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The Economic Case for Restoring Coastal Ecosystems

By Michael Conathan, Jeffrey Buchanan, and Shiva Polefka April 2014

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Introduction and summary

As America's coastal cities expanded throughout the 19th century, the wetlands were often considered a nuisance that stood in the way of progress and development. Marshy areas seemed little more than endless founts of pesky insects or quagmires blocking access between drier uplands and navigable waters. As cities outgrew their dry land footprints and sought additional space to grow, the obvious answer was to simply turn the wet places into dry places. Today, these regions—from Boston's Back Bay to New York's Wall Street to Miami's South Beach—comprise some of the most valuable real estate in the world.

We are increasingly learning the cost of losing landscapes once thought to be valueless. The wetlands ecosystem provided numerous services to society that we now are beginning to sorely miss. Sea levels continue to rise and the increasing frequency of extreme weather threatens our shores.[1] Many of our commercial and recreational fisheries are struggling to rebuild to sustainable levels.[2] Population growth continues to generate more pollution, including carbon dioxide. Coastal wetlands are perhaps nature's most effective solution to these problems.

The loss of wetlands is a human-caused problem, and we have the capacity to reverse this trend with smart, targeted investments. In addition to obvious environmental benefits, these investments provide economic returns in two categories. First, coastal restoration investments create jobs and stimulate spending. Second—but less studied—healthy, restored ocean and coastal wetlands ecosystems provide enhanced economic value.

On the issue of employment, for example, economists with the National Oceanic and Atmospheric Administration, or NOAA, have found that $1 million invested in coastal restoration creates 17.1 jobs on average.[3] This compares to job growth from industrial coastal activities, such as oil and gas development, in which $1 million of investment creates an average of just 8.9 jobs.[4]

The economic contribution of these activities, however, does not stop when workers lay down their shovels. In this report, the Center for American Progress and Oxfam America delve into the second economic metric—the ongoing economic contributions provided by healthy, restored coastal ecosystems such as wetlands, seagrass beds, and oyster reefs. An analysis of three federally funded projects reveals that investing in well-designed coastal restoration can be highly cost effective, returning significantly more than the cost of the restoration project. Averaging the benefit-cost ratios across the three restoration projects studied, each dollar invested by taxpayers returns more than $15 in net economic benefits.

These benefits include buffering storm surges; safeguarding coastal homes and businesses; sequestering carbon and other pollutants; creating nursery habitat for commercially and recreationally important fish species; and restoring open space and wildlife that support recreation, tourism, and the culture of coastal communities. The benefits are not simply environmental; they are economic and social as well. They are particularly salient in lower-income communities, where individuals frequently rely on fisheries for employment and sustenance and lack the resources to construct costly—and frequently less effective—manmade flood barriers or water treatment facilities.

In order to determine just how valuable these benefits might be, the Center for American Progress and Oxfam America collaborated with a research team at Abt Associates—a consulting firm based in Cambridge, Massachusetts—to identify and analyze 3 coastal restoration sites of the 50 that NOAA funded through the American Recovery and Reinvestment Act of 2009, or ARRA. Abt produced a detailed economic analysis[5] of three sites on three different coasts that could exemplify the potential economic benefits of coastal restoration. They are an oyster reef and sea grass restoration project in the Seaside Bays of Virginia, an oyster reef project in Mobile Bay, Alabama, and salt marsh restoration in San Francisco Bay, California.

In two of the sites—the San Francisco Bay Salt Ponds and Virginia Seaside Bays—the ecosystem restoration showed highly positive returns in ecosystem-service-related benefits relative to each project's cost at levels well above the economic output and job creation stimulated by project spending. The third site, an experimental oyster reef recovery project in Mobile Bay, did not produce sufficient data to soundly estimate the value of the ecosystem services.[6]

The reasons for this lack of data include the scarcity of sufficient long-term research into this form of restoration, as well as the disastrous BP Deepwater Horizon oil spill and other environmental factors, which set back oyster recruitment in the project's artificial reef structures. Although this study is unable to fully assess Mobile Bay's ecosystem services contributions, the project's implementation created high employment for the amount of money invested, yielding jobs that were accessible to low-income, natural-resource-dependent workers. As a result, the project provided valuable return on investment above the project's cost, in a region hit hard by both the financial crisis of 2009 and the BP Deepwater Horizon oil spill of 2010.

Overall, the CAP and Oxfam analysis found that the combined economic output from project spending and the long-term ecosystem service benefits in these three locations outweigh the cost of investment by more than 15 to 1.

TABLE 1

Economic benefits of coastal ecosystem restoration at three sites

	NOAA Recovery Act Investment project cost*	Total economic output from spending on project**	Lifetime value of benefits provided by restored ecosystem	Benefit-cost ratio
San Francisco Bay Salt Ponds	$8.27 million	$8.07 million	$68.9–$220M	18.45
Virginia Seaside Bays	$2.35 million	$2.57 million	$34.9–$84.8M	26.56
Mobile Bay, Alabama	$3.18 million	$3.46 million	Insufficient data	1.08
				Average: 15.36

Note: All values in 2013 U.S. dollars. Lifetime value of benefits provided by restored ecosystem excludes economic output from project spending. In the benefit-cost ratio, benefits equal output plus midpoint of ecosystem benefits. The Mobile Bay study produced an estimate of $0.2-0.3 million in ecosystem service benefits, but given the insufficient monitoring time, the limited number of other valuation studies for some of ecological benefits involved, and to be conservative in our valuations we counted this value as $0 for the sake of determining our summary benefit-cost ratio.

Source: *National Oceanic and Atmospheric Administration, "Restoration Atlas: Marine and Coastal Habitat Restoration Projects Funded Under the American Recovery and Reinvestment Act," available at http://www.nmfs.noaa.gov/habitat/restoration/restorationatlas/recovery_map.html (last accessed March 2014). Values adjusted to 2013 U.S. dollars via Bureau of Labor Statistics' CPI Inflation Calculator; **C. Coyle, "Job Creation through Coastal Restoration: An analysis of projects funded under the American Recovery and Reinvestment Act of 2009." Unpublished IMPLAN analysis (2012); Lifetime value of benefits are the total present value, or TPV, estimates calculated assuming a 40-year project lifespan.

Of course, the economic benefits of coastal restoration enumerated in Abt's final report have one disadvantage: They do not fit neatly into categories on the balance sheet of any one particular industry, corporation, or individual. Because of this, they have not been accounted for in coastal resource management decisions to date. Hopefully, the data discussed in this report will convince resource managers in federal, state, and local governments, as well as private-sector entities, to consider additional investments in coastal ecosystem restoration. This report and others have shown that these investments have clear benefits to communities and coastally dependent industries.

The following sections of this report will describe what coastal restoration projects entail and the methodology behind the findings about these three case studies. It will then move to an overall summary of the economic benefits of coastal restoration and a brief description of existing knowledge about the jobs created by NOAA's use of ARRA funds and the potential for additional employment benefits from the nearly 800 shovel-ready projects that could get underway tomorrow if adequate investment became available.

Finally, the report concludes with the following recommendations for future action:

- Federal, regional, and private-sector entities should increase their investment in coastal ecosystem restoration projects and fund ongoing monitoring of previously restored areas.
- Congress should enact and fund the National Endowment for the Oceans.[7]
- The state and federal agencies planning the use of funds from BP's fines resulting from the Deepwater Horizon disaster should focus on investing in ecosystem restoration projects that create employment for communities that were adversely affected by the disaster and support long-term ecosystem recovery.
- Federal, regional, state, and local coastal planners should give greater weight to natural solutions such as coastal wetlands restoration to protect at-risk developed areas.
- The Environmental Protection Agency, or EPA; U.S. Department of the Interior, or DOI; and NOAA should work with the Economic Development Administration and the U.S. Department of Labor, or DOL, to develop new pathways into ecosystem restoration careers in craft trades and science, technology, education, and math.
- NOAA or other partner organizations should seek funding to apply the evaluation techniques used in this report to the 47 other coastal restoration projects funded by the ARRA to broaden the scope of this analysis and provide a stronger foundation for future decisions.

President George H. W. Bush, recognizing these benefits, implemented a federal policy mandating there would be “no net loss” of coastal wetlands in the United States in 1989.[8] Every president since has upheld this policy. But we are failing to achieve even this status-quo target. NOAA released a major report on the “Status and Trends of Wetlands in the Coastal Watersheds of the Conterminous United States” in 2004. That report found that 16 years after President Bush’s implemented this policy, the United States was losing its wetlands at the staggering rate of more than 59,000 acres per year.[9]

When NOAA released the updated version of this report covering the years 2004 to 2009 in February, the rate of coastal wetland loss in the United States had accelerated to more than 80,000 acres of coastal wetlands annually—equivalent to seven football fields disappearing every hour of every day.[10] The aggregate result is that the United States lost an area of wetlands larger than the state of Rhode Island between 1998 and 2009.[11]

Investing in coastal restoration is good policy. It is not just the right thing to do for the environment; it is the right thing to do for coastal communities, vulnerable coastal populations, and the U.S. economy. In the words of former NOAA Chief Economist Dr. Linwood Pendleton, “restoring degraded marine and coastal habitat is critical if America’s coasts and oceans are to reach their economic and ecological potential.”[12]

The economic value of coastal restoration's environmental benefits

The importance of coastal ecosystems to the U.S. public interest has been formally recognized for decades. Open space for recreation and habitat for fish and wildlife are just some of the examples of important benefits that policymakers have tried to sustain. In 1972, protections for wetlands, including estuarine and coastal areas, were explicitly included in legislation that would become the Clean Water Act. In the same year, Congress passed the Coastal Zone Management Act, which encourages the 35 coastal and Great Lakes states and territories to systematically manage their shorelines "to preserve, protect, develop, and where possible, to restore … resources of the Nation's coastal zone for this and succeeding generations."[13]

As public understanding of the ecological and economic value of wetlands grew, these areas became the focus for additional protections. President George H.W. Bush established the no net loss of wetlands policy in 1989,[14] and more than half of states had their own laws to protect and manage wetlands by 2002.[15] The National Ocean Council released its final Implementation Plan in 2013, which mandated that federal agencies should cooperate with each other, with states, and with tribes to "provide jobs and economic value by protecting and restoring coastal wetlands, coral reefs, and other natural systems."[16]

Unfortunately, these policies have been inadequate to restore or even protect existing coastal wetlands. Ambiguities in the Clean Water Act's language have left the law vulnerable to litigation challenging federal wetlands protection.[17] And despite more than 40 years of federal policy and restoration efforts, we continue to lose coastal ecosystems at a staggering rate.

