RESTORING BISCAYNE BAY

AND THE ECONOMIC VALUE OF REHYDRATING COASTAL WETLANDS

EARTH ECONOMICS

Restoring Biscayne Bay

And the Economic Value of Rehydrating Coastal Wetlands

Valuation Framework, Results, and References

April, 2019

Authors:
Corrine Armistead, Cheri Jensen, Trygve Madsen, Maya Kocian

Acknowledgements:
Prepared for Miami Waterkeeper
Funding provided by: The Miami Foundation

The authors are responsible for the content of this report.
Any reproduction in full or part must mention the title and credit Earth Economics as the copyright owner.

MIAMI WATERKEEPER

The mission of Miami Waterkeeper is to protect South Florida's water through citizen engagement and community action to ensure swimmable, drinkable, fishable water for all.
miamiwaterkeeper.org

EARTH ECONOMICS

Earth Economics is a leader in ecological economics and has provided innovative analysis and recommendations to governments, tribes, organizations, private firms, and communities around the world.
eartheconomics.org | info@eartheconomics.org

© Earth Economics 2019
Reproduction of this publication for educational or other non-commercial purposes is authorized without prior written permission from the copyright holder provided the source is fully acknowledged. Reproduction of this publication for resale or other commercial purposes is prohibited without prior written permission of the copyright holder.

Table of Contents

© Earth Economics 2019

1. Biscayne Bay Valuation Framework

1.1 Coastal Wetland Rehydration and Biscayne Bay

Historically, rainfall and overland freshwater flows kept the waters of Biscayne Bay at low salinity levels, which enabled healthy ecosystems to thrive. Over the last 50-100 years, the Bay has become increasingly salty and has suffered lost productivity. As part of the Comprehensive Everglades Restoration Plan (CERP), rehydrating a portion of Biscayne Bay's wetlands can help lower salinity levels and reduce pressure on surrounding aquifers.[1] The analysis presented below offers a baseline ecosystem services valuation for both rehydrated wetlands specifically and Biscayne Bay's ecosystems overall. Coastal wetland rehydration is one key step towards ensuring a healthy, productive Biscayne Bay to support the region's future.

1.2 Natural Capital and Ecosystem Services

Natural capital refers to the stocks of resources existing in nature—plants, animals, soils, minerals, and energy resources. Like other forms of capital, natural capital provides a flow of goods and services. These goods and services are the basis of all other economic activity as they provide clean water, breathable air, nourishing food, flood-risk reduction, waste treatment, climate stability, and other critical services that communities and economies require. Wetlands, for example, are natural capital assets. These assets preform ecosystem functions (i.e. filtration of water) that result in ecosystem goods or services - potable water. The relationship among natural capital, ecosystem function, and ecosystem goods and services is illustrated via the role of a forest and watershed in water capture and storage, which results in reduced flood risk in Figure 1.

Figure 1. Visual of the pathway from a natural capital asset to an ecosystem service

Ecosystem services are the benefits people and communities receive from nature. For the purposes of economic valuation, we categorize ecosystem services into four primary types and 21 specific services, outlined in Table 1.

[1] https://www.saj.usace.army.mil/CFS-BBCWC/

Table 1. 21 Ecosystem Services

ECOSYSTEM SERVICES BY DEFINITION	
PROVISIONING	
Food	Can include crops, fish, game, and/or produce
Medicinal Resources	Can include traditional medicines, pharmaceuticals, and/or assay organisms
Ornamental Resources	Resources for clothing, jewelry, handicrafts, worship, and decoration
Energy and Raw Materials	Can include fuel, fiber, fertilizer, minerals, and/or energy
Water Storage	Amount of surface or ground water held and its capacity to reliably supply water
REGULATING	
Air Quality	Ability to create and maintain clean, breatable air
Biological Control	Pest and/or disease control
Climate Stability	Ability to support a stable climate at global or local levels
Disaster Risk Reduction	Ability to prevent and mitigate natural disasters, including flood, fire, drought, etc.
Genetic Transfer	Includes pollination and/or seed dispersal
Soil Formation	Soil creation for agricultural and/or ecosystem(s) integrity
Soil Quality	Soil quality improvement due to decomposition and pollutant removal
Soil Retention	Ability to retain arable land, slope stability, and coastal integrity
Water Quality	Water quality improvement due to decomposition and pollutant removal
Water Supply	Ability to provide natural irrigation, drainage, supply, flow, and use of water
Navigation	Ability to maintain neccersary water depth for recreational and commercial vessels
SUPPORTING	
Habitat and Nursery	Ability to maintain genetic and biological diversity, and to promote species growth
INFORMATION	
Aesthetic Information	Enjoyment and appreciation of nature through the senses (sight, sound, etc.)
Cultural Value	Use of nature in art, symbols, architecture, and religious/spiritual purposes
Recreation and Tourism	Can include hiking, boating, travel, camping, and more
Science and Education	Use of natural systems for education and scientific research

