HURRICANE SANDY AND THE VALUE OF TRADE-OFFS IN COASTAL RESTORATION AND PROTECTION

Prepared for:
NOAA Office for Coastal Management
Silver Spring, MD

Prepared by:
Eastern Research Group, Inc.
Lexington, Massachusetts

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FIGURES

EXECUTIVE SUMMARY

ES.1 Overview

On October 29, 2012, Hurricane Sandy struck the New York-New Jersey area causing $50 billion in damage (NHC, 2012) and resulting in the 117 fatalities in Connecticut, Maryland, New Jersey, New York, Pennsylvania, and West Virginia (CDC, 2013). Sandy provides opportunities to restore habitats and make informed decisions that take into account the full range of benefits offered by the restoration options. A key input into those decisions should be the economic value that restoration would create. Ecosystems provide a myriad of goods and services (ecosystem services) and those services have value to society. Ultimately, the value of restoration work rests in the value of the restored ecosystem services. Additionally, there is an active debate on whether living shoreline options or shoreline armoring offers better protection and more value to those being protected. This report provides information on the economic value of ecosystem services that can be used in making restoration and coastal protection decisions. We do this by providing the results of four analytical components addressed under this project:

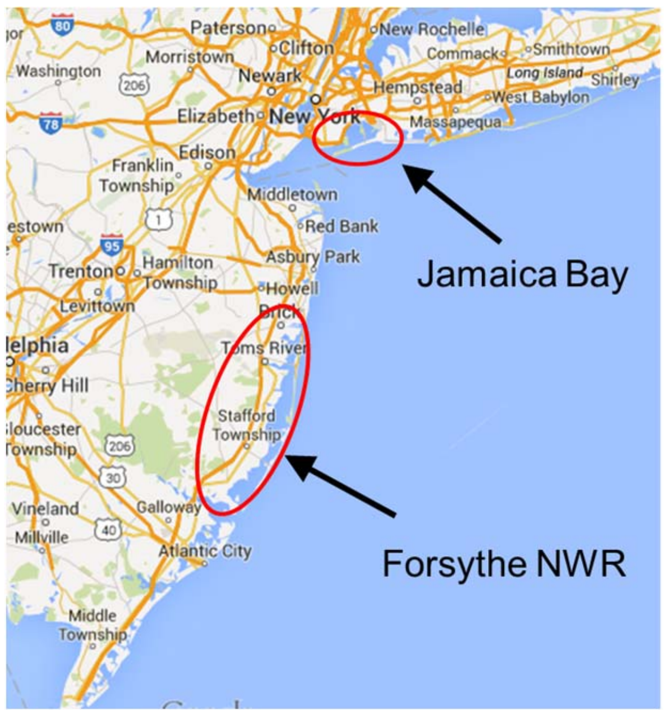

Figure ES-1 – Study Areas: Forsythe National Wildlife Refuge and Jamaica Bay (Source: Google Maps)

1) **Salt marsh restoration at Forsythe National Wildlife Refuge (NWR)** – We present estimates of the value that people place on trade-offs between ecosystem services provided by salt marshes. This was done by implementing a choice experiment survey in the New Jersey area.

2) **Preferences and values for shoreline armoring versus living shorelines** – This was done by implementing a discrete choice contingent valuation survey in the New York City (NYC) area using Jamaica Bay as the context for coastal protection. The results provide decision-makers with information on people's preferences for and valuation of shoreline armoring and living shorelines.

3) **Benefit transfer guidelines** – We present a set of guidelines that decision-makers can use to implement benefit transfers in restoration decisions and provide two case studies to demonstrate their use. The purpose of the guidelines is to provide decision-makers with a means of obtaining economic value information in the near term (i.e., not having to wait for

a complete primary valuation study to be performed or when funding is not available for a primary valuation study) to influence restoration decisions.

4) **Social cost of carbon** – We present an estimate of the social cost of carbon associated with salt marsh restoration at Forsyth NWR. This component provides a method and information that can be used for estimating carbon sequestration benefits from marshes.

ES.2 Valuing Trade-Offs in Ecosystem Services in Salt Marsh Restoration

The Forsythe National Wildlife Refuge spans nearly 47,000 acres and extends for 50 miles along the coast of New Jersey from Brick Township southward to five miles north of Atlantic City. The wildlife refuge serves as a regional attraction, with an estimated 100,000 visitors each year. The refuge is protected and managed for its coastal wetland habitat, which includes salt marshes and coastal forests and the wildlife that rely upon the wetland habitat, particularly wintering and migratory birds. There were several types of damage to the refuge resulting from Hurricane Sandy:

- Removal of sediment from coastal marshes
- The site's freshwater impoundment was inundated with highly saline bay water, which caused the elimination of freshwater invertebrates (e.g., crabs) and impacts to migratory birds reliant upon that habitat
- Flattening of dunes, particularly in the Refuge's Holgate Unit that resulted in sand being pushed into salt marshes
- Storm surge resulted in down trees and forest damage
- A 22–mile long debris field in the refuge's sensitive coastal marshes and wetlands, including contaminants from boats, fuel oil tanks, chemical drums, and other hazardous materials

Restoration efforts to address the impacts of Hurricane Sandy at Forsythe are being led by the U.S. Fish and Wildlife Service (FWS), who manages the refuge. FWS is aiming to restore and enhance the salt marshes of the refuge to increase storm protection as well as "associated social, economic, and recreational values" for nearby communities (USFWS, 2015). For marsh restoration, FWS is raising the elevation of the marshes by placing new sediment on the marsh (also referred to as "thin layer deposition").

The Forsythe valuation survey was implemented in August of 2015 and involved collection of data from 531 respondents. The choice experiment included four ecosystem services: bird habitat, recreation, protection of homes from storm surge, and protection of homes from non-surge flooding. We also included the number of acres being restored to capture how people valued the size of the restoration efforts and to capture the ecosystem services we did not explicitly include. Bird habitat and recreation were included in qualitative forms ("no improvement," "minimal improvements," and "significant improvements"). The statistical estimates indicated that households valued protection of homes from surge and protection of homes from non-surge flooding equally; this led us to develop a combined estimate for homes protected from flooding (surge and non-surge combined). Thus, our best estimates resulted in values for:[1]

- Minimal improvements in bird habitat
- Significant improvement in bird habitat
- Minimal improvements in recreation
- Significant improvement in recreation
- Protection of homes from flooding (surge and non-surge related)
- The number of acres being restored

Table ES-1 summarizes the estimated willingness to pay (WTP) values.

Table ES-1 – Estimated Willingness to Pay for Changes in Ecosystem Services in the Forsythe Analysis

Ecosystem Service/Level	Estimated WTP Values (per Household per Year)
Minimum bird habitat improvements	$50.33
Significant bird habitat improvements	$90.95
Minimum recreation improvements	$30.71
Significant recreation improvements	$45.35
Protecting 5,000 homes from storm surge	-
Protecting 5,000 homes from non-surge flooding	-
Protecting 5,000 homes from surge or non-surge flooding	$9.95
Restoring 1,000 acres of salt marsh	$8.96

We also explored how WTP varied with distance from Forsythe to assess how WTP values decline over distance from a restoration site. Comparing WTP amounts between those who live 100 miles from Forsythe and those whole live within a mile of Forsythe, we found that households living 100 miles away were willing to pay:

- 60 percent of the amount that households within a mile of Forsythe are willing to pay for protecting 5,000 homes from flooding
- 95 percent of the amount that households within a mile of Forsythe are willing to pay for minimal or significant bird habitat improvements
- 35 percent of the amount that households within a mile of Forsythe are willing to pay for minimal recreational improvements and 49 percent of the amount for significant recreation improvements

Finally, we explored how WTP varied with the reported impact of Sandy on the survey respondents. As expected, WTP increased as the reported impact of Sandy also increased. We found

[1] The survey instrument we used defined “minimal” and “significant” improvements for the respondents for both habitat and recreation.

that households that reported no impact of Sandy were not willing to pay anything for protecting homes from flooding, very little for minimal recreation improvements (approximately $2 per household per year), and slightly more for significant recreation improvements (approximately $17 per household per year). On the other hand, those who reported no impact were still willing to pay close to $70 (per household per year) for significant bird habitat improvements.

ES.3 Valuing Trade-Offs in Coastal Protection

Jamaica Bay is part of New York City and sits south of Brooklyn and Queens. Much of Jamaica Bay consists of salt marsh, although much of the historical marshlands in the Bay have been lost to open waters and mud flats. The Bay offers habitat to more than 300 species of birds and over 100 species of fish. The Bay is protected from the Atlantic Ocean by the Rockaway peninsula which contains a number of towns and communities. The Jamaica Bay area suffered significant damage from Hurricane Sandy. The communities along the Rockaway peninsula (Breezy Point, East Rockaway, West Rockaway, and Far Rockaway) all suffered significant property damage, as well as significant damage to beaches and dunes along the Atlantic-facing side. The community of Breezy Point, which sits at the end of peninsula, was particularly hard-hit with a fire that consumed more than 130 homes. Communities inside the Bay were also hard-hit with flooding affecting areas such as Broad Channel in the middle of the Bay and Howard Beach on the northern side of the Bay.

Over the last decade, there has been an active debate on the best ways to protect areas such as Jamaica Bay from storms. Hurricane Sandy only highlighted the need to provide better information. One possible approach involves building sea walls (or flood walls) and other "gray" structures that will work to stop storm surge and strong waves caused by coastal storms and stabilize shorelines. This is often referred to as "shoreline armoring." A second approach is to build "green" infrastructure such as dunes and marshes that will also protect coastal areas, as well as provide habitat and recreational opportunities. Some of these "green" approaches are referred to as "living shorelines."

ERG developed and implemented a discrete choice contingent valuation survey in the Jamaica Bay area that asked respondents about their preferences between shoreline armoring and living shoreline approaches for coastal protection. The survey included costs for the different options and varied the level of protection offered by each and the time each would last. This allows us to place a monetary value on the trade-offs that people are willing to make between the two options taking into account the level of protection being offered and the time that protection would last.[2]

The survey was implemented in July and August of 2015 and resulted in collection of data from 541 respondents in the New York City area. Based on the survey data, ERG estimated WTP values for living shorelines and shoreline armoring using two approaches. First, we estimated WTP values using the

[2] However, the statistical results indicated that respondents' WTP were not influenced by varying the levels of protection or longevity of protection.

Turnbull method, which provides a lower bound estimate of WTP; these estimates reflect what households are at least willing to pay for each coastal protection option. Second, we estimated WTP for each coastal protection option using a conditional logistic regression model; the statistical modeling results provide what we can consider a mean WTP value.

The results of both approaches appear in Table ES-2. The lower bound estimates for WTP were $110 per household per year for living shorelines and $33 per household per year for shoreline armoring. The mean WTP estimates were $278 per household per year for living shorelines and $59 per household per year for shoreline armoring. Thus, ERG found that households are willing to pay 3.3 times more for living shorelines compared to shoreline armoring in the lower bound WTP case and 4.7 times more in the mean WTP case. These ratios can be used by coastal decision-makers who are considering either living shorelines or shoreline armoring as a coastal protection measure. Specifically, if the costs of a living shoreline project are less than 4.7 times the cost of a shoreline armoring project, then the living shoreline project should be seriously considered; if the cost of the living shoreline project is less than 3.3 times the cost of the shoreline armoring one, the living shoreline project should be strongly preferred.[3]

Table ES-2 – Estimated WTP Value for Living Shorelines and Shoreline Armoring Using Turnbull Method and Statistical Modeling

Coastal Protection Option	Turnbull Method: Lower Bound WTP Estimates (per household, per year)	Statistical Modeling: Mean WTP Estimates (per household, per year)
Living shorelines (LS)	$110	$278
Shoreline armoring (SA)	$33	$59
Ratio of LS to SA	3.3	4.7

ES.4 Using Benefit Transfer to Assist in Restoration Decision-Making

ERG also developed a set of guidelines for applying benefit transfer approaches to restoration projects. This aspect of our project was inspired from the initial scoping work we performed under this project. NOAA's initial hope was to inform restoration decisions in the wake of Hurricane Sandy. As we researched potential areas, however, we found that the time-frame for making investments in restoration decisions was more immediate (i.e., needed in the short term) and ERG's work would not be able to influence those decisions. In researching Jamaica Bay, however, we determined that a number of projects were underway or had been proposed. Many of these were planned under New York State's NY Rising Community Reconstruction program (or, "NY Rising program").[4] NY Rising's descriptions for these projects contained information on the costs and benefits of the projects, but ERG found that the benefit descriptions were usually qualitative and often just re-iterated the project specifications. Costs, on the other hand, were better defined for the projects. Based on this, NOAA saw a need for providing

[3] This comparison approach is based on a benefit-cost ratio comparison.
[4] http://stormrecovery.ny.gov/community-reconstruction-program.

decision-makers with some guidance on how to develop quantitative information on benefits of restoration projects to better inform decisions.

The guidelines we developed consist of a set of steps to use in applying benefit transfers and a set of guiding principles. Appendix E of this report contains more details on the steps and the guiding principles. The guiding principles are:

1. **Use/rely on economic expertise in developing benefit transfers.** Benefit transfers take values estimated using economic valuation techniques at one location (a "study site") and apply those values (with some adjustment) to another location (a "policy site"). This process involves multiple crucial decisions that are best made by someone with economic expertise.
2. **Benefit transfers are a good choice for situations where information is needed in a short amount of time.** Developing a study that is specific to the restoration work will take time (and resources). However, the timeline for deciding on restoration work may be short. Benefit transfers can be done in a relatively short amount of time, usually within a few months.
3. **Benefit transfer values should be only *one* input into any decision-making process.** More specifically, we do not recommend that a value (or values) derived from a benefit transfer process be used as a sole (or driving) factor in making decision.
4. **If possible, work on the benefit estimates as the projects are being scoped/defined.** It is preferable to have economists working on the benefits estimates during the project scoping, or to at least have them sitting in on the meetings where the work is being defined.
5. **Post-disaster restoration differs from the context in which most value estimates are made.** Most studies that estimate the benefits of ecosystem services are not focused on post-disaster restoration. That matters for understanding benefit values. In the immediate wake of a disaster, the relative values that people place on different restoration options will mostly likely differ from what they were before a disaster. As the disaster fades from memory, people's relative valuation of restoration options will continue to evolve, but may never revert to pre-disaster levels. In using benefit transfer values, one should keep in mind that relative values can and will change in post-disaster situations and that the values being used in the transfer may not fully reflect the relative values of stakeholders who experienced the disaster.
6. **All benefit transfers involve error.** There are a number of reasons why benefit transfers involve error. First, study sites and policy sites will differ. Even if an economist can make adjustments based on data, some differences between the physical environment and the social characteristics will remain between study and policy sites. These differences generate some level of error. Second, a study that estimates benefits at a study site has some error itself. Specifically, if statistical procedures are used, the resulting estimates will end up with some confidence level around the final value. In summary, taking estimates from one site or sites (the study site(s)) and applying the estimates to another site (policy site) is an imperfect process.

7. **Benefit transfer may be better used to compare across projects rather than to assess the worth of any one project.** If only one restoration project is being considered, using benefit transfers to assess the value of the project is worthwhile. The resulting benefit estimate can provide a sense of whether the project will generate net benefits, subject to the errors involved. ERG expects a better approach would be to use benefit transfers to compare across projects.
8. **Look for specific studies first (or multiple studies to calculate an average) and then fill in any "gaps" using meta-function transfers.** There are a number of ways to perform benefit transfers: (1) find a specific study and use the value from that study, (2) use an average value from multiple studies, (3) apply the statistical function from a previously-estimated study, or (4) use a meta-function estimated from multiple studies. The process we recommend involves first applying (1) and (2) from above and, if no *directly relevant studies* are available, to turn to using a meta-function.
9. **Calculate benefits over a reasonable time frame.** The benefits will accrue to people over time, but costs are incurred up-front on restoration work. The benefits should be calculated for a reasonable time frame and the net present value of the benefits should be compared to costs.
10. **Do not necessarily aggregate over different benefit estimates.** In cases where benefit estimates for different ecosystem services are drawn from different studies, care should be taken in adding up the values. Additionally, care should also be taken in adding up estimates from a single study if the study used different methods to estimate different values.
11. **Always assess the possibility of double counting, especially if more than one study is being used.** When using more than one study to estimate benefits, it's necessary to understand if double-counting is occurring.
12. **The area being improved by the restoration work may be larger than then area where work is being performed.** The costs and project specifications for restoration work may involve a relatively small area compared to the area that benefits from the work.

We developed these principles and the steps to take by applying benefit transfer to two case studies in Jamaica Bay: a salt marsh restoration project at Sunset Cove in Broad Channel and the restoration of Upper and Lower Spring Creek Park in the Howard Beach section of Jamaica Bay. The Sunset Cove case study involves restoration of a former marina to a 13-acre salt marsh. The Spring Creek park case study involves restoration of 175 acres of salt marsh. We identified a relevant study from the Peconic Estuary System (PES) on the eastern end of Long Island to use (Opaluch, et al., 1999 and Johnston, et al., 2002). We also identified a study that estimated state-level monetary benefits associated with storm protection from wetlands (Costanza, et al., 2008). Table ES-3 provides the 25-year present values for both case studies. The difference in the magnitudes between the two case studies reflect the difference in the sizes of the two restoration efforts. The storm protection values, it should be noted, are more than the other values combined. These values, however, should be interpreted with caution since they were derived from a study that used a long time series of storm events correlated with salt marsh areas where the events occurred to derive a per-acre value for storm protection from salt marshes. The study we used may be better suited to estimating large-scale benefits (e.g., at a state of national level) rather than deriving benefits for specific marsh areas.

Table ES-3 – Summary of Benefit Transfer-Based Estimates for Sunset Cover and Spring Creek Park Case Studies, 25-Year Present Values

Category	Description	Sunset Cove (13 acres)	Spring Creek Park (175 acres)
Recreation	The increase in willingness to pay for swimming, boating, recreational fishing, and birdwatching using an assumed increase of activity at each site.	$ 13	$570,000
Open space	The willingness to pay as capitalized into property values for living near an open space wetland.	$1.4 million [a]	$12.4 million [a]
Salt marsh productivity for commercial fisheries	The increase in commercial fisheries value from salt marshes stemming from improved food web support and improved nursery habitat.	$27,000	$405,000
Wetland and shellfish existence values	The WTP for existence of the wetlands and shellfish areas being created under the restoration at Sunset Cove the wetlands areas at Spring Creek Park.	$14,000	$9.8 million
Storm protection	The value of reduced economic impact for storms on local-area GDP associated with the restoration projects.	$4.2 million	$56.6 million

Note: all numbers are rounded from the value that appear in the main text of the report.
[a] Values are not 25-year present values; see description.

ES.5 Valuing Carbon Sequestration Benefits from Salt Marshes

One of the potential benefits of salt marsh restoration at Forsythe National Wildlife Refuge will be to improve the marsh's ability to sequester carbon. Degraded marshes release long-stored carbon into the atmosphere. Restoring degraded marshes both reduces the amount of carbon dioxide (CO_2) that is released (avoided CO_2 emissions) and results in the sequestration of additional CO_2. ERG estimated the total carbon benefit (avoided CO_2 emissions plus increased sequestration of CO_2) associated with the planned restoration work at Forsythe as well as an assumed one percent (of acres) per year restoration of the marsh at Forsythe over 25 years.

