



Houston-Galveston

Green Infrastructure and Ecosystem Services Assessment

Executive Summary



THE
CONSERVATION FUND

The Case for Green Infrastructure

Greater Houston is America's sixth-largest metroplex – and growing. In less than 30 years, the Houston-Galveston area is expected to gain 3.5 million people, bringing its population to nearly 10 million. Now is the time for officials, planners, builders and other regional leaders to establish strategies that ensure the area remains competitive and attractive. Planning for a greener region is one such strategy.

By preserving the best natural assets, directing development away from flood-prone areas, and ensuring that residents have safe and easy access to local parks, trails and green space, the Houston-Galveston area can achieve lasting benefits in water management, air quality, climate, and community livability. These benefits include costs savings that can be estimated and environmental rewards that endure for generations.

In a recent survey by the Houston-Galveston Area Council (H-GAC), 95% of respondents agreed that steps should be taken to preserve the region's wetlands, forests, prairies and shorelines. Now, The Conservation Fund (the Fund) has developed a toolkit of maps and analyses for regional leaders to take these steps strategically. Working in collaboration with H-GAC and Houston Wilderness, and with support from several local foundations, The Conservation Fund has crafted a green infrastructure network and ecosystem service planning initiative to:

- **Make land use policy and development decisions more science-based and data-driven, through a shared base of common information.**
- **Encourage development in strategic locations, saving the region money while addressing sustainability issues such as flooding, food production and livability.**
- **Enhance current green and gray infrastructure planning by strengthening and expanding the original “Eco-Logical” model generated by H-GAC in 2010.**
- **Inform H-GAC's scenarios for growth and reinvestment, so that regional development can be accomplished with purpose, analysis and public participation.**
- **Identify programs, policies, and financing mechanisms to help quickly implement on-the-ground projects that protect green infrastructure and ecosystem services.**

We hope this report will lead to increased awareness of green infrastructure's contribution to Greater Houston's quality of life and a greater understanding of the relationship between the built environment and the region's ecological capital.

Project Overview

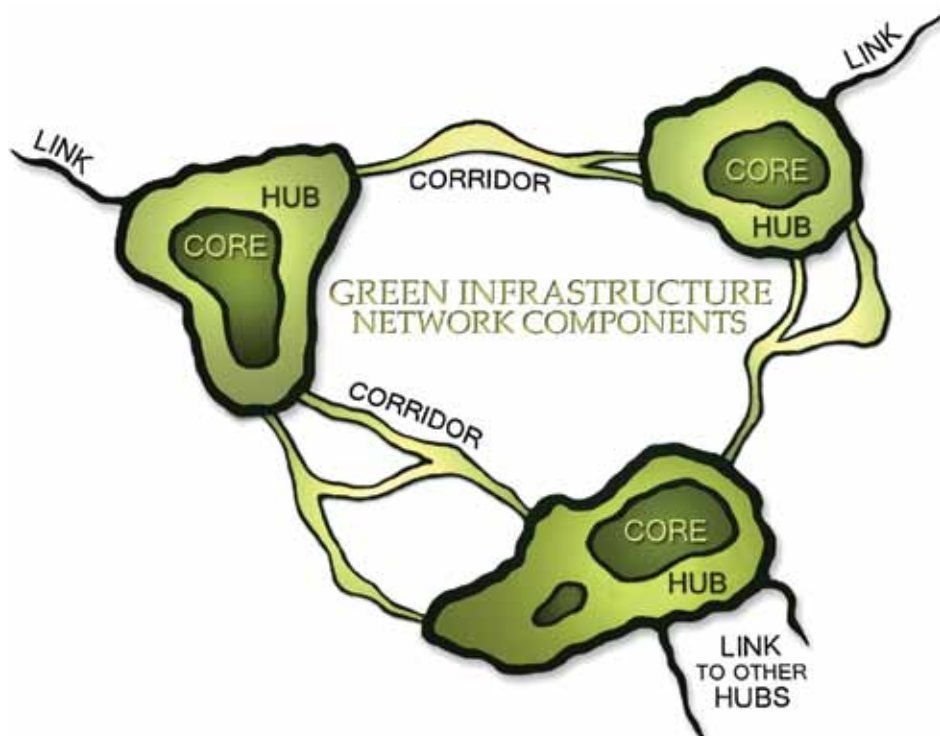
At the request of local leaders and with support from Houston Endowment and other local foundations, The Conservation Fund, in collaboration with Houston Wilderness and H-GAC has undertaken a green infrastructure network and ecosystem service planning initiative for the Houston-Galveston region. *The Fund's primary tasks included:*

1.