Source: Compiled from Daly and Farley 2004, de Groot 2002, and Boehnke-Henrichs et al. 2013.31

1.3 Linking Biscayne Bay's Ecosystems

Biscayne Bay's ecosystems are interconnected. Healthy wetlands serve to enrich the function of surrounding ecosystems. This effect ripples through the larger natural system and produces more high-quality ecosystem services as a result. In addition to strengthening the flow of wetland ecosystem services to communities, re-hydration helps surrounding marine ecosystems function by reducing salinity and nutrients, promoting biodiversity, managing sediment loads, and increasing carbon storage capacity.

Enhancing Biscayne Bay's overall health leads to improved resilience for the region - increasing protection from storms, ensuring reliable drinking water, enabling continued recreation and tourism, and buffering sea level rise to name a few benefits. The preliminary valuation presented in this analysis estimates the ecosystem service value derived from a healthy Biscayne Bay. The rehydration of coastal wetlands is one critical step to ensuring the health of the Bay. While the contribution of wetland rehydration to overall bay health has not been quantified, considering the overall value of a healthy bay helps to frame what is at stake in current and future regional decisions.

1.4 Economic Value of Natural Capital

While the services provided by nature are as diverse as ecosystems themselves, the bottom line is that humans benefit from these services and value them. The value of nature means many things to many people, but we know that when it comes to considering nature in the decision-making process, an economic approach is key. Decisions are made and policies developed using the language of budgets, costs, and return on investment. If we don't include an economic value for nature in those conversations or decision-making tools, it will be considered zero, and the policies and decisions that move forward will reflect that.

Because they are living systems, natural assets are often more resilient and less expensive to maintain than built infrastructure. Additionally, without natural capital, many of the benefits we receive for free could not exist and would need to be replaced and maintained at a high cost. Considering the economic value of natural capital helps elevate nature-based solutions as cost effective, sustainable solutions with an awareness of the long-term connections between people and natural assets.

1.4.1 Primary Valuation Methods

The goods and services provided by an ecosystem are similar to the goods and services provided in a traditional market in that they can be valued as a dollar figure. In the same way that economists can determine the value of a home as a private asset, economists can also determine the value of ecosystems as natural public assets. Many of these values are not set in traditional markets, but can be assessed through other means. For example, timber is bought and sold as a raw material but there is no "going rate" for the water filtration and flood-risk reduction services that the same ecosystems provide to neighboring communities. Benefits without a value in traditional economies are called non-market benefits. Because there is no price tag on them, their economic value is understood through other methods. Working together, economists and ecologists employ a range of valuation techniques to assess ecosystem service value dependent on the specific study context. These include:

- **Market Pricing:** The current market value of goods produced within an ecosystem (e.g., food, timber).

- **Replacement Cost:** The cost of replacing the services provided by functional natural systems with man-made infrastructure (e.g. the installation of a levee to replace natural floodplain protection).

- **Avoided Cost:** Ecosystem services can help communities avoid harm that would have incurred in the absence of those services (e.g. flooding reduction by wetlands and riparian buffers).

- **Production Approaches:** Ecosystem services which enhance output (e.g. rain-fed irrigation can increase crop productivity).

- **Travel Cost:** Demand for some ecosystem services may require travel, the cost of which reflects the implicit value of those services (e.g., recreation and tourism).

- **Hedonic Pricing:** Property values vary by proximity to some ecosystem services (e.g. homes with water views often sell for higher prices than similar homes without such views).

- **Contingent Valuation:** Estimates of value based on surveys of the values assigned to certain activities (e.g., willingness-to-pay to protect water quality).

