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# Introduction

This reference list was compiled with the intention of providing an idea of the potential value of the different services that ecosystems provide to human beings in the Houston Area. The basis for this list is research conducted by the Conservation Fund, which compiled a number of studies on ecosystem services and conducted original research on carbon storage in the greater Houston Area in their Ecosystem Services Assessment for the Houston-Galveston Region (referred to as ESA in this document). You can download an executive summary of this report here: <http://www.conservationfund.org/wp-content/uploads/2012/08/GI-Report-Houston-Galveston-The-Conservation-Fund-for-print.pdf>

This list attempts to compile information on both the value of these services and what the service actually is: for instance, what is the value of water filtration by an acre of wetland, and how much nitrogen can that acre of wetland actually filter? Some of these numbers come from the same study, but sometimes they differ depending on how these studies were conducted.

It is important to note the location and value type listed by the service, as these have an effect on the size of the value and the applicability of the figure to the Houston Area.

# Wetlands

## Water Supply

**(Nontidal)- $9320/acre/year ($2010)**

**Benefit Provided (Nontidal): 100,000 gallons/acre/day**

*Value*: Replacement Cost (Wetlands can provide water at a lower cost than procuring it elsewhere)

*Location of Study*: California

Methodology: It was calculated that an average acre of wetlands could provide 100,000 gallons per day at a rate of $16.56 per day less than water procured elsewhere

*Reference*: Page 18 of Ecosystem Services Assessment for the Houston-Galveston Region, available at http://www.conservationfund.org/wp-content/uploads/2012/08/GI-Report-Houston-Galveston-The-Conservation-Fund-for-print.pdf

California Dept. of Water Resources. 2005. Multi-Objective Approaches to Floodplain management on a watershed Basis: Natural Floodplain Functions and Societal Values

*Funding Source:* EPA Wetlands Protection Development Grant

## Water Quality

**(Nontidal) Median $3,500/acre/year ($2010)**

*Value*: Aggregate of Studies (Mostly Replacement Cost)

*Location of Study*: Set of studies across US, including California, Massachusetts, South Carolina, Georgia

Methodology: Median value of studies. The ESA takes a value of $188/kg for Nitrogen removal from Industrial Economics (2011)

*References*: Pages 9-11 of Ecosystem Services Assessment for the Houston-Galveston Region, available at http://www.conservationfund.org/wp-content/uploads/2012/08/GI-Report-Houston-Galveston-The-Conservation-Fund-for-print.pdf

California Dept. of Water Resources. 2005. Multi-Objective Approaches to Floodplain management on a watershed Basis: Natural Floodplain Functions and Societal Values

Sipple, B. 2007. Wetlands functions and values. http://www.epa.gov/watertrain/wetlands/

*Funding Source*: EPA Wetlands Protection Development Grant

**Water Quality (Nontidal) Benefit Provided: Can filter 63% of Nitrogen, 45% of Phosphorous**

*References*:

Industrial Economics, Inc. 2011. Economic valuation of wetland ecosystem services in Delaware: Final Report. Delaware Department of Natural Resources and Environmental Control, Division of Water Resources, Dover, DE. Page 3-11

Mean of 5 studies regarding nitrogen retention and 11 studies regarding phosphorous retention of wetlands as described in: Johnston, Carol A. "Sediment and Nutrient Retention by Freshwater Wetlands: Effects on Surface Water Quality." Critical Review in Environmental Science and Technology Volume 21 (1991): 491-565

*Funding Source*: Delaware Department of Natural Resources and Environmental Control (Industrial Economics)

**Water Quality (Tidal) $405, median $224/acre/year ($2010)**

*Value*: Examined variety of studies with different accounting methods for the value of clean water provided by tidal wetlands

*Location*: Set of Studies Across US

Methodology: Median value derived from summary of 12 studies covering 28 estimates of the disaggregate value of services provided by coastal and non-coastal wetlands. These values ranged from $3.57/ac/yr to $7,111/ac/yr.

*Reference*: Page 12 of Ecosystem Services Assessment for the Houston-Galveston Region, available at http://www.conservationfund.org/wp-content/uploads/2012/08/GI-Report-Houston-Galveston-The-Conservation-Fund-for-print.pdf

Kazmierczak, R. 2001. Economic linkages between coastal wetlands and water quality: a review of value estimates reported in the published literature. Department of Agricultural Economics, Louisiana State University, Baton Rouge, LA.