Design a green infrastructure network that identifies core areas to protect and landscape hubs and corridors that link these areas.

What is a green infrastructure network?

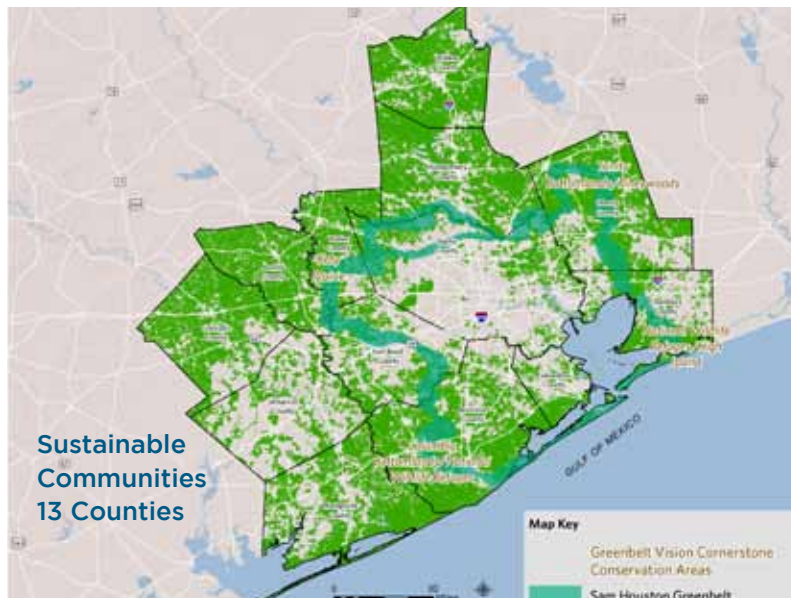
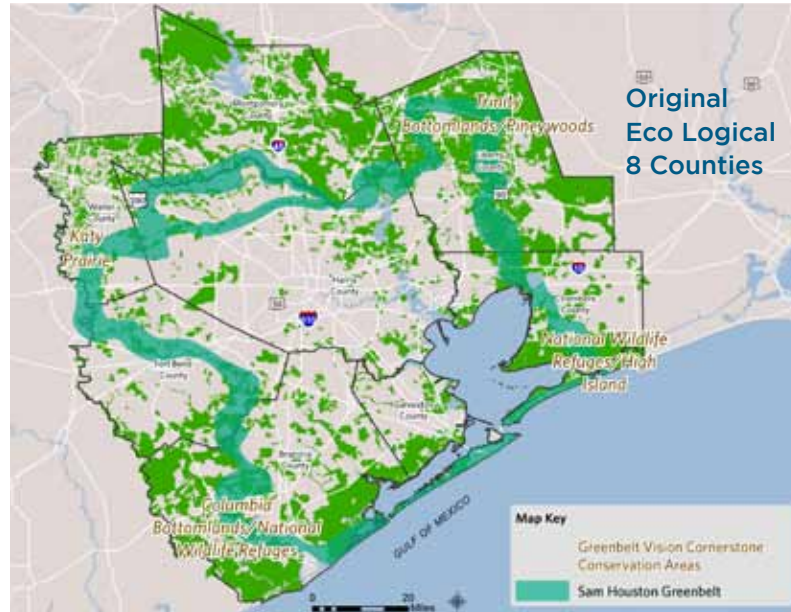
Green infrastructure is defined as a strategically planned and managed network of natural lands, working landscapes, and other open spaces that conserve ecosystem functions and values and provide associated benefits to human populations. The building blocks of the network are “core areas” that contain naturally functioning ecosystems that provide high quality habitat for native plants and animals. “Hubs” are aggregations of core areas and adjacent undeveloped land that provide ecosystem services like clean water, flood control, carbon sequestration, and recreation opportunities. Finally, “corridors” are relatively linear features linking cores and hubs together, providing essential connectivity for animal and plant movement.