The valuation of most ecosystem services is well-understood and straightforward. However, for ecosystem services that are difficult to value, the benefits are better described qualitatively. Cultural values, in particular, are difficult to define. Their worth lies in sense of place, personal identity, spiritual fulfillment, and other shared values that cannot be monetized. We have not assigned dollar values to these benefits of nature.

1.4.2 Benefit Transfer Methodology

The benefit transfer method (BTM) is broadly defined as "the use of existing data or information in settings other than for what it was originally collected".[2] As such, BTM is an efficient means of generating broad-based estimates at a fraction of the cost and time necessary to conduct multiple primary studies, which may require more than $50,000 per service–land cover combination.[3] BTM plays an important role in the field of ecosystem services valuation, as it is often the most practical option available for producing reasonable estimates. Additionally, as many primary valuation studies focus on one ecosystem service-land cover combination, BTM is used to provide an aggregate picture of natural capital value through a range of services across multiple ecosystem types.

BTM begins by identifying primary valuation studies of similar ecosystems and communities as reported in peer-reviewed journals. Each value estimate in these studies is then standardized for units of measure, inflation, and land cover classification to ensure "apples-to apples" comparisons, as these estimates are "transferred" to the new study site. To accomplish this transfer, Earth Economics has curated a repository of primary valuation studies that have been vetted through a multi-stage review process by analysts and external reviewers. Accepted studies are transcribed into the Ecosystem Valuation Toolkit (EVT), which simplifies the standardization process as described above.

[2] Rosenberger, R., Loomis, J., 2003. Benefit Transfer, in: Champ, P., Boyle, K., Brown, T. (Eds.), A Primer on Nonmarket Valuation. Kluwer Academic Publishers, Boston.
[3] Richardson, L., Loomis, J., Kreoger, T., Casey, F., 2014. The role of benefit transfer in ecosystem service valuation. Ecol. Econ. 8.

Different applications necessitate different criteria for identification of transferable valuation studies. Use of BTM for policy analysis or development of funding mechanisms requires a narrow scope and local data inputs. This analysis, on the other hand, is a screening level, or baseline, assessment of ecosystem service value intended for educational purposes. As such, studies are transferred from a broader geographic area in attempt to provide an estimate of value. Ecosystem service values reported in this study underestimate the full value of Biscayne Bay's natural capital. Additional site-specific data and more focused valuation studies would refine values by better accounting for functions and attributes unique to the study region.

1.4.3 Preliminary Valuation Steps

This valuation applies the benefit transfer method through four analysis steps to derive a value of a healthy Biscayne Bay. Methods are detailed in this section.

1. **Identification and Quantification of Ecosystems**

Using spatial data from a range of public sources, ecosystem types and their extent within Biscayne Bay were identified. Coastal wetlands and the extent of the estuary were derived from the US Fish and Wildlife Service's National Wetlands Inventory.[4] Coverage of mangroves and seagrass meadows were obtained from the Florida Fish and Wildlife Conservation Commission.[5]

2. **Identification and Valuation of Ecosystem Services**

This study estimated the value of each ecosystem service-land cover combination (e.g. habitat/water) using the benefit transfer method. Primary valuation studies were selected from accepted values in Earth Economics' Ecosystem Valuation Toolkit (EVT) using several criteria including geographic location, climate, and the ecological characteristics of the original primary study sites. Where available, primary ecosystem valuation studies from Florida are given preference, followed by values from the gulf coast and eastern seaboard. When applicable, values from other regions of the US were used to fill gaps for critical ecosystem services.

One ecosystem service, climate stability, was valued through a different method than described above. As opposed to transferring a primary valuation study, we followed two steps to estimate the carbon sequestration benefits of Biscayne Bay's ecosystems. First, based on the ecosystems and vegetation types present – coastal wetlands, mangroves, and seagrass meadows, the rate of annual carbon sequestration (tons/year) was estimated for each ecosystem, drawing on studies included in Section 4. Value Transfer Studies. Then a consistent dollar per ton value was used across all ecosystem types, relying in the US social cost of carbon – a measure of the damage done by emitting 1 ton of carbon in a given year.[6]

---

[4] https://www.fws.gov/wetlands/

[5] https://geodata.myfwc.com/datasets/

[6] Interagency Working Group on Social Cost of Carbon (For Year 2011).

