Lorenz inspects a floating mangrove island in Florida Bay with damage from Hurricane Irma.

PETER FREZZA/AUDUBON FLORIDA

Impacts from Irma

Hurricane Irma impacted many ongoing projects throughout the Greater Everglades Ecosystem. Estimates of damage to projects currently under construction include:

- C-111 South Dade: \$1.75 million
- Biscayne Bay Coastal Wetlands: \$100,000
- Picayune Strand: \$100,000
- C-44 Reservoir: \$1.35 million
- Kissimmee River: \$2 million

Funding is also needed to repair damages to national parks and refuges, which already have significant maintenance backlogs and cannot afford to absorb the costs of hurricane recovery.



JULIE HILL-GABRIEL/AUDUBON FLORIDA

Everglades Restoration Projects to Improve Resiliency

In addition to repairing damages to projects under construction, post-Hurricane Irma recovery efforts should focus on investing in Everglades restoration projects that can improve the resilience of Florida in the face of future storms. Below are projects that could receive immediate federal funding and provide critical infrastructure improvements to respond to Hurricane, flood, drought, wildfire, or other natural disasters.



PETER FREZZA/AUDUBON FLORIDA

U.S. Army Corps of Engineers Everglades restoration projects:

- **Central Everglades Planning Project: Levee removal and canal backfill at L-67 extension**
Beginning work on southern features of the Central Everglades Planning Project will allow more water to move from the Water Conservation Areas and south into Everglades National Park. This effort of delivering more fresh water south will push back against intruding salt water that threatens Florida's underlying aquifers which provide drinking water to millions of residents and businesses, strengthening South Florida's resiliency against



CELESTE DE PALMA/AUDUBON FLORIDA

storms and other climate impacts.

Cost: \$9.2 million

- **Everglades Agricultural Area Reservoir: Project planning**
The current water management system in the Everglades was stressed to the limit in 2017 by high water levels as a result of record rainfall and Hurricane Irma. This project will store a minimum of 240,000 acre/feet of water, as directed by the Florida Legislature, to add critical capacity to hold water in the Central Everglades. The water that is stored in the reservoir can then provide a source of fresh water in dry and drought conditions.
Cost: \$1.5 million
- **C-111 South Dade: Finish project construction** Remaining flood control features of this project will allow fresh water to move into Taylor Slough and hydrate Florida Bay without the risk of flooding private property. In turn, this project will help reconnect the freshwater flow from the north into Everglades National Park and improve the salinity balance of water in Florida Bay, which is so important for the commercial and recreational fishing

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In the aftermath of Hurricane Irma, the University of Florida reported that all 44 active Everglade Snail Kite nests on Lake Okeechobee were destroyed.

industry in the Florida Keys. The three final components of this project are under construction.

Cost: \$2 million

▪ **Biscayne Bay Coastal Wetlands: Complete the first phase**

Restoring wetlands that restore fresh-water flow into Biscayne Bay and Biscayne National Park near urban Miami will help attenuate storm surge and other impacts from future hurricanes.

Cost: \$32 million

▪ **Broward County Water Preserve Areas: Complete design for C-11 Impoundment**

This project, which includes a wetlands buffer and two reservoirs, provides system-wide benefits to the Everglades. By expanding the acreage of wetlands around urbanized areas, it will increase this important defense against future storm impacts. Increased water storage is achieved through the capture and storage of rainwater, which also helps prevent water from seeping out of the Everglades into urban areas. **Cost: \$3.5 million**

▪ **Picayune Strand: Construction of SW protection features**

By directly restoring 55,000 acres of wetlands and benefiting nearly 100,000 acres of habitat, the Picayune Strand project will reverse decades of drainage and destruction of a vital region of the Western Everglades. It will also help restore the watershed for Big Cypress National Preserve, Everglades National Park, the Ten Thousand Islands and Rookery Bay estuaries, which were impacted by Hurricane Irma. In order to restore this land that was at the center of a quintessential Florida swampland real estate scam, more than 19,000 individual parcels of land were purchased by the Florida Department of Environmental Protection. 90% of the project is complete. The remaining features are designed to protect neighboring communities from flooding, which could in turn enhance their flood protection during future storms. **Cost: \$2.5 million for design and \$35-\$40 million for construction**

