Coastal Wetland Restoration and the *Deepwater Horizon* Oil Spill

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I. INTRODUCTION

Both the 2005 Hurricanes Katrina and Rita and the 2010 BP *Deepwater Horizon* oil spill have focused attention on the need to restore coastal wetland habitats along the Gulf Coast of the United States. Although the spill affected all five Gulf states—Alabama, Florida, Louisiana, Mississippi, and Texas—the shoreline impacts have been greatest for Louisiana, Mississippi, and Alabama. Under the Oil Pollution Act of 1990 ("OPA"), the restoration of coastal wetlands will be required as part of BP's legal obligations.[1] Although plans to restore the Mississippi River Delta are well on their way, and some wetland projects have been implemented, the damages to the Gulf Coast wetlands caused by the BP spill are still occurring and

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1. 33 U.S.C. §§ 2701–20, 2731–38, 2751–52, 2761–62 (2006).

have yet to be fully assessed.[2] At this critical time for wetland restoration in the Gulf of Mexico, it is important to be clear about the ecological and economic challenges that need to be addressed in restoring the Gulf Coast wetlands after this series of disasters.

Part I of this Article reviews the current status of post-BP oil spill wetland restoration efforts in the Gulf. I discuss recent trends in wetland loss and restoration in the region. Even before the oil spill, a number of federal, state, and local wetland restoration initiatives had been launched. As the Natural Resource Damage Assessment ("NRDA") for the oil spill will likely inject more funding and political support for widespread coastal restoration in the Gulf states, it is important to understand how both current and previous restoration in the region have fared.

Part II focuses on the actual methods of the NRDA, which will likely emphasize compensatory restoration of coastal wetlands. The main method of assessment in the NRDA is habitat equivalency analysis ("HEA"), which is based on the principle that the public can be compensated for past losses of habitat resources through habitat replacement projects providing additional resources of the same type. I discuss the pros and cons of HEA from both an ecological and economic perspective. The HEA approach places restoration at the beginning of the NRDA process, which may expedite both restoration and compensation and avoids protracted and costly litigation as well as the need for expensive valuation studies. In addition, by guaranteeing funds for compensatory restoration, the HEA ensures financing of wetland restoration and enhancement projects. However, the HEA can misrepresent complex ecological services of wetlands, produce misleading estimates of the costs and benefits of wetland restoration, and in some cases, oversupply some wetland services in the long run.

Part III examines the state of knowledge of the ecological restoration of coastal wetlands and the available information on the economic benefits of such restoration. This review highlights the key ecological and economic issues that concern coastal wetland restoration, enhancement, and creation. It is clear that much more work is required in this critical area of ecological and economic analysis, given that restoring coastal wetlands along the Gulf is becoming a major policy focus.

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2. *See generally* M. LYNNE CORN & CLAUDIA COPELAND, CONG. RESEARCH SERV., R 41311, THE DEEPWATER HORIZON OIL SPILL: COASTAL WETLAND AND WILDLIFE IMPACTS AND RESPONSE (2010) (discussing the importance of wetlands, the effects of oil spills generally, and potential response options).

II. POST-SPILL WETLAND RESTORATION

The Oil Pollution Act makes parties releasing oil into the environment liable not only for the cost of cleaning up those releases but also for monetary compensation for injury (damages) to natural resources caused by the releases.[3] The OPA was enacted in response to the 1989 *Exxon Valdez* oil spill and a spate of similar incidents in U.S. coastal waters.[4] The OPA authorizes public trustees, which can include federal and state governments and some Native American tribes, to seek recovery of all natural resource damages arising from an oil spill.[5] Serving as the trustee for all coastal and marine resources, the National Oceanic and Atmospheric Administration ("NOAA") is the main agency responsible for assessing the effects of any spill, through a process known as Natural Resource Damage Assessment ("NRDA").[6]

Any NRDA has three principal phases: (1) a *pre-assessment* to determine whether impacts to coastal and marine natural resources have occurred; (2) *injury assessment* of the damages to these resources and any loss of public use; and (3) *restoration* of the damaged coastal and marine resources.[7] The party responsible for the oil spill is liable for the costs of assessment and restoration and is often a key participant in implementing any resulting restoration investments.[8] However, if the responsible party does not agree to damages, then all or some of the public trustees may file a lawsuit or submit a claim for damages to the Oil Spill Liability Trust Fund.[9]

The NRDA process is therefore highly complex, requires rigorous scientific study, and may take years to complete. For example, in February 2011, NOAA and other federal agencies announced that they are ready to initiate a restoration-scoping process

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3. 33 U.S.C. §§ 2701–20, 2731–38, 2751–52, 2761–62 (2006).

4. Douglas D. Ofiara, *Natural Resource Damage Assessments in the United States: Rules and Procedures for Compensation from Spills of Hazardous Substances and Oil in Waterways under US Jurisdiction*, 44 MARINE POLLUTION BULL. 96, 101 (2002).

5. 33 U.S.C. § 2702 (2006).

6. Natural Resource Damage Assessments, 15 C.F.R. § 990 (2011), *available at* http://www.gulfspillrestoration.noaa.gov/wp-content/uploads/2010/10/PPD_AP-A.pdf. For a detailed description of NRDA rules and procedures as applied to oil and other hazardous-substance spills, see Ofiara, *supra* note 4.

7. Ofiara, *supra* note 4, at 100.

8. *See* 15 C.F.R. § 990.62 (2011) (outlining what should be included in a trustee's written demand to a responsible party); Ofiara, *supra* note 4, at 100 (detailing what is factored into damage calculations).

9. 15 C.F.R. § 990.62.

for the *Deepwater Horizon* oil spill.[10] The process will involve public scoping meetings in each of the five affected Gulf states and will identify the appropriate restoration options to pursue in the NRDA of the BP spill. At such meetings, members of the public will learn about the environmental impacts of the spill and the region's natural resource restoration needs, and the public may submit comments on the types of programs and projects they would like to see incorporated in future restoration strategies in response to the oil spill.

OPA regulations state that recovery "means the return of injured natural resources and services to baseline,"[11] which implies that the damaged resource and the services that it provides should be restored to the condition that it would have been in had the spill not occurred. In implementing these regulations for coastal and marine resources, the NRDA procedures distinguish between *primary restoration*, the cost of restoring the damaged resource to its baseline condition, and *compensatory restoration*, any additional restoration that compensates the public for interim lost natural resource services between the time of the incident and the full recovery to pre-spill conditions.[12] As an illustration, for oil-spill damages to a salt marsh, the full range of restoration actions could include projects that: (1) accelerate the recovery of the marsh to the condition it would have been in had the spill not occurred; (2) compensate for lost recreational use of the marsh, such as hunting and fishing; and (3) compensate for the benefits of the marsh and its services from the time of the spill until recovery, possibly by acquiring additional marshland.[13]

Restoration of Gulf Coast wetlands will therefore be a major feature of NRDA efforts implemented in the aftermath of the *Deepwater Horizon* oil spill. Even before the 2010 disaster, however, significant wetland restoration was occurring throughout the Gulf Coast. Such restoration was meant to counter the substantial wetland loss and degradation that increased population and economic development caused throughout the region over the past decades. Wetland restoration, especially in Louisiana, also accelerated in the

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10. Press Release, Nat'l Oceanic & Atmospheric Admin., Federal Natural Resource Trustees Announce Next Step in BP *Deepwater Horizon* Spill Gulf Restoration Process (Feb. 19, 2011), *available at* http://www.noaanews.noaa.gov/stories2011/20110219_gulfspillrestoration.html.

11. 15 C.F.R. § 990.30 (2011).

12. NAT'L OCEANIC & ATMOSPHERIC ADMIN., HABITAT EQUIVALENCY ANALYSIS: AN OVERVIEW 2 (1995, rev. 2000, 2006), *available at* http://www.darrp.noaa.gov/library/pdf/heaoverv.pdf.

13. *Damage Assessment*, NAT'L OCEANIC & ATMOSPHERIC ADMIN., http://www.gulfspillrestoration.noaa.gov/assessment/restoration/ (last visited Sept. 6, 2011).

aftermath of the 2005 Hurricanes Katrina and Rita. Thus, before discussing further NRDA procedures for post-BP oil spill wetland restoration, it is worth briefly reviewing past Gulf Coast wetland loss and rehabilitation efforts. Evaluating previous efforts gives policymakers important insights into what restoration strategies might be most effective today.