*Funding Source:* Studies on wetland water quality by Kazmierczak were funded by Coastal Restoration and Enhancement through Science and Technology (CREST) Program

## Stormwater Regulation/Flood Protection

**(Nontidal) $7,990/acre/year ($2010)**

*Location*: Massachusetts

*Methodology*: ESA looked at a number of studies and decided on the value derived from predicted flood damages from loss of 8,442 acres of wetlands in the Charles River system in Massachusetts.

*Reference*: 24-25 of Ecosystem Services Assessment for the Houston-Galveston Region, available at http://www.conservationfund.org/wp-content/uploads/2012/08/GI-Report-Houston-Galveston-The-Conservation-Fund-for-print.pdf

Thibodeau, F.R. and B.D. Ostro. 1981. An Economic Analysis of Wetland Preservation. Journal of Environmental Management, 12:19-30.

*Note*: According to EPA, an acre of wetlands can typically store 1-1.5 million gallons of floodwater, which, using a replacement cost of $.27/gallon, translates to a value of $288,000 per acre (American Forests, 2010)

**Stormwater Regulation/Flood Protection (Nontidal) Benefit provided: Wetlands can typically store one million gallons of floodwater per acre**

*References*:

Reference: 24 of Ecosystem Services Assessment for the Houston-Galveston Region, available at http://www.conservationfund.org/wp-content/uploads/2012/08/GI-Report-Houston-Galveston-The-Conservation-Fund-for-print.pdf

US Environmental Protection Agency (EPA). 2006. Wetlands: Protecting life and property from flooding. EPA843-F-06-001

**Stormwater Regulation/Flood Protection Tidal $6,191/acre/year ($2013)(Hurricane specific)**

*Value*: Avoided cost- mitigated hurricane damage

*Location*: Gulf and Atlantic Coast (regressions testing the effect of wetlands on hurricane damage)

Methodology: Regression model using 34 major US hurricanes since 1980 with the natural log of damage per unit gross domestic product in the hurricane swath as the dependent variable and the natural logs wind speed and wetland area in the swath as the independent variable. The annual probability of hits by hurricanes of varying intensities was then taken into account. $5006 was the specific calculated value for Texas.

*References*: 25-26 of Ecosystem Services Assessment for the Houston-Galveston Region, available at http://www.conservationfund.org/wp-content/uploads/2012/08/GI-Report-Houston-Galveston-The-Conservation-Fund-for-print.pdf

Costanza, R. O. Perez-Maqueo, M. Luisa Martinez, P. Sutton, S. Anderson, and K. Mulder. 2008. The value of coastal wetlands for hurricane protection. Ambio 37(4):241-248

**Hurricane Flood Protection Benefit Provided**

**Reduces hurricane storm surge 2.5 to 9.5 inches for every mile of wetland traversed**

*Reference*: ENGLE, V. D. Estimating the Provision of Ecosystem Services by Gulf of Mexico Coastal Wetlands. WETLANDS. The Society of Wetland Scientists, McLean, VA, 31(1):179-193, (2011).

*Location*: Louisiana and Florida

*Methodology*: Review of studies on Gulf of Mexico Wetland flood protection, more specific reported figures are 4 to 15 cm/km for estuarine emergent wetlands and 4 to 9 cm/km for estuarine shrub wetlands.

*Funding Source*: U.S. Environmental Protection Agency

## Climate Regulation/Carbon Sequestration

**$68-236 /acre/year ($2010 in 2100)**

**Benefit Provided: from Average storage values range from 75,000 to 260,000 lbs carbon/acre**

*Value*: Avoided Cost (hurricane damage, real estate losses, energy costs, and water costs in 2100)

*Location*: Delaware (Values depend on hydroperiod and other parameters, see ESA page 32-33 for breakdown on different wetland types)

*Methodology*: Compiled data on carbon stored in vegetation and soil based mostly on information from industrial economics combined with data on vegetation storage values for forests from COLE, which was substituted for the vegetation values for forested wetlands from IE. This was multiplied by $2, which was what the ESA predicted would be the annualized economic damage from carbon stored by the year 2100. This $2 was calculated by dividing the $3.6 trillion annual price tag of carbon emissions in 2100 (Ackerman and Stanton) by the projected 1,773 gigatonnes of carbon added between 1990 and 2100 (IPCC A2 Scenario.)