ERG reviewed literature on carbon sequestration to develop estimates of the potential amount of sequestration from the Forsythe work. This resulted in three estimates of potential sequestration: a low estimate of 1.9 metric tons (MT) CO_2 per acre per year, an average estimate of 2.4 MT CO_2 per acre per year, and a high estimate of 2.9 MT CO_2 per acre per year. We were unable to identify reliable estimates of CO_2 emissions to provide an estimate of avoided CO_2 emission, so we assumed two scenarios: (1) the amount of avoided CO_2 emissions would be the same as the amount of sequestered CO_2 and (2) the amount of avoided CO_2 emissions would be 1.5 times the amount of sequestered CO_2. As discussed in the text, these assumption provide a conservative estimate of the amount of avoided CO_2 emissions. The three sequestration rates and two scenarios for estimating avoided emissions resulted in six estimates for both restoration scenarios (planned restoration at Forsythe and a one percent of the marsh per year restoration). We then used the social cost of carbon (SCC) estimates developed by EPA (2013) to value the total carbon benefits from salt marsh restoration.

Our estimates are provided in Table ES-4. We estimated that the currently planned restoration effort at Forsythe will result in benefits valued at $416,000 to $808,000 for 2015 to 2050. Additionally, if one percent of the marsh were restored each year over 25 years, we estimate the total benefits to be between $1.6 and $3.0 million for 2015 to 2050.

Table ES-4 – Estimated Benefits for Increased Carbon Sequestration at Forsythe: Planned Restoration and an Assumed One Percent per Year Restoration Effort (2015-2050, $1,000s, $2014)

CO_2 Sequestration Rate	Planned Restoration Effort at Forsythe		One Percent (of acres) per Year Restoration Effort Over 25 Years	
	Scenario 1	Scenario 2	Scenario 1	Scenario 2
Low (1.9 MT CO_2/year)	$416.2	$520.2	$1,565.5	$1,956.8
Average (2.4 MT CO_2/year)	$531.4	$664.2	$1,998.9	$2,498.6
High (2.9 MT CO_2/year)	$646.7	$808.3	$2,432.3	$3,040.3

Scenario 1: Avoided emissions of CO_2 from degraded marsh that get restored assumed to be equal to the amount of CO_2 sequestered in the restored marsh.
Scenario 2: Avoided emissions of CO_2 from degraded marsh that get restored assumed to be 1.5 times the amount of CO_2 sequestered in the restored marsh.

SECTION 1: INTRODUCTION

On October 29, 2012, Hurricane Sandy struck the New York-New Jersey area causing $50 billion in damage (NHC, 2012) and resulting in 117 fatalities in Connecticut, Maryland, New Jersey, New York, Pennsylvania, and West Virginia (CDC, 2013). The surge from the storm exceeded 12 feet at Kings Point, NY, was close to 10 feet in other parts or New York and Connecticut, and was 8.5 feet in Sandy Hook, NJ (NHC, 2012). The aftermath of the storm involved long-term power and other utility shortages, fuel shortages, long-term sheltering of displaced residents, and a massive rebuilding effort. The extent of the damage wreaked by the storm led to Congressional action to both restore and better protect the New York and New Jersey shoreline. Although much recovery and rebuilding has taken place, there is still much to be done.

Coastal restoration following storms such as Sandy involves making informed decisions that take into account the full range of benefits offered by the restoration options. In some cases, the decisions are straightforward; bridges and roads will need to be repaired, damaged buildings will need to be rebuilt or torn down, etc. In other cases, officials may need to decide between several options. A key input into those decisions should be the economic value that restoration would create. One area where economic value should play a role is in the restoration of ecosystems damaged by storms or other disasters. Ecosystems provide a myriad of goods and services (hereafter, “ecosystem services” for simplicity) to society and those services have value to society. Ultimately, the value of restoration rests in the value of the ecosystem services that are restored. While storms and other disasters generate the need for restoration, long-term degradation of ecosystems from either man-made or natural sources can also generate the need for restoration. According to a recent NOAA and U.S. Fish and Wildlife report, coastal wetlands lost an average of 80,000 acres annually between 2004 and 2009 (Dahl and Stedman, 2013). As these acres are lost, so are the values of the ecosystem services associated with them and decisions that are made to restore wetlands should take into account the value of the ecosystem services being restored.

Taking into account the economic value from restoration decisions will involve trade-offs between different ecosystem services and between restoration and other options. This report provides information that decision-makers can use in terms of the economic value of ecosystem services stemming from restoration. We do this by providing the results of four analytical components addressed under this project:

1) We present estimates of the values of ecosystem services generated in a salt marsh restoration project being conducted at Forsythe National Wildlife Refuge (NWR) in New Jersey following Hurricane Sandy. This was done by implementing a choice experiment survey in the New Jersey area. The results of this work provide decision-makers with information on how people value trade-offs in ecosystem system services generated from salt marshes.
2) We present estimates of people’s preferences and values for shoreline armoring versus living shorelines for storm protection using Jamaica Bay in New York City (NYC) as a study

area. This was done by implementing discrete choice contingent valuation survey in the NYC area. The results provide decision-makers with information on people's preferences for and valuation of shoreline armoring and living shorelines.

3) We present a set of guidelines that decision-makers can use to implement benefit transfers in restoration decisions and provide two case studies to demonstrate their use. The purpose of the guidelines is to provide decision-makers with a means of obtaining economic value information in the near term (i.e., not having to wait for a complete primary valuation study to be performed or when funding is not available for a primary valuation study) to influence restoration decisions.

4) We use a "social cost of carbon" method to estimate the carbon sequestration benefits associated with salt marsh restoration at Forsyth NWR.

1.1 Purpose

This report summarizes a two-year long effort by Eastern Research Group, Inc. (ERG) to value trade-offs in coastal restoration decisions. NOAA tasked ERG with developing information that could be used to assist decision-makers in deciding among restoration options. An original intent was to provide some input into restoration decisions being made in the immediate wake of Hurricane Sandy; however, funding for Sandy-related restoration work needed to be allocated in the short term and ERG's work would not be done in time to provide that input. NOAA and ERG agreed that the project should focus on developing information and tools that would be useful to future restoration decisions, using the work in response to Sandy as a backdrop.

Thus, one of the key purposes of this work is *transferability*. This principle guided our selection of analytical components. First, the outputs from this project should be useful in other areas. For example, our estimates of the relative values that households place on living shorelines compared to armored shorelines provides coastal decision-makers with a ratio to use in assessing the relative cost of projects. That ratio can be used to compare living shoreline and armored shoreline projects to assess which one would be preferred based on relative costs and benefits. Additionally, the willingness to pay (WTP) results from the Forsythe study can be used as inputs into benefit transfers to help place an economic value on restoration efforts. Second, this report is meant to convey the transferability in an understandable format. In that sense, we spend less time discussing the details of economic or statistical methods and more time discussing the results and the implications of the results for assisting decision-makers in assessing restoration options.

1.2 Overview

ERG's work early in the project focused on identifying potential opportunities to estimate the economic values of restoration work. A first step involved identifying specific geographic areas to focus on. Following a series of discussions with the U.S. Army Corps of Engineers' (USACE's) New York and Philadelphia District Offices, NOAA and ERG agreed to focus on the Forsythe National Wildlife Refuge in New Jersey and Jamaica Bay in New York City. These are depicted in Figure 1. Next, ERG worked to identify restoration projects that would be useful for conducting economic valuation.

Forsythe NWR

At Forsythe NWR, NOAA and ERG considered and discussed three potential restoration projects:

- A large-scale salt marsh restoration project covering several thousand acres of marsh. The project involves thin-layer placement of sediment to raise marsh elevation levels and improve tidal flow into and out of the marsh.
- Removal of unused telephone poles that have been in the marsh for several decades.
- Removal of debris that was washed into the marsh from Hurricane Sandy.

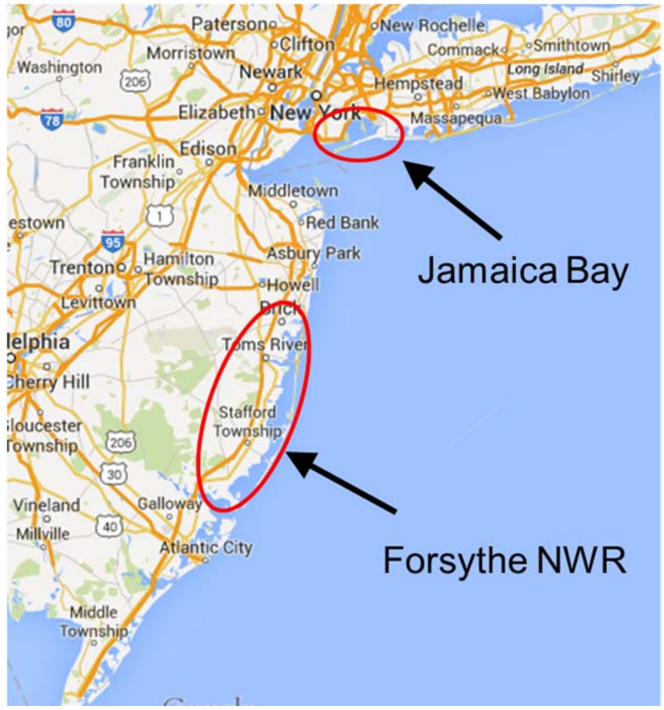

Figure 1 – Study Areas: Forsythe National Wildlife Refuge and Jamaica Bay (Source: Google Maps)

NOAA and ERG agreed that the salt marsh restoration work offered the best opportunity to develop information that could be used in future restoration decisions.

To value the work being done in Forsythe NWR, ERG developed a choice experiment survey and an analysis of the value of carbon sequestration in the marsh. Salt marshes provide a number of ecosystem services, including coastal storm protection, flood protection, contaminant containment, habitat, recreation, food web support for fish, and carbon storage. Salt marsh restoration projects will usually improve several of these services at the same time. Nevertheless, some restoration projects may focus on some services while others will focus on different ecosystem services. For example, some marsh restoration work may focus on storm and flood protection benefits, while others may focus on habitat improvements for birds or fish. ERG determined that information was needed to help decision-makers understand how people value trade-offs between the different services stemming from salt marshes. To do this, we developed a choice experiment survey. A choice experiment asks respondents to choose between restoration options (including a "do nothing" option) that vary the levels of services being provided by the option. When the options are combined with costs for implementing the options, it is possible to value the trade-offs that people make. In our choice experiment, we focused on four ecosystem services: storm protection, flood protection, bird habitat, and recreation. The reason for this focus is discussed in more detail in Section 2.

The choice experiment survey approach works well for most of the services in the list above since those services benefit people who are located near the site being restored. Improvements in carbon sequestration, however, will have global benefits. Thus, to assess the value of carbon sequestration, ERG used the "social cost of carbon" method. We describe this in more detail in Section 5.

Jamaica Bay

Selecting a focus area for our project within Jamaica Bay was complicated due to the fact that there were a number of active and potential projects in the Bay. Following discussions with USACE, Jamaica Bay Eco-Watches, the American Littoral Society, and NY City Department of Parks, ERG identified some potential projects in Jamaica Bay. After considering each in turn, NOAA and ERG determined that none of the original projects we identified were broad enough to provide information that would be useful and transferable to other situations. To remedy this, ERG recommended, and NOAA agreed, to follow a broader approach in Jamaica Bay. ERG recommended performing a broad study to estimate the relative preferences and values placed on coastal protection measures in Jamaica Bay with a focus on comparing built infrastructure (e.g., sea walls) to living shorelines. Additionally, ERG also recommended developing a set of guidelines for use in applying benefit transfers to restoration decisions.

As Hurricane Sandy made landfall in New Jersey, coastal waters were swept northward into both New York harbor and into Jamaica Bay. The water swept into Jamaica Bay and flooded the communities in the Bay causing significant damage. Figure 2 provides a visual depiction of the flooding experienced by Jamaica Bay during Hurricane Sandy. A number of proposals have been put forward on how to protect the Bay from future storms. Some plans have proposed armoring approaches (e.g., sea walls or surge barriers), while others have proposed living shorelines approaches. Furthermore, the choice between built infrastructure and living shorelines for coastal protection is an active area of interest in the coastal community. Our work contributes to these debates by asking those living in or near Jamaica Bay about their preferences between shoreline armoring approaches and living shorelines. We do this through a contingent valuation survey that asks respondents to choose between a "shoreline armoring" option, a "living shoreline" option, and a "do nothing" option. In the survey, we vary the level of protection offered by each option and the lifetime of the protection to better understand what leads stakeholders to prefer one option over another. We add in a cost for each option to allow for estimating the relative value (in dollars) that stakeholders are willing to pay for storm protection. The details of this survey are discussed in Section 3.

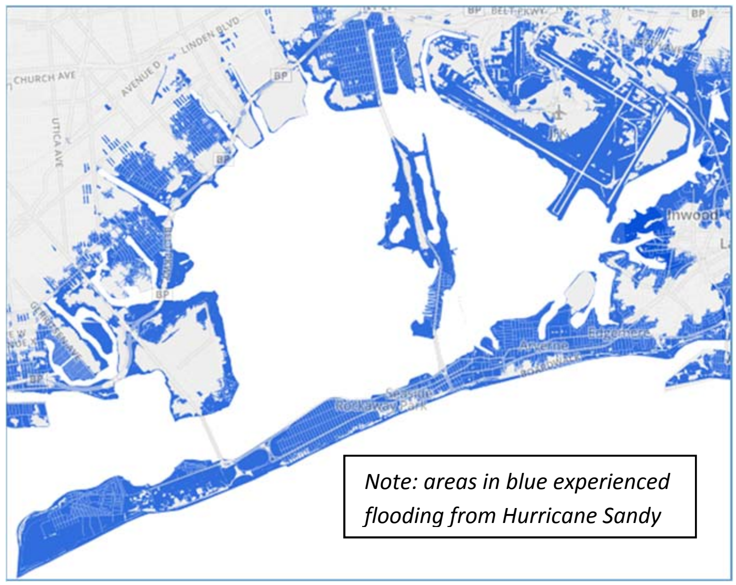

Figure 2 – Map of Flooding in Jamaica Bay (Source: Made by John Keefe, Steven Melendez and Louise Ma from the WNYC Data News Team, http://datanews.tumblr.com/)

The benefit transfer guideline component came from ERG's work in reviewing reconstruction plans being developed by the New York Rising Community Reconstruction Program (hereafter, "NY

Rising"). The Plans being developed by NY Rising for communities in New York City (NYC) all contained comprehensive and detailed information on what the project was intended to do, but contained little information on the economic value of those projects. Each project contained a "cost-benefit comparison" section that compared the qualitative benefits to an estimated value for the project cost. In reviewing these plans, ERG identified a need for providing quantitative values for benefits that could be used in assessing these plans. Furthermore, the benefit estimates would need to be developed in a short amount of time and within limited budget for valuation work. Thus, developing a set of guidelines for using benefit transfers in coastal restoration seemed a logical choice. The benefit transfer guidelines, including two case studies related to Jamaica Bay, are provided in Section 4.

1.3 Transferability and Usefulness of Project Components

This section provides some general thoughts on how the different project components will be useful in other situations. As noted, a primary purpose of this project is to develop information and methods that are transferable. Further discussion of the transferability of these components is provided in the main sections of this report.

1.3.1 Forsythe National Wildlife Refuge Choice Experiment Survey

The choice experiment survey we developed for Forsythe NWR's salt marsh restoration was designed to provide information on how people value trade-offs between levels of ecosystem service restoration in salt marshes. We focused on four ecosystem services provided by marshes: protection from storm surge, protection from (non-surge) flooding, improved bird habitats, and recreation opportunities. The information from the Forsythe survey is directly useful to the Refuge by providing a value of the work they have performed. The information on trade-offs is useful beyond the specific work being performed at Forsythe NWR. Our results indicate the extent to which people are willing to trade one ecosystem services for another and the willingness to pay for increases in specific services. The results we provide from the survey can be used to answer question such as:

- Among the four services, what do people value the highest?
- How much are people willing to pay for increases in specific ecosystem services?
- How much more of one service is required to compensate for partial loss of one of the other services?

1.3.2 Jamaica Bay Coastal Protection Contingent Valuation Survey

The survey in Jamaica Bay provides information on how people living in the New York City (NYC) area value storm protection measures. Despite the geographic focus on NYC, however, we expect the results are transferable to other areas. The survey compared protection from armoring approaches (e.g., sea walls) to protection from living shorelines. Whereas built structures may provide more immediate and stronger protection in the short term, living shorelines offer protection that may improve over time, require less maintenance, and also offer habitat and recreation benefits. The purpose of the Jamaica Bay survey was to assess the value people place on the trade-offs associated with these two general approaches to protection. Storm protection decisions need to be made not only in Jamaica Bay, but in any coastal area subject to storms. This survey provides data that can be used to assess the values that people place on different storm protection measures and can be used as one input into decisions for storm protection.

1.3.3 Benefit Transfer Guidelines for Restoration Decisions

The benefit transfer guidelines were designed with transferability in mind. We provide a set of principles and a process (set of steps) to follow in using benefit transfers in coastal restoration decision-making. Post-disaster restoration decisions often need to be made in the near term. Valuation work using surveys can, however, take a significant amount of time to perform. ERG saw a need to provide an approach that could be used in a short amount of time to provide input into the value of restoration decisions. The benefit transfer guidelines are designed to assist decision-makers, with the help of someone with economic expertise, in applying benefit transfers in a way that can be used to inform restoration decisions in a timely manner.

1.3.4 Social Cost of Carbon at Forsythe National Wildlife Refuge

One of the key services provided by salt marshes is their ability to sequester carbon. Healthy marshes will trap and hold carbon while degraded marshes will release carbon back into the atmosphere. The carbon sequestration aspect of this project provides a method (based on previous approaches) and estimates that can be used in other areas to value the benefits of marsh restoration in terms of carbon sequestration.

SECTION 2: VALUING SALT MARSH RESTORATION OPTIONS AT FORSYTHE NATIONAL WILDLIFE REFUGE

2.1 Overview

The Forsythe National Wildlife Refuge spans nearly 47,000 acres and extends for 50 miles along the coast of New Jersey from Brick Township southward to five miles north of Atlantic City. The wildlife refuge serves as a regional attraction, with an estimated 100,000 visitors each year. The refuge is protected and managed for its coastal wetland habitat, which includes salt marshes and coastal forests and the wildlife that rely upon the wetland habitat, particularly wintering and migratory birds. The refuge is considered a site of regional importance in the Western Hemisphere Shorebird Reserve Network, with a minimum of 20,000 shorebirds annually (WHSRN, 2015). The refuge is also considered a Wetland of International Importance under the Ramsar Convention, in part for the habitat and variety of wildlife that it hosts.[5]

There were several types of damage to the refuge resulting from Hurricane Sandy:

- Removal of sediment from coastal marshes
- The site's freshwater impoundment was inundated with highly saline bay water, which caused the elimination of freshwater invertebrates and impacts to migratory birds reliant upon that habitat.
- Flattening of dunes, particularly in the Holgate Unit[6] that resulted in sand being pushed into salt marshes
- Storm surge resulted in tree loss and forest damage
- A 22–mile debris field in the refuge's sensitive coastal marshes and wetlands, including contaminants from boats, fuel oil tanks, chemical drums and other hazardous materials

Restoration efforts to address the impacts of Hurricane Sandy at Forsythe are being led by the U.S. Fish and Wildlife Service (FWS), which manages the refuge. FWS is aiming to restore and enhance the salt marshes of the refuge to increase storm protection as well as "associated social, economic, and recreational values" for nearby communities (FWS, 2015). For marsh restoration, FWS is raising the elevation of the marshes by placing new sediment on the marsh (also referred to as "thin layer deposition"). USACE and New Jersey Department of Transportation (NJDOT) will supply dredged material to FWS to complete this marsh enhancement.