Our role

The Fund updated H-GAC's 2010 Eco-Logical decision support tool product by expanding the geographic scope from eight to 13 counties and by enhancing the mapping of the region's ecotypes using the best available geographic information systems (GIS) data. This interconnected resource network uses a science-based and data-driven approach to identifying areas that help maintain natural systems and functions while providing numerous other benefits for people, including hiking, hunting, bird-watching, and other passive recreational activities.

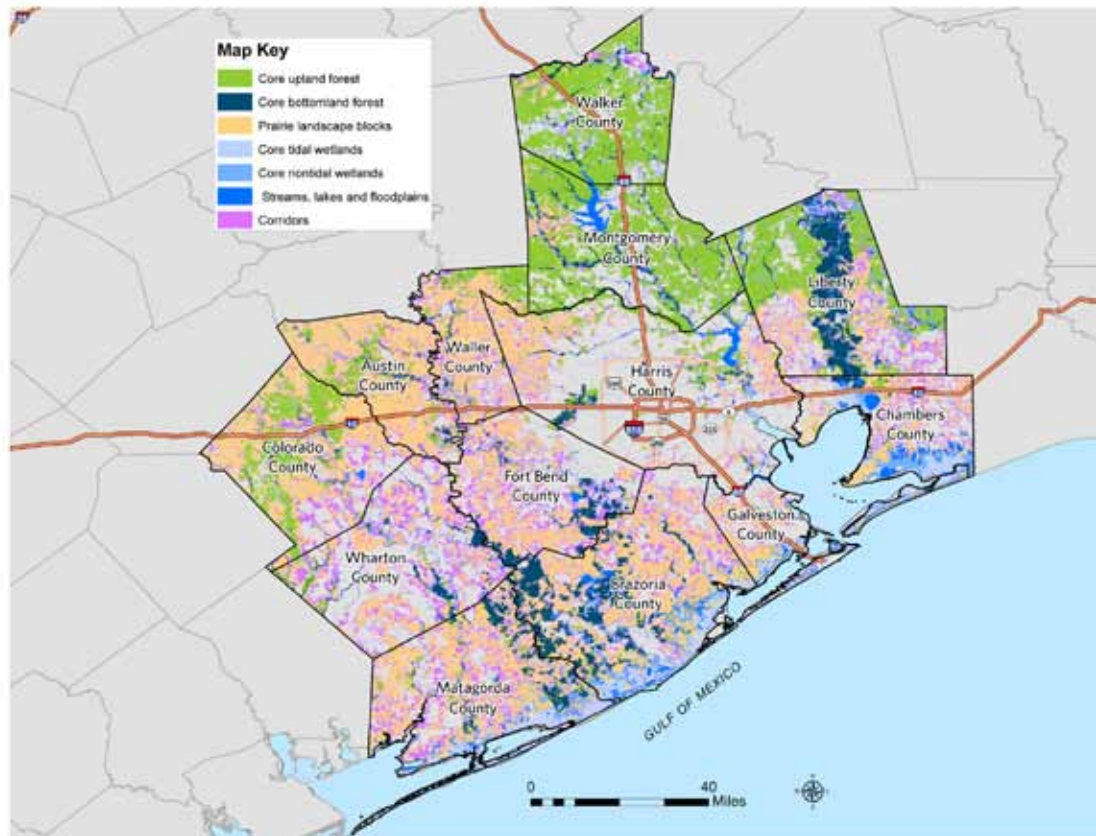


The green infrastructure maps help communities understand the array of valuable natural resources in their region that help minimize urban flooding, support food production, and promote livability. The maps also help decision makers understand tradeoffs for future growth and development scenarios while providing a framework for conservation and restoration actions in the region by a multitude of federal and state agencies and local nonprofits.