**Value Breakdown:**

Estuarine Emergent - $87.8/acre/year Estuarine Scrub Shrub - $136.8/acre/year

Lacustrine Emergent - $100.4/acre/year Palustrine Aquatic Bed - $67.6/acre/year

Palustrine Emergent - $100.4/acre/year Palustrine Scrub/Shrub - $120.6/acre/year

Forested Wetland (Outer Coastal Plain & Southeastern Mixed Provinces) - $236.4/acre/year

Forested Wetland (Prairie Parkland Province) - $207.2/acre/year

**Benefit Provided Breakdown:**

Estuarine Emergent - 43.9 tonnes/acre Estuarine Scrub Shrub - 68.4 tonnes/acre

Lacustrine Emergent - 50.2 tonnes/acre Palustrine Aquatic Bed - 33.8 tonnes/acre

Palustrine Emergent - 50.2 tonnes/acre Palustrine Scrub/Shrub - 60.3 tonnes/acre

Forested Wetland (Outer Coastal Plain and Southeastern Mixed Provinces) - 118.2 tonnes/acre

Forested Wetland (Prairie Parkland Province) - 103.6 tonnes/acre

*References*: Industrial Economics, Inc. 2011. Economic valuation of wetland ecosystem services in Delaware: Final Report. Delaware Department of Natural Resources and Environmental Control, Division of Water Resources, Dover, DE.

32-33 of Ecosystem Services Assessment for the Houston-Galveston Region, available at <http://www.conservationfund.org/wp-content/uploads/2012/08/GI-Report-Houston-Galveston-The-Conservation-Fund-for-print.pdf>

Ackerman, F. and E. A. Stanton. 2008. The cost of climate change: What we'll pay if global warming continues unchecked. <http://www.nrdc.org/globalwarming/cost/cost.pdf>

Intergovernmental Panel on Climate Change (IPCC). 200. Emissions Scenarios: Summary for Policymakers. ISBN: 92-9169-113-5. http://www.ipcc.ch/pdf/special-reports/spm/sres-en.pdf

Funding Source: Delaware Department of Natural Resources and Environmental Control (Industrial Economics)

*Funding sources*: Sea Change Foundation, The Streisand Foundation, The William and Flora Hewlett Foundation, The Energy Foundation, Public Welfare Foundation, and Wallace Genetic Foundation (Ackerman and Stanton)

Delaware Department of Natural Resources and Environmental Control (Industrial Economics)

## Provisioning

**Low Marsh Fisheries: $3,265/acre/year ($2013)**

Value: Replacement Cost

Location: Galveston Bay

Methodology: The future value of the replacement cost value from Rozas et al (2005) was calculated with a compounded 3% annual rate of accumulation from the current value, which is the rate recommened by the National Oceanic and Atmospheric Administration for fishery-based restoration values

Reference: Feagin, R. A, M. L Martinez, G. Mendoza-Gonzalez, and Costanza, R. 2010. “Salt Marsh Zonal Migration and Ecosystem Service Change in Response to Global Sea Level Rise: A Case Study from an Urban Region.” (Appendix) Ecology and Society 15, no. 4: 14.

**Benefit Provided: Marshland in Lower Galveston Bay provides average standing crop of 114 lbs/acre of brown shrimp, 97 lbs/acre of white shrimp, and 151 lbs/acre blue crab, which is 3.0, 2.2 and 4.2 times the standing crop estimates for shallow, open bay water.**

Reference: Minello TJ, Matthews GA, Caldwell PA, Rozas LP (2008) Population and production estimates for decapods crustaceans in wetlands of Galveston Bay, Texas. Transactions of the American Fisheries Society 137:129-146

*Location*: Galveston Bay

*Methodology*: In 17,673 ha of marsh complex (vegetation with a 150-m water buffer) in lower Galveston Bay, they estimated the standing crops (number/ha) at 19,382 for brown shrimp, 17,406 for white shrimp, and 16,726 for blue crabs, or 3.0, 2.2, and 4.2 times the standing crop estimates for shallow, open bay water. Annual production from the marsh complex was substantially higher than for open water and was estimated at 128 kg/ha for brown shrimp, 109 kg/ha for white shrimp, and 170 kg/ha for blue crabs.