This valuation is geared towards awareness raising and educational purposes – broadening the scope of transferred values. In cases where no published studies are available for a particular ecosystem service/land cover combination, no value is provided in this report. As a result, values presented here are underestimates due to both generalization and unvalued services.

3. Annual Value

The annual value of ecosystem services represents the flow of benefits derived from natural assets each year. To calculate the total annual value of Biscayne Bay, all ecosystem service values were summed by ecosystem type then multiplied by the spatial extent of that ecosystem within the study area. These total annual values by ecosystem type were then aggregated, generating a total value which represents the ecosystem services provided by the natural assets of Biscayne Bay every year.

The annual value of Biscayne Bay ecosystem services is presented as a range for this preliminary analysis. The range in estimated value of ecosystem services is largely the result of variation that exists within the primary valuation studies used in this analysis. While methodologically sound, these studies have various approaches to valuing ecosystem services, each with the potential for bias. Given the current gaps and inability to value some ecosystem services, the range presented remains an underestimate of the full value of Biscayne Bay to surrounding communities.

4. Asset Value

The asset value of built capital, such as a road, levee, home, or business, can be calculated as the net present value of its expected future benefits. In the same way that a home holds value year after year, natural capital also provides value over time. The annual flow of ecosystem services presented above will continue into the future. As such, analogous to built capital, we calculate the asset value of natural capital in Biscayne Bay.

The asset value calculated in this analysis is based on a snapshot representing a healthy Biscayne Bay and available valuation literature. It provides a measure of the expected benefits flowing from the study area's natural capital over time. The net present value formula is used to compare benefits that are produced at various points in time. In order for this to be accomplished, a discount rate must be used.

Discounting allows for sums of money occurring in different time periods to be compared by expressing the values in present terms. In other words, discounting shows how much future sums of money are worth today. Discounting is designed to take two major factors into account:

1. Time preference. People tend to prefer consumption now over consumption in the future, meaning a dollar today is worth more than a dollar received in the future.

2. Opportunity cost of investment. Investment in capital today provides a positive return in the future but renders those funds unavailable for other investment opportunities.

However, experts disagree on the appropriate discount rate for natural capital benefits. Public and private agencies vary widely in their standards for discount rates. The Office of Management and Budget (OMB) recommends a seven percent rate for average investments, while the United States Army Corps of Engineers (USACE) uses a two and three-quarter percent rate for water related projects (2018). The choice of discount rate is critical as this has a large influence on the present value of benefits occurring over a long period of time. This analysis uses a 2.75% discount rate to analyze the asset value of Biscayne Bay, following the 2018 USACE guidance for water projects. Lower discount rates better demonstrate the value of long-term, non-diminishing assets such as natural capital, as the present value of benefits occurring many years in the future remains more consistent with the value of current benefits.

Present values can be calculated over different timeframes depending on the purpose of the analysis and the nature of the project. In the case of natural capital valuations, ecosystems, if kept healthy, show long-term stability and productivity. Although many built capital projects are valued for shorter timespans, we chose a 50-year timeframe to reflect the longevity of ecosystems' stability and productivity. If kept healthy, Biscayne Bay's natural capital can provide benefits for much longer than 50 years.

2 Preliminary Valuation Results

This preliminary analysis focuses on the value of a healthy Biscayne Bay. Through wetland rehydration, the region can take an important step towards reviving a healthy Bay. Restoration benefits extend far beyond project area wetlands, enhancing the larger Biscayne Bay ecosystems and communities they support. Valuation results presented below first discuss Biscayne Bay as a whole, then zooms in on rehydrated wetlands and mangroves as a subset of the larger Biscayne Bay. Values represent the ecosystem service flows of fully functioning Biscayne Bay ecosystems – highlighting the value these natural assets can provide if well maintained into the future. This analysis has not assessed the marginal changes of varying ecosystem health.

2.1 Biscayne Bay Ecosystems

Following the steps detailed above, Earth Economics derived the annual and asset value of Biscayne Bay's ecosystem services. These results represent preliminary values and could be improved with additional site-specific data and more focused valuation studies, better accounting for functions and attributes unique to Biscayne Bay.

1. **Identification and Quantification of Ecosystems**

Using Geographic Information Systems (GIS), the ecosystems of Biscayne Bay were mapped and aggregated.