Conducting the thin layer enhancement of the marshes will serve two purposes in addition to raising the marsh elevation: 1) filling in linear mosquito ditches and 2) tidal flow restoration. When the additional sediment is added to the marshes, it will fill in ditches that were originally put in place to help

[5] http://www.ramsar.org/sites-countries/the-ramsar-sites

[6] The Holgate Unit is part of the Brigantine Wilderness approximately 11 miles north of Atlantic City.

control the breeding of mosquitoes. By filling in these ditches, a more natural flooding regime will be restored in the marsh. Adding sediment to the marsh will also help restore tidal flow, which is essential for carrying nutrients in and out of the marsh.

Salt marshes provide a number of benefits to society, including:

- Coastal storm protection – sand and thick grass in salt marshes protect coastal buildings and roads from surging storm waters and erosion.
- Flood protection – marshes reduce flooding by slowing and absorbing rainwater.
- Contaminant containment – marshes improve water quality for fish and bird habitats by filtering out contaminants (such as excess nitrogen from fertilizers).
- Habitat – marshes provides an important resting place for migratory birds, home for nesting birds, and space for fish and shellfish to spawn.
- Recreation – marshes provide numerous recreational opportunities such as bird watching, nature/walking trails, canoeing, and kayaking.
- Food web support for fish – biological processes in marshes provide the basis of the food web for recreational and commercial fisheries.
- Carbon storage – salt marshes absorb and store large quantities of carbon dioxide from the atmosphere, reducing the amount of carbon in the atmosphere (which can help to manage climatic change).

The Forsythe valuation work involved eliciting values that individuals are willing to pay for four of these services:[7] coastal storm protection, flood protection, bird habitat, and recreation. We used a choice experiment survey to estimate the values of each ecosystem services relative to the other services. These relative values can be used in assessing restoration decision trade-offs in the future. The results provide decision-makers with information on how people value trade-offs between protection from storm surge, protection from (non-surge) flooding, improved bird habitat, and recreation opportunities. This information can contribute to decisions on what types of restoration to perform in the future by helping decision-makers understand how people value the trade-offs. The information from Forsythe is directly useful to the Forsythe NWR by providing them with a value of the work they have performed.

2.2 Methods

As noted, ERG implemented a choice experiment survey to collect these data. Choice experiments are a more general form of a contingent valuation survey. In a standard contingent

[7] Our decision to include these four benefits and to exclude contaminant containment and food web support for fish is based on discussions we had with scientists working at Forsythe or who are familiar with the Refuge. Carbon sequestration was excluded since it can be valued using a social cost of carbon approach.

valuation survey (for a restoration project), respondents are provided with a description of the project (e.g., whether or not to restore a wetland), a description of the project's benefits, and are asked whether or not they are willing to pay a certain amount (usually in the form of increased property or income taxes) for the project to be performed.[8] The dollar amounts are varied among respondents and respondents' answers to the yes/no WTP question along with other data collected through the survey (e.g., income and attitudes) are used to characterize demand for the project.

In a choice experiment, respondents are also provided with a description of a restoration project and a description of the potential benefits of that project. The valuation question differs substantially, however. Instead of simply asking if the respondent is willing to pay a certain amount to have the project done, respondents are provided with two (or more) options to choose from, with the possibility of selecting neither one, and each option is characterized by a number of attributes. Table 1 provides the attributes we used in our survey. The attributes are listed in the "category" column and include amount of marsh restored, number of homes protected from storm surge, number of homes protected from non-surge flooding, bird habitat improvements, and recreation improvements, as well as cost. We use "attribute" to represent ecosystem services. The options presented to the respondents will have differing levels for the attributes.[9] A specific combination of levels for the attributes is referred to as a "choice profile"; when a respondent is asked to choose among a set of profiles, this referred to as a "choice set." In Table 1 "Option A" (with values inserted) is one choice profile and "Option B" (with values inserted) is another choice profile. Table 1 as a whole represents a choice set. In developing the survey, multiple choice sets were developed; in fact, we use 27 choice sets in our design. The specific choice sets that a respondent is confronted with are determined through the use a fractional factorial design (described below). Furthermore, each respondent may be provided with more than one valuation question; in our survey respondents were asked three valuation questions.

The advantages of choice experiments over a straight contingent valuation are (Holmes and Adomowicz, 2003):

1) A choice experiment allows the researcher to gain insight into how respondents value changes in the attributes that comprise a restoration project. For example, we can determine the value that people place on the number of homes protected from storm surge, the number of homes protected from flooding, improvements in bird habitat, and improvements in recreation.
2) A choice experiment allows the researcher to assess the trade-offs (in value) between attributes. This follows from #1 above; if we know how respondents value changes in attributes, we can also determine how they value those changes relative to one another.
3) A choice experiment allows the researcher to ask respondents multiple valuation questions and then uses each response to a valuation question as a separate response.

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[8] This description simplifies a standard contingent valuation survey.
[9] For example, Option A may involve 5,000 acres of marsh restoration, 3,000 homes protected from storm surge, etc. and Option B may involve 3,000 acres of marsh restoration, 1,000 homes protected from surge, etc.

For example, asking 500 respondents to vote on 3 different combinations of choice sets results in more than 500 data points that provide information on how respondents value combination of attributes (we describe this in more detail in Section 2.2.3).[10]

Table 1 – Example of Choice Experiment Valuation Question

Category	Status quo	Options A	Option B
Amount of the marsh that is restored	None	______ acres	______ acres
Storm protection	• Homes in the coastal area are under increased risk from storm damage.	• Protects ____ homes and businesses from a 5-foot storm surge (a rise of water generated by a storm that is 5 feet over and above the predicted tide level)	• Protects _____ homes and businesses from a 5-foot storm surge (a rise of water generated by a storm that is 5 feet over and above the predicted tide level)
Flood protection	• Homes in the coastal areas are under increased risk of suffering flood damage.	• Protects _____ homes and businesses from a 20-year flood	• Protects _____ homes and businesses from a 50-year flood
Habitat	• Habitats for wildlife continue to deteriorate with the marsh	• Provides {minor, moderate, significant} improvements in habitat for migratory birds	• Provides {minor, moderate, significant} improvements in habitat for migratory birds.
Recreation	• Recreational opportunities decline as the marsh deteriorates.	• Provides {minor, moderate, significant} improvements in recreation	• Provides {minor, moderate, significant} improvements in recreation
Cost	$0	$____	$_____
Vote	☐	☐	☐

2.2.1 Survey Instruments

ERG developed a survey instrument and submitted the instrument to the Office of Management and Budget (OMB) for review. Appendix A provides the OMB-approved instrument that was implemented under the project. The instrument covered a number of areas, including:

- Background for the respondent, including a description of Forsythe NWR, the impact of Sandy on Forsythe, and proposed restoration at Forsythe.
- Questions that asked about respondent's familiarity with Forsythe and issues related to restoration at the site. Included among these questions were questions that asked if the respondent had visited Forsythe recently and how many trips the respondent had taken to the refuge in the last 12 months.

[10] However, statistical adjustments are needed to be made for the fact that the 1,500 data points came from only 500 distinct respondents (Holmes and Adomowicz, 2003).

- A question that asked the respondent about the extent to which Sandy affected them personally.
- A question that asked for the respondent's zip code (used to determine how far each respondent lives from Forsythe).
- The choice experiment valuation questions that provided the respondent with background information and then followed by the attribute table described above in Table 1. Each respondent was asked three distinct valuation questions.
- A series of follow-up questions about the respondents' answers to the valuation questions.
- A set of attitudinal questions.
- A question that asked respondents about the types of outdoor activities that they participate in.

Setting Attribute Levels

As discussed above, choice experiments involve setting values for the attributes and providing choice set combinations for respondents to vote on. The values we used for the attributes are provided in Table 2. The first attribute was the number of acres being restored. Although not an ecosystem service, we felt that respondents should be allowed to react to the size of the restoration work. Forsythe provided the number of acres (approximately 3,000) and the areas of the marsh in which restoration would occur. We used 3,000 as a mid-point of the values for the attribute and selected reasonable values above (5,000) and below (1,000) the mid-point.

For coastal storm protection, we phase the values in terms of number of homes protected from a five foot storm surge. The reason for this is that some of the largest impacts from Sandy came from storm surge. The use of "five foot" surge was somewhat arbitrary, but was selected as a value below the peak surge levels in Sandy. We based the number of homes protected based on research into the communities surrounding the areas where restoration would take place. There are 34,051 houses in the five communities that border the area where the restoration will occur (Eagleswood, Little Egg, Stafford, Tuckerton, and Barnegat). In those five communities, 519 homes sustained "minor" damage (<$8,000), 2,284 sustained "major" damage ($8,000 - $28,800), and 788 sustained "severe" damage (>$28,800) from Hurricane Sandy (O'Dea, 2013). We used the 3,072 with major/severe damage as an approximate mid-point for the value and we added what we expected were reasonable values above and below 3,000.

Table 2 – Attribute Levels for Forsythe NWR Choice Experiment

Attribute	Attributes for options A and B	Status quo text
Amount of the marsh that is restored	• 1,000 acres • 3,000 acres • 5,0000 acres	• None
Storm protection	• Protects 1,000 homes from a 5-foot storm surge (a rise of water generated by a storm that is 5 feet over and above the predicted tide level) • Protects 3,000 homes from a 5-foot storm surge (a rise of water generated by a storm that is 5 feet over and above the predicted tide level) • Protects 6,000 homes from a 5-foot storm surge (a rise of water generated by a storm that is 5 feet over and above the predicted tide level)	• Homes in the coastal area are under increased risk from storm damage.
Flood protection [a]	• Protects 4,000 homes from a 20-year flood • Protects 7,000 homes from a 20-year flood • Protects 10,000 homes from a 20-year flood	• Homes in the coastal areas are under increased risk of suffering flood damage.
Bird habitat	• Provides no improvement - Habitats for migratory birds continue to deteriorate with the marsh; over time fewer birds would visit the marsh. • Provides minimal improvements in habitat for migratory birds – marsh restoration leads to a small increase in the number of birds that visit the marsh each year. • Provides significant improvements in habitat for migratory birds – marsh restoration leads to a large and noticeable increase in the number and variety of birds that visit the marsh each year.	• Habitats for migratory birds continue to deteriorate with the marsh; over time fewer birds would visit the marsh.
Recreation	• Provides no improvement - recreational opportunities decline as the marsh deteriorates; over time there would be fewer places to fish, hunt, and hike trails. • Provides minimal improvement in recreation – restoration would make some small improvements to fishing, hunting, and hiking opportunities at the marsh. • Provides significant improvement in recreation – restoration would make some large and noticeable improvements to fishing, hunting, and hiking opportunities at the marsh.	• Recreational opportunities decline as the marsh deteriorates; over time there would be fewer places to fish, hunt, and hike trails.
Cost, annually per household [b]	• $20 ($17, $18, $19, $21, $22, $23) • $65 ($62, $63, $64, $66, $67, $68) • $130 ($127, $128, $129, $131, $132, $133)	• $0

[a] In pre-tests for the Forsythe survey, most individuals that took the survey could distinguish between the storm surge and non-surge flooding; however, two individual suggested adding in clarifying language for storm surge to more clearly identify what was meant. ERG revised the survey instrument accordingly.
[b] We used three "base" values ($20, $65, and $130) in the survey. However, half of the respondents were provided with one of the values in parentheses instead of a base value. For example, if a respondent was selected to have a value of $65 and was in the sample that was selected to receive a non-base value, we inserted one of the values in the parentheses next to $65. This was done to explore the effect of using values not ending in a "0" or a "5"; we do not, however, explore this follow-on analysis in this report.

For non-surge flooding, we phrased the protection in terms the number of homes protected from a 20-year flood. The use of 20-year flood was also somewhat arbitrary, but was meant to reflect an infrequent, yet likely to occur event. There are 7,552 flood insurance policies in place in the five communities surrounding Forsythe (FEMA, 2015) and we rounded down to 7,000 and used that as the mid-point and varied it above and below.

For bird habitat and recreation, we used qualitative descriptions reflecting three levels of improvement (or non-improvement): none, minimal, and significant. Table 2 provides the text used for each.

The cost values we used represent values that are typically seen in the literature. For example, in a study on the value of restoring Louisiana wetlands, Petrolia at al. (2014) used values of \$25, \$90, \$155, \$285, \$545, and \$925 in their choice experiment. The Petrolia study, however, covered a large area of wetlands (all of Louisiana), so we restricted our range to the lower end and used \$20, \$65, and \$130. Additionally, for half of the respondents, we varied the cost value by plus or minus \$1-\$3. For example, if a respondent in the "varied cost" category was selected for the \$20 cost for an option, the respondent would not see \$20, but would see a randomly selected value from \$17, \$18, \$19, \$21, \$22, \$23 instead. The idea was to provide some respondents with a value not ending in a "0" or a "5", making the value appear to be more calculated rather than simply chosen.

Finally, Table 2 contains text used for the status quo options. An important aspect of a choice experiment is that the respondent can select a "do nothing" option (the status quo) and thus incur no additional cost.

Selecting Optimal Combinations of Attributes to Use in the Instruments

A key aspect of a choice experiment is selecting a manageable design for combining attributes in instruments while also ending up with reliable data for statistical analysis. Our design involves six attributes each with three levels which means there are 729 ($=3^6$) possible combinations of attributes; this is referred to as the full factorial. Using 729 combinations, however, would require an extremely large sample. One consideration is that some combinations will be "dominated" (unlikely to be chosen over another option) by other ones; for example, a combination with the lowest level for each attribute and the highest cost would be dominated by every other combination. ERG used fractional factorial design methods to (1) remove dominated combinations and (2) select a set of combinations that would allow for efficient statistical estimation. This process resulted in a 54 choice profiles that were combined into 27 choice sets (distinct versions of Table 1). Each of the 27 sets contain specific values for "Option A" and "Option B." The 27 sets are also combined into nine blocks of three sets each and respondents are then assigned to blocks. As discussed above, each respondent is asked three distinct valuation questions where he or she must select between two options and a status quo. For example, all respondents assigned to "Block 1" see the same three choice sets.[11] We used a number of SAS macros to

[11] However, the respondents who all see the same choice sets do not see them in the same order. We rotate the order of the sets to control for any ordering effects in the survey.

assign attribute levels to sets and blocks. We then ran simulation models to ensure the resulting assignment of sets and blocks would result in data amenable to statistical analysis.

2.2.2 Population and Sample Size

ERG worked with GfK Knowledge Networks on this data collection. GfK maintains an online panel of individuals (KnowledgePanel) who form a representative sample of the United States population (GfK, 2015). The respondents were selected from the GfK online panel from the following areas:

- The New Jersey counties of Hunterdon, Somerset, Middlesex, Monmouth, Ocean, Essex, Union, Morris in the New York-Newark-Jersey City Metropolitan Statistical Area (MSA)
- The entire Philadelphia-Camden-Wilmington PA-NJ-DE-MD MSA
- Trenton NJ MSA
- Vineland-Bridgeton, NJ MSA
- Ocean City NJ MSA
- Atlantic City-Hammonton, NJ MSA

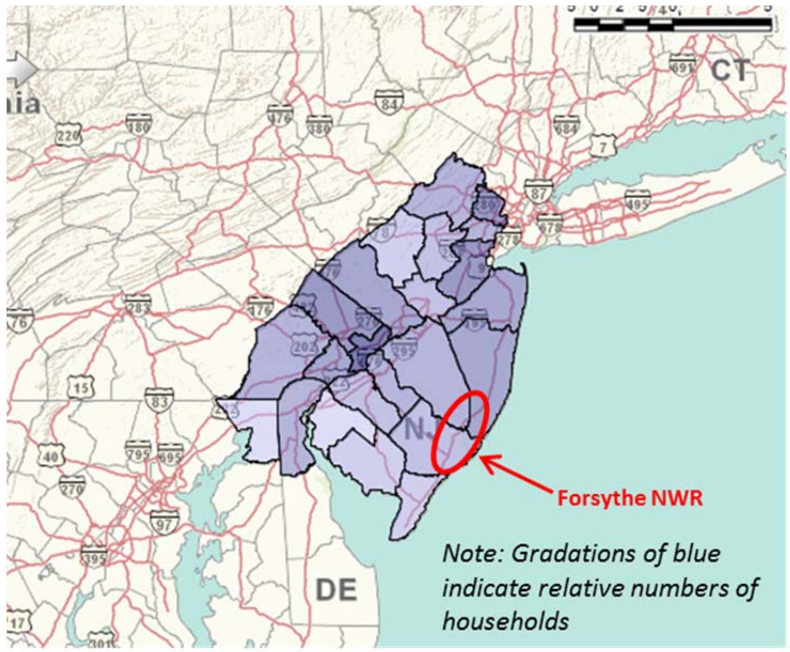

Figure 3 – Areas Included in the Forsythe NWR Survey (Source: U.S. Census Bureau, American Fact Finder

Figure 3 provide a map of the area that was used in the survey. The respondents selected for the sample reflect households in the area. According to 2015 U.S. Census Bureau data, the area we used for this survey has a total population of 4,142,629 households (Census Bureau, 2015).

The sample size for the survey was calculated using the rule of thumb developed by Johnson and Orme (1996) and summarized in Orme (2010). The rule of thumb value provides a minimum sample size needed for a choice experiment study that involves having respondents assess multiple alternatives in which the attributes of the alternatives have multiple levels. In our case, the alternatives are the options that we asked the respondents to vote on. The attributes and their levels are defined in Table 2. The rule of thumb is

$$n \geq \frac{500c}{ta}$$

where

- n is the (minimum) sample size.

- *t* is the number of tasks that each respondent is being asked to perform. In our case, this is the number of valuation questions we asked each respondent to vote on. Our original design involved asking two valuation questions and we used *t* = 2 in our sample calculation. We later refined the number of valuation questions to 3; however, at the time we increased the number to 3, we had already set the specifications with GfK for the survey. Thus, our calculation used *t* = 2.

- *a* is the number of alternatives being presented to respondents each time they are asked to vote (excluding the "status quo" or "no action" scenario). In our case, we are asking respondents to compare two options each time (*a* = 2).

- *c* is the number of levels for each attribute. In cases where the number of levels varies across the attributes, *c* is set equal to the largest number of levels for any attribute. The largest number of levels for any attribute is 3. Our calculation, however, used 4 levels as the maximum to allow for potential changes in design during pre-testing (*c* = 4).