## Recreation

**(All) $2092/acre/year ($2012)**

*Value*: Average willingness to pay and consumer surplus per recreation benefits.

*Location*: Galveston Bay (benefits transferred from values in South Texas

*Methodology*: Based on the average willingness to pay and consumer surplus per recreation benefits from three coastal sites in Texas, plus an added value for hunting based on study values that Texas hunters spend 2.5 times less than birdwatchers on average.

*Reference*: Feagin, R. A, M. L Martinez, G. Mendoza-Gonzalez, and Costanza, R. 2010. “Salt Marsh Zonal Migration and Ecosystem Service Change in Response to Global Sea Level Rise: A Case Study from an Urban Region.” (Appendix) Ecology and Society 15, no. 4: 14.

**$2170/acre/year ($2013) (Birding)**

Value Type: Contingent Value study estimating consumer surplus (generated from model based on aggregate of 39 studies using various techniques).

Methodology: Mean of 90% confidence interval for 39 studies on wetland value. The 90% confidence interval ranged from $528 to $2782

Reference: Woodward, R. T., Wui, Y. S. 2001. The economic value of wetland services: a meta-analysis. Ecological. Economics, 37(2), 257–270. doi:10.1016/S0921-8009(00)00276-7.

# Forest

## Water Supply

**(All) $194/acre/year ($2012)**

**Benefit Provided: Store 50% more water and allow 34% more groundwater recharge than urban land**

*Value*: Public Value of Groundwater Recharge (Overall Contribution from Primary Emergy)

*Location of Study*: Maryland

*Methodology*: Simulation

*References*: Pages 17-18 of the Ecosystem Services Assessment for the Houston-Galveston Region, available at http://www.conservationfund.org/wp-content/uploads/2012/08/GI-Report-Houston-Galveston-The-Conservation-Fund-for-print.pdf

Tilley, D., E. Campbell, T. Weber, P. May and C. Streb. 2011. Ecosystem based approach to developing, simulating and testing a Maryland ecological investment corporation that pays forest stewards to provide ecosystem services: Final Report. Department of Environmental Science and Technology, University of Maryland, College Park, MD.

*Funding Source*: Harry R. Hughes Center for Agro-Ecology, Inc

## Water Quality

**(All) $1200/acre/year ($2010)**

*Value*: Avoided Cost (Avoided cost of treating water for New York city)

*Location*: New York/California

*Methodology*: New York City avoided spending $6-8 billion in constructing water treatment plants and 500 million in operating expenses by investing $1.5 billion in buying 1583 square miles of forested lands around its reservoirs.

*References*: 8-9 of Ecosystem Services Assessment for the Houston-Galveston Region, available at http://www.conservationfund.org/wp-content/uploads/2012/08/GI-Report-Houston-Galveston-The-Conservation-Fund-for-print.pdf

Ernst, C. 2004. Land conservation and the future of America's drinking water: Protecting the source. Trust for Public Land, San Francisco, CA.

World Resources Institute. 1998. 1998-1999 World Resources. World Resources Institute, Washington, DC.

*Funding Source*: The Ernst study was funded by the Henry Phillip Kraft Family Memorial Fund of the New York Community Trust & Aquarion Water Company

**Riparian $750 /acre/year ($2010)**

*Value*: Replacement Cost

*Location*: Chesapeake Bay/Virginia

*Methodology*: Treatment plants to clean effluent to the bay would cost $8.56/lb of Nitrogen and $74/lb of Phosphorus. The ESA combined this with an assessment by Klapproth and Johnson that showed that forested buffers can remove up to 21 lbs of Nitrogen and 4 lbs of Phosphorus per acre per year.

*Reference*: 8-9 of Ecosystem Services Assessment for the Houston-Galveston Region, available at http://www.conservationfund.org/wp-content/uploads/2012/08/GI-Report-Houston-Galveston-The-Conservation-Fund-for-print.pdf

Chesapeake Bay Commission. 2004. Cost-effective strategies for the Bay: 6 smart investments for nutrient and sediment reduction. Chesapeake Bay Commission, Annapolis, MD.