A. Trends in Wetland Loss and Restoration

From the mid-1970s to the mid-1980s, the United States lost 71,000 acres (1.5% of the total) of estuarine vegetated (coastal) wetlands, with the majority of these losses occurring in the Gulf states.[14] From 1986 to 1997, the loss of U.S. estuarine vegetated wetlands slowed to 7,900 acres (0.2% of total), with most of the losses again occurring along the Gulf Coast.[15] However, between 1998 and 2004, estuarine vegetated wetlands declined by 45,430 acres (1.5% of total) in the five Gulf states. Very little wetland area was restored in the intertidal coastal systems of the Gulf of Mexico during this period. In addition, the coastal watersheds of the Gulf of Mexico lost another 329,000 acres of freshwater wetlands (2.7% of total) from 1998 to 2004.[16] These historic trends in the Gulf Coast wetlands resulted from flooding from storms in the Gulf, sea-level rise, flooding from rivers, natural land subsidence, and human-related activities, such as

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14. THOMAS E. DAHL & CRAIG E. JOHNSON, DEP'T OF THE INTERIOR, FISH & WILDLIFE SERV., STATUS AND TRENDS OF WETLANDS IN THE CONTERMINOUS UNITED STATES, MID-1970'S TO MID-1980'S, at 9, 15 (1991), *available at* http://www.npwrc.usgs.gov/resource/wetlands/classwet/index.htm. According to L.M. Cowardin et al., DEP'T OF THE INTERIOR, FISH & WILDLIFE SERV., CLASSIFICATION OF WETLANDS AND DEEPWATER HABITATS OF THE UNITED STATES 18 (1979), *available at* http://cpcb.ku.edu/progwg/html/assets/wetlandwg/1979Cowardin_review.pdf, an estuarine system "consists of deepwater tidal habitats and adjacent tidal wetlands that are usually semienclosed by land but have open, partly obstructed or sporadic access to the open ocean, and in which ocean water is at least occasionally diluted by freshwater runoff from the land." Within this system, typical vegetated wetlands include salt marsh and mangroves or other estuarine shrubs.

15. THOMAS E. DAHL, DEP'T OF THE INTERIOR, FISH & WILDLIFE SERV., STATUS AND TRENDS OF WETLANDS IN THE CONTERMINOUS UNITED STATES, 1986 TO 1997, at 29 (2000), *available at* http://library.fws.gov/Pubs9/wetlands86-97_lowres.pdf.

16. SUSAN-MARIE STEDMAN, NAT'L OCEANIC & ATMOSPHERIC ADMIN., NAT'L MARINE FISHERIES SERV., & THOMAS E. DAHL, DEP'T OF THE INTERIOR, FISH & WILDLIFE SERV., STATUS AND TRENDS OF WETLANDS IN THE COASTAL WATERSHEDS OF THE EASTERN UNITED STATES, 1998 TO 2004, at 22 (2008), *available at* http://www.fws.gov/wetlands/_documents/gSandT/NationalReports/StatusTrendsWetlandsCoastalWatershedsEasternUS1998to2004.pdf.

drainage, filling, canal dredging for navigation, construction of levees and other flood-control structures, and coastal development.[17]

Perhaps the most dramatic coastal wetland changes have occurred in Louisiana. The state still contains about 40% of the wetlands of the contiguous United States, but it has historically accounted for about 80% of total U.S. wetland losses. From 1932 to 2000, Louisiana lost about 1,900 square miles of coastal lands, primarily marshes. In 2005, Hurricanes Katrina and Rita may have caused another 200 square miles to disappear. Researchers estimate that Louisiana continues to lose about 16,000 acres of wetlands annually and that such loss is responsible for about 90% of the total coastal marsh loss in the contiguous United States each year.[18]

Much of the coastal wetland loss, especially in eastern Louisiana, is attributed to the isolation of the Mississippi River from the rest of the Delta.[19] Levees now almost completely hem in the river, preventing overbank flooding and crevasse flooding, while at the same time channeling the river's discharge into the deep Gulf of Mexico.[20] Over 9,300 miles have been dredged through the Mississippi River Delta for navigation, drainage, logging, and mostly for oil and gas development.[21] Both levee construction and dredging have gravely affected the hydrology and sediment flows that are critical to the wetlands of the Delta. Over the past several decades, the Gulf states, federal government, and localities have all been involved in a number of wetland restoration and recovery efforts through a variety of funding instruments.[22]

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17. *See generally* John W. Day, Jr. et al., *Restoration of the Mississippi Delta: Lessons from Hurricanes Katrina and Rita*, 315 SCIENCE 1679 (2007) (discussing the various influences on Mississippi Delta wetlands over the past several hundred years).

18. CORN & COPELAND, *supra* note 2, at 5.

19. Day et al., *supra* note 17, at 1680.

20. *Id.*

21. *Id.*

22. For an overview of wetland restoration in the Gulf, and especially Louisiana, see RAY MABUS, AMERICA'S GULF COAST: A LONG TERM RECOVERY PLAN AFTER THE DEEPWATER HORIZON OIL SPILL (2010), *available at* http://www.restorethegulf.gov/sites/default/files/documents/pdf/gulf-recovery-sep-2010.pdf (recommending, among other things, that Congress authorize a Gulf Coast Recovery Council that would include representatives from the states and federally recognized Gulf tribes); ROBERT R. TWILLEY, PEW CTR. ON GLOBAL CLIMATE, COASTAL WETLANDS & GLOBAL CLIMATE CHANGE: GULF COAST WETLAND SUSTAINABILITY IN A CHANGING CLIMATE (2007) (discussing how restoration planning must account for both climate change and human consequences); Denise J. Reed & Lee Wilson, *Coast 2050: A New Approach to Restoration of Louisiana Coastal Wetlands*, 25 PHYSICAL GEOGRAPHY 4 (2004) (discussing several 20th century Gulf Coast restoration efforts and proposing a new approach for the future); R. Eugene Turner, *Doubt and the Values of an Ignorance-Based World View for Restoration: Coastal Louisiana Wetlands*, 32 ESTUARIES & COASTS 1054.

Before the 2005 hurricanes, the largest effort to reduce coastal land-loss rates and restore wetlands was the Coastal Wetland Planning, Protection and Restoration Act ("CWPPRA") program initiated in 1991. Since its inception, the CWPPRA has had an annual budget ranging from $30 to $80 million and has authorized 151 projects benefiting over 110,000 acres in Louisiana.[23] However, the total area of CWPPRA's estimated "benefits" is about two to three times greater than the actual wetland area created or restored. Additionally, the current area gained, estimated at around 2,250 acres per year, is only a small proportion (less than 15%) of the total wetland loss that occurs annually in Louisiana.[24] Other major coastal and wetland restoration projects throughout the Gulf Coast include the Forever Wild Program to protect land in the Mobile-Tensaw River Delta in Alabama, the Everglades Restoration Plan in Florida, the Mississippi Coastal Improvement Program, and the Coastal Erosion Protection Planning and Response Act in Texas.[25]

Since Hurricanes Katrina and Rita in 2005, including the immediate aftermath of the 2010 BP *Deepwater Horizon* oil spill, efforts have been made to expand coastal restoration and recovery planning. For example, Congress created the Coastal Impact Assistance Program ("CIAP") in 2005, with a budget of $250 million for each of the fiscal years 2007 to 2010, to provide for ecosystem restoration to mitigate the impacts of offshore oil and gas production.[26] On October 5, 2010, President Obama issued Executive Order 13554 that directed the creation of a Gulf Coast Ecosystem Restoration Task Force.[27] The Task Force's mandate is to build on the ongoing spill-response and NRDA effort, as well as achieve overall recovery for the Gulf of Mexico through coordinating federal, state, and local initiatives. The Executive Order charged the Task Force with developing a Gulf of Mexico Regional Ecosystem Restoration Strategy within one year. Preliminary deliberations and strategy documents indicate that extensive coastal wetland restoration in the region is a

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23. *About The Coastal Wetlands Planning Protection and Restoration Act*, LACOAST.GOV, http://lacoast.gov/new/About/Default.aspx (last visited Sept. 1, 2011).

24. Turner, *supra* note 22, at 1060–61 (noting that according to CWPPRA estimates, 110,000 acres of wetlands have "benefited" from its 151 projects in Louisiana, but a total of approximately 52,000 acres have actually been restored or created).

25. MABUS, *supra* note 22, at 32–34.

26. *Coastal Impact Assistance Program Overview*, BUREAU OF OCEAN ENERGY MGMT., REGULATION & ENFORCEMENT, http://www.boemre.gov/offshore/ciapmain.htm (last visited Sept. 6, 2011).