NOAA and the U.S. Fish and Wildlife Service estimate that the United States suffered a net loss of 721,720 acres of wetlands from coastal watersheds between 1998 and 2009—an area larger than the state of Rhode Island.[18] Of particular concern, erosion-driven losses of intertidal marshes, swamps, and forests along the Gulf of Mexico totaled around 124,000 acres from 2004 and 2009 alone, representing a loss of 2.4 percent of the United States' remaining total area of these vital ecosystems. California has lost more than 90 percent of the coastal wetlands that historically vivified its bays and estuaries,[19] despite rigorous state management of its coastal zone. Similarly, oyster reefs—which have historically provided food and livelihoods for coastal residents and habitat for other valuable fish—have undergone drastic declines nationwide; researchers determined in 2012 that U.S. coastal oyster grounds have declined "precipitously," by 64 percent in area and 88 percent in oyster biomass, in the past century.[20]

Measuring economic value

Nationwide, degradation and loss of coastal ecosystems is often attributed to activities that can help grow local and regional economies, such as coastal development, extraction and processing of energy resources, and agriculture. Yet there are also long-term economic costs from these activities when they degrade the coastal environment, including increased erosion, reduction in water quality, and declines in wildlife populations. Each of these exacts an economic cost from the surrounding communities.[21]

While the gains from the conversion and development of public lands are often easy to measure—in construction or farm jobs, wages paid, or crops produced—accounting for the lost benefits provided by coastal ecosystems is much more difficult. How many fewer larval fish survived to commercially viable size due to a decrease in water quality? How much revenue did local motels and restaurants lose because birdwatchers or hunters opted to travel to areas with healthier wildlife populations? These are economic questions, but they require the measurement and analysis of numerous intermediate biological factors, making defensible estimates a complex, interdisciplinary research challenge.

Fortunately, in recent years, ecologists and economists have worked together to develop a robust body of knowledge, both in methodology and accumulated data, that provides these kinds of quantitative estimates, or "valuations" of the goods and services that coastal ecosystems provide to the economy.[22]

How are these valuations generated? One method is to closely study a specific aspect of coastal ecosystems that provides economic value, relying on ecologists to provide relevant data on biological production and economists to estimate the dollar value of that output.

This straightforward approach illuminates prominent examples of the remarkable value provided by coastal ecosystems. NOAA economists, for example, concluded that U.S. commercial and recreational saltwater fishermen generated more than $199 billion in sales in 2011, supporting more than 1.7 million jobs.[23] Simultaneously, ecologists determined that species with at least one stage of their life cycle occurring in estuaries make up approximately 46 percent by weight and 68 percent by value of the commercial fish and shellfish landed in the United States and approximately 80 percent of the recreationally harvested fish nationwide.[24]

Clearly, the existence and quality of estuary ecosystems are of significance not just to America's fishing fleet and sport fishing industry but also to the overall U.S. economy.

Abt researchers used an additional method in their analysis of the San Francisco Bay Salt Ponds Restoration Project. One way economists determine how people value certain nontangible economic benefits is a process called "contingent valuation," less formally known as "willingness to pay." This approach relies on the use of appropriate survey methods that ask subjects how much they would be willing to pay for a certain outcome—in this case, restored coastal wetlands. While this is a widely accepted survey method, the drawback is that it can be extremely expensive and time consuming.

To ease the burden, a subset of techniques has emerged that allow researchers to estimate willingness to pay. In their work, researchers at Abt used a technique called "benefit transfer." In so doing, they looked at contingent valuation studies of similar restoration projects and adapted the values assigned in those studies to the San Francisco Bay Salt Pond Restoration Project.

Economic benefits of coastal ecosystems

While providing the habitat necessary for the fish and seafood we catch and eat may be the most familiar of the valuable services provided by coastal ecosystems, it is just one of many. In fact, scientists and economists have begun to reveal that coastal ecosystems store and produce measurable quantities of

A striped bass is lifted out of the water in Casco Bay in Maine.

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economic value in a diversity of ways, often at surprising levels. Consider a few examples from recent research below.

Coastal hazard risk reduction

Coastal wetlands are well known to be "natural sponges" that absorb floodwaters, putting the brakes on destructive wave action and mitigating coastal erosion.[25] Following Hurricanes Katrina and Rita, researchers studied the economic damage of 34 major U.S. hurricanes that made landfall along the Gulf Coast since 1980, mapping the path of each storm and the spatial distribution of the destruction each one wrought on coastal communities and cities. Then, they overlaid a high-resolution map of the Gulf region's coastal wetlands to find out how the presence of wetlands affected the level of damage. They discovered that a loss of one hectare of coastal wetland—an area of 100 meters by 100 meters—corresponded to an average increase of $33,000 in damage from a given storm. By taking into account storm frequency over each square kilometer of the Gulf Coast, they found that coastal wetlands provided an annual benefit of between $250 and $51,000 per hectare per year. Cumulatively, this is worth about $23 billion in storm protection for the U.S. economy.[26]

As U.S. coastal cities continue to grow in population and economic importance, resilience to coastal hazards such as hurricanes and floods will continue to rise in importance—especially given the reality of climate-change-induced sea-level rise, which could exceed 4 feet along U.S. shorelines by the end of the century.[27] Accordingly, an entire section below is devoted to the value of coastal ecosystems in enhancing coastal resilience.

Absorption of nutrients and pollution

According to the EPA, nutrient pollution—primarily of nitrogen and phosphorus—"is one of America's most widespread, costly and challenging environmental problems."[28] These nutrients are vital for plant growth, but the burning of fossil fuels and over-application of fertilizers in commercial agriculture have led to a gross excess in many stream, lakes, rivers, and coastal areas. This causes algae to grow faster than ecosystems can handle, which degrades water quality, kills fish and other species, causes human health problems, and affects coastal economies.[29]

Wetlands help mitigate the impact of this nutrient pollution. One meta-analysis found that major classes of wetlands across the contiguous United States remove more than 5.8 million metric tons of nitrogen before it contaminates drinking water or contributes to eutrophication and coastal "dead zones."[30] Other researchers have found that unabsorbed nitrogen causes damage to ecosystem productivity, biodiversity, recreation, and the availability of clean water that exact costs of $2.20 to as much as $56 per kilogram of the nutrient.[31] In other words, the absorption of anthropogenic nitrogen by the remaining wetlands—both inland and coastal—averts a minimum of about $12.76 billion in additional nitrogen-pollution costs[32] to the U.S. economy.

Functioning coastal ecosystems can also serve as highly effective sinks for the carbon pollution that causes global climate change. A new study by Restore America's Estuaries, Western Washington University, and others found that tidal wetland restoration efforts at the mouth of Washington state's Snohomish River have significantly boosted the ecosystem's carbon capture and storage potential. They found that over the next 100 years, as the environmental health of this site continues to mature, the restored marshland will capture and store at least 2.55 million tons of CO_2 from the atmosphere.[33]

Property value enhancement

The desirability and therefore the economic value of landscapes is also linked to ecosystem health**.** Residents near Muskegon Lake, an offshoot of Lake Michigan along the Great Lake's eastern shore, benefitted from a $10 million grant in 2010 to restore 24 acres of open water wetlands, stabilize its degraded shoreline, and remove 182,862 metric tons of obsolete concrete and timber shoreline armoring and other debris.[34] The funding also supported socioeconomic monitoring by economists from nearby Grand Valley State University to track the impact of the investment on the local community. Through analysis of the recreational activities and the real estate market along discrete sections of Muskegon Lake, the researchers found that the restored shoreline, made more accessible and more conducive to recreational activities, will cumulatively enhance the community's real estate value by $11.9 million.[35]

Tourism and recreation

We are often drawn to natural, undeveloped lands and waters specifically because of the wildlife. We invest time, energy, and money for the chance to see dolphins at the beach, to drop a line for striped bass in at the mouth of a coastal river, and to watch migratory birds gather along the trail of a protected forest. While wildlife richness may seem like a nebulous, qualitative characteristic of any given geographic area, a recent study from the Gulf Coast region[36] revealed that the wildlife of the Southeast sustain a huge—and measurable—quantity of economic activity. Wildlife tourists there spend nearly $8 billion annually on recreational fishing, $6.5 billion on wildlife watching, and $5 billion on hunting.[37] Lodging and dining services receive $9.6 billion of this revenue, money that flows primarily through local businesses.[38] According to National Ocean Economics Project data, the tourism and recreation sector provided almost 2 million jobs in 2011—more than two-thirds of employment across all ocean industries.[39]

Economic benefits depend on ecosystem interdependence

These examples demonstrate some of the distinct, valuable services provided by coastal ecosystems. Just as physical capital such as factories and roads creates value for the economy through production of goods and provision of transport, reefs, estuaries, and other wetlands represent natural capital—assets that continue to provide economic value over time. It is important to remember, however, that the entirety of the economic value that ecosystems provide is not built simply on the sum of one or two individual, discrete services such as reproductive habitat for fish or nutrient absorption. Instead, the production of any one service depends on the simultaneous production of an ecosystem's full array of interdependent services.

Ecosystems, by definition, function due to the interdependence of many different living organ-

FIGURE 1

Wetland ecosystem structure and processes

Functions		
Hydrological	Biogeochemical	Ecological
• Floodwater retention • Surface and groundwater recharge	• Nutrient retention and export	• Nursery and habitat for plants, animals, and microorganisms • Landscape structure and diversity

↓

Socioeconomic benefits		
Hydrological	Biogeochemical	Ecological
• Flood protection • Reduced damage to infrastructure and property • Water supply • Habitat maintenance	• Improved water quality • Waste disposal	• Commercial and recreational fishing • Bird hunting • Other recreational amenities

isms interacting with each other and their physical surroundings. When the full complement of species is present in an ecosystem, energy produced by organisms such as algae and plants can flow up through a food chain of herbivores, predators, and scavengers. This allows nutrients such as nitrogen to be continuously cycled, generation after generation. Human society places high value on particular links in these food chains, such as the estuarine algae and marine plants that absorb our waste nitrogen and CO_2 and the fishable populations of higher-level consumers such as red drum or spotted sea trout. However, just as the fish depend on the sea grass for habitat and pollutant filtration and the submerged plants depend on predatory fish for control of marine herbivores, every link in the food chain of a coastal ecosystem is essential for the continued health of all the other links on that chain. In other words, ecosystem services do not just provide economic value, they also help maintain the function of the ecosystem itself.