Klapproth, J.C. and J.E. Johnson. 2001. understanding the science behind riparian forest buffers: benefits to communities and landowners. Virginia Cooperative Extension. Publication Number 420-153

*Funding Source:* Keith Campbell Foundation (Chesapeake Bay)

Virginia Department of Forestry, Stream Relief Program (Klapproth and Johnson)

**Water Quality Benefit Provided: Can filter 45% of Nitrogen, 40% of Phosphorous**

*Reference*:

Industrial Economics, Inc. 2011. Economic valuation of wetland ecosystem services in Delaware: Final Report. Delaware Department of Natural Resources and Environmental Control, Division of Water Resources, Dover, DE.

Estimates for forests in the Chesapeake Bay area from: Simpson, Thomas and Sarah Weamert. Developing Nitrogen, Phosphorus and Sediment Reduction Efficiencies for Tributary Strategy Practices. BMP Assessment: Final Report. Report of the University of Maryland, Mid-Atlantic Water Program. March 2009.

*Funding Source*: Delaware Department of Natural Resources and Environmental Control

## Erosion Prevention

**(All) $854 (2012)**

*Value*: The public value of stormwater avoided erosion (Overall Contribution from Primary Emergy)

*Location*: Simulation/Maryland

*Methodology*: Looked at effect of forests on erosion levels in urban/non-urban environments

References: 20-21 of Ecosystem Services Assessment for the Houston-Galveston Region, available at http://www.conservationfund.org/wp-content/uploads/2012/08/GI-Report-Houston-Galveston-The-Conservation-Fund-for-print.pdf

Tilley, D., E. Campbell, T. Weber, P. May and C. Streb. 2011. Ecosystem based approach to developing, simulating and testing a Maryland ecological investment corporation that pays forest stewards to provide ecosystem services: Final Report. Department of Environmental Science and Technology, University of Maryland, College Park, MD

*Funding Source*: Harry R. Hughes Center for Agro-Ecology, Inc

## Stormwater Regulation / Flood Protection

**(All) $290 (2012)**

*Value*: Public Value (Overall Contribution from Primary Emergy)

*Location*: Simulation/Maryland

*Methodology*: Simulation which valued stormwater flow mitigation by forests.

*References*: Pages 20-21 of Ecosystem Services Assessment for the Houston-Galveston Region, available at http://www.conservationfund.org/wp-content/uploads/2012/08/GI-Report-Houston-Galveston-The-Conservation-Fund-for-print.pdf

Tilley, D., E. Campbell, T. Weber, P. May and C. Streb. 2011. Ecosystem based approach to developing, simulating and testing a Maryland ecological investment corporation that pays forest stewards to provide ecosystem services: Final Report. Department of Environmental Science and Technology, University of Maryland, College Park, MD

Funding Source: Harry R. Hughes Center for Agro-Ecology, Inc

**Benefit Provided: 52% reduction in runoff depth and volume, 62% reduction in peak flow in a 24 hour storm event that rains 5 inches**

*Reference*: American Forests "Citygreen" Analysis conducted by Mickey Merritt, Texas Forest Service, letter to Patsy Gillham dated December 7, 2001

*Location*: Houston (Cypress Creek Watershed)

*Methodology*: Citygreen program was used to calculate the differences in runoff during a 2-year 24 hour storm event (5 inches of precipitation) between a typical acre of forest in the Cypress Creek Watershed and 100% concrete.

## Air Quality

**(All) $312/acre/year ($2010)**

**Benefit provided: Removes 88 lbs /acre/ year of criteria air pollutants**

*Value*: Absorption of pollutants harmful to human health and components of acid rain (median monetized dollars per ton externality values used in energy decision making from various studies)

Location: Houston area

*Methodology*: Median externality costs associated with air pollution applied to forests in the Houston area is nearly $300 million (1994) dollars. Benefit provided was calculated This based on two 2000 figures given by the Houston's Regional Forests report: Houston's regional forests removed 60,375 tons of criteria air pollutants (substances designated by the Clean Air Act) per year, and these regional forests then covered 2152 square miles.

*References*: Page 15 of Ecosystem Services Assessment for the Houston-Galveston Region, available at http://www.conservationfund.org/wp-content/uploads/2012/08/GI-Report-Houston-Galveston-The-Conservation-Fund-for-print.pdf

Nowak, D. J., D. E. Crane and J.C. Stevens. 2006. Air pollution removal by urban trees and shrubs in the United States. Urban Forestry and Urban Greening 4:115-123.