27. MABUS, *supra* note 22, at 35.

high priority.[28] For example, one proposal under consideration is that a large share of the penalties collected from the *Deepwater Horizon* oil spill should be directed to a Gulf Coast recovery fund, which would finance many recovery activities including substantial coastal wetland restoration over the long term.[29]

As a result of the 2005 hurricanes, Louisiana has engaged in a long-term planning effort for restoring the Mississippi River Delta, which occupies much of southern Louisiana. The Delta comprises 3.4 million acres of marsh, swamp, forest, and barrier islands and constitutes the largest wetland complex in the contiguous United States. By 2012, Louisiana's Office of Coastal Protection and Restoration ("OCPR") will complete its current update of the 2007 Master Plan strategy, "Louisiana's Comprehensive Master Plan for a Sustainable Coast."[30] The updated Master Plan will identify high-priority restoration and protection projects for the wetland complex of the Mississippi Delta. In addition, Louisiana is already initiating some projects. For example, the OCPR approved a plan for the fiscal year 2010 for $1.4 billion to finance nearly 150 coastal restoration and protection projects by 2012.[31]

B. Compensatory Wetland Mitigation

Since the Clean Water Act of the 1970s, the U.S. government has instigated a variety of policies to encourage wetland creation or restoration as compensation for wetlands damaged or lost through development. This policy of "compensatory wetland mitigation" to achieve "no net loss" of wetlands in the United States has assumed that both the structure and functions of destroyed wetlands can be adequately reestablished elsewhere by the new wetlands.[32] Such off-

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28. RESTORETHEGULF.GOV, http://www.restorethegulf.gov (last visited Sept. 6, 2011) (providing information on the ongoing meetings of the Task Force).

29. MABUS, *supra* note 22, at 5; *see also* KATE GORDON ET AL., BEYOND RECOVERY: MOVING THE GULF COAST TOWARD A SUSTAINABLE FUTURE 43–47 (2011) (recommending extensive wetland restoration and other environmental protection in the Gulf Coast region).

30. For the 2007 Master Plan and details on the 2012 update, see *Louisiana's 2012 Coastal Master Plan*, LOUISIANA OFFICE OF COASTAL PROTECTION & RESTORATION, http://coastal.la.gov/index.cfm?md=pagebuilder&tmp=home&nid=150&pnid=0&pid=172&catid=0&elid=0 (last visited Sept. 6, 2011).

31. *Project Updates*, LOUISIANA OFFICE OF COASTAL PROTECTION & RESTORATION, http://www.coastal.louisiana.gov/index.cfm?md=pagebuilder&tmp=home&pid=46 (last visited Sept. 6, 2011).

32. COMM. ON MITIGATING WETLAND LOSSES, NAT'L RESEARCH COUNCIL, COMPENSATING FOR WETLAND LOSS UNDER THE CLEAN WATER ACT 12 (2001) (noting that the loss of wetland functions led to the creation of a "no net loss" policy in 1998).

site compensatory mitigation is rapidly emerging as an alternative to on-site restoration or enhancement of wetlands lost or impacted by development.

One approach to off-site compensation is *mitigation banking*, which is the undertaking of wetlands restoration, creation, enhancement, and, in exceptional cases, preservation as a means of compensating for unavoidable wetland losses resulting from development activities.[33] The value of the new or restored wetland area, or "bank," is determined by quantifying the wetland functions restored or created in terms of "credits." Most conversions of wetlands through development activities require a federal or state government permit. The permitee can then acquire wetland banking credits to meet its requirements for compensatory mitigation.[34]

Over recent decades, wetland mitigation banking has grown considerably as a method of compensating for adverse wetland impacts throughout the United States.[35] However, coastal wetland systems are not frequently found in wetland banks, and they are underutilized in the Gulf states. Of the 139 banks with documented information on wetland types in 2002, only fourteen involve saltwater marshes or tidal wetlands. Six are located in Florida and one in Texas.[36] The 2010 evaluation of Louisiana's wetland banking program acknowledged the general lack of mitigation banks in coastal basins. Of the seven active banks in these basins, only one involves a saltwater marsh (123 acres) and one a freshwater marsh (77 acres). There are no marsh mitigation banks west of the Atchafalaya River,

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33. Federal Guidance for the Establishment, Use and Operation of Mitigation Banks, 60 Fed. Reg. 58,605, 58,606 (Nov. 28, 1995).

34. *Id.* at 58,611. Alternative off-site wetland compensation models include in-lieu fee mitigation and project-specific off-site mitigation. With in-lieu fee mitigation, the permitee pays mitigation fees to an approved third party that will use these funds to implement the required compensation through wetland restoration or creation elsewhere. A permitee can also undertake project-specific mitigation on an off-site location as compensation for any development impacts on wetlands. *See* COMM. ON MITIGATING WETLAND LOSSES, *supra* note 32, at 69.

35. JESSICA WILKINSON & JARED THOMPSON, 2005 STATUS REPORT ON COMPENSATORY MITIGATION IN THE UNITED STATES 2–6 (2006), *available at* http://www.elistore.org/reports_detail.asp?ID=11137; Shelley Burgin, *'Mitigation Banks' for Wetland Conservation: A Major Success or an Unmitigated Disaster?*, 18 WETLANDS ECOLOGY & MGMT. 49, 49–50 (2010) (noting the widespread use of mitigation banks).

36. ENVTL. LAW INST., BANKS AND FEES: THE STATUS OF OFF-SITE WETLAND MITIGATION IN THE UNITED STATES 53 (2002).

and there are only limited swamp and bottomland hardwood mitigation banks in most coastal basins.[37]

In sum, restoration of Gulf Coast wetlands will be a primary focus of federal, state, and local recovery initiatives in response to the *Deepwater Horizon* oil spill. Wetland restoration is seen as necessary and vital to overcoming long-term degradation and loss of Gulf wetlands and their valuable services and to ensuring the economic and environmental recovery of the Gulf Coast. Protection against future storm events and climatic change is also frequently cited as an important rationale.[38]

III. EVALUATING RESTORATION OPTIONS

The NRDA process is critical to the evaluation of post-spill wetland restoration options. First, the NRDA's primary and compensatory restoration assessments are essential for determining and monetizing the total damages to coastal wetlands as a result of the spill. These damages, in turn, are likely to form a substantial amount of the funding for wetland restoration and compensatory mitigation that will occur through federal, state, and local initiatives over the long term. Second, some of the actual compensatory projects identified and proposed by the NRDA will serve as the basis for both on-site coastal wetland restoration and off-site compensation through newly created or restored wetlands elsewhere. Finally, the challenges to the NRDA in quantifying and valuing the compensation for lost or affected services are essentially the same challenges faced by any investment that seeks to create, restore, enhance, or preserve coastal wetlands.

To inform this policy debate further, in this Section, I first describe habitat equivalency analysis, which is the main method currently used in an NRDA to determine damages from oil spills. I then discuss the pros and cons of this method of establishing and funding coastal wetland restoration.

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37. LOUIS BUATT ET AL., LA. DEP'T OF NAT'L RES., EVALUATION OF LOUISIANA'S MITIGATION PROGRAM 40 (2010), *available at* http://dnr.louisiana.gov/assets/OCM/Mitigation/CPRAOCMPresentation12082010.pdf.

38. *See, e.g.*, CORN & COPELAND, *supra* note 2, at 2; GORDON ET AL., *supra* note 29, at 21; MABUS, *supra* note 22, at 35–36, 38; TWILLEY, *supra* note 22, at 1; Day et al., *supra* note 17; K.L. Erwin, *Wetlands and Global Climate Change: The Role of Wetland Restoration in a Changing World*, 17 WETLANDS ECOLOGY & MGMT. 71 (2009); Reed & Wilson, *supra* note 22; Turner, *supra* note 22.

A. Habitat Equivalency Analysis

As noted above, under the OPA, NOAA is the main agency responsible for determining the amount of damages to coastal and marine resources that can be collected as a result of an oil spill. In an NRDA, restoration plays a key role in determining compensation for any resource damage, "given that restoration is the preferred method of compensating for damages, and that *all* compensation collected must be spent on restoration, even compensation collected for lost interim values of resources pending restoration."[39]

One way of compensating for damages resulting from lost interim services of a natural resource habitat is to determine the monetary value of these services, collect this money from the party responsible for the oil spill, and then determine how best to spend this compensation on resource enhancement or recovery activities. Full compensation based on restoration should also cover the cost of primary restoration, or the complete recovery of the damaged area to its pre-spill condition. This method of determining monetary compensation for the damages caused by a spill was used frequently in NRDAs prior to the 1990 OPA.[40]

The alternative approach, which is currently the main method employed in an NRDA to determine the resource damages arising from oil spills, is *habitat equivalency analysis* or HEA. As explained by NOAA, "the principal concept underlying the method is that the public can be compensated for past losses of habitat resources through habitat replacement projects providing additional resources of the same type."[41] HEA implements this principle through quantifying the interim losses in natural resource services arising from damages to a coastal and marine resource, such as a wetland, and then estimating the scale of compensatory restoration required to offset these service

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39. Marisa J. Mazotta et al., *Natural Resource Damage Assessment: The Role of Resource Restoration*, 34 NAT. RESOURCES J. 153, 162 (1994).