▪ **Kissimmee River Restoration: Complete construction**

In order to accommodate navigation in the 1960s, the Kissimmee River was channelized, changing the river's meandering path and draining its floodplain that historically reached two miles wide and was frequently inundated with water. The result is that rainfall in the surrounding floodplain is diverted rapidly into Lake Okeechobee. Hurricane Irma raised lake water levels by more than three feet and Lake Okeechobee is now at its highest level in more than a decade. Kissimmee River Restoration is underway to restore 20,000 acres of wetlands and 44 miles of historic river channel, which will help attenuate the flow of water from the Kissimmee River into Lake Okeechobee.

Cost: \$3 million

▪ **Indian River Lagoon South**

The C-44 reservoir project will provide 60,500 acre/feet of new water storage capacity to capture, store, and treat local basin runoff before it flows into the St. Lucie estuary. This and other reservoirs will improve the overall health of the estuary, making it more resilient to storm and high-water impacts. **Cost: \$50 million to complete construction on the C-44 Reservoir; \$3 million for design of the C-23/C-24 south component; \$3 million for design of the C-25 component**

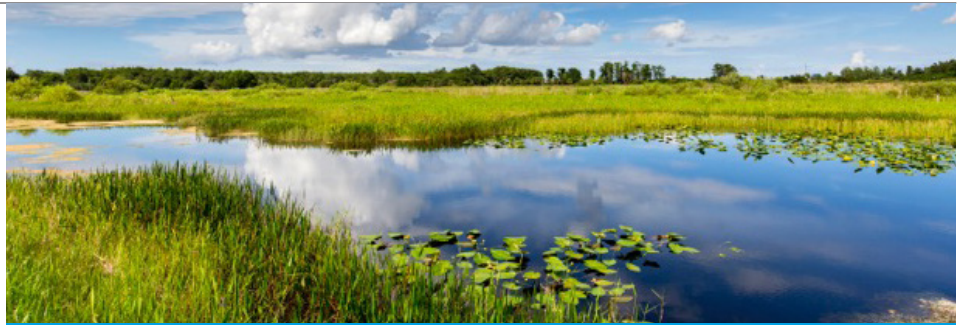
U.S. Department of the Interior restoration projects:

■ **Tamiami Trail Next Steps project: Road-raising component**

Tamiami Trail has acted as a dam to the natural Everglades north to south flow of water since its construction in 1928. A one-mile bridge on this roadway completed in 2012 has begun to increase the amount of fresh water that flows south. The next 2.6-mile bridge is under construction, but additional roadway improvements that will help increase the amount of water that can flow under the bridge are not yet funded. **Cost: \$23 million**

■ **Cape Sable Dams Restoration Phase II: Raulerson canal construction**

Located at the southern tip of the Florida peninsula in Everglades National Park, manmade canals in this area have resulted in significant salt water intrusion and coastal erosion, impairing critical fishing habitat.



Wetlands like those pictured here at the Arthur R. Marshall Loxahatchee National Wildlife Refuge, help attenuate extreme weather impacts like those brought on by Hurricane Irma.

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Through plugging canals and the construction of dams, this project seeks to reverse these impacts and improve the fishery. A stated purpose of the project is to bring about greater resilience to the Cape in the face of sea-level rise and the possibility of more frequent and intense hurricanes. Hurricane Irma's landfall over Cape Sable further demonstrated the importance of restoring this area that acted as a buffer to storm surge that protected other parts of Everglades National Park and urbanized areas. **Cost: \$4 million**

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Audubon Florida biologist Michelle Robinson investigates debris washed up on Sandy Key, an important bird rookery in Everglades National Park.

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