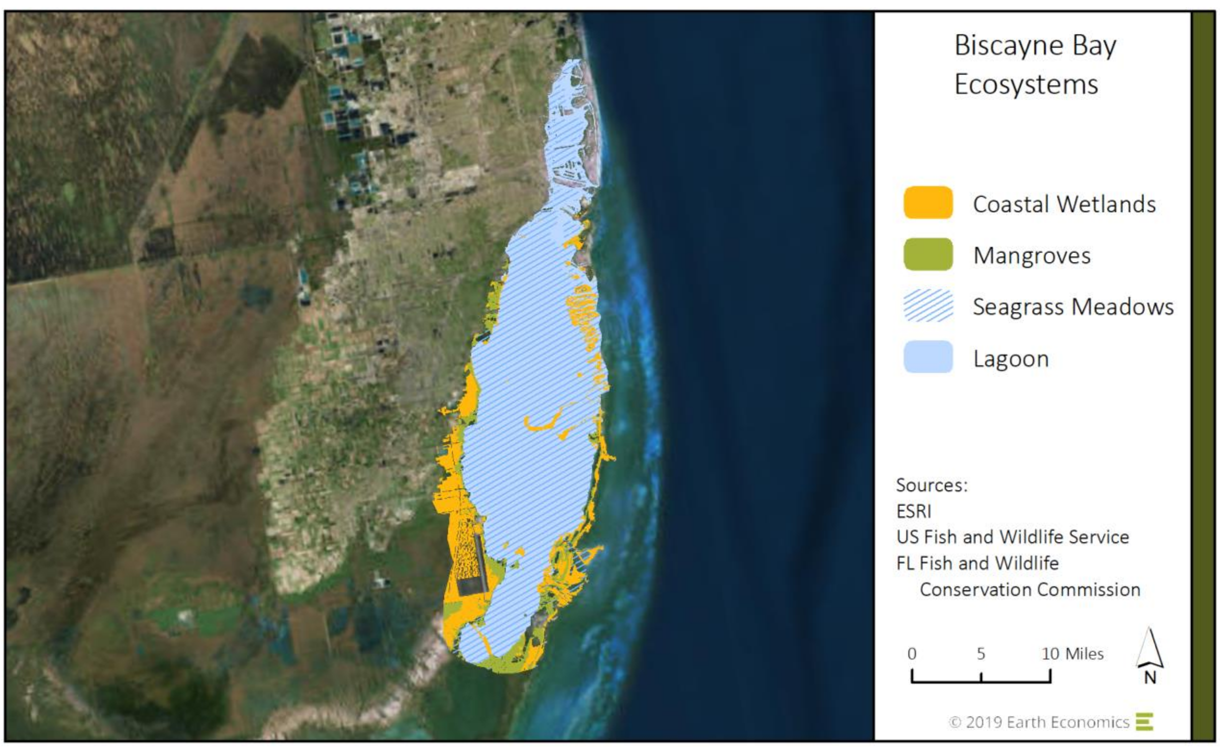

Figure 2. Biscayne Bay Ecosystems

2. Identification and Valuation of Ecosystem Services

Applying the benefit transfer method, primary valuation studies were selected and reviewed for appropriate transfer to Biscayne Bay. Studies from Florida's east coast were given preference, with additional values added from coastal regions of eastern seaboard states and well as the Gulf. Ultimately, there were 24 primary valuation studies included in this preliminary valuation – representing primary analyses of all four key ecosystem types, coastal wetlands, mangroves, estuary, and seagrass meadows (See section 4. Value Transfer Studies). While not all ecosystem services could be valued across each ecosystem, ten different ecosystem services were included in this analysis.

Table 2. Gap Analysis Table

ECOSYSTEM SERVICES BY LAND COVER TYPE	COASTAL WETLANDS	MANGROVES	ESTUARY/ LAGOON	SEAGRASS
Aesthetic Information	●		●	
Climate Stability	●	●	●	●
Disaster Risk Reduction	●	●		
Existence			●	
Food	●	●	●	
Habitat and Nusery	●	●		●
Ornamental Resources	●			
Recreation and Tourism	●		●	
Water Quality	●	●		●
Water Storage	●			

● = VALUE INCLUDED IN THIS ANALYSIS

© 2019 EARTH ECONOMICS

3. Annual Value

The estimated annual value of Biscayne Bay ecosystem services is captured by aggregating the identified ecosystem services for each land cover type. These total annual values are included in Table 2 below. As described above, values are presented as a range, reflecting variation in valuation method across applicable benefit transfer studies.