40. *See, e.g.*, Deborah S. Bardwick, *The American Tort System's Response to Environmental Disaster: The Exxon Valdez Oil Spill as a Case Study*, 19 STAN. ENVTL. L.J. 259, 271–72 (2000) (noting that this approach was used in the *Exxon Valdez* oil-tanker spill that occurred in Prince William Sound, Alaska, on March 24, 1989); Linda B. Burlington, *An Update on Implementation of Natural Resource Damage Assessment and Restoration Under OPA*, 7 SPILL SCI. & TECH. BULL. 23, 27 (2002) (noting that this approach was used for the *World Prodigy* oil-tanker spill, which occurred on June 23, 1989, when the tanker ran aground on Brenton Reef, off Newport, Rhode Island); Mazotta et al., *supra* note 39, at 160–62 (noting that this approach was employed to determine compensation in the case of the *Amazon Venture* oil spill into the lower Savannah River near Savannah, Georgia, on December 4–6, 1986).

41. NAT'L OCEANIC & ATMOSPHERIC ADMIN., *supra* note 12, at 1. This method was also used in the NRDA for the Lake Barre oil-tanker spill. *See* Burlington, *supra* note 40, at 28.

losses. In the case of a wetland damaged by an oil spill, an HEA would not necessarily estimate or value the damages to the wetlands or its services; instead, "it calculates the natural resource service losses in discounted terms and then determines the scale of restoration projects needed to provide equal natural resource service gains in the future in discounted terms, thereby fully compensating the public for the natural resource injuries."[42] Determining the amount of compensation or replacement wetland habitat required is therefore critical to the HEA, although the scale of this compensation will depend on whether or not primary restoration of the damaged wetland takes place. Moreover, compensatory restoration may not necessarily take place at the primary restoration site; in other words, it may involve the creation, restoration, or enhancement of wetlands in a site nearby and equivalent to the original wetlands damaged by the spill.

Figure 1 illustrates the differences between the economic valuation and HEA approaches to compensation and restoration. For example, suppose an offshore oil spill occurs in time T_0 and damages a coastal wetland ecosystem. Before the incident occurs, the wetland provides a range of valuable services, including wildlife viewing and recreational benefits, a nursery and breeding habitat for offshore commercial and recreational fishing, and storm protection and flood control for shoreline properties. Assuming some common metric for measuring these services, the baseline level of services before the oil spill is S_0, as indicated in the upper diagram of Figure 1. If the wetland is allowed to recover naturally, then eventually, in some future time T_N, the full level of ecosystem services will be restored. The interim losses will be areas A plus B in the upper diagram. However, if primary restoration activities take place starting at time T_1, then wetland recovery will occur much faster, and full services will

42. Richard W. Dunford et al., *The Use of Habitat Equivalency Analysis in Natural Resource Damage Assessments*, 48 ECOLOGICAL ECON. 49, 50 (2004); *see also* NAT'L OCEANIC & ATMOSPHERIC ADMIN., *supra* note 12, at 5–7; Steven M. Thur, *Refining the Use of Habitat Equivalency Analysis*, 40 ENVTL. MGMT. 161, 163–64 (2007); Matthew Zafonte & Steve Hampton, *Exploring Welfare Implications of Resource Equivalency Analysis in Natural Resource Damage Assessments*, 61 ECOLOGICAL ECON. 134 (2007). As pointed out by NAT'L OCEANIC & ATMOSPHERIC ADMIN., *supra* note 12, at 3–4 and Zafonte & Hampton, *supra*, HEA can be adjusted for the difference in any values between the natural resource services lost at the primary restoration site and the services created at the compensatory restoration site. Also, the original conceptual framework for HEA proposed a monetary compensation approach. *See, e.g.*, Mazotta et al., *supra* note 39; Robert E. Unsworth & Richard C. Bishop, *Assessing Natural Resource Damages Using Environmental Annuities*, 11 ECOLOGICAL ECON. 35 (1994) (proposing that the compensation principle should be that the present value of any service gains in dollars from the replacement habitat should equal the present value of any service losses in dollars from the impacted habitat).

be restored at T_P. The amount of interim services lost would be equal to area *A* only. Under the monetary compensation approach, the full damages assessed would be the monetary value of the interim services lost plus the costs of primary restoration. That is, compensation would equal the present value in *dollars* of the loss in interim services from time T_0 to T_P (i.e., area *A*) plus the present value *dollar* cost of the primary restoration undertaken from time T_1 to T_P.[43]

The bottom diagram of Figure 1 illustrates the HEA approach. At some time T_2 after the initial oil-spill incident, a new wetland is created at a nearby site to provide the same type of services lost as in the damaged wetland. Creating a new wetland at this site is assumed to be cost effective; that is, there is no other comparable site for creating the same level of wetland services at a lower cost. Compensatory restoration occurs at this site not only until time T_3, when the created wetland delivers a full amount of services S_C, but also until time T_C, when the total amount of created wetland services, areas *C* plus *D*, compensate completely for the interim loss of services in the original oil-damaged wetlands (i.e., area *A*).

In other words, compensatory restoration occurs until the ecosystem service losses from the spill equal the service gains from the newly created wetland. No monetary valuation of these services is necessary, however. The scale of the newly created wetland project is chosen to ensure that the present value in *ecosystem service units* gained from compensatory restoration from time T_2 to T_C (i.e., areas *C* plus *D*) is sufficient to offset the present value in *ecosystem service units* lost as the oil-damaged wetland recovers from time T_0 to T_P (i.e., area *A*). Compensation is then sought from the responsible party for the present value monetary costs of the project that creates the new wetland at the nearby site.[44]

The HEA approach to coastal wetland restoration and compensation has been applied to a major oil-spill incident in the Gulf of Mexico in the case of the Texaco oil-pipeline rupture on May 16, 1997, that discharged 6,561 barrels of crude oil into Lake Barre,

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43. The fact that the damage assessment is in terms of the monetary value of lost ecosystem services due to the oil spill suggests that the common metric for measuring different wetland services (e.g., recreational benefits, habitat-fishery linkages, and storm protection) is dollars. In other words, the vertical axis in the upper diagram and the baseline level of total ecosystem services S_0 could easily be depicted as the monetary value of all wetland benefits.

44. As pointed out by NAT'L OCEANIC & ATMOSPHERIC ADMIN., *supra* note 12, at 2, as an alternative to submitting a damage claim for the costs of the compensating wetland project, the responsible parties may agree to undertake this project, subject to performance criteria established by the trustees.