Furthermore, in some cases, people value coastal ecosystem services in a complementary way. Researchers found, for example, that recreational anglers offshore Southern California often chose to fish in spots that produced inferior catches if the destination also provided opportunities to view wildlife or carry out other non-consumptive recreational activities such as surfing.[40]

The following section will show how ecosystem restoration projects can yield remarkable long-term economic impacts through careful analysis of both individual ecosystem services and contingent valuation of the complete ecosystems that animate coastal spaces.

Three restoration case studies

On February 13, 2009, the U.S. Congress responded to the worsening economic crisis with passage of the American Recovery and Reinvestment Act, which authorized the expenditure of $787 billion in federal funds for projects that would "create new jobs and save existing ones" and "spur economic activity and invest in long-term growth." Money was also authorized to shore up unemployment insurance and cut taxes for households and businesses.[41]

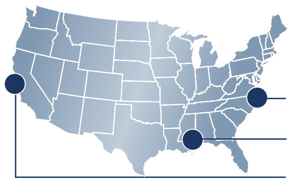
Additionally, ARRA authorized funding for federal contracts, grants, and loans, including $167 million for NOAA to make grants for coastal and marine habitat restoration.

After circulating a request for proposals, NOAA was inundated with 814 of them, comprising more than $3 billion in requests and illustrating the extent of coastal restoration needs throughout the United States. According to NOAA, more than 200 technical reviewers from across the agency selected 50 projects based on the agency's priorities for ecological resto-

FIGURE 2

Restoring coastal ecosystems boosts the economy

Averaging the benefit-cost ratios across the three restoration projects we studied, each dollar invested by taxpayers returns more than $15 in net economic benefits. These restoration dollars support long-term economic and environmental benefits to our local communities.



What are some of those benefits?

FOOD: 75 percent of commercially important fish stocks rely on coastal habitats

PROTECTION: An acre of wetlands can store 1 million to 1.5 million gallons of floodwater

RECREATION: 200 million Americans visit the coast each year

HABITAT: 7 football fields of wetlands are lost every hour in the United States

JOBS: 17 jobs are created for every $1 million invested in restoration

HEALTH: Wetlands filter water, making it safer for drinking, swimming, and wildlife

INNOVATION: "Geosynthetics" are a $2 billion industry, and new wetland-friendly levees protect coasts and save money

Sources: National Ocean and Atmospheric Administration, Habitat Restoration (U.S. Department of Commerce, 2008), available at http://www.noaa.gov/factsheets/new%20version/habitat_restoration.pdf; Peter Edwards, Ariana Sutton-Grier, and G.E. Coyle, "Investing in nature: Restoring coastal habitat blue infrastructure and green job creation," Marine Policy 38 (2013): 65–71; Shawn Stokes and others, "Geosynthetics: Coastal Management Applications in the Gulf of Mexico" (Durham, NC: Duke Center on Globalization, Governance & Competitiveness, 2012), available at http://www.cggc.duke.edu/pdfs/CGGC_Geosynthetics.pdf; U.S. Environmental Protection Agency, "Functions and Values of Wetlands" (2001), available at http://water.epa.gov/type/wetlands/outreach/upload/functions-values.pdf; Thomas E. Dahl and Susan-Marie Stedman, "Status and trends of wetlands in the coastal watersheds of the Conterminous United States 2004 to 2009" (Washington: National Oceanic and Atmospheric Administration, 2013), p. 46, available at http://www.habitat.noaa.gov/highlights/coastalwetlandsreport.html; U.S. Environmental Protection Agency, "Fact Sheet: Economic Benefits of Wetlands," available at http://water.epa.gov/type/wetlands/outreach/upload/EconomicBenefits.pdf.

ration; readiness for project commencement, or being "shovel ready;" and labor intensiveness, or projects that would generate the largest number of jobs in the shortest period of time.[42]

These ARRA-funded projects had significant potential to illuminate how coastal restoration investments can provide long-term economic value because they are recent, publicly funded, have similar timelines for completion, and consistent performance-reporting requirements. Accordingly, CAP and Oxfam America selected three geographically diverse projects—in South San Francisco Bay, in Mobile Bay, Alabama, and along the Atlantic coast of Virginia—that each aimed to restore distinctive coastal and marine habitats, employing a mix of techniques and each seeking a distinct set of ecological objectives.

Economists have already examined the direct, short-term job creation of these projects. For example, researchers found that among NOAA's 50 ARRA-funded coastal restoration projects, employment averaged about 17 jobs created per $1 million spent,[43] compared with about 8.9 jobs created per $1 million spent by the offshore oil and gas industry.[44] According to their data, these three projects created an average of about 19 jobs per $1 million spent,[45] more than twice that of the coastal fossil-fuel sector.

However, ARRA was also intended to enhance American economic vitality over the long term, and NOAA used projects' potential to enhance long-term ecological health as one of the selection criteria. Consequently, CAP and Oxfam worked with economists and ecologists to find out just what kind of economic impact these three projects are going to have.

Virginia Seaside Bays

Less well known than the state's Chesapeake Bay shoreline, Virginia's Seaside Bays face the Atlantic Ocean and include a variety of shallow coastal ecosystems, including two key habitats that have critical roles in ecosystem structure and function: oyster reefs and submerged aquatic vegetation, or SAV, in seagrass meadows. Similar to many temperate estuaries of the United States, these habitats were once ecologically and economically dominant but have experienced sharp declines in quality and coverage in the past century.

Centuries of intensive exploitation, coastal zone development, and deteriorating water quality have damaged or eliminated many oyster reefs. An estimated 85 percent of historic oyster reefs have been lost globally, making oyster reefs one of the most severely imperiled marine habitats on the planet.[46] Sharp declines in SAV habitats are similarly caused by a multitude of factors, including increased nutrient and sediment runoff, invasive species, artificial alterations to the flow of water and coastal currents, and unsustainable commercial fishing practices. Recent estimates suggest that 14 percent of SAV species globally are at elevated risk of extinction.[47]

The Virginia Seaside Bays region* has experienced two major ecosystem declines: the loss of vast beds of one SAV species—eelgrass—due to disease and a devastating hurricane in 1933 and the collapse of the commercial oyster fishery in the 1990s due to overharvesting.[48] Loss of the eelgrass habitat also largely eliminated the bay scallop, which was once an important shellfish resource for the region.

To restore degraded oyster reefs and eelgrass beds in the Virginia Seaside Bays, NOAA awarded $2,167,000 in 2009 to The Nature Conservancy and a project team that included the Virginia Institute of Marine Science, Virginia Marine Resources Commission, and Virginia Coastal Zone Management Program.[49]

Restoration activities included:

- Constructing functional oyster reefs at 14 sites by installing hard substrate for larval oysters to settle on, such as oyster shell mounds and other hard material.

- Planting eelgrass seeds in the non-vegetated bottom in four adjacent areas along the lower Delmarva Peninsula, including South Bay, Cobb Bay, Spider Crab Bay, and Hog Island Bay.

- Deploying adult bay scallops as spawning stock in the restored eelgrass beds to support the reintroduction of a self-sustaining bay scallop population.

Restoration partners completed these activities—along with associated water quality, vegetation, oyster, and scallop population monitoring—from 2009 to 2011.[50] As a result, 22.1 acres of oyster reef were created, contributing to offsite oyster harvests, onsite reef habitat for many other invertebrates and finfish, and other ecological services. (see Table 2) Meanwhile, 133 acres of bare seabed sedi-

***Correction, May 2, 2014:** *This sentence was corrected to better specify the geographic extent of identified ecosystem declines.*

ment were seeded with eelgrass, and evidence suggests that the resulting meadows will expand to more than 1,703 acres over the next 24 years, providing onsite habitats for fish and shellfish, coastal erosion mitigation, carbon capture and storage, and other services. (see Table 2) Finally, the project placed 15,000 bay scallops as a preliminary investigation of a new method to increase wild bay scallop stocks in the recovering eelgrass meadows.

This project aimed to restore socioeconomically important ecological services to an already disadvantaged area of Virginia. Northhampton County faces a 22.4 percent poverty rate, more than double the statewide level.[51] Restoring oyster reefs and other habitat not only helps the commercial fishing industry—which has played an important role in providing livelihoods to area residents for generations—it also aids ecotourism and recreational fishing, a key focus for recent local economic development plans.[52]

Benefits of oyster reef and seagrass ecosystems

Oyster reefs

Stabilization of underwater and intertidal habitat: Oyster reefs generally form the only hard substrate in predominately soft sediment environments and stabilize and settle out suspended sediments.

Oyster production: Oysters are a highly valued commercial shellfish.

Fish production: Juvenile fish and mobile crustaceans use oyster reefs as refuge and foraging grounds, such that oyster reefs augment the tertiary productivity of estuaries.

Provision of habitat for invertebrates: The reef structure formed by vertically upright oyster aggregations creates habitat for dense assemblage of mollusks, polychaetes, crustaceans, and other resident invertebrates.

Trophic structuring: Oysters promote pelagic fauna by preventing primary production from entering microbial loops and thus allowing it to pass up the food chain first to oyster predators such as bottom-feeding fishes and crabs and then to higher-order predators such as red drum, tarpon, and dolphins.

Water filtration and concentration of biodeposits: Removal of nutrients, including nitrogen, sediments, and phytoplankton, from the water column improves local water quality and routes energy, carbon, and nitrogen to benthic communities by biodeposition, or the excretion of feces.

Carbon sequestration: Collection of carbon through filtration feeding on phytoplankton and organic material and deposition into shell material provides for semi-permanent carbon sequestration.

Eelgrass: Eelgrass is a type of underwater plant—often called submerged aquatic vegetation, or SAV—that grows in shallow bays and estuaries. Eelgrass is not an algae or seaweed such as kelp; rather it is a perennial, flowering plant that reproduces by seed dispersion and germination, similar to many terrestrial plants.

Stabilization of benthic or intertidal habitat: The eelgrass leaf canopy, roots, and rootstalks consolidate unvegetated areas, stabilizing the sediment and contributing to water clarity.