Designing the Green Infrastructure Network

As part of its mission to promote the region's orderly development and the safety and welfare of its citizens, H-GAC released the Eco-Logical project in 2010 to facilitate transportation planning by developing a decision-making tool to identify potential environmental concerns early in the project planning process. In addition, the Eco-Logical model was created to help conservation groups be strategic in their efforts by identifying the high value environmental resources in the region. As part of the original Eco-Logical project, six ecotypes were delineated for eight counties in the region: Brazoria, Chambers, Galveston, Fort Bend, Harris, Liberty, Montgomery, and Waller. In this project, the Fund expanded the delineation of five of the original ecotypes (tidal wetlands, coastal prairies, bottomland forest, upland forest, and water bodies) to five more counties: Austin, Colorado, Matagorda, Wharton, and Walker. Additionally, the Fund delineated two other ecotypes: non-tidal wetlands and aquatic systems. Each ecotype contains distinct characteristics that require distinct mapping methodologies to delineate their locations within the region.



Elements of Green Infrastructure

The ecotypes mapped for the 13-county area are described below. They are described in more detail in a technical report under separate cover.



Prairies

The Prairie ecotype includes landforms indicative of undisturbed prairie within an overall matrix of potential prairie land covers as well as potential prairie restoration sites. Prairie types include Coastal, Blackland, and Texas claypan.



Tidal Wetlands

Tidal wetland types include saline marshes, brackish marshes, freshwater marshes and swamps, and mud flats subject to tidal inflows and outflows.



Non-Tidal Wetlands

Non-tidal wetlands, including (but not limited to) floodplain/bottomland wetlands, prairie potholes, cypress domes, barrier island non-tidal interior wetlands, and pine flatwoods wetlands. There can be some overlap between non-tidal wetlands and other categories (e.g., bottomland forest; prairies).



Bottomland Forest

Bottomland forests are areas along rivers, large streams, and other water bodies that are periodically inundated or saturated during the growing season, and dominated by tree species able to tolerate standing water or saturation.



Upland Forest

Forest outside floodplains and wetlands; dominated by trees unable to tolerate long periods of standing water or saturation.



Water Bodies and Floodplains

Aquatic systems include perennial streams, rivers, lakes, ponds, reservoirs, and other bodies of water. These could be dry during severe droughts. Also included is the approximate 100-year floodplain. The original Eco-Logical report lists riparian corridors, which is a similar concept.

Landscape Connectivity

After identifying core ecotype areas, the Fund identified a system of linkages or corridors that connect core forests, wetlands, and prairies. Corridors are relatively linear features that link core areas together, wind through land otherwise hostile to organisms of interest, and allow animal, seed, and pollen movement between core areas, thereby promoting genetic exchange and long-term persistence. The Fund calculated linkages separately between forest, wetland, prairie, and aquatic core areas, and emphasized connecting relatively large, high quality sites.



Hubs

Hubs are aggregations of core areas that also provide ecosystem services like clean water, flood control, carbon sequestration, and recreation opportunities. Core areas were merged and adjacent natural land and restorable areas were added. Hubs had to contain at least 100 contiguous acres.

Mega-Hubs and Mega-Corridors

Mega-hubs (hubs that are greater than 10,000 hectares) are regions within the Green Infrastructure Network that represent dense congregations of the elements of green infrastructure. Mega-corridors connect the mega-hubs. Together, these two elements serve to illustrate the functions of green infrastructure at a large scale.



2.

Evaluate the “Ecosystem Services,” or economic value, of key natural systems, including identifying areas most important to maintain for economic and environmental benefit.

What are ecosystem services?

Ecosystem services are the collective benefits from an array of resources and processes that are supplied by nature. Forests, wetlands, prairies, water bodies, and other natural ecosystems support our existence. They provide services like cleaning the air, filtering and cooling water, storing and cycling nutrients, conserving and generating soils, pollinating crops and other plants, regulating climate, sequestering carbon, protecting areas against storm and flood damage, and maintaining hydrology and water supplies. These lands also provide marketable goods and services like forest products, fish and wildlife, and recreation. They serve as vital habitat for wild species, maintain a vast genetic library, provide scenery, and contribute in many ways to human health and quality of life.