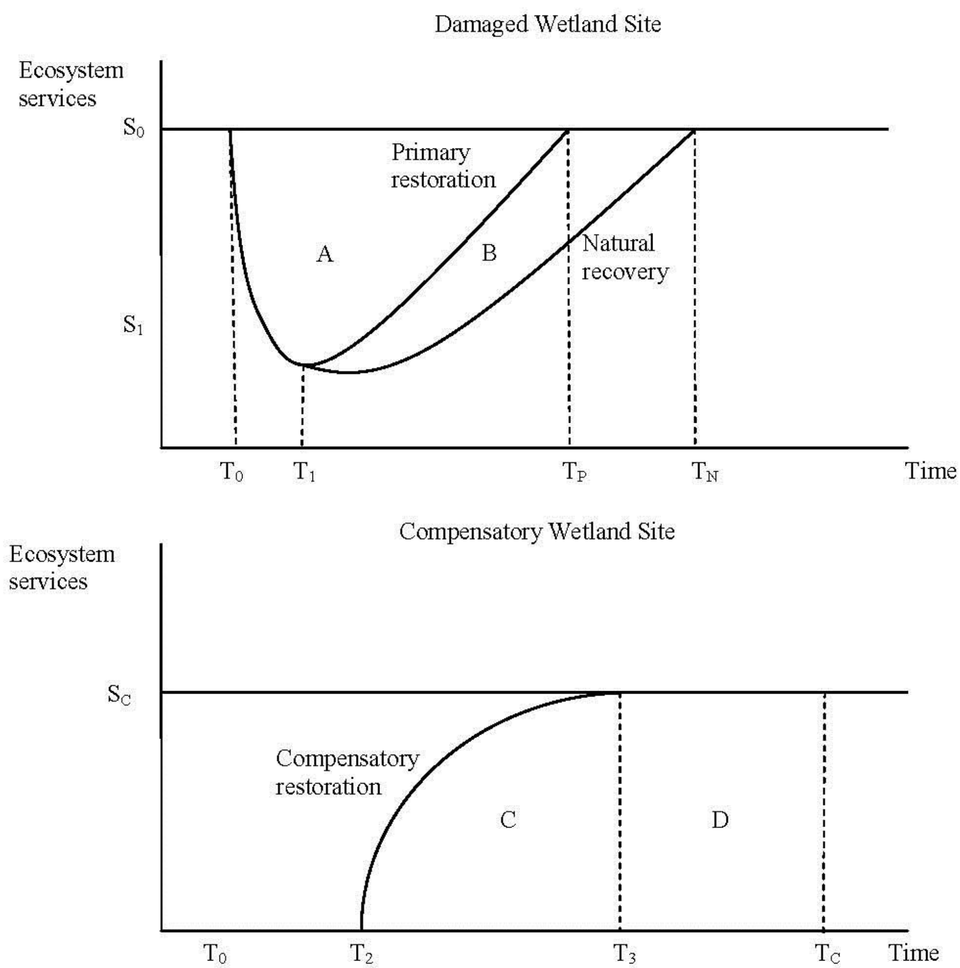
Louisiana.[45] The spill resulted in slick and oil sheen damage to over 4,300 acres of estuarine salt marshes in the vicinity, although more than 95% of the affected area suffered only limited service losses with full recovery occurring after four months. NOAA decided that salt marsh creation and/or enhancement was the appropriate restoration to compensate for the interim marsh, aquatic fauna, and bird damages caused by the spill, and HEA was used for the assessment. The selected compensatory restoration project for the Lake Barre incident was planting salt marsh vegetation on newly deposited dredged materials on the nearby East Timbalier Island. The HEA concluded that planting 18.5 acres of new salt marsh on the barrier island would compensate the public for marsh, aquatic fauna, and bird interim losses.[46] In addition, the planted marsh would create another 39.3 acres through vegetative spreading, eventually yielding a total new marsh area of around 58 acres.[47] Texaco agreed to undertake the planting project on East Timbalier Island as compensation for the oil-spill damages.

45. Burlington, *supra* note 40, at 28; Tony Penn & Theodore Tomasi, *Calculating Resource Restoration for an Oil Discharge in Lake Barre, Louisiana, USA*, 29 ENVTL. MGMT. 691, 691–92 (2002).

46. *See* Burlington, *supra* note 40, at 28 ("Texaco also has successfully planted just over 18 acres of marsh grasses to compensate for the incident.").

47. *See* Penn & Tomasi, *supra* note 45, at 671 ("The planting will spread vegetation to an additional 15.9 ha. Altogether, the project will enhance 23.4 ha of dredge platform as compensation for the natural resource injuries.").

FIGURE 1. PRIMARY AND COMPENSATORY RESTORATION OF AN OIL-DAMAGED WETLAND



B. Pros and Cons

Proponents of HEA suggest that it has several advantages over the conventional monetary compensation approach to assessing natural resource damages.[48] First, the HEA focuses the NRDA on the goal of resource restoration from the beginning of the assessment process, which may result in expediting both restoration and compensation. In addition, since both trustees and the responsible parties for an oil spill have an opportunity to agree to a settlement, HEA avoids protracted and costly litigation to recover damages. By recovering the costs of compensatory restoration, the HEA ensures that enough money is collected to implement the proposed habitat creation or enhancement projects. For example, using the monetary compensation approach, damage assessment of the 1989 *World Prodigy* oil-tanker spill off the coast of Rhode Island did eventually produce a settlement, but restoration projects did not begin until 1996. In contrast, the Lake Barre oil-pipeline rupture occurred in May 1997, the HEA commenced immediately afterwards, and the marsh creation project began in the summer of 2000.[49]

In addition, as the damages collected from the responsible parties are for the costs of restoration and not for the value of the interim losses to impacted resources and habitats, the HEA avoids the need to conduct economic valuation studies of these services. For example, as explained by Jones and Pease:

> In some cases, it may not be necessary to conduct valuation studies to determine the appropriate scale of compensatory restoration. In cases where valuation studies are conducted, selecting the appropriate scale of compensatory restoration actions generally requires precision only up to the relative value of losses from injuries to gains from resource projects, rather than the absolute dollar amounts of lost value as required for calculating monetary compensation.[50]

However, to implement this compensatory restoration approach, an HEA often makes a number of simplifications, such as assuming a preference for compensation with the same services that were damaged, a fixed proportion of habitat services to habitat value, and a constant real value of services over time.[51] HEA also requires that complex ecological services be expressed in terms of a single metric and assumes that any ongoing impacts of a damaging effect can be estimated reliably over time.[52] These simplifying assumptions can

48. *See, e.g.*, Burlington, *supra* note 40, at 26–27; Carol A. Jones & Katherine A. Pease, *Restoration-Based Compensation Measures in Natural Resource Liability Statutes*, 15 CONTEMP. ECON. POL'Y 111, 112 (1997); Thur, *supra* note 42, at 168–69; Zafonte & Hampton, *supra* note 42, at 143 (all arguing HEA's relative advantages over the conventional monetary compensation approach).

49. Burlington, *supra* note 40, at 27.

50. Jones & Pease, *supra* note 48, at 112.

51. Mazotta et al., *supra* note 39, at 162; Unsworth & Bishop, *supra* note 42, at 38.

52. Dunford et al., *supra* note 42, at 49.

be especially problematic if the value of the lost interim services changes significantly over time, which is likely to occur if the period of recovery is long.[53]

The HEA could also lead to the oversupply of some wetland services in the long run.[54] Recreation, wildlife viewing, and other services may be used to full capacity before a coastal wetland is damaged by an oil-spill incident. The baseline level of supply S_0 basically satisfies the demand for these services. Creation of a new wetland at an alternative site may compensate for the interim loss of these services from the damaged wetland, but when the latter is eventually restored, both the original and compensatory habitat will offer the same set of services. If the demand for recreation, wildlife viewing, and other services does not change, then there will be excess supply.

Perhaps the main criticism of an HEA is that it may not provide an accurate reflection of the actual costs and benefits of compensatory restoration. As pointed out by Flores and Thacher, "by avoiding money in the estimation of preferences, there is no way to judge whether costs are disproportionately high relative to benefits."[55] This problem may arise because an HEA is based on a *replacement cost* approach to valuation. This method is frequently used in circumstances where an ecological service is unique to a specific ecosystem and is difficult to value, so that the cost of replacing the service or treating the damages arising from the loss of the service is estimated instead. However, economists urge caution in using the replacement cost approach as it has a tendency to overestimate values.[56] This method can provide a reliable valuation estimation for an ecological service, but only if the following conditions are met: (1) the considered alternative provides the same services; (2) the considered alternative is the least-cost alternative; and (3) there is

53. Nicholas E. Flores & Jennifer Thacher, *Money, Who Needs It? Natural Resource Damage Assessment*, 20 CONTEMP. ECON. POL'Y 171, 173 (2002).

54. Jones & Pease, *supra* note 48, at 118–19.

55. Flores & Thacher, *supra* note 53, at 176.

56. *See, e.g.*, A. MYRICK FREEMAN III, THE MEASUREMENT OF ENVIRONMENTAL AND RESOURCE VALUES: THEORY AND METHODS (2d ed. 2003); Edward B. Barbier, *Valuing Ecosystems as Productive Inputs*, 22 ECON. POL'Y 178, 194 (2007) [hereinafter Barbier, *Valuing Ecosystems*]; Edward B. Barbier, *Valuing Environmental Functions: Tropical Wetlands*, 70 LAND ECON. 155, 161 (1994); Gregory M. Ellis & Anthony C. Fisher, *Valuing the Environment as Input*, 25 J. ENVTL. MGMT. 149 (1987); Kenneth E. McConnell & Nancy E. Bockstael, *Valuing the Environment as a Factor of Production*, *in* 2 HANDBOOK OF ENVIRONMENTAL ECONOMICS 621 (K.-G. Mäler & J.R. Vincent eds., 2005); L.A. Shabman & S.S. Batie, *Economic Value of Natural Coastal Wetlands: A Critique*, 4 COASTAL ZONE MGMT. J. 231 (1978).