Fish production: The highly productive eelgrass habitat provides food, shelter, and essential nursery areas to commercial and recreational fishery species. Juvenile stages of many fish species spend their early days in the relative safety and protection of eelgrass.

Provision of habitat for invertebrates: The eelgrass habitat supports diverse groups of invertebrate species such as crustaceans, bivalves such as bay scallops, echinoderms, and other groups that are produced within or migrate to eelgrass.

Provision of habitat for wildlife: Eelgrass is an important food source for mega herbivores such as green sea turtles.

Mitigation of shoreline erosion: Eelgrass meadows dampen the effects of strong currents, providing protection to marine life and preventing the scouring of bottom areas.

Maintain biodiversity: Eelgrass provides attachment sites to small macroalgae and epiphytic organisms such as sponges, bryozoans, foraminifera, and other taxa that use eelgrass as habitat. The abundance and diversity of the fauna and flora of eelgrass meadows are consistently higher than those of adjacent unvegetated areas.

Carbon sequestration: Primary production among eelgrass and other SAV species is only 1 percent of total primary production in the oceans, but SAV is responsible for 12 percent of the total amount of carbon stored in ocean sediment.

Oyster reefs and eelgrass beds provide a remarkable variety of ecosystem services. (see text box above). For example, in addition to shellfish production, oyster reefs create the physical structure and microhabitats needed for fish and invertebrate species to thrive. Eelgrass beds produce a variety of goods, such as harvestable finfish and shellfish, and provide valuable ecological services, such as maintenance of marine biodiversity, regulation of coastal water quality by filtering nutrients, capture and storage of carbon dioxide, and protection of the coastline by slowing wave action. In addition, they are excellent indicators of environmental quality in the coastal zone, serving as sentinels for changes in ecosystem health.[53] The federal investment in ecosystem restoration Virginia's Seaside Bays not only represents a remarkable transformation in the area's marine environment—one that turns back the clock on decades of degradation—but also will produce economic returns for years to come.

TABLE 2

Summary of estimated oyster reef and eelgrass restoration benefits at Virginia Seaside Bay Restoration Project

Benefit category	Annualized value	Total present value	Notes
Oyster reef restoration			
Carbon sequestration	$132	$4,392	
Nitrogen sequestration	$11,449 – $55,519	$268,058 - $1.30 million	
Commercial fin fisheries	$34,113	$798,675	
Commercial oyster fisheries	Unknown		
Recreational fin fisheries	$3,439 – $22,696	$80,510 – $531,366	
Total oyster reef benefit	$49,133 – $112,460	$1,121,635 – $2,634,433	
Eelgrass restoration			
Total value of eelgrass via WTP	$2,577,182 – $3,510,943	$60,338,014 – $82,199,613	Incorporates a mix of use and non-use values, including existence value, crab, scallop finfish, waterfowl, wildlife, recreation.
Habitat provision	$1,407,432	$32,951,354	Overlaps with total WTP for eelgrass restoration
Coastal erosion mitigation	$36,216 – $137,638	$847,902– $3,222,432	Overlaps with total WTP for eelgrass restoration
Total eelgrass benefit estimate	$1,446,216 – $3,510,000	$33,797,902 – $82,200,000	Range of total values based on either the sum of habitat provision plus erosion mitigation or total WTP.
Bay scallop reintroduction			
Bay scallop fishery	Not monetized independently		Outcomes of reintroduction are currently uncertain, but existing eelgrass beds may provide habitat for sea scallops; these values are included in the eelgrass benefits.
Total economic value of oyster reef restoration, eelgrass restoration, and bay scallop reintroduction			
Total Economic Value	**$1,495,349 – $3,622,460**	**$34,949,537 – $84,834,433**	

Note: All values in 2013 U.S. dollars

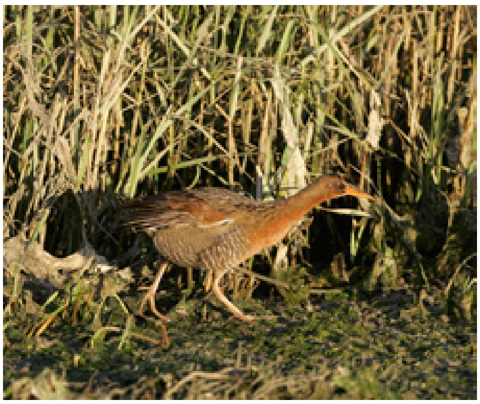
Source: Abt Associates, "Estimating the Change in Ecosystem Service Values from Coastal Restoration" (2014), available at http://www.americanprogress.org/wp-content/uploads/2014/04/AbtCoastal-Restoration-Benefits.pdf.

South San Francisco Bay Salt Ponds

San Francisco Bay is the largest estuary on the Pacific coast of North America, yet more than 90 percent of its historic wetlands have been converted to agriculture, urban and suburban development, and commercial salt production.[54] As part of regional efforts to reverse this habitat loss, federal, state, and local agencies and groups began a collaborative effort to restore salt production ponds in South San Francisco Bay to productive ecological habitats. Federal and state agencies have purchased more than 27,000 acres within the estuary since 1994. In the current phase of work, the California State Conservation Board, the U.S. Fish and Wildlife Service, the Hewlett, Packard, and Moore Foundations, and the Goldman Fund contributed approximately $100 million to purchase 16,500 acres of Cargill salt ponds and associated habitats in the South Bay.[55] The groups are now working toward a 50-year regional plan designed to eventually convert 50 percent to 90 percent of the entire South Bay's former salt ponds and other artificially disconnected areas to tidal influence,[56] making it the largest tidal marsh restoration effort in the western United States.

An ARRA grant totaling $7,620,943 was awarded to the California Coastal Conservancy in 2009 to help restore 2,751 acres of these former salt ponds to the hydrologically connected salt marsh that once encircled the entire bay. The restoration activities focused on breaching and excavating existing levees to allow natural tidal flushing and control invasive plant species. These activities facilitate growth of native vegetation and create habitat for shorebirds, waterfowl, fish populations, and other marsh dependent wildlife. Where possible, the tidal marsh restoration targeted improvements to existing populations of threatened and endangered species such as the California clapper rail and salt marsh harvest mouse.[57]

Local human populations benefit from this restoration as well. Many of the neighborhoods nearest the South Bay project are home to disproportionately high percentages of residents who are people of color or live below the poverty line.[58] Restoring the salt ponds, and the San Francisco Bay in general, may reduce these socially vulnerable populations' exposure to environmental hazards such as flooding and sea-level rise, while also increasing their access to environmental services such as fishing and recreation.



Clapper rails are an endangered bird species dependent on healthy coastal ecosystems.

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TABLE 3

Summary of estimated oyster reef and eelgrass restoration benefits at South San Francisco Bay Salt Ponds Restoration Project

Benefit category	Annualized benefit	Total present value	Notes
Total value of wetland restoration, or WTP	$2,983,046 –$9,528,353	$68,952,427 – $220,245,700	Incorporates a mix of use and non-use values: flood control; biodiversity supply; size of wetland area restored; presence of boardwalks and/or viewing towers; endangered species; and preferences for preservation versus restoration
Commercial fishing and recreational fishing	$23,332 – $29,987	$539,078 – $693,139	Overlaps with total WTP value
Threatened and endangered species protection	$2.08 million	$2,844,300	Overlaps with total WTP value
Carbon sequestration	$54,303	$1,810,111	
Biodiversity maintenance	Not monetized independently; included in WTP value		
Bird watching			
Recreation			
Total benefit estimate	**$3,037,349 –$9,582,656**	**$68.9 – $220.3 million**	

Note: All values in 2013 U.S. dollars.

Source: Abt Associates, "Estimating the Change in Ecosystem Service Values from Coastal Restoration" (2014), available at http://www.americanprogress.org/wp-content/uploads/2014/04/AbtCoastal-Restoration-Benefits.pdf.

Mobile Bay, Alabama

Mobile Bay, part of Alabama's Gulf Coast shoreline, is an estuary of national significance. It supports a diversity of nationally important bird, fish, and wildlife species and provides federally designated critical habitat areas for the piping plover, a shorebird listed under the Endangered Species Act. However, changes in sedimentation patterns and salinity and increased use of shoreline armoring have altered wildlife habitats, exacerbated shoreline erosion, and reduced the bay's "ability to withstand and recover from unusual wave stresses like those that occur during tropical storms and hurricanes."[59]

The Nature Conservancy received a $2,931,446 two-year ARRA grant from NOAA in July 2009 to restore oyster habitat and create protective breakwaters under the auspices of the existing Coastal Alabama Economic Recovery and Ecological Restoration Project, also know as the Alabama Coastal Restoration, or ACR, project. The goal of this project was to create a vertical oyster reef breakwater to provide shoreline stabilization and restoration along several stretches of shoreline within Mobile Bay. The project began in July 2009 with partners including the Dauphin Island Sea Lab, or DISL, of the University of South Alabama; the State Lands Division of the Alabama Department of Conservation and Natural Resources, or ADCNR; and the National Wildlife Federation.

Unfortunately, it is not yet possible to accurately quantify all of the ecological and economic benefits of the Mobile Bay project because post-construction monitoring and data collection were extremely limited. In fact, more than 12 months of monitoring data were collected for only one of the four installed oyster reefs—an insufficient quantity of information to assess the project's performance. This is due in large part to external factors that slowed the project's implementation schedule, including the BP Deepwater Horizon oil spill, poor water quality, and an influx of predatory snails that feast on young oysters.[60] According to project implementation staff, midterm monitoring for four to six years after construction will help draw more accurate conclusions about the ecological and economic benefits of this project.[61] This lack of data is exacerbated by the fact that—unlike other cases cited in this report, such as salt marsh restoration in San Francisco Bay—there have not been many evaluations of projects using similar oyster reef technology that can be used to fully calibrate analysis of all of the data.