Smith, P. D., M. Merritt, D. Nowak, and D. Hitchcock. 2005. Houston's Regional Forests. Texas Forest Service.

*Funding Source*: USDA Forest Service (Smith study)

## Carbon Sequestration/Climate Change

**(All) $67/acre/year ($2013)**

*Value*: Market Simulation (Social cost of carbon)

*Location*: Synthesis of information from global and regional Houston sources.

Methodology: Estimate of annualized damage from carbon combined with information on how much carbon forests in the Houston region can store. This used an estimate of $57.3/ton of carbon, which is derived from the most recent estimates by the federal government of the social cost of a metric ton of carbon in 2013 discounting at 2.5%, which was listed as $56 in 2007 dollars. The average amount of carbon sequestration was calculated based on the estimate that Houston area forests cover 2152 square miles (1,377,280 acres) and sequester 1.6 million tons of carbon annually, which is taken from the 2005 Houston Regional Forests Report.

*Funding Source:* USDA Forest Service (Smith study)

*Reference*: 29-30 of Ecosystem Services Assessment for the Houston-Galveston Region, available at http://www.conservationfund.org/wp-content/uploads/2012/08/GI-Report-Houston-Galveston-The-Conservation-Fund-for-print.pdf

Nordhaus, W. 2011. Estimates of the Social Cost of Carbon: Background and Results from the RICE-2011 Model. Cowles foundation for Research in Economics, Yale University, New Haven, CT.

Smith, P. D., M. Merritt, D. Nowak, and D. Hitchcock. 2005. Houston's Regional Forests. Texas Forest Service

Technical Support Document: - Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis - Under Executive Order 12866 - Interagency Working Group on Social Cost of Carbon, United States Government. http://www.whitehouse.gov/sites/default/files/omb/inforeg/social\_cost\_of\_carbon\_for\_ria\_2013\_update.pdf

*Funding* Source: USDA Forest Service (Smith study)

**Carbon Sequestration/Climate Change (All) *Benefit Provided*: On average Houston regional forests store 57,000 lbs carbon/acre and sequester 2300 lbs carbon/acre/year**

Calculated based off figure that Houston regional forests store 39.2 million tons of carbon, sequester 1.6 million tons each year and cover 2,152 square miles

*Reference*:

Page 30 of Ecosystem Services Assessment for the Houston-Galveston Region, available at http://www.conservationfund.org/wp-content/uploads/2012/08/GI-Report-Houston-Galveston-The-Conservation-Fund-for-print.pdf

Smith, P. D., M. Merritt, D. Nowak, and D. Hitchcock. 2005. Houston's Regional Forests. Texas Forest Service.

*Funding Source*: USDA Forest Service

**Carbon Sequestration/Climate Change Upland**

**Benefit Provided- Stores 101,000-163,000 lbs carbon/acre**

Location: Houston (Simulation)

*Methodology*: This $2 was calculated by dividing the $3.6 trillion annual price tag of carbon emissions in 2100 (Ackerman and Stanton) by the projected 1,773 gigatonnes of carbon added between 1990 and 2100 (IPCC A2 Scenario.)

*Reference*: Pages 30-32 of Ecosystem Services Assessment for the Houston-Galveston Region, available at http://www.conservationfund.org/wp-content/uploads/2012/08/GI-Report-Houston-Galveston-The-Conservation-Fund-for-print.pdf

Ackerman, F., and E. A. Stanton. 2008. The cost of climate change: What we'll pay if global warming continues unchecked. http://www.nrdc.org/globalwarming/cost/cost.pdf

http://www.ncasi2.org/COLE/index.html

Intergovernmental Panel on Climate Change (IPCC). 2000. Emissions Scenarios: Summary for Policymakers. ISBN: 92-9169-113-5. <http://www.ipcc.ch/pdf/special-reports/spm/sres-en.pdf>.