Evaluating Ecosystem Services

In 2010, Houston Wilderness published *A Strategy for Realizing the Economic Value of the Ecological Capital of the Greater Houston Region*. This document provides the ‘business case’ and general strategies for protection of many of the region’s ecosystem services, including flood abatement, water quality, carbon sequestration, fish and wildlife habitat; and recreation, health, eco-tourism, and education. The Fund then built on this report.

Our role

The Fund estimated economic values of five important ecosystem services in the Houston-Galveston region:

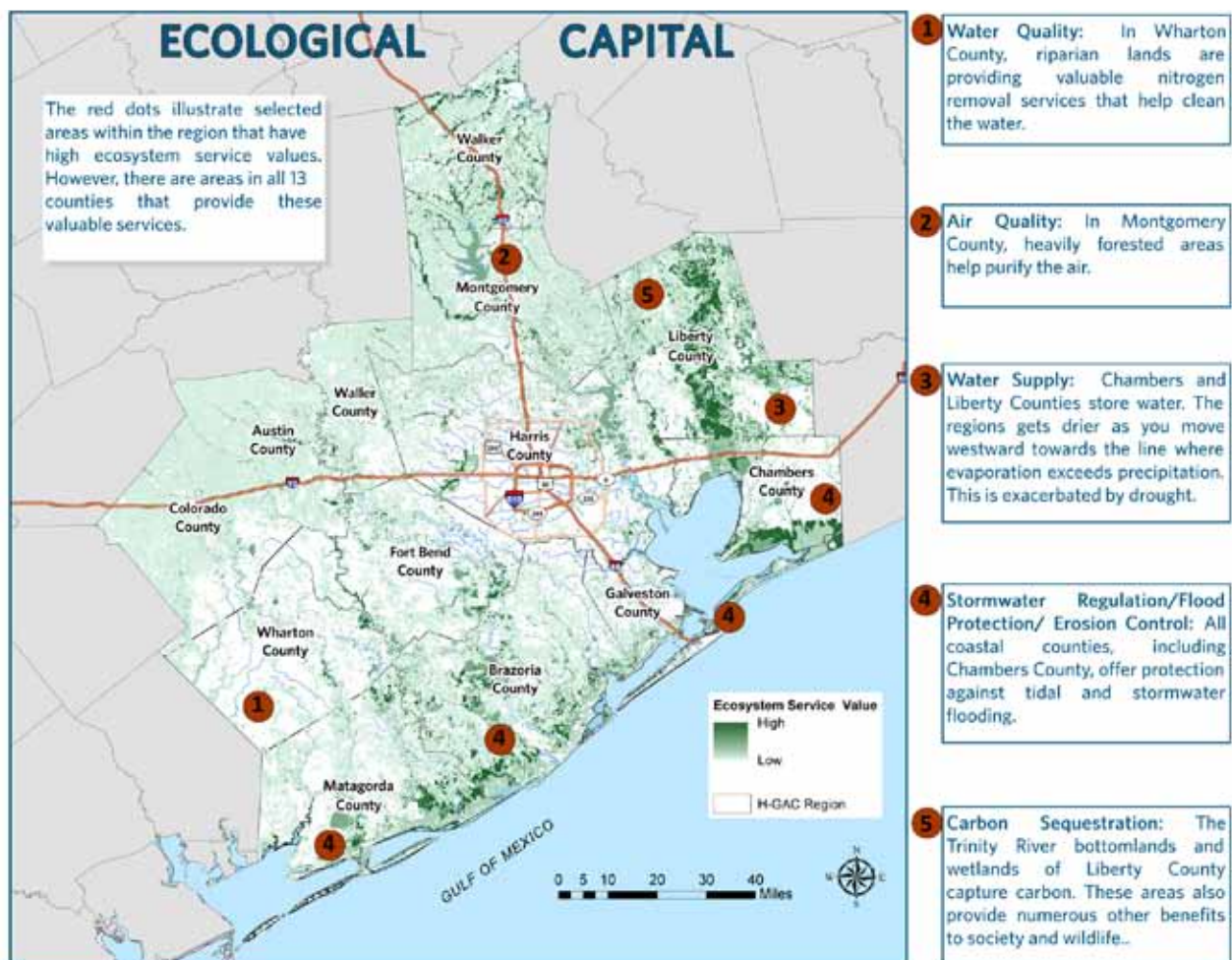
- 1) **Water quality**
- 2) **Air quality**
- 3) **Water supply**
- 4) **Stormwater regulation/flood protection/erosion control**
- 5) **Climate regulation/carbon sequestration**

A detailed summary of the ecosystem services analysis completed by the Fund is available in a technical report under separate cover.