Research indicates, however, that oyster breakwater reefs, such as the ones constructed in the Mobile Bay ARRA project, provide numerous benefits in the form of commercial and recreational fisheries production, carbon and nitrogen sequestration, enhanced recreational opportunities, and coastal erosion mitigation. Even with only a few months of data available, Abt Associates determined that the project is already on course to provide meaningful economic returns. Based on available background studies, for example, Abt estimated commercial and recreational fisheries benefits of nearly $140,000. Furthermore, other studies emphasize that oyster restoration can provide high-quality habitat for numerous species of fishes and invertebrates—many of which are commercially and recreationally significant, including spotted sea trout, red drum, black drum, gag grouper, blue crabs, and, of course, oysters.[62] Reef construction provides significant economic value and can positively affect nitrogen removal and erosion reduction.[63]

Projects such as the Mobile Bay oyster reef restoration use relatively new restoration techniques for which best practices for construction and monitoring are still being developed and refined.[64] However, the qualitative evaluation of this small-scale project confirms an increasing body of engineering and scientific work showing that oyster reef construction does have significant positive ecological and economic value for the Gulf Coast.

In fact, this value was sufficient to motivate the formation of a public-private partnership to expand oyster reef restoration in the region. The 100-1000: Restore Coastal Alabama project aims to restore 100 miles of oyster reef in Mobile Bay, while also protecting and promoting the growth of more than 1,000 acres of coastal marsh and seagrass habitat.[65] In line with this effort, several private companies across the Gulf region are developing and testing new oyster reef restoration technology, which may facilitate additional ecological and economic benefits.

In addition to the array of valuable services identified in the three case studies, research on coastal ecosystems and restoration initiatives at other locations has revealed that coastal ecosystems provide another vital service that is increasingly important in a warming world—resilience from coastal hazards such as extreme weather and sea-level rise.

Wetlands' role in increasing coastal communities' resilience to climate change

By any measure, Superstorm Sandy, which struck the eastern seaboard in late October 2012, was an historic catastrophe. By the time the storm dissipated, it had exacted an economic cost of more than $68 billion—the second costliest hurricane in U.S. history behind Katrina[66]—and taken the lives of 117 Americans[67] and 69 people throughout the Caribbean and Canada.[68] The storm's incalculable social and human toll and gargantuan economic effects rank it as a rarity in U.S. history. However, research suggests that the storm foreshadows a future of significantly greater risks to life and property from coastal hazards.

America's coastal counties increasingly represent the demographic and economic center of our nation. Despite comprising less than 10 percent of the land area of the lower 48 states,[69] coastal counties are the most populous in America. With a population that has grown by nearly 40 percent since 1970,[70] these counties today are home to nearly 40 percent of U.S. residents[71] and contribute more than 45 percent of annual U.S. gross domestic product.[72]

While U.S. coasts are more economically vibrant than ever, this immense growth in population and wealth means that more Americans are in harm's way when it comes to coastal hazards such as tropical storms and floods. In fact, research on Superstorm Sandy shows that while the storm may have been a historical anomaly, human impacts on the environment make Sandy a harbinger of a future in which devastating coastal floods become the new normal.

It has become clear that the effects of climate change enhanced the storm's unprecedented size and nearly unparalleled destructive power. Warmer sea-surface temperatures—the highest ever recorded for the waters of the Northeast[73]—almost certainly increased the intensity of the storm's rainfall.[74] In addition, sea levels along the eastern seaboard are significantly higher today than at any point in the past 2,000 years,[75] and they are rising at an accelerating rate and in close correlation with greenhouse gas emissions and the corresponding increase of global average temperatures.[76] The net effect of these human-driven dynamics, according to Princeton University earth scientist Michael Oppenheimer, is that about 50,000 people experienced flood effects from Superstorm Sandy who would have otherwise been spared.[77]

As then NOAA Administrator Dr. Jane Lubchenco put it, "Storms today are different. Because of sea-level rise, [Sandy's] storm surge was much more intense, much higher than it would have been in a non-climate changed world."[78]

Sea-level rise is also driving an increase in the frequency and intensity of destructive coastal floods. According to a September 2013 report from the American Meteorological Society, sea-level rise caused by global warming is significantly reducing the time between major coastal flood events.[79] In 1950, the more than 8-foot-high storm surge caused by Sandy in New Jersey would have been considered a once-in-435-years event. But given the accelerating rate of sea-level rise, scientists now predict that Sandy-scale flooding will occur there every 20 years by 2100.[80]

The problem is not going away any time soon. Scientists warn that global greenhouse gas emissions have already locked in a significantly greater risk from coastal hazards such as storms and flooding. Even if we cease emitting fossil-fuel-based greenhouse gases today, sea levels will continue to rise for the next several centuries. According to the geologic record, the last time the atmosphere was as carbon rich as we have made it today, seas were 20 meters higher.[81]

Our increasing economic dependence on our coasts and the greater risks they face from climate change and sea-level rise mean that any discussion of coastal land use must address the question of how we reconcile these conflicting trends. In other words, how do we affordably adapt our coasts so that our coastal communities, assets, and infrastructure become safer and more secure, while also continuing to invest in the coastal ecosystem restoration needed to ensure that our coasts are ecologically healthy? Research, especially in the aftermath of Hurricane Katrina, has revealed that healthy coastal ecosystems play a vital role in reducing risks from coastal hazards.

First, as mentioned in the previous section, coastal wetlands with healthy plant communities, such as salt marshes, mangroves, and estuaries, serve as highly effective buffers against storm surge. These ecosystems soak up and hold floodwaters similar to a sponge and shield landward areas from inundation. Estimates of the hurricane protection value of existing coastal wetlands in the Gulf and eastern seaboard have shown that the absence of healthy coastal ecosystems explains as much as 60 percent of the damage suffered by communities along the Gulf Coast that are struck by hurricanes.

The researchers concluded that "coastal wetlands function as valuable, self-maintaining 'horizontal levees' for storm protection … their restoration and preservation is an extremely cost-effective strategy for society" to mitigate the damage from tropical storms.[82] These studies found that the Gulf Coast's remaining coastal wetlands provide around $23.2 billion per year in storm protection services.[83]

More recently, scientists have begun to account for future trends in sea-level rise and socioeconomic data in their examination of the relationship between healthy coastal ecosystems and the most vulnerable members of society—primarily the poor, communities of color, and the elderly. A new body of research on social vulnerability, led by organization such as the University of South Carolina's Hazard Vulnerability Research Institute, combines data on physical risk with social and economic data sets.[84]

This robust literature explains how socioeconomic dynamics contribute to communities facing greater challenges in responding to, recovering from, and preparing for climate-related hazards.[85] Researchers from Stanford University and The Nature Conservancy overlaid a map of coastal wetlands with data on the spatial distribution of individuals most likely to be harmed or killed during catastrophic storm events. Then, they modeled several scenarios in which sea-level rise and coastal ecosystem degradation continue at current rates. Relative to the most likely scenarios, the scientists reported in *Nature Climate Change* that:

> *The likelihood and magnitude of losses may be reduced by intact reefs and coastal vegetation, especially when those habitats fringe vulnerable communities and infrastructure. The number of people, poor families, elderly and total value of residential property that are most exposed to hazards can be reduced by half if existing coastal habitats remain fully intact.*[86]

The value of restoration-driven risk reduction in the South San Francisco Bay

Research conducted for this report further underscores how ecosystem restoration reduces flood risk and therefore benefits coastal economies. State and federal authorities have stated that the South San Francisco Bay Salt Pond restoration—an inexpensive intervention completed largely by breaching the old salt pond levees—could provide beneficial reductions in flood risk for approximately 32,902 households in South Bay neighborhoods in Santa Clara and Alameda counties. Assuming this yields even a marginal—approximately 1 percent—

reduction in flood hazard risk, the benefits can translate to an increase in property values of 0.60 percent[87] to 2 percent.[88] For homeowners along the South San Francisco Bay, that would represent a sum enhancement to property values of between $857,300 and $27.97 million estimated in net present value terms.**

Furthermore, the estimated risk reduction was assessed based on historical data and does not account for sea-level rise driven by climate change. Best available climate projections suggest that with increasing sea-level rise, the areas at risk from a 100-year coastal flood event may be 22 percent to 44 percent larger by 2100.[89] Research shows that most of the communities at risk of flooding in the bay are also home to high concentrations of socially vulnerable people, low-income people, and people of color, who face increased challenges to coping with these hazards. [90]

***Correction, May 2, 2014:** This paragraph was corrected to attribute the original flood risk benefits prediction to state and federal authorities and to clarify the assumption of the quantitative value of those benefits.*

Hurricane Katrina

Hurricane Katrina took the lives of 1,836 people and inflicted more than $150 billion in economic damages when it slammed into the Louisiana coast in August 2005. It was an eye-opening tragedy for communities across the Gulf Coast. The storm brought storm surges as high as 20 feet and was exacerbated by the failure of the federally constructed levee system surrounding the greater New Orleans area.[91] Because many of those left stranded or displaced were low-income families, the disaster also highlighted the connection between poverty, social vulnerability, and recovery.

In addition, the storm helped draw attention to the issue of coastal land loss. Decades of short-sighted management decisions had already starved the delta's coastal wetlands of nourishing sediment that was historically deposited from upstream along the Mississippi River. And the numerous canals built in coastal wetlands exacerbated an ongoing process of erosion and subsidence in the southeastern portion of Louisiana. Before the storm hit, 1,880 square miles of land had been lost to the Gulf of Mexico in the previous 80 years.[92] Today, the state is losing a football field of wetlands every 38 minutes.[93] These wetlands are critical for risk reduction and reducing storm surge and flood hazards. New modeling conducted after the storm showed annual losses from extreme weather could top $23 billion per year in Louisiana, almost 10 times what they are today.[94]

Recognizing these increased risks, federal and state officials saw the need for a new approach to reduce disaster risk. A new concept emerged from academic and nonprofit researchers that uses multiple lines of defense, integrating the flood and wave attenuation value of natural resources such as healthy marshes, ridges, and barrier islands with stronger levees and elevated buildings to reduce future risks of flooding.[95]

As a result, the state of Louisiana took action in 2005 to consolidate its coastal disaster risk programs under one roof—the Coastal Protection and Restoration Authority, or CPRA—and require science-based plans, updated every five years, to reduce these enormous threats. CPRA made significant investments to help the state develop cutting edge modeling for risks and create plan, not just for strengthening levees, but also for restoring coastal wetlands and barrier islands. The result is the nation's largest comprehensive flood protection and ecosystem restoration project, a proposed 50-year, $50 billion plan to protect Louisiana.[96]

In Louisiana, researchers found that overwhelming floods destroy or wash away artificial levees built for flood control. During Hurricane Katrina, levees in St. Bernard Parish in South Louisiana, which were fronted by extensive wetlands, survived the storm despite being overtopped by floodwaters. Yet levees of similar scale near the Mississippi River Gulf Outlet that lacked wetland buffers were destroyed by waves before they had even been overtopped.[102] These findings led a blue ribbon panel of coastal engineering experts to recommend that policymakers prioritize the preservation of existing wetlands and invest in large restoration measures related to preserving natural flows of freshwater and sediment. [103]

Taking these and similar data into account, planners around the country are starting to meld coastal ecosystem restoration with active floodplain management in the design of new flood control infrastructure. As a result, governments could realize improved resilience to coastal flooding and sea-level rise, direct fiscal savings relative to traditional coastal armoring, and accrual of economic benefits in the form of ecosystem services provided by the restored areas.