Simulations for Houston Area generated using COLE

http://www.ncasi2.org/COLE/index.html

COLE Calculations for average metric tonnes/acre of carbon stored in forests

By County:

Walker County - 58.93 tonnes/acre Montgomery Country - 82.61 tonnes/acre

Harris - 61.55 tonnes/acre Chambers and Liberty - 51.19

Galveston, Brazoria and Matagorda - 51.28

Austin, Colorado, Wharton, Waller, and Fort Bend - 44.44 tonnes/acre

By tree type:

*In the Outer Coastal Plain and Southeastern Mixed forest provinces*

Loblolly, shortleaf or slash pine - 73.77 tonnes/acre Loblolly pine/hardwood - 56.38 tonnes/acre

Post oak/blackjack oak, sassafras/persimmon, sweet gum/yellow polar, and Elm/ash/black locust, mixed upland hardwoods - 59.57 tonnes/acre

*In the Prairie Parkland Province*

Loblolly, shortleaf or slash pine - 67.43 tonnes/acre Loblolly pine/hardwood - 45.98 tonnes/acre

Post oak/blackjack oak, sassafras/persimmon, sweet gum/yellow polar, and Elm/ash/black locust, mixed upland hardwoods - 46.83 tonnes/acre

*Funding Source*: Sea Change Foundation, The Streisand Foundation, The William and Flora Hewlett Foundation, The Energy Foundation, Public Welfare Foundation, and Wallace Genetic Foundation

**Carbon Sequestration/Climate Change (Bottomland)**

**Benefit: Stores 117,000-148,000 lbs carbon/acre**

Location: Houston (Simulation)

*Value breakdown:*

In the Outer Coastal Plain and Southeastern Mixed Forest province - $134/tonnes/year

Prairie Parkland province – $105/acre/year

*Benefit breakdown****:***

In the Outer Coastal Plain and Southeastern Mixed Forest province - 67.19 metric tonnes/acre

Prairie Parkland province - 52.61 metric tonnes/acre

*Methodology*: Carbon On-Line Estimator was used to perform regression equations on plots of forested land with estimates of the carbon stored by different types of forest (see ESA 30-31

*Reference*: Page 32 of Ecosystem Services Assessment for the Houston-Galveston Region, available at http://www.conservationfund.org/wp-content/uploads/2012/08/GI-Report-Houston-Galveston-The-Conservation-Fund-for-print.pdf

Ackerman, F., and E. A. Stanton. 2008. The cost of climate change: What we’ll pay if global warming continues unchecked. http://www.nrdc.org/globalwarming/cost/cost.pdf

http://www.ncasi2.org/COLE/index.html

Intergovernmental Panel on Climate Change (IPCC). 2000. Emissions Scenarios: Summary for Policymakers. ISBN: 92-9169-113-5. http://www.ipcc.ch/pdf/special-reports/spm/sres-en.pdf.

*Funding Source*: Sea Change Foundation, The Streisand Foundation, The William and Flora Hewlett Foundation, The Energy Foundation, Public Welfare Foundation, and Wallace Genetic Foundation

Simulations for Houston Area generated using COLE

<http://www.ncasi2.org/COLE/index.html>

## Energy Savings

**(Urban Forest) $3-15/tree/year ($2005), average 8.5**

*Value*: Cost Avoided

*Location*: Colorado, Wyoming, North Dakota, California, Arizona

*Methodology*: Computer simulation incorporating building shading effects and localized weather, energy cost, and tree distribution.

References: McPherson, E.G., J.R. Simpson, P.J> Peper, S.E> Maco, and Q Xiao. 2005. Municipal Forest Benefits and Costs in Five US Cities. Journal of Forestry. 103(8):411-416.

*Note*: It was estimated that overall benefits from urban trees (Energy Savings, CO2 reductions. Air Quality benefits, stormwater protection, and property value increase) provided between $1.37 and $3.09 for every dollar invested in the trees. Net annual tree benefits ranged from $21 to $38 per tree.

# Prairie

## Water Quality (Prairie Wetland Pothole)

**Benefit Provided: Retains 98.7% of inorganic Nitrogen, 56.7% of organic Nitrogen, 92% of inorganic Phosphorus, and 69% of organic phosphorus**

*Reference*: Forbes, M., Doyle, R., Clapp, A., Yelderman, J., Enwright, N., & Hunter, B. Baylor University, Texas Commission on Environmental Quality, US Environmental Protection Agency, (2010). Freshwater Wetland functional assessment study (582-7-77820). Retrieved from website: <http://www.baylor.edu/content/services/document.php/119417.pdf>

summarized at:

nwn.radcampaign.com/site/default/files/docs/forbes.pdf

*Funding Source*: Galveston Bay Estuary Program

*Location: Houston area*

## Erosion Control

**Benefit Provided: Including prairie strips occupying 10% of cropland can reduce sediment loss up to 97%**

*Reference*:

H. Asbjornsen, V. Hernandez-Santana, M. Liebman, J. Bayala, J. Chen, M. Helmers, C.K. Ong and L.A. Schulte. Targeting perennial vegetation in agricultural landscapes for enhancing ecosystem services. Renewable Agriculture and Food Systems, available on CJO2013. doi:10.1017/S1742170512000385.