The Fund assessed these services separately for bottomland forest, upland forest, non-tidal wetlands, tidal wetlands, and prairie. Although most ecosystem services do not currently have established markets, the Fund estimated values by comparing them to human-engineered solutions (e.g. stormwater basins) or avoided damages (e.g. hurricane surges reduced by coastal wetlands).

When wetlands, forests, and prairies are converted to roads, buildings, and other developed land, there are costs incurred that are typically not accounted for in the marketplace. The losses in ecosystem services are hidden costs to society. These services, such as cleansing the air and filtering water, meet fundamental needs for humans and other species, but in the past, the resources providing them have been so plentiful and resilient that they have been largely taken for granted. In the face of a tremendous rise in both population and land consumption, we now realize that these natural or ecosystem services must be afforded greater consideration. The breakdown in ecosystem functions causes damages that are difficult and costly to repair, as well as taking a toll on the health of plant, animal, and human populations.

In October 2011, the Fund convened a technical advisory committee that was provided a list of 15 ecosystem services and asked them to select the five that they felt were the most important for the 13-county Houston-Galveston region. Participants gave the most votes to water quality, clean air, water supply, flood control, and carbon sequestration. The estimated service values are described below.



The thirteen H-GAC counties currently provide an estimated \$15 billion per year of water quality, air quality, water supply, flood protection, and carbon sequestration benefits. Green Infrastructure core areas, hubs, and corridors comprise 62% of land but provide approximately 91% of these benefits.



Water Quality

Forests, wetlands, and prairies protect water bodies from pollutants and sedimentation by absorbing and filtering water. By slowing surface runoff and providing opportunities for settling and infiltration, forests help remove nutrients, sediments and other pollutants. Infiltration rates 10-15 times higher than grass turf and 40 times higher than a plowed field is common in forests. Tree roots remove nutrients from settled runoff and groundwater, and store them in leaves and wood. Through the process of de-nitrification, bacteria in the forest floor convert harmful nitrate to nitrogen gas, which is released into the air. In stream and river floodplains, vegetation traps and removes water-borne particulates during storms. Riparian forest buffers have proven to be effective at reducing nutrient loads in areas that have largely been deforested. Numerous studies have demonstrated that wetlands change water quality through retention and/or modification of sediments, toxins, and nutrients in the water. The Fund used the program InVEST to calculate non-point nitrogen retention by subwatershed. **The economic value of nitrogen removal was estimated at \$188/kilogram for the Houston-Galveston region.** As nitrogen is removed, phosphorus is simultaneously filtered, but it was not counted twice.



Air Quality

Trees provide air quality benefits by absorbing sulfur dioxide (SO₂) and nitrogen oxide (NO₂), two major components of acid rain. In addition, trees can trap air pollutants, carbon monoxide, and particles in the air, all of which can be harmful to humans. **Trees in the Houston-Galveston region provided an estimated \$312/acre/year of human health benefits by improving air quality.**

Water Supply

Even on clay soils, forests, wetlands, and prairies retain much more rainfall than paved surfaces, which direct water away as fast as possible, usually where it cannot be used. Water is essential to life, and this service is especially important during drought years. **Forests in the Houston-Galveston region provide an estimated \$200/acre/year of groundwater recharge. Wetlands are especially important, serving as local reservoirs worth more than an estimated \$9,000/acre/year.**