Table 3. Biscayne Bay Annual Ecosystem Services

Ecosystem Type	Acres	USD/Year Low		USD/Year High	
Coastal Wetlands	32,110	$	238,221,000	$	648,982,000
Mangroves	13,400	$	46,938,000	$	66,144,000
Estuary / Lagoon	146,200	$	771,309,000	$	772,728,000
Seagrass	139,400	$	471,228,000	$	702,064,000
Totals		**$**	**1,527,696,000**	**$**	**2,189,918,000**

4. Asset Value

Treating Biscayne Bay as an asset, we calculated the net present value of ecosystem services flows over a 50-year project life. A 2.75% discount rate was applied, as detailed in the methods section above.

Table 4. Biscayne Bay Asset Value

Asset Value - 2017$ Low		Asset Value - 2017$ High	
$	42,377,639,000	$	60,747,450,000

2.2 Highlighting Rehydrated Coastal Wetlands

As a subset of Biscayne Bay – wetlands within the rehydration project area provide a critical link to the larger ecosystem. The value of rehydrated coastal wetlands and mangroves is separated out from the larger Biscayne Bay valuation results and presented below.

Table 5. Rehydration Project Annual Ecosystem Services

Ecosystem Type	Acres	USD/Year Low		USD/Year High	
Coastal Wetlands	5,472	$	40,596,000	$	110,596,000
Mangroves	1,809	$	6,337,000	$	8,929,000
Totals	**7,281**	**$**	**46,933,000**	**$**	**119,525,000**

Table 6. Rehydration Project Asset Value

Asset Value - 2017$ Low		Asset Value - 2017$ High	
$	1,301,897,000	$	3,315,579,000

3. Recommendations

3.1 Monitoring Wetland Rehydration

Rehydrating wetlands of Biscayne Bay provides an opportunity to engage in further study of the dynamics of wetland rehydration through the lens of ecosystem function. Monitoring shifts throughout the rehydration project would build valuable knowledge around rehydration and shifting ecosystem health. The decline of ecosystem function as wetlands transition from a freshwater ecosystem towards a saline dominant environment is currently better studied than the reverse. Close monitoring of changes in species presence, soil retention rates, and nutrient processing for example, would increase metrics available for building knowledge around wetland health and ecosystem function. Monitoring and evaluation of this coastal wetlands rehydration project would create opportunity for improved valuation of project benefits for comparable efforts.

3.2 Linking Ecosystem Dynamics and Ecosystem Service Impacts

Continuing to build out the framework of ecosystem interconnection, function, and ecosystem service provision would provide key inputs for in-depth valuation studies. To compare ecosystem services between wetlands of varying health and to extend impacts to additional ecosystems types (e.g. seagrass meadows), more research linking ecosystem function to specific ecosystem service provision is needed. Some ecosystem services are more sensitive to changing wetland health, while others are provided to communities simply through the presence of wetlands. Additionally, improving ecosystem function will impact some aspects of surrounding ecosystems ability to produce ecosystem services, but may not change all aspects of ecosystem function. Building out these effects would provide a base for future ecosystem service analyses appropriate for policy analysis, such as a full project benefit-cost analysis discussed below.

3.3 Rehydration Project Benefit-Cost Analysis

Building on the preliminary valuation presented here and additional analysis linking ecosystem health to ecosystem service flows, conducting a holistic benefit-cost analysis (BCA) would provide a valuable next step in assessing project tradeoffs. A holistic BCA is key to understanding the broad range of benefits that will be provided by wetland rehydration. Many BCAs are framed to exclude all benefits and costs that occur outside of a traditional market. However, it is critical that non-market benefits be incorporated into a decision-making process because ultimately, non-market benefits are just as tangible as economic benefits. Incorporating into a BCA a broad range of ecosystem service benefits, in addition to traditional economic benefits and costs, provides a more comprehensive perspective of what the region's residents value, and what they stand to gain when the project is completed. This perspective supports more informed decision making by leaders who are ultimately responsible for determining how public dollars are invested.

4. Value Transfer Studies

Barbier, E. B., Strand, I. 1998. Valuing Mangrove-Fishery Linkages: A Case Study of Campeche, Mexico. Conference of European Association of Environmental and Resource Economics.