Using these values specified above for *t*, *a*, and *c* in the rule of thumb results in an estimated sample size of 500 respondents; this was the sample we ask GfK to target in their implementation. As noted, however, the actual value for the number of valuation questions (tasks, *t*) was greater than the value we used (*t* = 3) and the actual value for the attribute levels was lower (*c* = 3). Using the actual values in the rule of thumb (*t* = 3, *a* = 2, and *c* = 3) results in a sample size of 250; thus, our targeted sample of 500 was more than adequate for our intended purpose.

2.2.3 Statistical Analysis and Valuation

To analyze the data that were collected from the survey, ERG used a conditional logistic regression analysis. Before describing our use of conditional logistic regression to derive values, we will provide some context on the analytical data set. First, respondents represented multiple records in the final analytical data set. For example, we asked each individual to make a choice from three separate choice sets and each set had three choices (e.g., "Status quo," "Option A," and "Option B"). Thus, each respondent represented nine records in the data (3 choice sets × 3 options to choose from within each set). That is, each record in the data corresponded to a choice profile. Each record had a binary variable set equal to 1 (= yes) if the respondent selected that option or 0 (= no) if the respondent did not select that option.[12] Second, for the number of homes protected from surge and the number of homes protected from non-surge flooding, we use the levels for those attributes (e.g., 1,000 and 3,000); it should be kept in mind, however, that both the number of homes protected from surge and the number protected from non-surge flooding only take on three distinct values in the data.[13] Thus, our statistical

[12] Thus, since each respondent had nine records in the data and was presented with three choice sets, each respondent must have 3 records with a "yes" in the "selected option" binary variable and 6 records with a "no."
[13] For the number of home protected from storm surge, the values were 1,000, 3,000, and 6,000 homes. For the number of homes protected from non-surge flooding, the values were 4,000, 7,000, and 10,000 homes. By design, the value for the status quo (do nothing) option was zero home protected for surge and non-surge flooding.

results for the number of homes protected reflect the change in value associated with an increase of one home; for relevancy, we multiplied the resulting estimate by 5,000 homes. Third, for the qualitative attributes we included in the model (bird habitat and recreation), we formulated binary control variables. For example, we defined two binary variables for bird habitat:

- The choice profile described a minimal improvement in bird habitat (yes = 1; no = 0)
- The choice profile described a significant improvement in bird habitat (yes = 1; no = 0)

Two similar binary variables were formulated for recreation improvements. This formulation implicitly used the "no improvement" category as the basis for comparison. Thus, our statistical results reflect the value associated with moving from no improvement in bird habitat (or recreation) to either a minimal improvement or a significant improvement. Finally, the value for cost to the respondent was used in its quantitative form; this is necessary to derive willingness to pay values.

The conditional logistic regression analysis used the binary variable for selection of the option (1 = respondent selected the option, 0 = respondent did not select the option) as the dependent variable. The independent variables were the binary variables used to represent the attributes (described above) and the cost of the option.

Respondent level characteristics (e.g., age, gender, and distance from site) cannot be used in this type of analysis directly, however, since the statistical modeling groups the records for the same respondent together; thus, variables such as age or distance from the site are the same value for each respondent and a statistical estimate cannot be calculated due to this lack of variability. It is possible, however, to interact the respondent-level characteristics with the attributes to account for factors such as distance to the site. We did this for several factors, but we report on two specific ones: distance from the respondents' zip codes and Forsythe and the impact of Sandy on the respondents. For example, we use both the number of home protected from surge and the number of homes protected from surge multiplied by the distance to Forsythe in the regression analysis. The interaction provides an indication of whether the value respondents place on protecting home from surge declines with distance from Forsythe.

To calculate willingness to pay, we divide the estimated marginal effects by the negative[14] of the marginal effect for the cost variable. Comparing the estimated willingness to pay values for the attribute levels and the different attributes provided estimates of trade-offs between levels within the attribute and between attributes.

[14] The value must be multiplied by -1 for algebraic reasons.

2.3 Data

2.3.1 Source

ERG used GfK Knowledge Network's online "Knowledge Panel" as a sample for this survey. GfK recruits its online panel members from non-internet sources using a combination of random digit dialing (RDD) and address-based sampling (ABS). The ABS sampling allows for inclusion of cell-only households; non-internet households who join the panel are provided with computers to allow them to take the online surveys. Using non-internet sources avoids some issues related to "opt-in" panels on the internet.

2.3.2 Response Rate and Descriptive Statistics

GfK performed a pre-test of the survey from August 11, 2015 – August 13, 2015, followed by full implementation from August 19, 2015 to August 24, 2015 (a total of nine days in the field including pre-tests). The survey was sent to 1,000 potential respondents and 543 completed the initial screener questions.[15] Of the 543 who were in-scope, 531 (98 percent) completed the survey. The percentage that completed the screener questions, 54 percent, represents the overall response rate among those who received the survey in the GfK panel.

Table 10 provides some basic summary statistics on the sample and compares the summary statistics to Census Bureau data for the counties that were included in the sample. The demographics can be summarized as follows:

- **Age** – The sample tends to be older than the general population with almost three-quarters of the sample being 45 or older and 45 percent being 60 or older. This is in contrast to Census Bureau data which has a near-uniform distribution across the four categories of the 18 and older population in the counties we used in the survey.
- **Education** – More than half of the sample holds a bachelor degree or higher, a percentage that is higher than the percentage in the general population for these counties (32 percent). This over-representation of those with bachelor degrees or higher comes at the expense of those with a high school education or less (18 percent in the sample, but 41 percent in the overall population).
- **Race/Hispanic Origin** – Approximately 80 percent of the sample identifies as "white," approximately 11 percent as "black," and approximately 3 percent as Hispanic. In comparison, Census reports that 69 percent of the population is white, 18 percent is African American, and 12 is of Hispanic origin in this area.[16]
- **Gender** – The sample contained 59 percent women whereas the total population in the area is comprised of 52 percent women.

[15] To qualify for the survey, respondents had to be 18 years or older and reside in the in-scope counties.

[16] GfK collects its own data on race and Hispanic origin and provided these data to ERG. Thus, our data on race and Hispanic origin reflect the GfK categories and not Census Bureau categories. Consequently, the sample data and the Census data are not fully comparable for race and Hispanic origin.

- **Household Income**[17] – The sample tends to be concentrated among higher income categories with a median income in the $75,000 to $100,000 range.[18] The distribution in the sample compares well to the income distribution found in the Census Bureau data.
- **Employment** – Approximately 49 percent of the sample is working and slightly more than one quarter of the population is retired. About 4 percent of the population falls into a category that could be classified as "unemployed" (i.e., not working and looking for work) by the Bureau of Labor Statistics (BLS). According to BLS, the unemployment rate in the New York-New Jersey metropolitan statistical area was 5.0 percent in August of 2015 (BLS, 2015a) and was 6.9 percent in the Philadelphia MSA (BLS, 2015b).

In summary, our sample for the Forsythe survey is significantly older than the general population in the area we surveyed and also tends to have a higher level of education and less representation of minority populations. On the other hand, the samples matches well in terms of gender, income, and employment status.

[17] It should be noted, that income is the only demographic variable that we summarize that is measured at the household level; all other demographics are at the individual level.
[18] The income categories we present here are compacted from the one collected by GfK to be able to compare to Census Bureau categories. More detailed income categories in the GfK data indicate that the median income is in the $75,000 to $85,000 range.

Table 3 – Demographic Summary of Forsythe Survey Sample with Comparison to Census Bureau Data for Counties Included in the Survey.

Category	Number of Respondents in Sample (N = 531)	Percentage of Sample	Percentage of Population [a]
Age [a]			
18-29	38	7.2%	24.8%
30-44	85	16.0%	24.4%
45-59	165	31.1%	27.2%
60+	243	45.8%	23.5%
Education			
Bachelor's degree or higher	285	53.7%	32.2%
Some college	150	28.3%	26.3%
High school	87	16.4%	29.8%
Less than high school	9	1.7%	11.6%
Race/Hispanic Origin			
White	423	79.7%	68.1%
Black (non-Hispanic)	57	10.7%	18.2%
Hispanic	18	3.4%	11.6%
Other	33	6.2%	6.8%
Gender			
Female	312	58.8%	51.6%
Male	219	41.2%	48.5%
Household Income			
Less than $10,000	11	2.1%	6.2%
$10,000 to $14,999	10	1.9%	4.2%
$15,000 to $24,999	24	4.5%	8.6%
$25,000 to $34,999	36	6.8%	8.4%
$35,000 to $49,999	62	11.7%	11.3%
$50,000 to $74,999	99	18.6%	16.3%
$75,000 to $99,999	98	18.5%	12.7%
$100,000 to $149,999	122	23.0%	16.3%
$150,000 or more	69	13.0%	16.0%
Employment Status			
Not working - disabled	23	4.3%	-
Not working - looking for work	21	4.0%	-
Not working - on temporary layoff	6	1.1%	-
Not working - other	39	7.3%	-
Not working - retired	141	26.6%	-
Working - as a paid employee	258	48.6%	-
Working - self-employed	43	8.1%	-

[a] Census data were taken from the Census Bureau's American Factfinder database which combines data from several sources. Data for age, race/Hispanic origin, and gender were taken from the 2010 decennial Census. Data for educational attainment and income were taken from the 2013 American Community Survey.
[b] Census data for age reflect the distribution of above 18 population only.

Figure 4 provides tabulations for respondents' familiarity with salt marshes and Forsythe NWR. Overall, respondents to the survey indicated that, prior to reading the background on salt marshes we provided, they were not very familiar with salt marshes. More than half of the respondents indicated that they were "not at all familiar" with marshes and another 20 percent indicated they were "somewhat unfamiliar." Only 3.4 percent (18 respondents) indicated they were "very familiar" with marshes. Almost two-third of the respondents indicated that they had never heard of Forsythe NWR and another 23 percent indicated that they were "not very familiar" with Forsythe NWR. Only 6 percent of respondents have ever visited Forsythe NWR with only half of those having visited since Hurricane Sandy. Despite this lack of familiarity with Forsythe, almost 60 percent of respondents indicated they were "very" or "somewhat" concerned about the Forsythe marshes after reading the background provided in the survey instrument.

Figure 5 summarizes responses to questions related to respondents' experience with Hurricane Sandy. First, only 57 percent indicated they were living in the New York/New Jersey area when Hurricane Sandy occurred. However, the Forsythe survey also included Pennsylvania; of the 43 percent who indicated they were not living in the New York/New Jersey area when Sandy occurred, 78 percent were from Pennsylvania (only 9 respondents who indicated they were not in the New York/New Jersey area when Sandy occurred were current New Jersey residents). Given the large number from Pennsylvania, we expect that most respondents were in the New Jersey/Pennsylvania area when Sandy occurred.[19] Approximately 8 percent of respondents experienced a "very significant" impact and another 27 percent experienced a "moderate" impact; 22 percent indicated they were not impacted by Sandy. Thus, overall we would expect that our survey was relevant to the respondents given the large number living the in area and the fact that most respondents experienced some impact from Sandy.

Figure 6 summarizes respondents' selection of an option in the three valuation questions compared to selecting the status quo option or refusing the answer the question. Very few respondents elected to skip each valuation question with 18 refusing the answer the first valuation question, 16 refusing to answer the second, and 12 refusing to answer the third. Nine respondents refused to answer all three questions (not depicted in the figure). For each valuation question, approximately three-quarters selected a restoration option and about 20 percent selected the status quo option.

[19] We asked about residing in the New York/New Jersey area since the two states were hardest hit by Sandy.

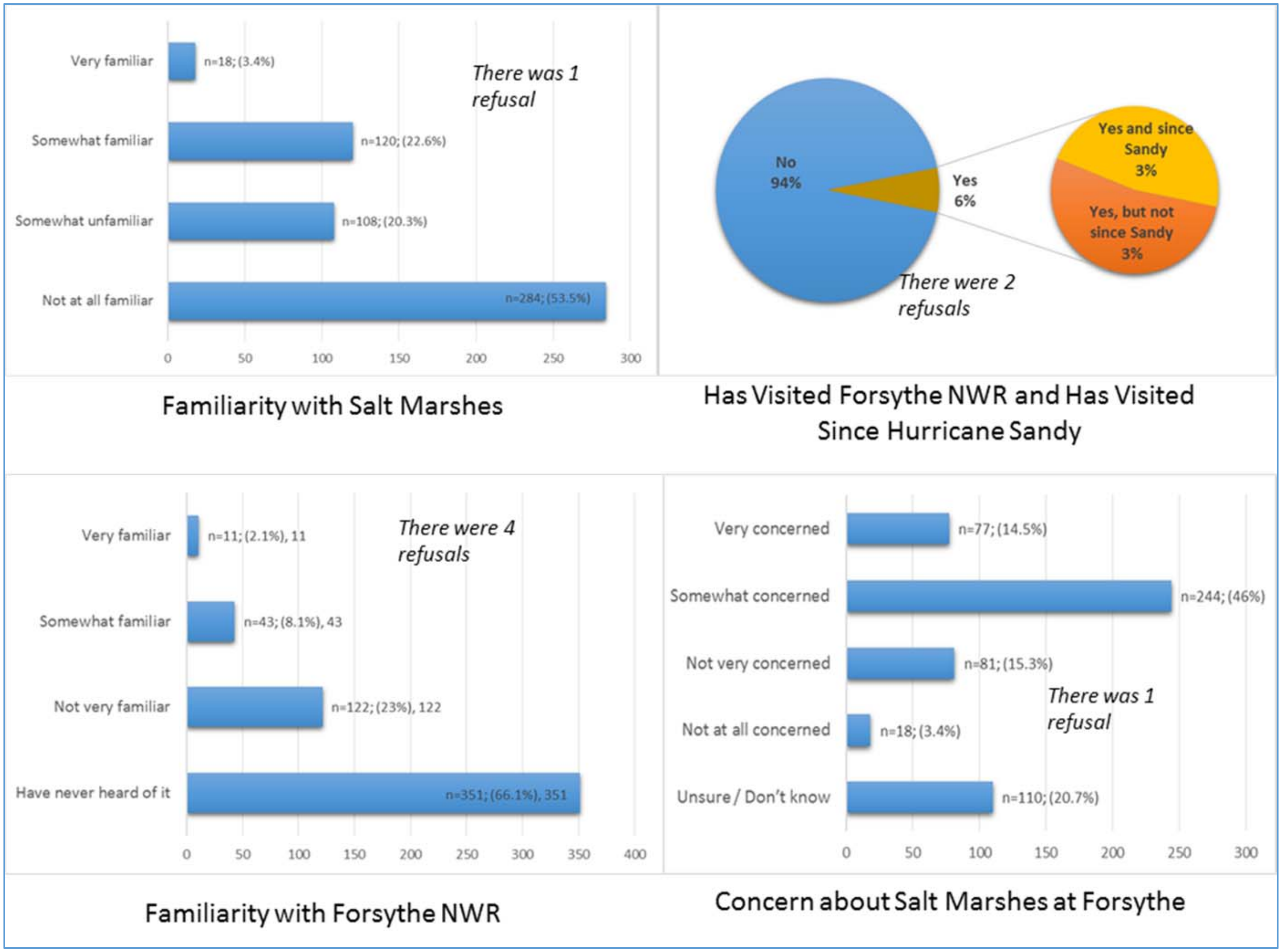

Figure 4 – Respondents' Familiarity with Salt Marshes and Forsythe NWR, Visits to Forsythe NWR, and Concern about Forsythe NWR Salt Marshes

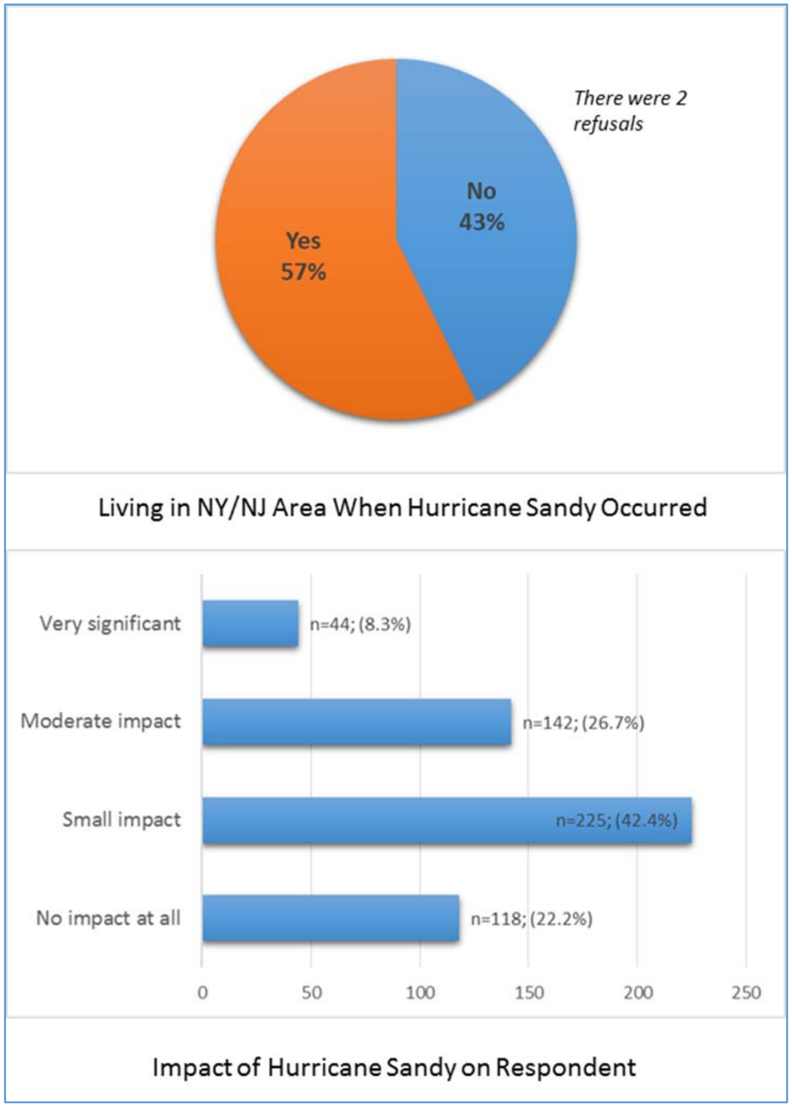

Figure 5 – Place of Residence when Hurricane Sandy Occurred and Self-Reported Impact of Sandy

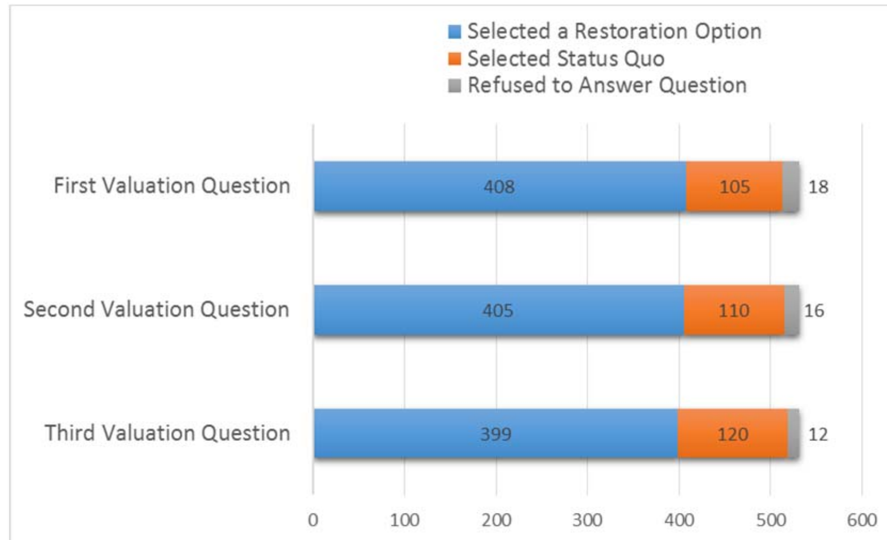

Figure 6 – Responses to Valuation Questions

2.4 Willingness to Pay Estimates

This section presents the WTP estimates for the Forsythe analysis. We begin by providing a base set of estimates. The base estimates provide WTP estimates for the ecosystem services we explore in this analysis: protecting homes from storm surge, protecting homes from non-surge flooding, bird habitat improvements, and recreation improvements, as well as for the number of marsh acres restored. Following the discussion of the base estimates, we explore how WTP estimates for the ecosystem services vary with distance from Forsythe and with reported impact of Sandy on the respondents. The WTP estimates are based on a set of estimated statistical models. We provide the statistical results for those models in Appendix B.