Stormwater Regulation/Flood Protection/Erosion Control

The Fund grouped flood protection and erosion control because both are services tied to stormwater regulation. Standing vegetation stabilizes soils, especially along stream banks, on steep slopes, and where soils are highly erodible. Forests intercept rainfall, slow the flow of water over the ground,

and store much of it in soils and aquifers. **Forests in the Houston-Galveston region provide an estimated \$105/acre/year of flood protection that would otherwise have to be performed by engineered stormwater facilities.** As flood waters move into riparian floodplains, vegetation slows the water's movement, reducing its erosive potential and capturing water and sediments alike. **Wetlands are especially effective at absorbing stormwater, reducing flood damages almost \$8,000/acre/year by one estimate.** Coastal wetlands such as tidal marshes protect inland areas from winds and ocean waves, including hurricane storm surges, and reduce shoreline erosion. Coastal wetlands provide natural "horizontal levees" that are far more cost-effective than constructed levees. **Nationwide, coastal wetlands reduce hurricane damage in the U.S. by over \$3,800/acre/year, and this number will probably grow.**

Climate Regulation/Carbon Sequestration

Climate change is already exacting an enormous economic toll at both the global and local level, and scientists expect this to increase. If current trends continue, the impacts could cost \$3.6 trillion (in current dollars) each year in the U.S. by 2100. Forests remove CO₂, the leading greenhouse gas, from the air, converting it to oxygen and carbon-based plant matter. **Depending on the forest type and location, forests in the Houston-Galveston region can store 47 to 74 metric tons of carbon per acre. Depending on the type, wetlands store an estimated 81 to 216 metric tons of carbon per acre, and upland prairie 78 metric tons of carbon per acre. Each metric ton of carbon removed from the atmosphere is projected to prevent \$2 of damage annually.**

3.

Provide more than two dozen recommendations for implementing protection of the green infrastructure network and maintaining and enhancing the region's ecosystem services, beginning immediately.

What is an implementation quilt?

An implementation quilt is a framework for matching available resources such as planning tools, existing programs, funding opportunities and people with the needs identified by the green infrastructure network. *The detailed list of recommendations is described in a technical report under separate cover.*

Our role

The Fund analyzed and tested the capacity of existing government programs and private efforts at conservation, determining if current programs are underutilized. The Fund also assessed innovative and new programs across the country to see if they could be adopted in this region.



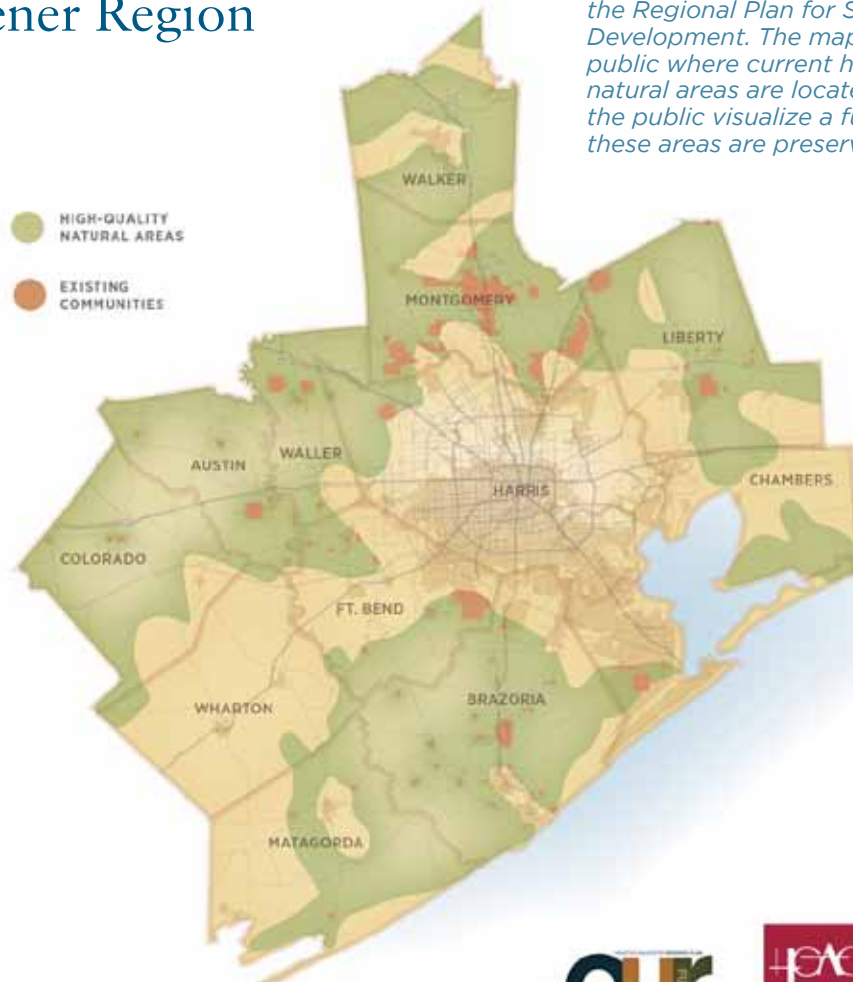
Maximizing existing programs, private conservation efforts, and more effectively targeting resources, are key parts of the implementation of the green infrastructure network. Financial support for the implementation of the green infrastructure network will come in part from existing programs but also from new sources. The largest share of implementation rests on encouraging a land stewardship ethic within the private sector and rewarding private landowners for their sound stewardship. Many private landowners are already excellent stewards. Rewarding landowners for their stewardship efforts and encouraging other landowners to adopt ecologically beneficial management practices are crucial strategies to make the green infrastructure network a reality. The implementation quilt illustrates many opportunities to connect landowners to technical assistance programs for best management practices, conservation easements, and funding for habitat restoration.