*Methodology*: In an extreme rainfall year (2010), watersheds with 100% annual crops lost an average 6412 kg/ha, while watersheds with strips or prairie lost 180-314 kg/ha.

In a dry year (2009), watershed with 100% crops lost an average 4114 kg/ha, while watershed with strips of prairie lost 129-173 kg/ha.

*Location*: Iowa

## Stormwater Regulation

**Pending Study:** Katy Prairie Consevancy and Harris County Flood Control District have partnered for a study of the water infiltration rates of prairie grasses in the Katy Prairie. This study will compare the absorption of the prairie grasses to that of open space and developed land to determine the adverse impact of future development and the efficacy of land preservation as a solution to Cypress Creek flooding. Hydrographs suggest development of prairie land could increase peak flooding flow by almost 20,000 cubic feet per second.

More information can be found at: http://www.hcfcd.org/cypresscreekoverflow/

**Benefit Provided: Including prairie strips occupying 10% of cropland can reduce runoff by 37.5%.**

*Reference*:

H. Asbjornsen, V. Hernandez-Santana, M. Liebman, J. Bayala, J. Chen, M. Helmers, C.K. Ong and L.A. Schulte. Targeting perennial vegetation in agricultural landscapes for enhancing ecosystem services. Renewable Agriculture and Food Systems, available on CJO2013. doi:10.1017/S1742170512000385.

*Methodology*: Annual total runoff was 1.6 times greater for watersheds with 100% crops compared with watersheds with the perennial strips.

*Location*: Iowa

**NOTE**:

Initial results from 5 year study which will be conducted in the Houston Area in a study by Harris County Flood Control District indicate that Prairie grasses can absorb 40-60% more water

## Carbon Sequestration/Climate Change

**$63/acre/year ($2010 in 2100)**

**Benefit: Rangeland stores approximately 70,000 lbs carbon/acre**

*Value*: Avoided Cost (hurricane damage, real estate losses, energy costs, and water costs in 2100)

*Location*: Delaware

*Methodology*: Rangeland is reported to store 78 metric tonnes/ha, which equates to 31.6 metric tonnes/acre. This is was multiplied by $2/tonne, which was what the ESA predicted would be the annualized economic damage from carbon stored by the year 2100. This $2 was calculated by dividing the $3.6 trillion annual price tag of carbon emissions in 2100 (Ackerman and Stanton) by the projected 1,773 gigatonnes of carbon added between 1990 and 2100 (IPCC A2 Scenario.)

*References*: Page 32 of Ecosystem Services Assessment for the Houston-Galveston Region, available at http://www.conservationfund.org/wp-content/uploads/2012/08/GI-Report-Houston-Galveston-The-Conservation-Fund-for-print.pdf

Industrial Economics, Inc. 2011. Economic valuation of wetland ecosystem services in Delaware: Final Report. Delaware Department of Natural Resources and Environmental Control, Division of Water Resources, Dover, DE.

Ackerman, F., and E. A. Stanton. 2008. The cost of climate change: What we'll pay if global warming continues unchecked. http://www.nrdc.org/globalwarming/cost/cost.pdf

Intergovernmental Panel on Climate Change (IPCC). 2000. Emissions Scenarios: Summary for Policymakers. ISBN: 92-9169-113-5. http://www.ipcc.ch/pdf/special-reports/spm/sres-en.pdf.

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# Miscellaneous

### Water Quality

**Pending Study:** Harris County Precinct Three, US Corps of Engineers, Texas Parks & Wildlife, and the Houston Food Bank received a large Coastal Impact Assistance Program (CIAP) grant to study the effects of feral hogs on water quality in the Barker and Addicks reservoirs, through the large-scale capture of hogs to be trapped, then processed for food and distributed through the Houston Food Bank.