The cities built around the shores of the San Francisco Bay are ill-prepared for the increased flooding that will be associated with sea-level rise, in part due to the extensive loss of salt marshes that once ringed the bay. According to the *San Jose Mercury*

Typhoon Haiyan

Typhoon Haiyan tore across the northern Philippines on November 8, 2013, killing more than 6,000 people and displacing more than 4 million others.[97] One of the most powerful storms ever recorded, the 370-mile-wide behemoth sustained winds of more than 195 miles per hour when it made landfall. While a storm of this size would have left devastation in its wake even in the most prepared location, degraded coastal mangrove forests certainly did not improve matters.

In the past century, the Philippines has lost more than half of its mangrove forests due to conversion for aquaculture and farming.[98] The result has both devastated critical fish habitat along the coast and increased disaster risk for many communities that also depend on fisheries for their livelihoods. These same fishers—many of whom live in or on the brink of poverty—have suffered enormous losses from Haiyan, including the destruction more than 30,000 boats.[99]

In Haiyan's aftermath, restoring the health of coastal mangrove forests has become a focal point in the nation's recovery. Mangroves can reduce storm surge levels by up to half a meter for each kilometer of mangrove and reduce the height of wind and swell waves by 13 percent to 66 percent within the first 100 meters of mangroves.[100] Filipino President Benigno Aquino announced plans in November 2013 to launch a "comprehensive programme of environmental protection," including $8 million in mangrove restoration.[101] Efforts to restore mangrove areas protect against storm surges and waves, prevent coastal erosion, provide a nursery for commercially important species, and protect traditional livelihoods.

News, "As global warming escalates, San Francisco Bay's existing flood protection system will be no match for rising sea levels." [104] However, The Bay Institute investigated fortifying the bay's shoreline with new levees fronted by restored tidal marshes and found that such a system would reduce wave heights by as much as 50 percent, would be significantly more environmentally benign, and would require levees that were lower and more aesthetically benign than traditional levees.[105]

Furthermore, they estimate that these shorter, wetland-fronted levees would lower the cost of the needed flood protection from more than $12 million per mile for traditional levees to less than $7 million per mile, while providing the equivalent flood protection.[106] As the *San Jose Mercury News* reported, given that cities on the shores of the San Francisco Bay have more than 275 miles of bay shoreline to protect, "total savings could eventually exceed more than a billion dollars."[107]

In a similar fashion, former New York City Mayor Michael Bloomberg's 2013 comprehensive plan for economic development and climate resilience identified specific areas throughout the city for this type of investment. In these places, coastal ecosystem restoration is a better, more cost-effective option than grey infrastructure constructed with concrete and steel for vital civic services such as flood control, management of storm water runoff, and water treatment.[108]

Finally, coastal ecosystem restoration underpins one of the Federal Emergency Management Agency's, or FEMA's, most successful flood hazard mitigation programs: providing property owners who are repeat victims of floods with full market value if they voluntarily sell their home. The buildings are then demolished, the natural habitat is restored, and title for the land is turned over to the state on the condition that it is preserved as public, undeveloped open space, which can serve as a storm surge buffer during the next catastrophe. While voluntary buyout is certainly not an appropriate option for every homeowner, it can provide an option for families looking to move out of harms way. Also, FEMA and independent researchers have found that this voluntary program, which has facilitated ecosystem restoration in both coastal and riverine flood plains around the country, has been highly cost effective and saved federal dollars at many times the costs incurred.[109]

Coastal ecosystem restoration is an important tactic to help physically adapt our coastlines to sea-level rise. Furthermore, evidence from around the country shows that this is one of the least costly means of achieving something that nearly all experts and local leaders agree we must do.

Job creation and coastal restoration

Coastal restoration not only brings the long-term benefits of stronger fishing, tourism, and real estate industries but can also be a substantial source of job creation. Restoration work involves a range of career opportunities, the overwhelming majority of which pay wages well above the national average, even for workers with less than a four-year degree. As the nation continues to wrestle with high unemployment, growing economic inequality, and stagnant wages, investments in ecosystem restoration and new efforts to link these jobs to worker training and career ladders could help address some of the economic and environmental challenges facing coastal communities.

Restoration in the ARRA: Tackling national challenges and unemployment

Launched during the Great Recession when unemployment stood at 8.2 percent and would soon peak at 10.1 percent, the primary objective of the ARRA was to employ American workers and stimulate economic recovery while tackling other major national needs, including infrastructure maintenance and environmental restoration. NOAA's Coastal and Marine Restoration Program selected projects not just for their environmental impact but based on how quickly it could employ construction crews and how well it could support economic and community recovery.[110] In the end, 50 projects across 22 states and two territories were awarded $167 million dollars out of the total of more than $3 billion worth of proposals for shovel-ready coastal and marine restoration projects.[111]

Ecosystem restoration may evoke images of volunteers in waders planting native grasses. But often these projects bare greater resemblance to more traditional grey infrastructure projects, both in terms of the components of work involved and the types of occupations, firms, and even heavy equipment engaged in their implementation. While many of the grant recipients were conservation organizations, these organizations often still relied on private-sector engineering and general contracting firms to complete the work.

Generally speaking, most ecosystem restoration projects can be divided into three phases of work: planning and design, implementation and construction, and operations and monitoring. While all funding streams do not finance all three phases—in the case of the ARRA funding, many of the projects had already started planning and design—they are essential to developing and assessing restoration:

- **Planning and design:** Project sponsors work with planners and engineers to set objectives and develop a plan for implementing and evaluating projects. While there is no singular process for designing an ecosystem restoration project, this design phase often involves tasks such as site selection, land-rights acquisition, examination of historical and present ecological conditions, and cost and scheduling.[112] This design work also often involves some level of stakeholder engagement and any necessary federal or state regulatory compliance, such as the requirements of the National Environmental Policy Act.[113]

- **Implementation and construction:** Depending on the type of project, the implementation of a project is often very similar to a marine construction project. The lead organization selects construction contractors. Workers carry out the labor such as dredging sediment, building components of artificial reefs, or harvesting native plants from greenhouses and transporting them to project sites. Crews mobilize heavy equipment to reshape the function of the coastal landscape. [114]

- **Operations and monitoring:** The last phase of the work involves steps needed to maintain the restored ecosystem and evaluate its effectiveness. This includes maintenance activities such as plantings to support soil retention and other ecological enhancements, as well as conducting regular field sampling to monitor the impact of the project and any unanticipated environmental changes not related to the project that may require adaptation of future maintenance plans.[115]

According to NOAA economists, the ARRA coastal restoration projects created 17.1 total jobs for every $1 million invested over the first 18 months that these projects were implemented.[116] In this case, one job is defined as one year of full-time work. This figure also includes job creation that was indirectly driven by these investments through supporting services such as lawyers, real estate firms and professional services, boat and equipment manufacturers and repair shops, nurseries, and supply chains, including fuel, lodging, and food service. Additionally, as workers and businesses spend their paychecks in the local economy, money circulates back to fuel what is known as induced job creation.

Projects' job creation ranged from 9.39 jobs to 35.78 jobs per $1 million. The greatest differences emerged across the types of projects—namely, the techniques used in restoration and the related skill level of workers and expense of capital.[117]

Other research—from institutions such as The Nature Conservancy and the University of Massachusetts Amherst's Political Economy Research Institute, or PERI—has found that ecosystem restoration can create as many as 39 jobs for every $1 million invested. Taken together, there is a wide range of possible outcomes, but coastal restoration can be a substantial source of job creation. When compared to other grey infrastructure such as new roads and bridges or water infrastructure, coastal restoration projects fare well in comparison. A NOAA analysis finds that these projects also offer greater levels of job creation than other green investments such as building retrofits or smart grid upgrades. The coastal restoration projects also far outpace fossil-fuel projects such as oil and gas in terms of job creation by as much as 7 to 1. Add this to the list of long-term economic benefits brought by improved ecosystem services, and you can see the tremendous power of investing in ecosystem restoration.

Ecosystem restoration can create as many as 39 jobs for every $1 million invested.

TABLE 4

Comparison of blue and grey infrastructure job creation

Investment	Jobs per million dollars*
Blue infrastructure	
Reforestation, land, and watershed restoration	39.7
TNC's coastal restoration projects	36
Labor intensive, NOAA's ARRA coastal and marine restoration	33
NOAA ARRA coastal and marine restoration	17.1
Grey infrastructure	
Water infrastructure	19.8
Energy infrastructure	16.8
New roads and bridges	14.5
Oil and Gas	5.2

Correction, April 16, 2014: *This report has been updated to clarify the type of data conveyed in this chart.*

Sources: Robert Pollin, James Heints, and Heidi Garrett-Peltier, "How Infrastructure Investments Support the U.S. Economy" (Amherst, MA: Political Economy Research Institute, 2009), available at http://www.peri.umass.edu/236/hash/efc9f7456a/publication/333/; Oxfam America and the Nature Conservancy, "Rebuilding our economy, restoring our environment" (2012), available at http://www.oxfamamerica.org/explore/research-publications/rebuilding-our-economy-restoring-our-environment/; Robert Pollin, James Heints, and Heidi Garrett-Peltier, "The Economic Benefits of Investing in Clean Energy"(Political Economy Research Institute and Center for American Progress, 2009), available at http://www.peri.umass.edu/fileadmin/pdf/other_publication_types/green_economics/economic_benefits/economic_benefits.PDF.

NOAA's ARRA projects can be divided into six categories based on the restoration techniques employed:[118]

1. **Marine-debris removal** deploys cleanup crews to remove solid man-made materials, including abandoned fishing gear, that threaten to damage marine habitat or species.