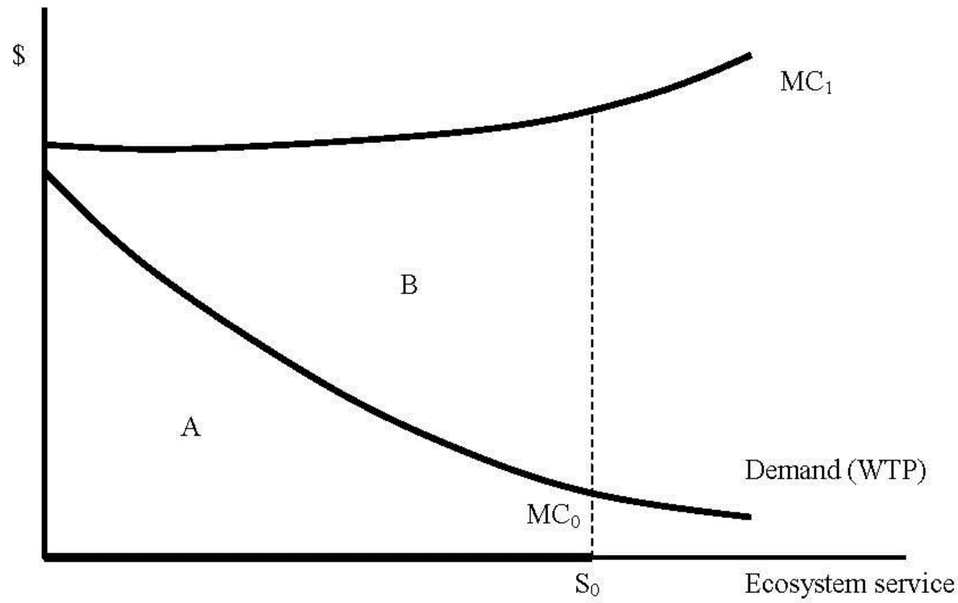
substantial evidence that society would demand the service if the least-cost alternative provides it.[57] In the case of the HEA, the first two criteria can be met, but the third is more difficult to determine. The result can lead to disproportionately high costs as compared to the benefits gained from compensatory restoration.

Figure 2 illustrates this potential inaccuracy in the HEA approach.[58] Before it was damaged by an oil spill, the original coastal wetland provided a range of ecosystem services (e.g., recreation, habitat support for offshore fisheries, and storm protection). As depicted in the diagram, the baseline level of each ecosystem service supplied by the wetland before the spill is S_0. However, as the wetland provided this service "free" without any human inputs, the marginal cost of this service, MC_0, corresponds to the horizontal axis. The willingness to pay ("WTP") for all those who benefit from this service is the downward-sloping demand curve. Thus, the total net benefits, measured in monetary terms, of the baseline level of service S_0 is area *A* in Figure 2. In comparison, the creation of a compensatory wetland at a nearby site to provide the same baseline level of ecosystem service is not costless. As indicated in the figure, the marginal costs of creating the new wetland is MC_1, and the total cost of this compensatory habitat up to S_0 is areas *A* plus *B*. Thus, the "replacement cost" of compensatory restoration clearly exceeds the benefits of the ecosystem service provided. If the cost of creating the new wetland is used as the basis for compensation for the interim loss in baseline services S_0 as a result of the oil spill, then these damages to the original wetland are overestimated. Moreover, unless an estimate is made of the value of the interim loss of wetland services (i.e., area *A*), it is impossible to determine how much the compensatory restoration replacement cost approach overestimates these foregone benefits.

57. Shabman & Batie, *supra* note 56.

58. Figure 2 is a modified version of Ellis & Fisher, *supra* note 56, at fig.3.

FIGURE 2. BENEFITS AND COSTS OF COMPENSATORY RESTORATION OF A WETLAND



IV. ECOLOGICAL AND ECONOMIC ISSUES

Up until the year 2000, coastal wetland restoration in the United States underwent three distinct phases.[59] The first can be considered an initial experimental phase, during which the technical aspects of replanting and ensuring the survival of marsh, mangrove, and other vegetation was the primary emphasis. The second phase was the start of compensatory mitigation, such as the introduction of wetland banking, and stressed the need for "functional equivalency" between any wetlands lost and those created. The third and most recent phase focuses on "ecosystem restoration," where compensation now involves either ensuring the full recovery of any lost or damaged wetland ecosystems and their services or compensating for this loss or damage through creating or enhancing similar wetland ecosystems elsewhere. As I discussed in previous sections, interest in coastal wetland restoration has continued to the present day.

59. Roy R. Lewis, III, *Ecologically Based Goal Setting in Mangrove Forest and Tidal Marsh Restoration in Florida*, 15 ECOLOGICAL ENGINEERING 191, 191 (2000).

The current emphasis on restoring coastal wetlands in the Gulf has been laudable but ultimately insufficient, because "the political will is not there to properly fund effective wetland compensatory mitigation programs and thus the success of these is marginal and cannot be expected to improve."[60] However, as discussed in previous sections, Hurricanes Katrina and Rita and now the *Deepwater Horizon* oil spill have dramatically changed at least the political landscape in the Gulf states. Federal, state, and local policymakers are now promising substantial long-term funding of coastal wetland restoration programs throughout the region.[61] The post-spill NRDA, with its approach of basing damage claims on compensatory restoration of wetlands, is likely to provide a substantial source of the funding for federal, state, and local wetland restoration and creation initiatives.[62] Now that the "political will," as well as the means, for funding of coastal wetland restoration in the Gulf of Mexico has been established, it is important to focus on ecological and economic challenges that such restoration efforts will face. The purpose of the following Section is to review and discuss these challenges.

A. Ecological Issues

According to the Environmental Protection Agency, wetland restoration is "the return of a degraded wetland or former wetland to its preexisting naturally functioning condition, or a condition as close to that as possible."[63] Reviews of the ecological success of such wetland restoration efforts in the United States have identified three important lessons. First, to be successful, wetland restoration strategies need to be conducted at watershed or landscape scales. Second, as hydrological conditions provide the basic control of wetland structure and function, the reestablishment of the ecological production of key wetland ecosystem services is critically dependent on determining the appropriate hydrological regime and water management for the restored wetlands. Third, in terms of providing key ecosystem services, restored wetlands tend to perform better than *created wetlands*, or the establishment of wetlands where they

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60. *Id.*

61. CORN & COPELAND, *supra* note 2, at 65; MABUS, *supra* note 22, at 114.

62. MABUS, *supra* note 22, at 30.

63. ENVTL. PROT. AGENCY, OFFICE OF WATER & OFFICE OF WETLANDS, OCEANS & WATERSHEDS, WETLAND RESTORATION, 843-F-01-022e (2001).

previously did not exist.[64] Although ecological restoration of coastal wetland systems, including in the Gulf of Mexico, has received attention only very recently, similar conclusions have been reached concerning these efforts in the past.[65]

Employing compensatory wetland mitigation to achieve "no net loss" of wetlands in the United States assumes that both the structure and functions of destroyed wetlands can be adequately reestablished elsewhere by the new wetlands. However, this critical assumption has been challenged by a number of studies, which have found that too much emphasis has been placed on recreating the acreage of wetland area lost rather than on ensuring that the restored or created wetlands provide equivalent ecological structure and functions.[66] As

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64. *See, e.g.*, NAT'L RESEARCH COUNCIL, COMPENSATING FOR WETLAND LOSS UNDER THE CLEAN WATER ACT 4–7 (2001); Barbara L. Bedford, *Cumulative Effects on Wetland Landscapes: Links to Wetland Restoration in the United States and Southern Canada*, 19 WETLANDS 775, 783 (1999); Royal C. Gardner et al., *Compensating for Wetland Losses under the Clean Water Act (Redux): Evaluating the Federal Compensatory Mitigation Regulation*, 38 STETSON L. REV. 213 (2009); Stephanie E. Gwin et al., *Evaluating the Effect of Wetland Regulation Through Hydrogeomorphic Classification and Landscape Profiles*, 19 WETLANDS 477, 486 (1999); Jeffrey W. Matthews et al., *Relative Influence of Landscape vs. Local Factors on Plant Community Assembly in Restored Wetlands*, 19 ECOLOGICAL APPLICATIONS 2108, 2120 (2009); Charles Simenstad et al., *When Is Restoration Not? Incorporating Landscape-Scale Processes to Restore Self-Sustaining Ecosystems in Coastal Wetland Restoration*, 26 ECOLOGICAL ENGINEERING 27, 34–37 (2006); Joy B. Zedler, *Progress in Wetland Restoration Ecology*, 15 TRENDS ECOLOGY & EVOLUTION 402, 403 (2000); Joy B. Zedler & Suzanne Kercher, *Wetland Resources: Status, Trends, Ecosystem Services, and Restorability*, 30 ANN. REV. ENV'T & RESOURCES 39, 52–53 (2005).