2.4.1 Base Willingness to Pay Estimates

We provide two sets of base willingness to pay estimates based on two separate statistical models (see Table B-1 in Appendix B). The base WTP estimates appear in Table 4. The two statistical models differ in how we treat the number of homes protected from surge and non-surge flooding. In one model (Model 1A), the number of homes protected from surge and non-surge flooding are separate factors that we place a WTP value on; in the other model (Model 1B), we combined the two into one factor that we place a values on.[20] Our reason for combining the two is that it appears that respondents did not differ in how they valued protecting homes from surge or non-surge flooding.[21] The results in Table 4 indicate that households are willing to pay:

- $50 per year for minimal bird habitat improvements at FNWR, but closer to $90 per year for significant improvements.
- $30 per year for minimal recreation improvements at FNWR and $44-$45 per year for significant recreation improvements.
- $8-$10 per year to protect 5,000 homes from flooding (both surge and non-surge flooding)
- $9 per year to restore 1,000 acres of salt marsh at FNWR

The values for bird habitat improvements, recreation improvements, and protecting homes from flooding reflect values for ecosystem services from salt marsh restoration. Given that we included bird habitat, recreation, and flood protection in the choice experiment, the value for acres should capture the value of other ecosystem services we did not include (e.g., fishery productivity), as well as non-use value.

[20] To calculate the combined variable, we used the maximum of the two values. That is, if the option presented to the respondent used “3,000 homes protected from surge” and “7,000 homes protected from flooding” we used 7,000 as the value for this variable.
[21] The estimated regression coefficients for surge and non-surge flooding are almost identical and not statistically different (see Table B-1, Model 1A).

Table 4 – Estimated Willingness to Pay for Improvements in Ecosystem Services from Salt Marsh Restoration at Forsythe National Wildlife Refuge

Attribute	Model 1A (Surge and Non-Surge Protection Separate)	Model 1B (Surge and Non-Surge Protection Combined)
Minimum bird habitat improvements	$49.01	$50.33
Significant bird habitat improvements	$89.23	$90.95
Minimum recreation improvements	$30.29	$30.71
Significant recreation improvements	$43.60	$45.35
Protecting 5,000 homes from storm surge	$9.01	-
Protecting 5,000 homes from non-surge flooding	$8.22	-
Protecting 5,000 homes from surge or non-surge flooding	-	$9.95
Restoring 1,000 acres of salt marsh	$8.78	$8.96

Note: All values reflect per household, per year estimates.

2.4.2 Willingness to Pay Adjusting for Distance to Forsythe

Table 5 provides estimates of willingness to pay adjusted for distance to Forsythe. ERG derived these estimates by interacting each of the ecosystem services included in the statistical model with each respondent's distance from the refuge; the full statistical models appear in Appendix B, Table B-2. To derive these estimates, however, it was necessary to remove the number of restored acres from the statistical model for statistical reasons.[22] The removal of acres from the modeling process led to the WTP values as a function of distance being higher than the values for base model. For example, the WTP for minimal bird habitat improvements does not decline under $50 (the value from the base model) after 200 miles from Forsythe; the average respondent in our survey only lives 61 miles from Forsythe.

Despite this lack of comparability to the base estimates, the rate of decline of WTP over distance is useful. First, we see that the WTP for households that are 100 miles from FNWR is 60 percent of the value for those within a mile of the refuge. ERG interprets this as showing some robustness of the value to distance from the site. Second, we see that WTP for bird habitat improvements declines very slowly over distance showing a significant robustness to distance from the refuge. Finally, we see that the WTP for recreation improvements declines rapidly with households 100 miles away only willing to pay 35 percent of the WTP amount for households who are within a mile of the refuge for minimal improvements and only 49 percent of the value for significant improvements.

[22] The number of acres is partially correlated with the ecosystem services included in the statistical model; this was by design since we would expect larges increases in ecosystem services from larger restoration efforts. The degree of correlation, however, has little impact on the base statistical models. However, once we included variables that reflected an interaction with an ecosystem service and distance, which are also correlated with the ecosystem service, the level of inter-correlation between all terms in the model caused for estimation issues.

Table 5 – Willingness to Pay Estimates for Forsythe NWR Analysis Adjusted for Distance to the Refuge

Distance in Miles from Forsythe / Ratio of Distance	Protecting 5,000 Homes from Flooding	Minimum Bird Habitat Improvements	Significant Bird Habitat Improvements	Minimum Recreation Improvements	Significant Recreation Improvements
1	$23.94	$66.16	$104.83	$60.93	$78.10
5	$23.61	$65.94	$104.62	$59.33	$76.50
10	$23.20	$65.67	$104.34	$57.34	$74.51
20	$22.38	$65.13	$103.80	$53.35	$70.52
40	$20.75	$64.05	$102.72	$45.36	$62.53
60	$19.12	$62.96	$101.64	$37.38	$54.55
80	$17.48	$61.88	$100.55	$29.40	$46.57
100	$15.85	$60.80	$99.47	$21.41	$38.58
120	$14.21	$59.71	$98.39	$13.43	$30.60
200	$7.68	$55.38	$94.05	-$18.50	-$1.33
60 miles to 1 mile	74%	95%	97%	61%	70%
100 miles to 1 mile	60%	95%	95%	35%	49%

Note: All values reflect per household, per year estimates.

2.4.3 Willingness to Pay Adjusted for Impact of Sandy on Respondents

Table 6 provides willingness to pay estimates adjusted for the impact of Hurricane Sandy on respondents. As noted in Section 2.3.2, the survey asked respondents about the impact that Sandy had on them, allowing them to select "none at all," "small," "moderate," or "very significant". ERG calculated the values in Table 6 by interacting the reported impact of Sandy with the different ecosystem services and the number of acres; the statistical models for these estimates appear in Appendix B, Table B-3. As expected, WTP increases with the impact of Sandy on the respondents. Of note, households that experienced no impact were not willing to pay anything to protect homes from flooding, but households who experienced a very significant impact were willing to pay close to $32 per year to protect 5,000 homes from flooding.

Table 6 – Willingness to Pay Estimates for Forsythe NWR Analysis Adjusted for Reported Impact of Sandy on Respondents

Reported Impact of Sandy on the Respondent	Protecting 5,000 Homes from Flooding	Minimum Bird Habitat Improvements	Significant Bird Habitat Improvements	Minimum Recreation Improvements	Significant Recreation Improvements	Restoring 1,000 acres of salt marsh
None	-$4.43	$27.30	$67.27	$2.07	$17.42	$2.21
Small	$7.65	$46.69	$86.65	$25.56	$40.91	$7.80
Moderate	$19.73	$66.07	$106.04	$49.06	$64.41	$13.39
Very significant	$31.81	$85.46	$125.43	$72.55	$87.90	$18.97

Note: All values reflect per household, per year estimates.

2.5 Trade-Offs in Salt Marsh Ecosystem Values

Our approach of using a choice experiment allows us to assess the trade-offs between the ecosystem services that we used in the analysis; to do this, we compare the estimated WTP values. To compare bird habitat and recreation, which are phrased in qualitative terms in the statistical model, we simply calculate ratios of the estimated WTP values. This ratio then provides a percentage difference between what households are willing to pay for one qualitatively-described level of a service (e.g., a minimal habitat restoration) compared to another (e.g., significant habitat restoration). When comparing the number of homes protected from flooding, which is phrased in quantitative terms in the statistical model, to bird habitat and recreation (qualitative factors), we calculate the number of homes that would need to be protected from flooding to equate the two WTP values (e.g., the number of homes that would need to be protected to equal the amount that households are willing to pay for minimal recreation improvements).

The comparisons between bird habitat and recreation appear in Table 7; we calculated the ratios between each of the four qualitative factors used to represent the ecosystem services in the statistical model. To perform these calculations, we used the WTP values from Model 1B in Table 4. The column headers represent the numerators in the ratios and the rows represent the denominators; for example, WTP for minimum habitat improvements ($50.33 per household per year) represents 55 percent of the value for significant habitat improvements ($90.95 per household per year).

Table 8 provides the number of homes that need to be protected to provide an equivalent WTP value to the bird habitat and recreation improvements. For example, a restoration project would need to protect 17,133 homes to provide the same value as a project that results in minimal recreation improvements.

Table 7 – Trade-Off Ratios for Comparing Bird Habitat and Recreation

Ecosystem service	Minimum bird habitat improvements	Significant bird habitat improvements	Minimum recreation improvements	Significant recreation improvements
Minimum bird habitat improvements		1.81	0.61	0.90
Significant bird habitat improvements	0.55		0.34	0.50
Minimum recreation improvements	1.64	2.96		1.48
Significant recreation improvements	1.11	2.01	0.68	

Table 8 – Estimated Number of Homes Protected that Equals the WTP Values for Improvements in Bird Habitat and Recreation

Category	Minimum bird habitat improvements	Significant bird habitat improvements	Minimum recreation improvements	Significant recreation improvements
Number of homes protected from flooding	28,078	50,742	17,133	25,303

One consideration in interpreting these ratios and comparisons in Table 7 and Table 8 is that most restoration projects provide multiple benefits; that is, a project will both protect homes from flooding and will provide habitat benefits. Nevertheless, these ratios provide an indication of how households in our sample viewed the relative values of the ecosystem services we used in our analysis.

2.6 Transferability

As noted, a key aspect of this study is to develop results that are transferable to other situations. This section discusses how the estimates from Sections 2.4 and 2.5 can be used for assessing restoration projects.

Naturally, one use of our estimates would be as values for a benefit transfer exercise. That is, other economists can use these estimates, with appropriate adjustments (see Section 4), to place a value on restoration work being done in other places. The benefit transfer use of our estimates would rely primarily on the estimates in Section 2.4. These estimates provide information on the average value per household, as well as on how those values decline over distance and decline as the impact of a storm/event declines for households.

Another use of the estimates is to compare the trade-offs between ecosystem services for restoration projects. For example, the ratios between bird habitat and recreation (see Table 7) can be used to compare projects using benefit-cost ratios. A benefit-cost ratio analysis would compare the benefit-cost ratio of the two projects; the project with the larger ratio would be preferred. This can be written as:

$$\frac{TB_1}{TC_1} ? \frac{TB_2}{TC_2}$$

where TB refers to total benefits, TC refers to total cost, and the '1' and '2' represent two distinct projects. If project "1" has a larger benefit-cost ratio, then project "1" is preferred, otherwise, project "2" is preferred. This ratio, however, can be rearranged to:

$$\frac{TB_1}{TB_2} ? \frac{TC_1}{TC_2}$$

That is, if the ratio of benefits (project 1 to project 2) exceeds the ratio of costs, then project 1 is preferred; if not, project 2 is preferred. The ratio of WTP estimates in Table 7 can be used as a proxy for the ratio of benefits. For example, suppose a coastal restoration effort is considering a project that could be described as "minimum bird habitat improvement" and one that is considered a "significant bird habitat improvement." If the ratio of costs (estimated by those considering the restoration effort) is less than 1.81, then the project considering significant improvements has a better benefit-cost ratio.

There are some important caveats, however, to this use. First, restoration decision-makers would need to ensure that their area is similar to the one used here (e.g., Forsythe in New Jersey). Second, decision-makers would need to categorize their projects into the categories that we used in this project (e.g., minimal bird habitat improvements), which are qualitative descriptions only. Third, benefit-cost analysis is far more complex than simply comparing a ratio of WTP values to a ratio of costs. Benefits are usually calculated as discounted stream of benefits over time.[23] Finally, a benefit-cost ratio analysis is not the same as the comparing the magnitude of benefits to the magnitude of costs. For example, a benefit-cost ratio analysis could lead to selection of a low benefit, low cost project over a higher benefit, higher cost project.[24] Thus, this type of analysis should only be one input into the decision-making process and only projects that are reasonably comparable should be subject to this type of analysis.

The comparison of homes protected from flooding to bird habitat and recreation benefits in Table 8 can be used in a similar manner to the bird habitat and recreation ratios. For example, a restoration effort is considering two projects: one will result in flood protection benefits for 20,000 homes and the second will provides recreation benefits. The recreation-oriented project would need to generate *significant* improvements in recreation to be preferred to the flood protection project.

[23] On the other hand, WTP values can be used to monetize benefit streams; if so, the ratio of the benefits of one project to another may reduce to roughly the ratio of two WTP values.

[24] For example, project 1 may have benefits of $10 million and a cost of $5 million (benefit cost ratio of 2), but project 2 may have benefits of $50 million and costs of $30 million (benefit cost ratio of 1.67). Although project 1 has a higher benefit cost ratio, project 2 has $20 million in net benefits compared to just $5 million in net benefits for project 1.

SECTION 3: VALUING PREFERENCES BETWEEN LIVING SHORELINES AND ARMORED COASTAL PROTECTION IN JAMAICA BAY

3.1 Overview

Jamaica Bay is part of New York City and sits south of Brooklyn and Queens. Much of Jamaica Bay consists of salt marsh, although much of the historical marshlands in the Bay have been lost to open waters and mud flats. The Bay offers habitat to more than 300 species of birds and over 100 species of fish. The Bay is protected from the Atlantic Ocean by the Rockaway peninsula that contains a number of towns and communities.

The Jamaica Bay area suffered significant damage from Hurricane Sandy (see Figure 2 on page 4). The communities along the Rockaway peninsula (Breezy Point, East Rockaway, West Rockaway, and Far Rockaway) all suffered significant property damage, as well as significant damage to beaches and dunes along the Atlantic-facing side. The community of Breezy Point was particularly hard-hit with a fire that consumed more than 130 homes. Two man-made freshwater ponds in the Bay were breached. Communities inside the Bay were also hard hit with flooding affecting areas such as Broad Channel in the middle of the Bay and Howard Beach on the northern side of the Bay.

Jamaica Bay also offers protection to the much of the New York City area. Jamaica Bay sits just south of the two heavily populated areas: Queens and Brooklyn. Additionally, JFK Airport borders the Bay on its northeastern edge. Over the last decade, there has been an active debate on the best ways to protect areas such as Jamaica Bay from storms. Hurricane Sandy only highlighted the need to provide better information. One possible approach involves building sea walls (or flood walls) and other “gray” structures that will work to stop storm surge and strong waves caused by coastal storms. This is often referred to as “shoreline armoring.” A second approach is to build “green” infrastructure such as dunes and marshes that will also protect coastal areas and provide habitat as well recreational opportunities. The “green” approaches are sometimes referred to as “living shorelines.” This section discusses ERG’s work to investigate preferences between shoreline armoring and living shorelines as sources of coastal protection.

Significant work is underway to restore Jamaica Bay from the impacts of Sandy. The New York Rising Community Reconstruction Program (NY Rising) was established to provide rebuilding and revitalization assistance to New York communities severely damaged by Hurricanes Sandy and Irene and Tropical Storm Lee. Under this program, local communities in Jamaica Bay have identified a number of projects to increase their resiliency to coastal storms. Some of these projects involve building sea walls and others involve restoration or establishment of dunes and marshes. In addition to the work being funded by NY State and NYC, the Federal government (U.S. Army Corps of Engineers, National Parks Service, etc.) is also working on building storm protection and resiliency measures.

Although much work is either underway or planned, there is still much to be done to protect Jamaica Bay and other parts of NYC from future storms and a good deal of thought has been given to what types of protective measures should be used. There are many options being considered, some of which involve shoreline armoring and some of which involve living shorelines. In 2013, NYC released its Special Initiative for Rebuilding and Resiliency (SIRR) report, which included recommendations for increasing coastal edge elevations in which NYC would “increase the height of vulnerable coastal edges with bulkheads, beach nourishment, and other measures” and protecting against storm surge by using “flood protection structures such as floodwalls, levees, and local storm surge barriers” (New York City, 2013; page 46).

The NY Rising reconstruction plans all contain a set of “Additional Resiliency Recommendations.” These additional recommendations are projects that would further enhance the protection of the shoreline in the Jamaica Bay area. Text such as the following can be found in these plans:

> *“The Planning Committee recommends working with relevant government agencies to build up and expand upon existing ocean edge strengthening projects such as additional, stronger dunes, ocean side jetties, and possibly flood walls” (NY Rising, 2014a, page V-1).*
>
> *“The planning committee recommends the siting of a Jamaica Bay surge barrier by the City or State that does not exacerbate flooding in Roxbury and Breezy Point” (NY Rising, 2014b, page V-2).*
>
> *“The Committee recommends that a study be undertaken to determine the feasibility of a Jamaica Bay surge barrier, proposed in the SIRR [Special Initiative for Rebuilding and Resiliency] report, which could protect all communities surrounding Jamaica Bay” (NY Rising, 2014c, page V-2).*

Reports for other communities in Jamaica Bay contain similar recommendations, as well as specific recommendations for using gray and green options to protect those communities.

The purpose of this analytical component is to provide (1) input into the debate on how to protect Jamaica Bay from future storms and (2) information that coastal area decision-makers can use in thinking about coastal protection in other areas as well. We did this by estimating the value that people living in the NYC area place of different shore protection options using a contingent choice survey.

3.2 Methods

ERG developed and implemented a survey in the Jamaica Bay area that asked respondents about their preferences between shoreline armoring and living shoreline approaches for coastal protection. The survey also included costs for the different options and varied the level of protection offered by each and the time each would last. This section describes the methods we used in implementing the survey and estimating the value of storm protection options.

3.2.1 Survey Instrument

ERG developed a survey instruments and provided it to OMB for review. The final, OMB-approved version of the instrument appears in Appendix C. The instrument we developed was similar to the one we developed under the Forsythe NWR valuation study, but with several important differences. As an overview, the instrument contains:

- Background for the respondent, including a description of Jamaica Bay and information on shoreline armoring and living shorelines. The background information also included pictures depicting both armored shorelines and living shorelines.
- Questions that asked about respondents' familiarity with Jamaica Bay, including whether they live in the Bay communities and, if they do not live in the Bay communities, how many times they had visited the Bay in the last 12 months.
- A question that asked the respondent about the extent to which Sandy affected them personally.
- A question that asked for the respondent's zip code to allow us to determine how far they are from Jamaica Bay.
- A valuation question that provided the respondents with a shoreline armoring option and a living shoreline option followed by a question that asked the respondent which option they would prefer. Each option was assigned a level of protection being offered, a lifetime of the protective measure, and a cost. The respondents were allowed also select a "do nothing" response which would result in no additional cost. The options and the associated attributes (level of protection, lifetime, and costs) are described in more detail below.
- A series of questions that followed the valuation question that asked the respondent about their response to the valuation question.
- A set of attitudinal questions.
- A question that asked respondents about the type of outdoor activities that they participate in.