2. **Restoring fish passages and dam removal** involves construction crews that remove man-made barriers and re-engineer hydrological flows to help promote fish production.

3. **Hydrological restoration** reconnects wetlands and watersheds that have been impaired by man-made changes in the landscape such as levees, dikes, and dredging.

4. **Invasive species removal** involves identifying fast-spreading, disruptive non-native species that can lead to loss of key ecosystem services and removing them.

5. **Oyster reef restoration** involves constructing and deploying artificial oyster reefs and populating them with oysters to improve water quality and provide fish habitat.

6. **Riparian restoration and living shorelines** involves construction and/or replanting native species to provide additional fish habitat, improve water quality, and reduce erosion.

These different techniques create approximately 15 jobs to 33 jobs per $1 million invested.[119] Among the techniques, hydrological restoration—a more capital-intensive project—created the fewest jobs, while invasive species removal—which primarily entails the detailed physical labor of, simply put, identifying and pulling weeds—created the most. Of course, it is also important to consider the jobs' skill and wage levels when determining a project's overall economic impact. While invasive species created the most jobs, many of these were low-skilled and low-paying jobs. The other techniques had a wider range of wage levels in the occupations associated with their projects.

TABLE 5

Coastal restoration techniques and job creation under NOAA's ARRA program

Technique	Types of workers	Total jobs per million dollars*
Marine-debris removal	Cleanup crew (laborers), small boat operators, administrative staff, marine salvors, welders, heavy equipment managers, lawyers, and accountants	17.3
Restoring fish passages and dam removal	Environmental consultants, engineers, construction workers, landscapers, lawyers, scientists, and administrative positions	18.2
Hydrological restoration	Geologists, engineers, landscapers, heavy equipment operators, construction workers, helicopter pilots, biotechnologist, and project managers	14.6
Invasive species removal	Pilots, construction workers, feral goat hunters, landscapers, and administrative positions	33.3
Oyster reef restoration	Barge, tug operators and loading crews, fishermen, scientists, technicians, biologists, divers, mining and quarry workers, truck drivers, project managers, outreach specialists, and administrative positions	16.6
Riparian restoration and living shoreline	Construction workers (foremen, surveyors and survey assistants, heavy equipment operators, laborers, and dump truck drivers), and nursery workers	19
Total		**17**

**Correction, April 16, 2014:* *This report has been updated to clarify the type of data conveyed in this chart.*

Source: Peter Edwards, Ariana Sutton-Grier, and G.E. Coyle, "Investing in nature: Restoring coastal habitat blue infrastructure and green job creation," *Marine Policy* 38 (2013): 65–71.

The case studies profiled earlier in this report—San Francisco Bay, Virginia Seaside Bays, and Mobile Bay—encompass a range of project types. The biggest job creator in the group by far was the Alabama Coastal Restoration Project. It created 32.06 jobs per $1 million invested—the second-highest average of any of the projects under NOAA's program.[120] The other projects, South Bay Salt Pond Restoration and Virginia Seaside Bays, employed slightly below average numbers of workers—12.44 jobs and 12.57 jobs per $1 million invested, respectively.[121]

Together, these techniques and phases involve a wide variety of workers across a large range of skills and occupations. A number of the jobs, particularly within the science and engineering fields, employ high-wage, high-skilled individuals. These most frequently occur in the design phase and largely require college or even graduate-level education. Still, a number of the restoration jobs provide above-average wages for workers with as little as some vocational training or certification and a moderate amount of on-the-job experience. Overall, almost 80 percent of the occupations identified by NOAA economists as being required by these projects have annual median wages above the national median wage of $34,750, as of May 2012.[122] Even among the jobs that require less than a bachelor's degree, more than half have median wages above the national median.

TABLE 6

Wages and training of occupation utilized in NOAA ARRA coastal restoration projects

Occupation	Median wage	Entry-level training and education	Growth 2012 –2022
Fishermen and fisheries worker	$33,430	Short-term on-the-job training	Decline: -5 percent
Construction laborer	$29,190	Short-term on-the-job training	Much faster: 25 percent
Nursery workers	$18,670	Short-term on-the-job training	Decline: -13 percent
Construction equipment operator	$40,980	Moderate-term on-the-job training	Faster: 19 percent
Surveying assistant	$39,670	Moderate-term on-the-job training	Average: 14 percent
Material moving operator	$31,530	Moderate term on-the-job training	No change: 1 percent
Conservation workers	$24,340	Moderate-term on-the-job training	Slower: 4 percent
Administrative assistant	$35,300	High school diploma	Average: 12 percent
Commercial pilot	$73,280	Vocational training	No change: -1 percent
Diver	$46,880	Vocational training	Much faster: 29 percent
Barge or tug operators	$48,980	Vocational training	Faster: 13 percent
Motor boat operator	$38,560	Vocational training	Average: 13 percent
Dump truck drivers	$38,200	Vocational training	Average: 11 percent
Welder	$36,300	Vocational training	Slower: 6 percent
Environmental engineering technician	$45,350	Associate's degree	Slower: 1 percent
Forest and conservation technicians	$33,920	Associate's degree	Decline: -4 percent
Geoscientist	$90,890	Bachelor's degree	Faster: 16 percent
Construction project managers	$82,790	Bachelor's degree	Faster: 16 percent
Environmental engineer	$80,890	Bachelor's degree	Faster: 15 percent
Civil engineer	$79,340	Bachelor's degree	Faster: 20 percent
Landscape architect	$64,180	Bachelor's degree	Average: 14 percent
Environmental scientists and specialists	$63,570	Bachelor's degree	Faster: 15 percent
Accountant	$63,550	Bachelor's degree	Average: 13 percent
Surveyors	$56,230	Bachelor's degree	Average: 10 percent
Biotechnologist	$39,750	Bachelor's degree	Average: 10 percent
Lawyers	$113,530	Graduate degree	Average: 10 percent
Hydrologist	$75,530	Graduate degree	Average: 10 percent

Source: Bureau of Labor Statistics, *Occupational Handbook 2014–2015 Edition* (U.S. Department of Labor, 2014), available at http://www.bls.gov/ooh/.

Creating new pathways out of poverty

The occupations associated with ecosystem restoration can provide significant pathways out of poverty in low-income coastal communities. In two of the three projects highlighted in this report, the surrounding communities faced rates of poverty exceeding the national average.[123] The areas where restoration activities are most needed also tend to be areas with high rates of poverty. In these regions, the influx of coastal restoration jobs with wages that exceed the national average are a welcome economic driver, in addition to providing environmental benefits that can help sustain the physical infrastructure to maintain communities' new economic viability. In some parts of the country, increased demand for some of these occupations, such as welders and boat operators, has led to even higher wages.

There are positive examples in the region for leveraging these jobs to lift workers out of poverty. For example, global engineering giant AECOM recently formed a partnership with Limitless Vistas, Inc., a job training organization in New Orleans that prepares low-income, youth of color for jobs in the environmental sciences. AECOM has agreed to provide apprenticeship opportunities to Limitless Vista's students, which can lead to jobs for program graduates.[124] Another exciting partnership in Louisiana involves local industry associations such as the Coast Builders Coalition, the state's Coastal Protection and Restoration Authority, workforce agencies, the Louisiana community college system, as well as non-profits such as Oxfam America.[125] This partnerships involves working together to

Leveraging local knowledge and jobs: Southeast Asian community building oyster reefs in Alabama

Efforts to start construction of the Alabama Coastal Restoration Project coincided with the occurrence of one of the largest environmental disasters in U.S. history: the 2010 Deepwater Horizon oil spill. The shutdown of waters in the Gulf of Mexico delayed the project and also had a major impact on workers within the fisheries and fish processing industries in nearby Bayou La Batre, Alabama. The seafood workers reflect the demographics of a town where the poverty rate hovers around 28 percent and about 32 percent of the population is Asian American, primarily of Vietnamese, Cambodian, or Laotian descent. Focus groups conducted by The Nature Conservancy found that as many as three-quarters of Asian Americans in the community derived at least a portion of their income from seafood-related businesses, which all suffered tremendously from the spill. As part of the oyster reef restoration project, The Nature Conservancy partnered with a local social service agency, Boat People SOS, to employ out-of-work fishermen and processing workers to construct and bag oyster shell for the reef project. This helped provide much-needed income to families at a critical time. The project stands as a model for reaching affected, disadvantaged workers for employment in future restoration projects along the Gulf.[127]

better connect existing training programs and local workers to restoration contractors, who will be ramping up their work in coming years as Louisiana launches its 50-year, $50 billion plan for coastal resiliency.[126]

Ecosystem restoration is not just good for coastal workers; it is good for other businesses too. In fact, hundreds of companies across the country are engaged in designing and constructing restoration projects and providing the necessary technology and equipment to get the job done.[128] Initial estimates put the annual market for ecosystem restoration services in the United States at $10.6 billion.[129] Ecosystem restoration is also a growing portion of the more than $100 billion annual water management market.[130] As U.S. companies develop innovative solutions to coastal challenges here at home, restoration could prove a new export industry. SwissRe, a global reinsurance firm, estimates that countries will be investing as much as $120 billion in coastal adaptation efforts by 2020 in response to climate change.[131]

Oyster restoration with a side order of innovation

Oyster reefs are beginning to gain attention from the private sector, in addition to the environmental community. Oyster aquaculture is on the rise nationwide, with high-end restaurants serving new variations of oysters from Maine to Louisiana to Puget Sound. But they do not only provide a tasty and profitable harvest; they also deliver a tremendous number of ecosystem services that coastal communities depend on, including fish habitat, improved water quality, and reduced sediment erosion. Still, oyster reefs in the United States and around the world are under threat due to a range of issues, including poor water quality, development impacts, and climate change. To counteract these threats, a new industry has sprung up in recent years that is comprised of inventors and small businesses engaged in restoring oyster reefs. In total, more than 132 U.S. businesses are engaged in elements of oyster reef restoration, of which more than 85 percent are small businesses.[132]

Two of the case studies—Virginia Seaside Bays and Mobile Bay, Alabama—contained oyster reef restoration projects. One example of a small business that has taken advantage of this opportunity is Coastal Environments Inc., a contractor that participated in the Coastal Alabama Restoration Project. While the oysters being grown in Mobile Bay are not targeted for commercial harvest, Dr. Sherwood "Woody" Gagliano—one of the first scientists to investigate coastal land loss along the Gulf Coast—and his son Mark have found a way to profit from these activities. They invented ReefBlk™, a patented structure used to accelerate the growth of oyster reef across the Gulf of Mexico. Their firm builds a welded metal triangle filled with geotextile bags of oyster shells for installation in near-shore areas. Their business prides itself on employing local welders, many of whom transitioned from the fishing industry in the aftermath of the BP spill and Hurricane Katrina. The innovative product hopes to one day serve as a natural-fish- and bird-friendly alternative to engineered bulkhead and other erosion control structures that are currently used along the coast.