65. *See, e.g.*, Michael Elliott et al., *Estuarine, Coastal and Marine Ecosystem Restoration: Confusing Management and Science—A Revision of Concepts*, 74 ESTUARINE COASTAL & SHELF SCI. 349, 349–66 (providing a framework for the restoration of estuarine, marine, and coastal ecosystems); Roy R. Lewis, III, *Ecological Engineering for Successful Management and Restoration of Mangrove Forests*, 24 ECOLOGICAL ENGINEERING 403, 403–18 (2005) (outlining the relevant considerations and methods for restoring mangrove forests); Reed & Wilson, *supra* note 22, at 12 (describing Louisiana's coastal restoration efforts during the 1990s); Simenstad et al., *supra* note 64 (exploring the approaches and challenges of coastal restoration); Turner, *supra* note 22 (arguing that an acknowledgement of societal ignorance is central to effective restoration efforts of coastal Louisiana).

66. For reviews, see NAT'L RESEARCH COUNCIL, *supra* note 64; Todd Bendor, *A Dynamic Analysis of the Wetland Mitigation Process and its Effects on No Net Loss Policy*, 89 LANDSCAPE & URB. PLAN. 17, 17–27 (2009) (discussing the problems associated with delaying wetland mitigation efforts); Burgin, *supra* note 35, at 49–55 (2010) (suggesting that "mitigation banks" have been moderately successful in conserving and restoring wetlands); Lisa Dale & Andrea K. Gerlak, *It's All in the Numbers: Acreage Tallies and Environmental Program Evaluation*, 39 ENVTL. MGMT. 246, 246–60 (2007); Gardner et al., *supra* note 64 (reviewing federal regulation pertaining to wetlands and suggesting a greater emphasis on avoiding wetland impacts); John J. Gutrich & Fred J. Hitzhusen, *Assessing the Substitutability of Mitigation Wetlands for Natural Sites: Estimating Restoration Lag Costs of Wetland Mitigation*, 48 ECOLOGICAL ECON. 409, 409–24 (2004); Rebecca L. Kihslinger, *Success of Wetland Mitigation Projects*, NAT'L WETLANDS NEWSL. (Envtl. Law Inst., Washington, D.C.), Mar.–Apr. 2008, at 14, 14–16 (suggesting that

summarized by Kihslinger: "Currently, many permits simply require a certain percentage of herbaceous cover as a criterion for accessing the success of a mitigation site because it is easily measured and may quickly reach required thresholds. However, percent herbaceous cover may not be a sufficient surrogate for most wetland functions."[67] In addition, delays in initiating and completing restoration activities frequently occur, which means that the waiting lag between wetlands lost and new ones restored can lead to a consistent and considerable net functional loss over time.[68]

Such problems have been prevalent in restoring and creating new coastal and estuarine wetlands in the United States, where poor site location with respect to the surrounding landscape, limited understanding of natural patterns of plant community succession and recruitment, and lack of consideration of the appropriate hydrological regime have been common ecological factors in the failure of compensatory mitigation.[69] In the case of forested wetlands, such as mangroves, full establishment of ecosystem structure and function may take decades, yet typical monitoring periods for compensatory wetland mitigation projects are relatively short, only three to five years. A long-term monitoring study of eighteen mangrove mitigation sites in Florida from 1988 to 2005 reveals the discrepancies that can occur between short-term project targets and ecological criteria.[70] Although most of the created mangroves complied with the typical mitigation permit requirements, such as ensuring revegetation with natural wetland species, after thirteen to fifteen years, the composition of trees still differed from that of comparable natural mangrove sites. The number of mangrove species was similar, but mitigation sites had not yet reached mature canopy height and were

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federal mitigation projects may lead to a net loss of wetlands); Jeffrey W. Matthews & Anton G. Endress, *Performance Criteria, Compliance Success, and Vegetation Development in Compensatory Mitigation Wetlands*, 41 ENVTL. MGMT. 130, 130–41 (2008); Zedler & Kercher, *supra* note 64 (recommending alternative techniques for wetland restoration).

67. Kihslinger, *supra* note 66, at 16.

68. Bendor, *supra* note 66, at 17; Burgin, *supra* note 35, at 53; Gutrich & Hithusen, *supra* note 66, at 409; Matthews et al., *supra* note 64; Matthews & Endress, *supra* note 66.

69. *See* Lewis, *supra* note 65, at 405; Lewis, *supra* note 59 (outlining the general problems associated with marsh restoration); Roy R. Lewis, III. & Richard G. Gilmore, Jr., *Important Considerations to Achieve Successful Mangrove Forest Restoration with Optimum Fish Habitat*, 3 BULL. MARINE SCI. 823, 823 (2007); Reed & Wilson, *supra* note 22, at 11–12; Deborah J. Shafer & Thomas H. Roberts, *Long-Term Development of Tidal Mitigation Wetlands in Florida*, 16 WETLANDS ECOLOGY & MGMT. 23, 25–26 (2008); Simenstad et al., *supra* note 64, at 34; Elizabeth Strange et al., *Determining Ecological Equivalence in Service-to-Service Scaling of Salt Marsh Restoration*, 29 ENVTL. MGMT. 290, 293 (2002).

70. Shafer & Roberts, *supra* note 69, at 23.

more dense and complex than were natural sites. In addition, at two sites where the presence of mangroves conflicted with nearby commercial properties, the mangroves were dramatically altered or even destroyed.

These issues raise concern about the principle of *ecological equivalence*, which is defined as "the capacity of a restored, created, or enhanced habitat to reproduce the ecological structures and functions provided by a resource before injury."[71] As I have shown, this concept underlies both compensatory wetland mitigation, such as that undertaken through wetland banking, and compensatory restoration, as it underlies an HEA conducted for an NRDA of damaged coastal wetlands. Ecological equivalency is especially problematic, given that short-term recovery of certain wetland characteristics, such as establishment of native vegetation species, may not necessarily ensure long-term sustainability. Even in the case of salt marshes, for example, where successful recovery or creation of marsh vegetation can occur within a relatively short time, full recovery of the entire coastal wetland system is not ensured. Important ecological processes, such as nutrient cycling, take much longer to recover, yet are vital for a fully functioning marsh.[72]

Given that the scale of wetland restoration undertaken along the Gulf Coast is likely to increase substantially in the aftermath of Hurricanes Katrina and Rita and the *Deepwater Horizon* oil spill, these ecological issues must be addressed if such restoration is to be successful.

B. Economic Issues

As the overall aim of wetland restoration, enhancement, and creation is to recover valuable ecosystem goods and services, assessing these benefits will be vital to determining the success of many coastal wetland restoration efforts. A review of the peer-reviewed literature on ecosystem restoration found that socioeconomic benefits are generally not adequately quantified and assessed and that aquatic ecosystems (including coastal wetlands) are poorly represented.[73] As the review concludes, "the concept of explicitly linking ecosystem services to beneficiaries of ecosystem restoration, and demonstrating

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71. Strange et al., *supra* note 69, at 290.

72. *Id.* at 291.

73. James Aronson et al., *Are Socioeconomic Benefits of Restoration Adequately Quantified? A Meta-analysis of Recent Papers (2000–2008) in* Restoration Ecology *and 12 Other Scientific Journals*, 18 RESTORATION ECOLOGY 143, 143 (2010).

their values to society, has only recently begun to enter the mainstream academic literature on the science and practice of ecological restoration."[74]

In identifying the ecosystem services provided by natural habitats, such as coastal wetlands, a common practice is to adopt the broad definition of the Millennium Ecosystem Assessment that "ecosystem services are the benefits people obtain from ecosystems."[75] Thus, the term "ecosystem services" is usually interpreted to imply the contribution of nature to a variety of "goods and services," which in economics would normally be classified under three different categories: (1) "goods" (e.g., products obtained from ecosystems, such as resource harvests, water, and genetic material); (2) "services" (e.g., recreational and tourism benefits or certain ecological regulatory and habitat functions, such as water purification, climate regulation, erosion control, and habitat provision); and (3) cultural benefits (e.g., spiritual and religious beliefs and heritage values).[76]

To assess the contribution of a coastal wetland in providing such "goods and services," one needs to measure its impact on human welfare. Or, as Freeman succinctly puts it: "The economic value of resource-environmental systems resides in the contributions that the ecosystem functions and services make to human well-being," and consequently, "the basis for deriving measures of the economic value of changes in resource-environmental systems is the effects of the changes on human welfare."[77] As a National Research Council report on valuing aquatic ecosystem services has emphasized, "the fundamental challenge of valuing ecosystem services lies in providing an explicit description and adequate assessment of the links between the structure and functions of natural systems, the benefits (i.e., goods and services) humanity derives from them, and their subsequent values."[78]

Table 1 provides some examples of how specific wetland ecosystem services are linked to the ecological structure and functions underlying each service. It also lists, where possible, the number of valuation estimates for each service found in the surveyed literature on wetland valuation. The studies reviewed for Table 1 are not

74. *Id.* at 150.