ERG used the non-valuation questions, as well as demographic information provided by the survey contractor (i.e., GfK Knowledge Networks) as covariates in our regression modeling to help explain variation among respondents in their responses to the valuation questions.

3.2.2 Coastal Protection Options

The survey was designed to discern respondents' preferences between shoreline armoring approaches and living shorelines for coastal protection. The valuation question we posed to respondents first describes two options (one for shoreline armoring and one for living shorelines) and then asks respondents to vote on one of the two options or for neither. The text we used in the survey instrument was as follows:

- ***Shoreline armoring option****. Under this option, sea walls would be built to protect coastal areas within Jamaica Bay. The walls would provide protection against a* ***[LEVEL]****. The walls would take two to three years to plan and build and, once completed, would provide immediate protection from storms. The walls would last approximately* ***[LONGEVITY]****, but* *would require some maintenance every year with more maintenance being required toward the end of the wall's lifetime. Any beaches in front of the sea walls would erode completely within 1-2 years after completion. Building these walls to protect coastal areas in Jamaica Bay would result in an increase of* ***[COST]*** *each year to your household income taxes over the next 10 years.*

- ***Living shorelines option.*** *Under this option, living shorelines would be built in Jamaica Bay to provide coastal protection. The living shorelines would be built to provide protection against a* ***[LEVEL]****. The living shorelines would take a year to plan and build and, once built, would provide immediate protection. The living shorelines would require little maintenance over time and, if built properly, would become stronger over time as they become "established". Large storms, however, can and will damage these areas. Under this option, we would expect the living shorelines to last* ***[LONGEVITY]*** *before being damaged by storms and needing repair. The living shorelines would also provide habitat for birds and other animals. Building living shorelines to protect coastal areas in Jamaica Bay would result in an increase of* ***[Cost****]* *each year to your household income taxes over the next 10 years.*

Within each description, the instrument coding randomly inserted values for the level or protection (**[LEVEL]**), longevity of the protection (**[LONGEVITY]**), and the cost (**[COST]**). The values that were used in the random selection appear in Table 9.

Table 9 – Levels Used to Define Shoreline Protection Options in Jamaica Bay Survey Instrument

Category	Levels/Descriptions (text/values inserted in option descriptions)
Level (of protection) [a]	• Category 2 hurricane (waves from the storm would be approximately 6-8 feet above high tide level) • Category 4 hurricane (waves from the storm would be approximately 13-18 feet above high tide level)
Longevity	• 10 years • 30 years
Cost	• $30 • $70 • $140 • $200

[a] Saffir-Simpson hurricane categories relate to wind spend and not storm surge as we have done in these descriptions. Nevertheless, we felt that wave heights would be more relevant for this survey. We used information from https://www.pilotbrief.com/tropical/hurcat.html to translate the categories to wave heights.

Given that the levels that fully define each option are randomly selected values, there is the possibility that some respondents will see both options containing the exact same levels for each category in Table 9. This possibility, however, is not an issue for estimating the value of coastal protection options. First, the two options, shoreline armoring and living shorelines, are fundamentally different. If the described levels for the attributes are exactly the same, the respondent would be voting on whether they prefer built infrastructure for protection or whether they would prefer protection that incorporates natural features. Second, the living shoreline option is described as also having recreation and habitat benefits. Thus, even if the two have identical assigned attributes, the living shoreline option still offers additional benefits.

A second issue has to do with one option "dominating" the other. For example, a respondent may see a set of attributes such that the shoreline armoring option has higher levels than the living shoreline one, but the cost associated with shoreline armoring is lower; that is, the armoring option appears to "dominate" the living shoreline option. However, this is not the case since, as discussed above, the two are fundamentally different options. Additionally, respondents still have the option of selecting the status quo option and incur no additional cost.

3.2.3 Geographic Area and Sample Size

The respondents were selected from GfK's panel from New York City area and included the following counties:

- Bronx County
- Kings County
- Nassau County
- New York County
- Queens County
- Richmond County
- Rockland County
- Suffolk County
- Westchester County

This is depicted in Figure 7. The area we used for this survey has a total population of 4,504,708 households (Census Bureau, 2015).

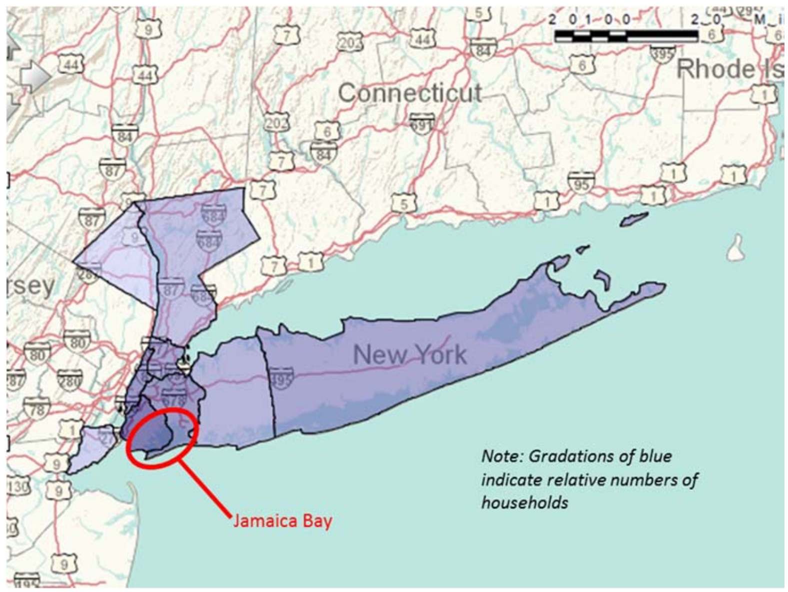

Figure 7 – Area Included in Jamaica Bay Survey (Source: U.S. Census Bureau, American Factfinder)

ERG specified a sample of 500 respondents from these areas; the final sample size was 541 total respondents. The sample size was selected using the same criteria we used in the Forsythe survey. The original Jamaica Bay design was similar to the Forsythe design and included more attributes and levels than the version that was implemented. Based on a limited set of pre-tests, ERG decided to simplify the design. However, we had already settled on project specifications with GfK and the number of respondents was already fixed at 500.

3.2.4 Statistical Analysis and Valuation

ERG used two approaches to estimate the WTP for the two coastal protection options: the Turnbull lower bound estimate of WTP and McFadden's (1974) conditional logistic regression model. We describe each in turn.

Turnbull Method

The Turnbull method uses only the amount of the tax posed to the respondents and the respondents' "yes" or "no" responses to the valuation question to estimate willingness to pay. Haab and McConnell (2002) provide a detailed discussion of the method. The method involves calculating an expected value for willingness pay and the resulting estimate is considered a lower bound on a WTP estimate. For each level of the tax, we calculate the percentage of respondents that we know (from the survey) who are willing to pay at least that level of the tax. This information is then used to calculate WTP; since the method uses information on the amount that respondents are *at least* willing to pay, the value must be considered a lower bound estimate.

In applying this method, we need to ensure the proportion who say "no" increases as the amount of the tax increases (i.e., there is an inverse relationship between the tax amount of respondents' willingness to accept the tax amount). If this is not case, tax amounts are pooled together until the proportion of "no" responses increases for each increase in the tax amount. ERG had to perform some pooling to estimate WTP for shoreline armoring in our analysis.

McFadden's (1974) Conditional Logistic Regression with Individual-Specific Controls

The McFadden (1974) model allows for consideration of both choice-specific information and respondent-specific information in a logistic regression model. As we did with the Forsythe analysis, a description of the data highlights the importance of this distinction. Each respondent in the data represents three records in the analytical data set: one for each potential choice that could be made (living shorelines, shoreline armoring, and status quo); we set a variable called "choice" equal to one for the option selected by the respondent and zero otherwise. Thus, each respondent has one record with "choice" equal to one and two with "choice" equal to zero. The details of the choice (levels of protection, longevity of protection, and the tax) vary between the individuals and over the set of choices within each individual, but individual characteristics (e.g., income) do not; this lack of variation within the individual's set of records causes estimation issues without some adjustments. McFadden's (1974) model allow for modeling both set of characteristics by interacting the individual characteristics with the respondent's choice. In short, we can include both choice-specific and respondent-specific factors using the McFadden model.

In estimating the McFadden model, we use three choice-specific factors:

- The level of protection specified in the survey question for the respondent (see Table 9)
- The longevity of protection specified in the survey question for the respondent (see Table 9)
- The amount of tax (per household per year) proposed to the respondent (see Table 9)

We also use four respondent-specific factors:

- The respondent's income
- The reported impact of Sandy on the respondent on a four-point scale (very significant, moderate impact, small impact, or no impact at all)

- The extent to which respondents agreed with the statement "I expect coastal storms will be more destructive in the future than in the past"
- A yes/no variable indicating the respondent participated in one of the following outdoor activities: boating/canoeing, hunting, bird watching, or hiking/nature walking

3.3 Data

3.3.1 Source

As with the Forsythe survey, ERG used GfK Knowledge Network's online "Knowledge Panel" to collect these data. GfK recruits its online panel members using a combination of random digit dialing (RDD) and address-based sampling (ABS). The ABS sampling allows for inclusion of cell-only households; non-internet households who join the panel are provided with computers to allow them to take the online surveys. Thus, GfK builds its internet panel from non-internet sources. This avoids some issues related to "opt-in" panels on the internet.

3.3.2 Response Rate and Descriptive Statistics

GfK performed a pre-test of the survey from July 24, 2015 – July 26, 2015, followed by full implementation from August 7, 2015 to August 13, 2015 (a total of ten days in the field including pre-tests). The survey was sent to 1,103 potential respondents and 566 completed the initial screener questions.[25] Of the 566 who were in-scope, 542 (96 percent) completed the survey. The percentage that completed the screener questions, 51 percent, represents the overall response rate among those who received the survey in the GfK panel.

Table 10 provides some basic summary statistics on the sample and compares the summary statistics to Census Bureau data for the counties that were included in the sample. The demographics can be summarized as follows:

- **Age** – The sample tends to be older than the general population with almost three-quarters of the sample being 45 older and 44 percent being 60 or older. This is in contrast to Census Bureau data which has a near-uniform distribution across the four categories of the 18 and older population in the counties we used in the survey.
- **Education** – More than half of the sample holds a bachelor degree or higher, a percentage that is higher than the percentage in the general population (34 percent). This over-representation of those with bachelor degree or higher comes at the expense of those with a high school education or less (15 percent in the sample, but 42 percent in the overall population).
- **Race/Hispanic Origin** – Approximately 64 percent of the sample identifies as "white," approximately 12 percent as "black," and approximately 18 percent as Hispanic. In

[25] To qualify for the survey, respondents had to be 18 years or older and reside in the in-scope counties.

comparison, Census reports that 54 percent of the population is white, 21 percent is African American, and 25 is of Hispanic origin in this area.[26]

- **Gender** – The sample contained 55 percent women whereas the total population in the area is comprised of 52 percent women.
- **Household Income** – The sample tends to be concentrated among higher income categories with a median income in the $50,000 to $75,000 range.[27] The distribution in the sample compares well to the income distribution in the Census Bureau data.
- **Employment** – Approximately 57 percent of the sample is working and one quarter of the population is retired. About 5.4 percent of the population falls into a category that could be classified as "unemployed" (i.e., not working and looking for work) by the Bureau of Labor Statistics (BLS). According to BLS, the unemployment rate in the New York-New Jersey metropolitan statistical area was approximately 5 percent in July and August of 2015 (BLS, 2015a).[28]

In summary, our sample for the Jamaica Bay survey is significantly older than the general population in the area we surveyed and also tends to have a higher level of education and less representation of minority populations. On the other hand, the samples matches well in terms of gender, income, and employment status.

[26] GfK collects its own data on race and Hispanic origin and provided these data to ERG. Thus, our data on race and Hispanic origin reflect the GfK categories and not Census Bureau categories. Consequently, the sample data and the Census data are not fully comparable for race and Hispanic origin.
[27] The income categories we present here are compacted from the one collected by GfK to be able to compare to Census Bureau categories. More detailed income categories in the GfK data indicate that the median income is in the $60,000 to $75,000 range.
[28] http://www.bls.gov/regions/new-york-new-jersey/data/xg-tables/ro2xg02.htm.

Table 10 – Demographic Summary of Jamaica Bay Survey Sample with Comparison to Census Bureau Data for Counties Included in the Survey.

Category	Number of Respondents in Sample (N = 541)	Percentage of Sample	Percentage of Population [a]
Age [b]			
18-29	51	9.4%	26.6%
30-44	86	15.9%	26.1%
45-59	168	31.1%	25.1%
60+	236	43.6%	22.3%
Education			
Bachelor's degree or higher	299	55.3%	33.7%
Some college	159	29.4%	24.6%
High school	70	12.9%	24.9%
Less than high school	13	2.4%	16.9%
Race/Hispanic Origin			
White	348	64.3%	54.3%
Black (non-Hispanic)	63	11.7%	20.6%
Hispanic	96	17.7%	24.7%
Other	34	6.3%	10.9%
Gender			
Female	297	54.9%	52.1%
Male	244	45.1%	47.9%
Household Income			
Less than $10,000	44	8.1%	8.3%
$10,000 to $14,999	27	5.0%	5.1%
$15,000 to $24,999	34	6.3%	9.4%
$25,000 to $34,999	44	8.1%	8.3%
$35,000 to $49,999	59	10.9%	10.9%
$50,000 to $74,999	96	17.7%	15.3%
$75,000 to $99,999	78	14.4%	11.5%
$100,000 to $149,999	84	15.5%	14.8%
$150,000 or more	75	13.7%	16.5%
Employment Status			
Not working - disabled	37	6.8%	-
Not working - looking for work	29	5.4%	-
Not working - on temporary layoff	4	0.7%	-
Not working - other	26	4.8%	-
Not working - retired	131	24.2%	-
Working - as a paid employee	265	49.0%	-
Working - self-employed	49	9.1%	-

[a] Census data were taken from the Census Bureau's American Factfinder database which combines data from several sources. Data for age, race/Hispanic origin, and gender were taken from the 2010 decennial Census. Data for educational attainment and income were taken from the 2013 American Community Survey.
[b] Census data for age reflect the distribution of above 18 population only.

Figure 8 provides tabulations for questions related to respondents' experience with Jamaica Bay. First, a majority of respondents (54 percent) have either never heard of or are "not very familiar" with Jamaica Bay, however, only 9 percent of the sample has never heard of Jamaica Bay and 45 percent consider themselves not very familiar. When asked if they lived in the Jamaica Bay communities, 92 percent indicated that they did not. Among the 92 percent that did not indicate they lived in Jamaica Bay communities, 57 percent indicated that they "never" visit Jamaica Bay. Thus, our sample may have limited direct experience with Jamaica Bay itself. This is not surprising, however, since (1) we are using the GfK panel and must rely on who they have available to take the survey in the panel and (2) Jamaica Bay is a relatively small area in relation to the total area covered by the survey (see Figure 7). Furthermore, this is not necessarily a drawback to the data that were collected. Since we are concerned with valuing coastal protection trade-offs in general and not in valuing aspects that are specific to Jamaica Bay.

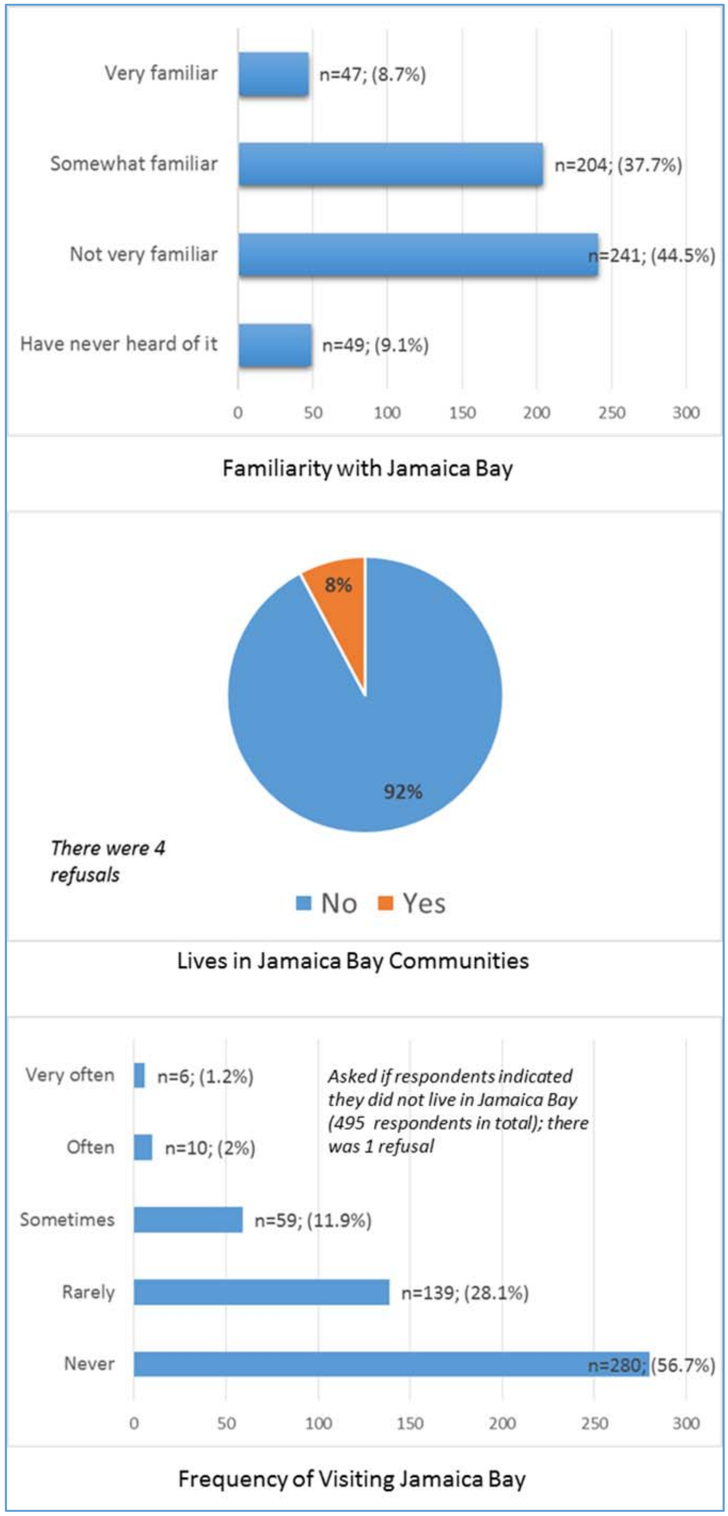

Figure 8 – Familiarity with, Living in, and Frequency of Visiting Jamaica Bay

Figure 10 summarizes responses to questions about where respondents lived when Hurricane Sandy occurred and the impact (self-reported) of Sandy on them. Despite the lack of familiarity with Jamaica Bay, the sample does exhibit experience with Hurricane Sandy. Among those who answered the question, 96 percent indicated they were living in the area when Hurricane Sandy occurred. Furthermore, 81 percent of the sample were impacted in some way by Sandy with 45 percent experiencing at least a moderate impact.