Bauer, D. M., Cyr, N. E., Swallow, S. K. 2004. Public Preferences for Compensatory Mitigation of Salt Marsh Losses: a Contingent Choice of Alternatives. Conservation Biology 18(2):

Bell, J. J. 1997. The economic valuation of saltwater marsh supporting marine recreational fishing in the southeastern United States. Ecological Economics 21(3): 243-254.

Bell, J. J., Bell, F. W. 1989. Application of Wetland Valuation Theory to Florida Fisheries. Florida Sea Grant College.

Cabrera, M. A., Seijo, J. C., Euan, J., Perez, E. 1998. Economic Values of Ecological Services from a Mangrove Ecosystem. Intercoast Network 32: 1-2.

Chmura, C., Anisfeld, S.C., Cahoon, D.R., Lynch, J.C. 2003. Global carbon sequestration in tidal, saline wetland soils. Global biogeochemical cycles 17(4).

Clarke, C., Canto, M., Rosado, S. 2013. Belize Integrated Coastal Zone Management Plan. Belize Coastal Zone Management Authority and Institute.

Cooper, E., Burke, L., Bood, N. 2009. Coastal Capital: Belize. The Economic Contribution of Belize's Coral Reefs and Mangroves. World Resources Institute.

Costanza, R., Pérez-Maqueo, O., Martinez, M. L., Sutton, P., Anderson, S. J., Mulder, K. 2008. The Value of Coastal Wetlands for Hurricane Protection. Ambio: A Journal of the Human Environment 37(4): 241-248.

Duarte, C.M., Middelburg, J.J., Caraco, N. 2005. Major role of marine vegetation on the oceanic carbon cycle. Biogeosciences 2: 1-8.

Farber, S. C. 1996. Welfare loss of wetlands disintegration: A Louisiana study. Contemporary Economic Policy 14: 92-106.

Garrard, S., Beaumont, N. 2014. The effect of ocean acidification on carbon storage and sequestration in seagrass beds; a global and UK context. Marine Pollution Bulletin 86: 138-146.

Grabowski, J. H., Brumbaugh, R. D., Conrad, R. F., Keeler, A. G., Opaluch, J. J., Peterson, C. H., Piehler, M. F., Powers, S. P., Smyth, A. R. 2012. Economic Valuation of Ecosystem Services Provided by Oyster Reefs. BioScience 62(10): 900-909.

Gupta, T. R., Foster, J. H. 1975. Economic criteria for freshwater wetland policy in Massachusetts. American Journal of Agricultural Economics 57(1): 40-45.

Johns, G. M., Kiefer, J., Blacklocke, S., & Sayers, D.2008. Indian River Lagoon Economic Assessment and Analysis Update.

Johnston, R. J., Opaluch, J. J., Grigalunas, T. A., Mazzotta, M. J. 2001. Estimating Amenity Benefits of Coastal Farmland. Growth and Change 32(3): 305-325.

Ko, J. 2007. The Economic Value of Ecosystem Services Provided by the Galveston Bay/Estuary System. Texas Commission on Environmental Quality.

Laffoley, D., Grimsditch, G. (eds). 2009. The management of natural coastal carbon sinks. IUCN, Gland, Switzerland. 53 pp.

Lavery, P., Mateo, M., Serrano, O., Rozaimi, M. 2013. Variability in the Carbon Storage of Seagrass Habitats and Its Implications for Global Estimates of Blue Carbon Ecosystem Service. PLoS ONE 8(9): 1-12.

Mazzotta, M. J. 1996. Measuring Public Values and Priorities for Natural Resources: an Application to the Peconic Estuary System.

Piehler, M. F., Smyth, A. R. 2011. Habitat-specific distinctions in estuarine denitrification affect both ecosystem function and services . Ecosphere 2(1): 1-16.

Polunin, N., Roberts, C. M. 1993. Greater biomass and value of target coral reef fishes in two small Caribbean marine reserves. Marine Ecology Progress Series 100: 167-176.

Thibodeau, F. R., Ostro, B. D. 1981. An economic analysis of wetland protection. Journal of Environmental Management 12: 19-30.

Xu, B. 2007. An Hedonic Analysis of Southwestern Louisiana Wetland Prices Using GIS. Louisiana State University.