Recommendations

Previous reports have clearly shown the value of coastal restoration projects in terms of economic development and job creation. This new analysis brings scientific confirmation of an additional logical conclusion: Restored coastal ecosystems provide long-term economic benefits to society. This analysis reveals that, averaging the benefit-cost ratios across the three restoration projects studied, each dollar invested by taxpayers returns more than $15 in net economic benefits.

Over the three restoration projects studied, more than $15 in ecosystem service benefits will be returned for every dollar invested by taxpayers.

As CAP and Oxfam found in the 2010 report "Beyond Recovery," which focused on helping the Gulf Coast in the aftermath of the BP Deepwater Horizon oil disaster, the aggregate economic effect of a sustained investment in the coastal restoration industry can lead to the establishment of centers of excellence and other exportable expertise. This will create an industry with employment and revenue contributions to coastal regions, particularly along the Gulf Coast, that will be greater than the sum of the individual component ecosystem restoration projects.[133]

As a result, this report recommends the following actions to promote additional investment in and analysis of coastal restoration projects, which will lead to the dramatic environmental and economic benefits described earlier.

Increase federal, regional, and private-sector investment in coastal wetlands restoration projects and fund ongoing monitoring of previously restored areas

While federal funding is difficult to come by in today's political climate, this report shows that a continued investment can pay dividends to American taxpayers. In addition to the potential for job creation and economic development, the result of these labors can benefit a number of other economic sectors for generations to come. The commercial fishing, recreation and tourism, and insurance industries can all benefit and should consider their own investments in restoring degraded coastal wetlands and ocean ecosystems.

Furthermore, in order to quantify these ongoing benefits, the U.S. Department of Commerce should continue to fund scientific monitoring of restored areas through NOAA to help capture learning, encourage innovation, and promote experimentation. This work will ensure that future investments provide the greatest return across all economic sectors.

Congress should enact and fund the National Endowment for the Oceans

In 2010, Sens. Sheldon Whitehouse (D-RI) and Olympia Snowe (R-ME) introduced legislation to establish the "National Endowment for the Oceans, a dedicated, off-budget funding stream of that would fund state, regional, and federal priorities, including coastal restoration activities[134] . Since then, Sen. Whitehouse has worked tirelessly to pass its framework into law. It was included in the version of the RESTORE Act that passed the Senate in 2012 but was not included in the final version of the bill that President Obama signed into law. It has also been included in the Senate version of the Water Resources Reform and Development Act. This legislation is currently in conference with the House and is expected to be enacted later this year. The fate of the National Endowment for the Oceans remains in limbo, however, pending the outcome of congressional deliberations.

If the framework establishing a National Endowment for the Oceans is enacted, Congress should seek every opportunity to begin funding this account as it has done with the Land and Water Conservation Fund. If the endowment fails to be enacted this time around, its proponents in Congress must continue to prioritize it and the ongoing availability of funds for ocean and coastal programs so that managers can be assured of a consistent, off-budget revenue stream.

Gulf of Mexico states should set aside a significant portion of their RESTORE Act funding to invest in coastal restoration projects

The RESTORE Act, enacted in 2012, would implement a recommendation of CAP and Oxfam's "Beyond Recovery" report that would require the federal government to send 80 percent of BP's Clean Water Act fines from the 2010 Deepwater Horizon oil spill to the Gulf Coast states for economic development and ecological restoration.[135] The law divides civil penalties for violation of the Clean Water Act into three separate funds:

1. A state allocation fund that equally distributes 35 percent of the total fund to the Gulf Coast states—or in the case of Florida, to the coastal counties—for an array of eligible uses, including ecosystem restoration, land conservation, flood protection, job training, seafood promotion, and tourism.

2. A fund focused on ecosystem restoration giving 30 percent of the total fund to a comprehensive plan developed by the Gulf Coast Ecosystem Restoration Council, a collaboration of state and federal agency heads.

3. An oil spill allocation fund, which splits 30 percent of the funds, based off of a formula to define the impacts of the spill, across the five Gulf States for the same variety of eligible uses of the state allocation.

The RESTORE Act's Gulf Coast Ecosystem Restoration Council, which includes federal and state decision makers, has taken critical steps toward restoring coastal and marine ecosystems along the Gulf, including releasing a much anticipated comprehensive plan for restoration in 2013.[136] Still, in some states, early planning efforts for use of state-specific funds have lacked a focus on ecosystem restoration. According to some analysts, a lack of transparency in many of these states also contributes to questions about whether RESTORE Act funds will be used to restore economically and socially important ecosystems. While Louisiana has set an example by agreeing to spend its money on coastal restoration and flood protection, other states should focus on spending a significant portion of their funds on restoring ecosystems.[137]

Additionally, a separate process, called the Natural Resource Damage Assessment, has led to a disappointing lack of focus in ecosystem restoration. According to the Ocean Conservancy, only 9 of the 44 projects selected by trustees—including NOAA; the U.S. Department of Interior, or DOI; EPA; the U.S. Department of Agriculture, or USDA; and representatives of the governors of Alabama, Florida, Louisiana, Mississippi, and Texas—could qualify as ecosystem restoration.[138] The other projects—including boardwalks and expansions of science centers to compensate for loss of recreational use during the spill—are possible under the law but fail to support the long-term health and resiliency of spill-damaged ecosystems.

Opportunities also exist along the coast to better connect workers to jobs and training in forthcoming ecosystem projects. Two states, Louisiana and Mississippi, have passed laws to promote the consideration of local workers in restoration efforts.[139] Additional policies and investments at the federal and state levels could promote job training and build new partnerships within the community. In particular, the Gulf Coast Ecosystem Restoration Council could adopt contracting terms and policies to give preference to local workers and support new pathways to jobs and training for low-income and displaced workers on restoration project.[140]

Federal, regional, state, and local coastal planners should give greater weight to natural solutions that protect at-risk developed areas

While the RESTORE Act represents a rare funding opportunity for states along the Gulf Coast, it is no secret that federal funding is extremely difficult to come by in the current budget and economic climate. At the same time, the increasing frequency of extreme weather events and perpetually elevating sea levels have made increasing preparation for disaster a priority for many coastal communities. Traditionally, the primary solutions have been increased armoring of shorelines and other man-made, physical infrastructure projects to gird against inundation.

Yet as we learn more about natural or green infrastructure as a means of community protection, these solutions are becoming more popular. Their value was clearly shown in the aftermath of Superstorm Sandy, where one community in the Rockaways section of New York City that was protected by a secondary dune system experienced far less storm-related damage than its neighboring communities.[141] Factoring in the additional long-term economic benefits of restored coastal ecosystems should lead coastal planners at all levels of government to prioritize natural solutions wherever possible.

In addition, planners should reframe their metrics for evaluating the potential uses of the coastal areas under their jurisdiction. Additional research to understand the mechanics of natural coastal protection will reinforce this potential benefit and lead to smarter, more efficient investment of the limited available funding.

DOI, EPA, and NOAA should collaborate with DOL to develop pathways into craft and STEM careers related to ecosystem restoration

Ecosystem restoration involves a range of career opportunities—both in construction crafts such as welding, pipefitting, and heavy equipment operation and science, technology, engineering, and math, or STEM, fields—that are likely to be in high demand in many communities for years to come. Many of the jobs in restoration provide above-median wages even with only a two-year degree and a potential pathway out of poverty for low-income coastal workers. An opportunity exists to create partnerships between job training institutions and ecosystem restoration project sponsor agencies to help prepare the next generation of scientists, engineers, and trades workers.

Strong examples exist for connecting natural resource and environmental programs to job training and career paths, including EPA's Environmental Worker Training Program and the 21st Century Conservation Corps. In particular, efforts should be made to connect low-income and disadvantaged workers to such programs, as they are typically underrepresented in these jobs. In areas where significant regional restoration is underway, such as San Francisco Bay, the Gulf Coast, and the Chesapeake Bay, the U.S. Department of Labor should find ways to leverage existing training resources and better align them to program needs. In particular, efforts should be made to coordinate federal resources supporting on-the-job training connected to restoration projects and give new opportunities and apprenticeships to disconnected youth.

NOAA and partner organizations should seek funding to apply this report's evaluation techniques to the other ARRA-funded coastal restoration projects

This report shows that there is tremendous value in ecosystem services from restored coastal wetlands. But additional work will be required in order to have a stronger foundation on which to build support for future investments. Conducting a similar analysis of the remaining 47 sites where restoration work was undertaken with NOAA's ARRA funding would lend greater certainty and clarity to this work. It would also allow comparisons between different types of projects, including dam or marine-debris removal, and bring a diverse geographic distribution into play.

Conclusion

As we try to manage risk and protect communities from the looming threat of climate change and the increasing frequency of extreme weather events, we must prioritize solutions that work on multiple levels. As this report shows, coastal restoration is just such a solution.

Previous work already established that restoration activities provide jobs and economic development, including the potential to develop new industries and centers of excellence. This could establish American coastal communities as leaders in this emerging field. Healthy ecosystems have also proven effective at diffusing storm surges, boosting water quality by filtering pollutants, increasing marine biodiversity, and providing nurseries for commercially important fish and shellfish species. And they provide additional areas for recreation and tourism that raise real estate values, generate economic activity, and give local residents additional opportunities for relaxation and spiritual fulfillment.

The data contained in this report have started to quantify the overall economic effects of these services and make a clear economic argument for additional investment in healthy coastal ecosystems. At minimum, the investment translates to a direct boost in short-term job creation and economic activity. But well-designed projects can give back as much as $8 to $24 in benefits for every $1 invested. That should be enough to make economists, politicians, and coastal managers stand up and take notice.

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