Finally, Figure 9 summarizes responses to valuation question we asked in terms of the coastal protection options that were selected by respondents. Living shorelines were selected by 54 percent or respondents, shoreline armoring was selected by 21 percent of respondents, and 25 percent selected neither (status quo).[29] A total of 14 respondents refused to answer the question.

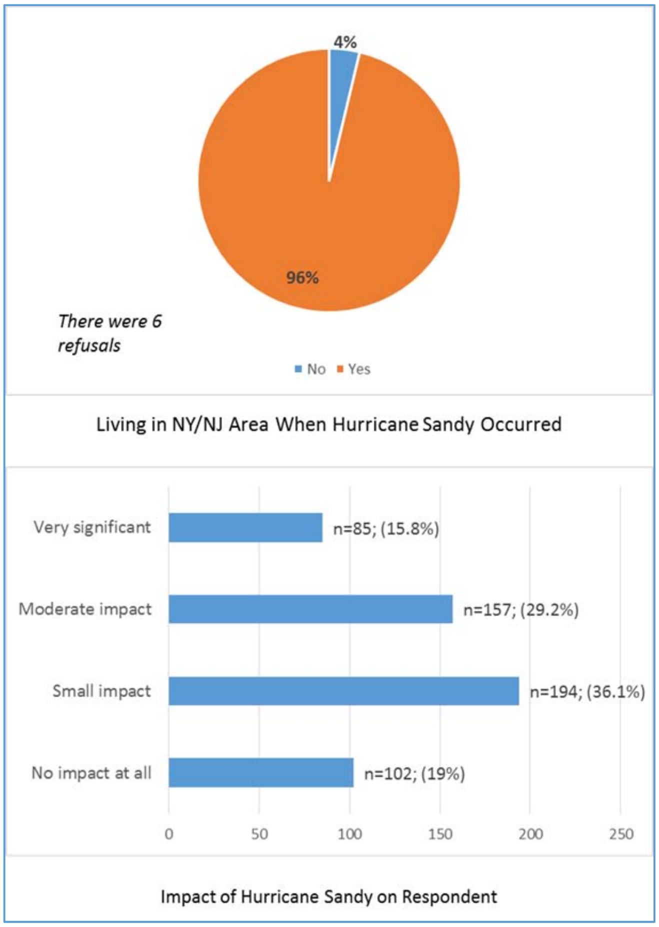

Figure 10 – Living in NY/NJ Area when Sandy Occurred and Reported Impact of Sandy on Respondent

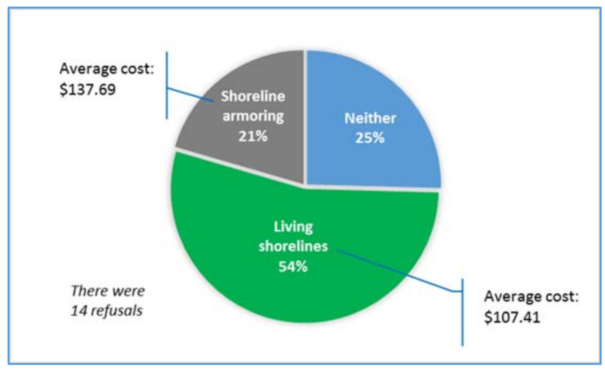

Figure 9 – Coastal Protection Options Selected by Respondents

[29] These percentages exclude refusals.

3.4 Willingness to Pay Estimates

As noted above, ERG calculated the willingness to pay (WTP) estimates using two different methods. First, we calculated Turnbull estimates using tabulations of the "yes" and "no" responses to the valuation questions from the survey; the Turnbull estimates only take into account the amount of the tax that respondents were asked about and their choice (i.e., selecting living shorelines, shoreline armoring, or neither). The calculation procedure for a Turnbull estimate generates a lower bound since it attempts to calculate the value that respondents were "at least" willing to pay for the coastal protection option. Second, we estimated a conditional logistic regression model that accounts for other factors besides the amount of the tax. The estimates based on the logistic regression model provides a mean value for WTP.

3.4.1 Turnbull WTP Estimates

Table 11 summarizes the input data and the final WTP estimates using the Turnbull approach to estimating WTP. The key input for the Turnbull approach are the percentage of "no" responses for each tax level; we have provided these, as well as the number of "no" responses and the total number of responses, in Table 11. For this analysis, a "no" refers to any response other than the coastal protection option being analyzed; that is, a "no" for living shorelines includes anytime a respondent selected the shoreline armoring option or the status quo/do nothing option.

Appendix D, Table D-1 and Table D-2 provide detailed calculations using the Turnbull method; the final WTP estimated are provided in Table 11. The estimates indicate that the minimum amount that households are willing to pay for living shorelines is approximately $110 per year per and the minimum amount for shoreline armoring is approximately $33 per year. That is, these estimates indicate that households are willing to pay slightly more than 3 times for living shorelines compared to shoreline armoring for coastal protection. The 95 percent confidence interval for the living shoreline estimate is $99 to $121 and the 95 percent confidence interval for shoreline armoring is $27 to $40.

It should be noted that the Turnbull estimates represent only a lower bound (amounts that households are at least willing to pay) and do not take into account other factors that could influence willingness to pay.

Table 11 – Turnbull WTP Estimates for Living Shorelines and Shoreline Armoring

Tax Amount	Living Shoreline			Shoreline Armoring		
	"No" Responses	All Responses	Percent "No" Responses	"No" Responses	All Responses	Percent "No" Responses
$30	60	137	43.8%	108	130	83.1%
$70	65	136	47.8%	116	140	82.9%
$140	72	135	53.3%	114	138	82.6%
$240	72	119	60.5%	103	119	86.6%
	Estimated WTP: $109.91			**Estimated WTP: $33.38**		
	95% Confidence Interval: $98.53 - $121.28			**95% Confidence Interval: $26.96 - $39.81**		

Note: Details of the WTP calculation based on the data in this table appear in Table D-1 (living shorelines) and Table D-2 (shoreline armoring) in Appendix D.

3.4.2 WTP Estimates Based on Conditional Logistic Regression

ERG estimated a conditional logistic regression model using McFadden's alternative-specific model specification (McFadden, 1974). The modeling approach allows for three choices: living shorelines, shoreline armoring, and do nothing. The McFadden model allowed us to consider how aspects of the choices (e.g., level of protection offered by the coastal protection option), as well as aspects of the respondents (e.g., income), affected respondents' choices between living shorelines, shoreline armoring, or doing nothing. The following factors were included in the model:

- The level of protection specified in the survey question for the respondent (see Table 9)
- The longevity of protection specified in the survey question for the respondent (see Table 9)
- The amount of tax (per household per year) proposed to the respondent (see Table 9)
- The respondent's income
- The reported impact of Sandy on the respondent one a four-point scale (very significant, moderate impact, small impact, or no impact at all)
- The extent to which respondents agreed with the statement "I expect coastal storms will be more destructive in the future than in the past"
- A yes/no variable indicating the respondent participated in one of the following outdoor activities: boating/canoeing, hunting, bird watching, or hiking/nature walking

The resulting estimated statistical model appears in Appendix D, Table D-3.

Willingness to pay was calculated from the model for living shorelines and shoreline armoring separately.[30] The estimated WTP values from the conditional logistic regression modeling appear in Table 12. As can be seen, the WTP value for living shorelines is 4.7 times the amount for shoreline armoring. Thus, households are willing to pay significantly more for living shorelines compared to armored shorelines in our estimates.

Table 12 – Estimated WTP Values Based on Conditional Logistic Regression

Coastal Protection Option	Estimated WTP (per household, per year)
Living shorelines	$278
Shoreline armoring	$59

[30] The process of calculating WTP in the model involved eliminating one option (e.g., shoreline armoring) from the choice set to calculate the WTP value for the other option (e.g., living shorelines).

3.5 Trade-Offs and Transferability

Both the Turnbull and the conditional logistic regression modeling can be used to assess trade-offs between living shorelines and shoreline armoring options for coastal protection. These trade-offs are directly relevant for transferability. The estimates in Section 3.4 can be used in two ways: (1) to estimate the value that those potentially affected by storms place on the two coastal protection options and (2) to assess the relative benefits and costs of competing projects. We recommend, however, that using our estimates to assess living shoreline and armoring projects should be only one input into a more comprehensive decision-making process.

The first use is a standard benefit transfer approach to using the estimates. If a decision-maker is assessing a coastal protection project, he or she can use the estimates we developed to assess the value that residents affected by the storm protection would place on the project. This information could be combined with other benefit information (e.g., value of homes and infrastructure protected) to assess the benefits against the costs of the project. It should be noted, however, that the values we estimated most likely include some aspect of home and infrastructure protection; thus, our estimates cannot be added to the value of protecting homes and infrastructure.

The second use would involve comparing relative benefits of living shoreline and shoreline armoring projects when being considered as two options for one area. This would follow a similar approach as we described in Section 2.6 for assessing trade-offs in salt marsh ecosystem services using benefit-cost ratios. In this case, our estimates from Section 3.4 provide the benefit ratios (i.e., TB_1/TB_2). The Turnbull estimates provide a lower bound for the benefit ratio (3.3 = \$109.91/\$33.38) and the conditional logit analysis provide a mean value (4.7 = \$278/\$59). If a coastal decision-maker is considering either a living shoreline project or a shoreline armoring project, these ratios can be compared to the ratio of costs. If the cost of the living shoreline project relative to the cost of the armoring project is above 4.7, then the armoring project should be preferred. If the ratio of costs is below 4.7, then there is strong evidence that the living shoreline option should be preferred. If the ratio of costs is less than 3.3, then the living shoreline option is clearly preferable.

SECTION 4: USING BENEFIT TRANSFER TO ASSIST IN RESTORATION DECISION-MAKING

4.1 Overview

This section discusses a set of guidelines for applying benefit transfer approaches to restoration projects. This aspect of our project was inspired from the initial scoping work we performed under this project. NOAA's initial hope was for the work under this project to inform restoration decisions in the wake of Hurricane Sandy. As we researched potential areas, however, we found that the time-frame for making investments in restoration decisions was more immediate (i.e., needed in the short term) and ERG's work would not be able to influence those decisions.

In researching Jamaica Bay, however, we determined that a number of projects are currently underway or proposed. Many of these were being scoped and planned under New York State's NY Rising Community Reconstruction program (or, "NY Rising program").[31] NY Rising's descriptions for these projects contained information on the costs and benefits of the projects, but ERG found that the benefit description was usually qualitative and often just re-iterated the project specifications. Costs, on the other hand, were better defined for the projects. Based on this, ERG saw a need for providing decision-makers with some guidance on how to develop quantitative information on benefits of restoration projects to better inform decisions. This was further confirmed when ERG spoke with the NY Rising program which indicated that most projects had a better sense of costs than benefits. Additionally, the NY Rising program also indicated to ERG that benefits of flood and storm protection were more easily developed and understood since funding from FEMA and USACE were tied to those categories. However, the NY Rising program indicated to ERG that habitat and amenity benefits were also of interest beyond flood and storm protection benefits.

Thus, ERG saw the need to develop a set of guidelines that could be used in applying benefit transfers in the short run to allow for better assessment of restoration options. In Appendix E, we provide a standalone document that provides a set of guiding principles and a process to use for valuing restoration decisions using benefit transfers.[32] In this section of the report, we demonstrate use of the guidelines in two Jamaica Bay case studies: Sunset Cove in Broad Channel and Spring Creek Park in Howard Beach. The case studies also serve to demonstrate the process we use in applying benefits transfers to restoration projects. The section begins by describing the NY Rising program and restoration work in Jamaica Bay. We then turn to discuss an overview of the guiding principles we recommend for applying benefits transfer in coastal restoration decisions. We then provide each case study in turn.

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[31] http://stormrecovery.ny.gov/community-reconstruction-program.

[32] We refer to Appendix E (guiding principles and process to use) as the "benefit transfer guidelines."

4.2 New York Rising Projects and Jamaica Bay Restoration Work

Over the course of approximately 14 months, New York State was hit by three significant coastal storms: Hurricane Irene, Tropical Storm Lee, and Hurricane Sandy. Recognizing that the future may continue to bring significant storms, the State of New York developed the New York Rising Community Reconstruction (NYRCR) Program, or the NY Rising Program. The program allocated more than $650 million in State funds for post-storm reconstruction and to build more resilient communities in the future. The program includes 124 storm-affected localities organized into 45 communities with each community in the program having a Planning Committee. The NY Rising Program is state-wide and includes the New York City area as one Region within the program. The New York City Region includes 15 communities under the program, five of which are located within Jamaica Bay.

Figure 11 – Map of Jamaica Bay Communities Included in Benefits Transfer Approach (Map Source: Center for International Earth Science Information Network (CIESIN))

The five Jamaica Bay communities are Howard Beach, Broad Channel, Rockaway East, Rockaway West, and Breezy Point. Figure 11 provides a map of Jamaica Bay, highlighting the five NY Rising communities in Jamaica Bay. Our two case studies presented in this section focus on projects in Sunset Cove (Broad Channel) and Spring Creek Park (Howard Beach).

The NY Rising program resulted in the development of restoration and resiliency plans for each of its communities. These plans are publicly available and ERG reviewed the five plans for the Jamaica Bay communities. Each plan for the Jamaica Bay communities contained between 9 and 11 projects for a total of 50 projects across the five communities. Not all of these projects, however, are potential projects for ecosystem service benefit transfers. First, NY Rising developed a set of categories for projects:

- Community Planning and Capacity Building
- Health and Social Services
- Economic Development

- Housing
- Infrastructure
- Natural and Cultural Resources

Most projects were assigned more than one category. The most relevant category for our purposes appears to be the "Natural and Cultural Resources" one. On the other hand, Broad Channel contains a "Boardwalk repair/new sewer connection" project that was classified as "Housing" and "Infrastructure." The project, however, will result in both amenity benefits (from the boardwalks) and water quality benefits (from the new sewer connections). Of the 50 projects, only 18 projects were classified as "Natural and Cultural Resources" projects. These 18 plus another 7 projects that appeared to have ecosystem service benefits were considered for benefit transfer valuation.

Second, even among the 25 projects that we considered, some focused solely on coastal protection measures such as building new dunes or living shorelines. As discussed above, coastal and flood protection are often covered by USACE and FEMA. Thus, we avoided projects where coastal or flood protection was the sole or primary benefit. Finally, some projects were just too small to consider. For example, Breezy Point contained a project for "Enhanced Dune Walkways" which improved beach access over dunes at one specific location along the coastline; we deemed this to be too small to consider for our purpose.

Our selection of two case studies came from discussions with stakeholders and our own research. First, ERG had discussions with the NYC Parks Department who indicated both Spring Creek Park and Sunset Cove as being two areas we should focus on. Second, NY Office of Storm Recovery also indicated those two projects would represent good case studies. Finally, in our work to select project for primary valuation, both of these project were identified by ERG as potential areas.[33]

4.3 Applying Benefit Transfer to Coastal Restoration: Some Guiding Principles

As noted, benefit transfers offer the possibility of developing estimates for coastal restoration projects in a relatively short amount of time, allowing the information to be used as part of the decision-making process. In this section, we provide some guiding principles to consider in using benefit transfers in coastal restoration decision-making. These principles also appear in Appendix E along with a set of steps to use in performing benefit transfers. ERG developed these principles through the research we performed under this project on Hurricane Sandy restoration work and in developing two case studies which are presented in sections that follow.

[33] During the process of identifying primary valuation opportunities under this project, ERG assessed both of these as potential opportunities.

Principles

13. **Use/rely on economic expertise in developing benefit transfers.** Benefit transfers take values estimated using economic valuation techniques at one location (a "study site") and apply those values (with some adjustment) to another location (a "policy site"). This process involves multiple crucial decisions that are best made by someone with economic expertise. For example, decisions need to be made on the appropriateness of the methods used at the study site, how to make adjustments, and valid data to use for the adjustments. These decisions are best done by someone who understand the underpinnings of the economic valuation studies.
14. **Benefit transfers are a good choice for situations where information is needed in a short amount of time.** Developing a study that is specific to the restoration work will take time (and resources). However, the timeline for deciding on restoration work may be short. Benefit transfers can be done in a relatively short amount of time, usually within a few months. Thus, in situations such as coastal restoration where some information is needed quickly, benefit transfers offer the ability to develop benefit estimates that can be used in decision-making.
15. **Benefit transfer values should be only *one* input into any decision-making process.** More specifically, we do not recommend that a value (or values) derived from a benefit transfer process be used as a sole (or driving) factor in making decision. A number of the guiding principles deal with reasons why this is the case. First, all benefit transfer involve error in some form or another; this is discussed in more detail below. Second, in using benefit transfer, only values for some ecosystem services may be available.
16. **If possible, work on the benefit estimates as the projects are being scoped/defined.** It's preferable to have economists working on the benefits estimates during the project scoping, or to at least have them sitting in on the meetings where the work is being defined. This will allow the economist to begin collecting studies and review options early on.
17. **Post-disaster restoration differs from the context in which most value estimates are made.** Most studies that estimate the benefits of ecosystem services are not focused on post-disaster restoration. That matters for understanding benefit values. In the immediate wake of a disaster, the relative values that people place on different restoration options will mostly likely differ from what they were before a disaster. For example, people may be more willing to pay for protective measures immediately following a disaster. As the disaster fades from memory, people's relative valuation of restoration options will continue to evolve, but may never revert to pre-disaster levels. For example, many people living along the New Jersey shoreline may have an increased value of dunes (as protective measures) relative to the amenity value (ocean views) that dunes degrade compared to before Sandy. Thus, in using benefit transfer values, one should keep in mind that relative values can and will change in post-disaster situations and that the values being used in the transfer may not fully reflect the relative values of stakeholders who experienced the disaster.
18. **All benefit transfers involve error.** There are a number of reasons why benefit transfers involve error. First, study sites and policy sites will differ. Even if an economist can make

adjustments based on data, some differences between the physical environment and the social characteristics will remain between study and policy sites. These differences generate some level of error. Second, a study that estimates benefits at a study site has some error itself. Specifically, if statistical procedures are used, the resulting estimates will end up with some confidence level around the final value. In summary, taking estimates from one site or sites (the study site(s)) and applying the estimates to another site (policy site) is an imperfect process.