Building the Implementation Quilt

Like the intricate patterns in a quilt, the protection of the green infrastructure network and its associated ecosystem services relies on bringing together a wide range of existing government programs, private sector initiatives and focused public action. One key step is to understand and test the capacity of existing government programs and private sector efforts at conservation. Determining if current programs are underutilized is crucial before considering new efforts or adopting new tools for conservation. Then, new and innovative programs from across the country can be assessed for their feasibility of use within the Houston-Galveston region. Regardless of the evaluation of these programs, the largest share of implementation will always rest with the encouraging a land stewardship ethic within the private sector and rewarding private landowners for their sound stewardship. The Fund also hopes that this implementation quilt will provide useful information to H-GAC's Regional Plan for Sustainable Development, which will be a high-level, long-range plan for enhancing the region's quality of life and economic opportunity for residents (<http://www.ourregion.org>).

The Greener Region map was used by H-GAC as the basis of one of the alternative futures presented in the Think 2040 survey as part of the Regional Plan for Sustainable Development. The map showed the public where current high quality natural areas are located and helped the public visualize a future in which these areas are preserved.

Greener Region





Recommendations

To fulfill the promise of Greater Houston's natural assets, improving quality of life, the Fund makes the following recommendations:

Short-term actions:

- Target the location of mitigation projects for Natural Resource Damage Assessments, Supplemental Environmental Programs and transportation improvement projects as identified in the green infrastructure network design.
- Support implementation of the Houston Wilderness Sam Houston Greenbelt vision.
- Support the establishment of the Lone Star National Recreation Area.
- Support implementation of the greater Houston Bayou Greenways Initiative.
- Expand landowner awareness of the US Department of Agriculture programs.
- Protect land with acquisition and easements on high value lands within the green infrastructure network, including linkages to Big Thicket National Park and National Wildlife Refuges.

Medium-term actions:

- Establish an easement purchase program to maintain and enhance water quality.
- Submit land acquisition grants to the Coastal and Estuarine Land Conservation Program Plan (CELCP) program.
- Build community resiliency through the Community Rating System and other hazard mitigation programs.
- Expand forest landowner interest in the Forest Legacy and Community Forest conservation easement programs.



Long-term actions:

- Explore an easement approach to expanding the Sam Houston National Forest.
- Pursue funding for water-quality based green infrastructure projects through the Clean Water Act State Revolving Fund (SRF) programs.
- Encourage pro-active flood mitigation through establishment of entities like the Harris County Flood Control District throughout the region.
- Consider the use of installment purchase agreements and zero coupon bonds to compensate landowners for their sound stewardship of their land.
- Facilitate restoration of public conservation lands by removing exotic species for use in biomass energy generation.
- Support climate adaptation and mitigation through carbon capture demonstration projects in areas identified as having high carbon sequestration value.
- Explore use of nutrient farming to help delist streams from TCEQ's 303d impairment list.

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