75. MILLENNIUM ECOSYSTEM ASSESSMENT, ECOSYSTEMS AND HUMAN WELL-BEING: A FRAMEWORK FOR ASSESSMENT 57 (2005).

76. Barbier, *Valuing Ecosystems*, *supra* note 56, at 182.

77. FREEMAN, *supra* note 56, at 7.

78. NAT'L RESEARCH COUNCIL, VALUING ECOSYSTEM SERVICES: TOWARD BETTER ENVIRONMENTAL DECISION MAKING 2 (2005).

inclusive.[79] Nevertheless, the valuation studies surveyed are representative of the literature and thus instructive of which wetland goods and services tend to be more routinely valued compared to those that are not.

As Table 1 indicates, wetland valuation studies have tended to focus on only a few ecosystem services, such as recreation, coastal habitat-fishery linkages, raw materials and food production, and water purification. In recent years, a handful of more reliable estimates of the storm protection service of coastal wetlands have also emerged. But for a number of important wetland ecosystem services, very few or no valuation studies exist. Clearly, if the assessment of ecosystem services is to assist coastal wetland restoration in the Gulf of Mexico and elsewhere, then much more work needs to be done on improving not only the number of wetland valuation studies, but also the range of benefits valued and the reliability of methods and estimates.

79. For more comprehensive summaries of the literature on economic valuation of wetlands, see EDWARD B. BARBIER ET AL., ECONOMIC VALUATION OF WETLANDS: A GUIDE FOR POLICYMAKERS AND PLANNERS (1997) (detailing various techniques and methods and examples of how to economically valuate wetlands); R. KERRY TURNER ET AL., VALUATION OF ECOSYSTEM SERVICES: THE CASE OF MULTI-FUNCTIONAL WETLANDS (2008); Luke M. Brander et al., *The Empirics of Wetland Valuation: A Comprehensive Summary and a Meta-Analysis of the Literature*, 33 ENVTL. & RESOURCE ECON. 223 (2006); Richard T. Woodward & Yong-Suhk Wui, *The Economic Value of Wetland Services: A Meta-Analysis*, 37 ECOLOGICAL ECON. 2257 (2001).

TABLE 1. EXAMPLES OF WETLAND ECOSYSTEM SERVICES AND VALUATION STUDIES

Ecosystem Structure and Function	Ecosystem Services	Number of Valuation Estimates
Attenuates and/or dissipates waves, buffers wind	Coastal protection	5 estimates
Provides sediment stabilization and soil retention	Erosion control	1 estimate
Water flow regulation and control	Flood protection	1 estimate
Groundwater recharge/discharge	Water supply	2 estimates
Provides nutrient and pollution uptake, as well as retention, particle deposition	Water purification	5 estimates
Generates biogeochemical activity, sedimentation, biological productivity	Carbon sequestration	1 estimate
Climate regulation and stabilization	Maintenance of temperature, precipitation	No estimates
Generates biological productivity and diversity	Raw materials and food	6 estimates
Provides suitable reproductive habitat and nursery grounds, sheltered living space	Maintains fishing, hunting, and foraging activities	10 estimates
Provides unique and aesthetic landscape, suitable habitat for diverse fauna and flora	Tourism, recreation, education, and research	14 estimates
Provides unique and aesthetic landscape of cultural, historic or spiritual meaning	Culture, spiritual and religious benefits, bequest values	3 estimates

Large-scale wetland restoration projects need also to be assessed for their appeal to different stakeholder groups, especially when there are several alternative restoration options. One study by Milon and Scrogin analyzes three distinct groups, who vary significantly in socioeconomic characteristics and in their preferences for ecosystem restoration of the Greater Everglades in Florida, to assess their willingness-to-pay or WTP for different restoration options.[80] The Greater Everglades wetlands ecosystem extends over 69,000 square kilometers, but by 1990 it had declined to less than 50% of its original area due to extensive land-use conversion and hydrological changes. The researchers offered two overall restoration options for the Everglades to the surveyed stakeholder groups: a *functional* restoration option that focused on the hydrological regime and its management as the primary restoration strategy and a *structural* restoration option that focused on conserving key populations of native fauna (e.g., birds, alligators, deer, hawks, and fish). In addition, a comparison was made of partial and full restoration scenarios under each of these options. The analysis reveals that stakeholder groups generally preferred the structural restoration option to the functional option. For both options, the groups that expressed a strong preference for Everglades restoration had a higher WTP for restoration than other groups. Thus, the results suggest that public support and WTP for Everglades restoration is more likely to favor plans that emphasize conserving key populations of native fauna rather than hydrological regime restoration and management, which is currently stressed by wetland scientists and the U.S. Army Corps of Engineers as the proposed restoration plan.

In concluding their analysis of stakeholder preferences for Everglades restoration options, Milon and Scrogin make an important observation: "Policy analysis for wetland ecosystems is especially difficult because these systems provide multiple, interdependent services that vary by type of wetland, location, ecohydrological management, and other factors."[81] Too often, policies for ecological restoration focus exclusively on the rehabilitation of natural systems for one primary service at the exclusion of others and ignore the wider political and developmental context that led to the destruction of the natural systems in the first place. This is a critical lesson that policymakers should heed as large-scale coastal wetland restoration

80. J. Walker Milon & David Scrogin, *Latent Preferences and Valuation of Wetland Ecosystem Restoration*, 56 ECOLOGICAL ECON. 162, 162–75 (2006).

81. *Id.* at 172.

and compensation projects are implemented throughout the Gulf states in the coming years.

V. CONCLUSION

There is no doubt that one of the consequences of the massive BP *Deepwater Horizon* oil spill is that coastal wetland restoration and compensatory mitigation will feature prominently in future recovery plans for the five affected Gulf of Mexico states. Already, ambitious restoration plans are underway with considerable political and financial support at the federal, state, and local levels. The NRDA process of assessing and seeking damages from BP and other responsible parties for the spill also ensures that compensatory wetland restoration in the Gulf will soon receive substantial funding.

This newfound political will to promote coastal wetland restoration, enhancement, and creation in the Gulf states is a welcomed change from the decades-long destruction and degradation of these vital ecosystems. Wetland restoration will feature prominently not only in the Master Plan for the Mississippi River Delta but also in any future plans for ecosystem restoration and economic recovery of the entire Gulf Coast. This development represents how profoundly coastal management policy has changed in the region since 2005.

As these ambitious plans for large-scale coastal wetland restoration in the Gulf proceed, however, it is important to learn from the ecological and economic challenges faced by previous coastal wetland restoration efforts. Addressing these issues will be especially important given the lack of attention to coastal wetland restoration in the past, as well as the dearth of ecological and economic assessments of why past projects have succeeded or failed.

As currently practiced in the United States, the implementation of compensatory wetland mitigation, such as wetland banking, and compensatory restoration, as conducted through an HEA in an NRDA of post-spill wetland damage, depends on the principle of ecological equivalence. This principle refers to the capacity of a restored, created, or enhanced wetland to reproduce the ecological structures and functions provided by a wetland damaged by a hazardous incident, such as an oil spill. A number of ecological studies question whether ecological equivalence is actually fulfilled in many compensatory wetland mitigation and restoration projects. Greater attention needs to be paid to site location with respect to the surrounding landscape, the natural patterns of plant community succession and recruitment, and the appropriate wetland hydrological regime.

From an economic perspective, there is also concern that relying on the replacement cost approach of estimating the cost of creating equivalent wetland ecological structures and functions, rather than valuing the benefits that the newly created wetlands provide, may not provide an accurate reflection of the actual costs and benefits of compensatory restoration. Developing methods of assessing natural resource damages, such as the effects of oil spills on coastal wetlands, is an important objective because it reduces costly litigation and expedites funding for restoration. But actual ecological and economic assessment of wetland enhancement, restoration, and creation requires much more consideration of the long-term ecological establishment of wetland structure and functions and of the economic benefits derived from any resulting wetland goods and services.