19. **Benefit transfer may be better used to compare across projects rather than to assess the worth of any one project.** If only one restoration project is being considered, using benefit transfers to assess the value of the project is worthwhile. The resulting benefit estimate can provide a sense of whether the project will generate net benefits, subject to the errors involved. ERG expects a better approach would be to use benefit transfers to compare across projects. If benefit transfers are used to generate benefit estimates for multiple projects and those estimates are compared across the projects, the errors will, presumably, be roughly the same for each benefit estimate. This means it may be better to compare relative values derived from benefit transfers rather than a single value itself. A caveat to this, however, would be if studies of differing quality are used in generating the benefit estimates; in this case, the relative values also reflect errors related to the quality of the studies.
20. **Look for specific studies first (or multiple studies to calculate an average) and then fill in any "gaps" using meta-function transfers.** There are a number of ways to perform benefit transfers: (1) find a specific study and use the value from that study, (2) use an average value from multiple studies, (3) apply the statistical function from a previously-estimated study, or (4) use a meta-function estimated from multiple studies. The process we recommend involves first applying (1) and (2) from above and, if no *directly relevant studies* are available, to turn to using a meta-function. One particularly useful set of tools we recommend are the ones developed by John Loomis and colleagues at Colorado State University which provides meta functions to use in benefit transfer exercises.[34]
21. **Calculate benefits over a reasonable time frame.** The benefits will accrue to people over time, but costs are incurred up-front on restoration work. The benefits should be calculated for a reasonable time frame and the net present value of the benefits should be compared to costs. In other words, restoration project costs should be viewed as an investment with the return being the ecosystem service values that are generated. To determine the time frame to use, one needs to determine how long the restoration will benefit people. Additionally, all benefit estimates need to be adjusted for inflation.
22. **Do not necessarily aggregate over different benefit estimates.** In cases where benefit estimates for different ecosystem services are drawn from different studies, care should be taken in adding up the values. Additionally, care should also be taken in adding up estimates

[34] http://dare.agsci.colostate.edu/outreach/tools/

from a single study if the study used different methods to estimate different values.[35] This is where economic expertise is valuable. An economist can determine when estimated values are comparable and can be added together. Also, there may be some usefulness in providing separate values for different services, allowing stakeholders to better understand where value is being derived in a particular project.

23. **Always assess the possibility of double counting, especially if more than one study is being used.** When using more than one study to estimate benefits, it's necessary to understand if double-counting is occurring. Double-counting may not be clearly seen either. For example, a study may not be explicitly estimating the value of a specific service, but the study's estimates may implicitly include the value of the service. Once again, having an economist selecting and reviewing studies is crucially important.
24. **The area being improved by the restoration work may be larger than then area where work is being performed.** The costs and project specifications for restoration work may involve a relatively small area compared to the area that benefits from the work. For example, in our Sunset Cove case study below, we found that the project was specified as a 0.2 acre restoration. This was true, approximately 0.2 acres were going to have work performed. However, the Sunset Cove salt marsh was closer to 13 acres.

4.4 Sunset Cove Case Study

Sunset Cove sits at the southern end of Broad Channel in Jamaica Bay. Broad Channel is part of the New York City Borough of Queens and has a population of approximately 2,500 residents. It is an island within Jamaica Bay with bridges connecting it to both the main area of Queens in the north and the Rockaway Peninsula in the South. The community is surrounded on both sides by the Jamaica Bay Wildlife Refuge. The surge from Hurricane Sandy swept across the community and severely damaged homes, cars, and businesses.

The Cove had a small marina in the 1940s that expanded in the 1970s and 1980s by illegally filling in parts of the marsh. A number of legal actions in the late 1990s led to the reduction in size of the marina; however, further violations at the marina led to its eventual closing. In 2009 Sunset Cove was placed under the jurisdiction of the NYC Parks Department.

4.4.1 Restoration Project Description

Following acquisition by NYC Parks, a number of plans were developed to restore the Cove. Hurricane Sandy further highlighted the need for restoration at the Cove. Sandy made clear some of the issues that Broad Channel faces including potential for flooding, inadequate sewer hookups, and infrastructure not equipped to handle flooding. A number of NY Rising projects in Broad Channel are

[35] This will be highlighted in the case studies we present below.

meant to address these issues. Recovery-related funding from the Federal and State governments made it possible to significantly improve the Cove.

Figure 12 provides a map of the work being performed at Sunset Cove. The restoration project will:

- Remove debris (including and bulkheads) left over from the marina;
- Install an oyster revetment that will also act as a wave attenuator;
- Restore the salt marsh around the marina;
- Restore high marsh area that will provide habitat;
- Install a berm/dune system behind the marsh areas to protect from storm surge and flooding;
- Restore the upland maritime forest area to provide recreation opportunities and bird habitat;
- Install walking trails through the marsh to provide recreational and educational opportunities for visitors; and
- Install an interactive boardwalk over the wetlands to provide recreational and educational opportunities for visitors.

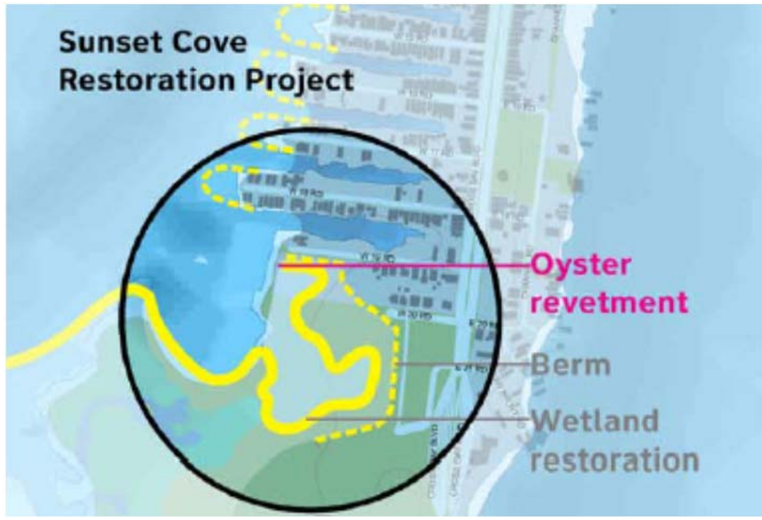

Figure 12 – Graphical Map of Sunset Cove Restoration Project (Source: NY Office of Storm Recovery, *Broad Channel Community Reconstruction Plan*, March 2014)

Table 13 summarizes the improvements to ecosystem services that will be provided by the Sunset Cove restoration project. We used the ecosystem services in Table 13 to guide our selection of studies to use in the benefit transfer.

Table 13 – Improvements to Ecosystem Services from Sunset Cove Restoration Project

Ecosystem Service	Description of improvement
Flood Prevention	The current area offers little flood protection due to the degraded nature of the site. The restoration work will restore the wetland area of Sunset Cove and will add in a berm; both of which will improve the absorption of water, reducing potential flooding.
Water Quality	The current area is a former marina that left contamination. The restoration project will remove the contamination and improve water quality. Additionally, the project includes an oyster revetment that will also lead to improved water quality by filtering the water that comes into the marsh.
Recreational Fishing	The project will improve opportunities for recreational fishing. Currently, recreational fishing was not possible in the Cove due to contamination. The improvements will allow fishing to occur in the Cove and will lead to more fish being available for fishing in the Bay itself.
Commercial Fishing	Improvements to the marsh area of the Cove will improve/restore the Cove area as a nursery area for commercial fishing.
Birdwatching	Jamaica Bay itself is known for its bird habitat and as a place for migratory birds to stop. The restoration of the Cove will allow the Cove to be one of those areas and allow better opportunities for birdwatching.
Swimming	The improvements to water quality will allow for swimming in the area in front of the Cove.
Recreational boating	The improvements to water quality will allow for improved access for boating.
Amenity	The Cove is significantly degraded with a number of wooden pilings and other leftover pieces from the marina. The project will also add in a boardwalk and path that will allow better access to the marsh. The restoration work will improve the look of the marsh.
Habitat	The restored marsh will offer habitat for a number of species that live in the Jamaica Bay area. This includes improving nursery habitat for fish.
Storm protection	The project includes both marsh improvements and an oyster revetment; these two features will improve storm protection.

4.4.2 Identifying Relevant Ecosystem Service Values

This section discusses the process we followed in identifying relevant ecosystem service values from available studies. Our first step was to look for specific, directly relevant studies. ERG began by performing searches in the GECOSERV data base (http://www.gecoserv.org/). The database is maintained by the Harte Research Institute at Texas A&M University. Although GECOSERV's intent is to provide a set of studies that are useful to the Gulf of Mexico, the database also provides a broad range of studies that cover many areas of the United States.

Our search criteria are detailed in Table 14. In short, we searched for saltwater wetlands-related studies that covered the ecosystem services that the Sunset Cove project will influence. We limited the search to just U.S. and Canada and, within the U.S., to just states that were near New York. We also excluded any study where the primary method was already a benefit transfer. This led to identifying four studies; after reviewing the four, ERG settled on three studies: Opaluch, et al., 1999; Johnston, et al., 2002; and Costanza, et al., 2008.

Table 14 – Search Criteria Used in GECOSERV Database

Category	Search Parameters
Ecosystem Type	➢ Saltwater wetlands
Ecosystem Services	➢ Habitat ➢ Disturbance Regulation ➢ Recreation ➢ Water Regulation ➢ Nutrient Cycling ➢ Aesthetics ➢ Cultural/Spiritual ➢ Science/Education
Countries	➢ U.S. ➢ Canada
States	➢ New York ➢ New Jersey ➢ Massachusetts ➢ Connecticut ➢ Rhode Island
Valuation methods	➢ Excluded benefit transfer studies

Table 15 provides information on the three studies, the relevant estimated ecosystem services from the studies, and the relevancy to our analysis. Two of the three studies are related to valuing the Peconic Estuary System (PES) in eastern Long Island; in fact, both studies were generated under the same project.[36] The third study uses a national-level analysis (over time) to estimate the relationship between the economic impact from coastal storms and the presence of coastal wetlands; the resulting relationship is then applied to coastal states to estimate the value of coastal wetlands for storm protection in each state.

As can be seen in Table 15, we make significant use of the PES study. We selected the PES-based estimates since they focused on a coastal area and the PES is located approximately 75 miles from Broad Channel (see Figure 13). The close proximity between Jamaica Bay and PES make the PES-based study particularly appealing.

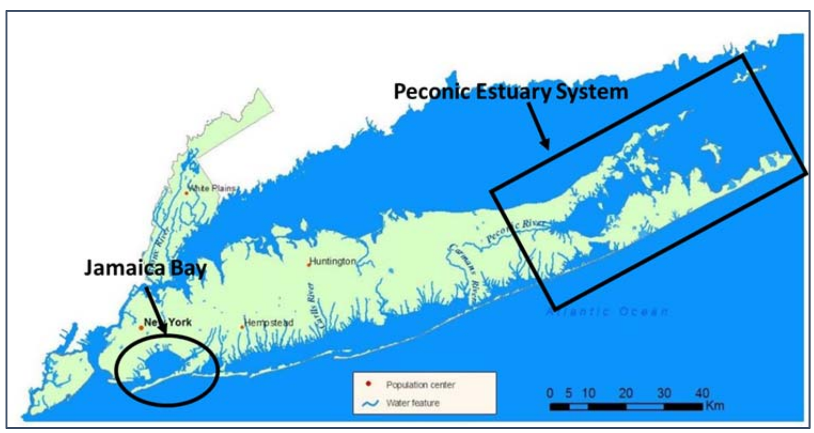

Figure 13 – Long Island Map Depicting Jamaica Bay and Peconic Estuary System (Source: NY State Department of Environmental Conservation)

There are, however, some limitations of using the PES-based

[36] The two studies actually summarize the same estimates. The Johnson et al. (2002) paper provides discussion of the estimates in terms of combing and using different methodologies to estimate values. The Opaluch et al. (1999) report provides the details of the methods and the results.

estimates for this benefits transfer. First, the PES is significantly larger than Jamaica Bay itself and Sunset Cove is only a small part of Jamaica Bay. If there are scale effects (i.e., the values in the PES are partly based on the large size of the area), then we may be overestimating the values for Sunset Cove. Second, the PES study was performed in the mid-1990s. People's valuation of ecosystem services may have changed over the last 20 years.

Another consideration to keep in mind is the current state of the site. Sunset Cove is currently a severely degraded area due to contamination from the previous marina and the remaining debris. Thus, the restoration work will essentially create a coastal wetland area and the associated services where little previously existed. In that sense, the estimated benefits are new values being bestowed on the stakeholders to some degree. To be sure, the Cove may currently offer some recreation in the form or birdwatching of wildlife viewing now, but the current level of services could be considered low.

Table 15 – Summary Information for Studies being used for Benefit Transfer at Sunset Cove

Study and Description	Ecosystem Service	Estimated Value ($year)/method	Relevancy to Sunset Cove Benefit Valuation
Peconic Estuary System (PES) Valuation Study - Estimated the values of several ecosystem services related to the Peconic Estuary System (PES) on eastern Long Island. (Opaluch, et al., 1999 and Johnston, et al., 2002).	Recreational swimming – consumer surplus value for people to be able to swim in clean water.	$8.59 per trip ($1995)/travel cost model	The improvements to the Cove will allow for swimming, boating, and recreational fishing in the area in front of the cove. These values can be combined with an estimate of the increased number of trips to estimate the value associated with each.
	Recreational boating – consumer surplus value for people to take boating trips in clean water	$19.23 per trip ($1995) /travel cost model	
	Recreational fishing – consumer surplus value for people to take recreation fishing trips in clean water	$40.25 per trip ($1995) /travel cost model	
	Birdwatching – consumer surplus value for people to enjoy birdwatching from existing wetlands	$49.83 per trip ($1995) /travel cost model	The improvements to the Cove will improve birdwatching opportunities in the Cove. This value can be combined with the increased number of birdwatching trips to estimate values.
	Open space – willingness to pay amount (as percentage of property value) for owning property near a wetland	12.83% increase in property values properties that are adjacent (within 25 feet) to wetlands/hedonic property value model	This can be combined with the value of adjacent properties to estimate the WTP for living near a marsh.
	Eelgrass productivity value – commercial fishing value that eelgrass produces in terms of food web support and habitat	$1,065 per acre per year ($1995)/simulation model using market values	The improvements to the Cove may result in better conditions for the development of eelgrass in the area in front of the Cove. However, ERG does not have a method for estimating the increase in eelgrass acres associated with the Cove restoration.
	Salt marsh productivity values – commercial fishing value that salt marshes produce in terms of food web support and habitat	$338 per acre per year ($1995) /simulation model using market values	This value can be combined with the number of marsh acres being restored to estimate the value to commercial fishing.
	Intertidal mudflat productivity values – commercial fishing value that intertidal mudflats produce in terms of food web support and habitat	$67 per acre per year ($1995) /simulation model using market values	Although relevant, ERG has no method for estimating he amount of increased mudflat in the marsh area.
	Wetland existence value – existence (non-use) value associated with salt marshes	$0.066 per acre per household per year ($1995)/contingent choice	ERG can combine each with number of households and the number of acres being restored to estimate these existence values. However, the number of eelgrass acres is not available.
	Shellfish area existence value – existence (non-use) value associated with shellfish area	$0.037 per acre per household per year ($1995) /contingent choice	
	Eelgrass existence value – existence (non-use) value associated with eelgrass	$0.082 per acre per household per year ($1995) /contingent choice	
Costanza et al storm protection study [b] - Estimated the value of salt marshes in providing storm protection using a national-level dataset of coastal storms. (Costanza, et al., 2008).	Protection from storms (salt marsh) – value of salt marsh to protect against coastal storms in terms of impact on Gross Domestic Product (GDP) for the area.	$62,100 per hectare per year ($2012) for wetlands in New York [a]/regression modeling	ERG can combine this estimate with the amount of acres being restored to estimate the value of storm protection from the restored marsh.

[a] This value was taken from the GECOSERV database.

4.4.3 Value Estimation

This section presents our estimates for the ecosystem service values in Sunset Cove based on the values transferred from the PES study and the national-level storm damages study (see Table 15). We present four sets of estimates based on the different methods used in the original studies:

- The values per trip for swimming, boating, recreational fishing, and birdwatching
- The value of open space applied to property values
- The value of improved productivity for commercial fisheries from restored salt marshes
- Existence values for wetlands and shellfish areas
- The value of storm protection from the restored marsh area

We do not provide a total that sums the values together. The Johnson et al. (2002) study discusses the limitations of summing the estimates from the PES study. In particular, there may be some overlap between the recreational (per trip) estimates, the value of open space, and the value of improved productivity estimates due to the methods used. The existence values are not captured in the other methods, however. Also, Johnson et al. (2002) notes that the estimates for the PES study do not contain values for storm protection.

We provide both an annual value and a value over 25 years. The 25-year lifetime assumption follows the PES study. We also apply a 7 percent discount rate to the future values (also following the PES study).

Recreation Values: Swimming, Boating, Recreational Fishing and Birdwatching

ERG updated the estimates from the original study to 2015 dollars using the change in the Consumer Price Index (CPI) for the New York Metropolitan Statistical Area (MSA) between June of 1995 and June 2015 (BLS, 2015c). These appear in Table 16. ERG does not have a source of information to estimate the increased number of trips the restoration will generate. Instead, we assume that each activity will increase by 10 person trips per week during the 15 weeks between Memorial Day and Labor Day; that is, 150 additional trips each year. We expect this to be a conservative estimate of the increase in recreation trips associated with the Cove restoration project.

Table 16 – Recreational Per Trip Values Updated to 2015 Dollars

Activity	Original estimate ($1995)	Estimate in 2015 dollars
Swimming	$8.59 per trip	$13.85 per trip
Boating	$19.23 per trip	$31.00 per trip
Recreational fishing	$40.25 per trip	$64.89 per trip
Birdwatching	$49.83 per trip	$80.34 per trip

Our estimates of the value of improved recreational opportunities appear in Table 17. Overall, we estimate that improved recreation in the Cove will lead to $28,513 in annual benefits with a present value of $355,900 over 25 years. As noted above, this based on an assumed increase of 10 trips per week in the summer for each recreational activity for a total of 150 trips per year. Given the simplicity of the calculation, however, the values in Table 17 can be scaled up or down easily. For example, if 15 trips per week were a more reasonable estimate for swimming, then both the annual and 25-year present value could be multiplied by 1.5 (= 15 ÷ 10).

Table 17 – Estimate Values for Improved Recreation from Sunset Cove Restoration Project

Activity	Value per Trip ($2015)	Assumed Number of Annual Trips [a]	Annual Value of Increased Activity	Present Value Over 25 Years [b]
Swimming	$13.85	150	$2,077	$25,904
Boating	$31.00	150	$4,651	$57,990
Recreational Fishing	$64.89	150	$9,734	$121,378
Birdwatching	$80.34	150	$12,051	$150,628
Totals	-	-	**$28,513**	**$355,900**

[a] ERG assumed an increase of 10 trips per week over the 15 weeks between Memorial Day and Labor Day.
[b] ERG used a 7 percent discount rate.

Value of open space

Restoring the Cove and preserving it as open space has a value to property owners that are adjacent to the Cove. The PES study found that properties that are adjacent to the marsh (defined as within 25 feet of the open space) are worth 12.8 percent more than other properties. ERG reviewed a Broad Channel property map and identified a set of properties we felt were "adjacent" to the Cove based on the layout of Broad Channel (NYC, 2015a).[37] This most likely included properties that were further than 25 feet from the marsh area, but we also expect that 25 feet is a somewhat arbitrary value and the more important aspect was for a property to be "adjacent" to the marsh. This included a total of 30 properties for a total of $11.12 million in total valuation ($370.7 thousand on average) (NYC, 2015a).[38] Thus, using the percentage associated with being adjacent to an open space marsh area, the value of the marsh (as capitalized into home values), is approximately $1.4 million. On average for the 30 properties we assessed, this means a value of $47.6 thousand per property adjacent to the Cove.

Productivity value from salt marshes for commercial fisheries

Salt marshes provide input into commercial fishing in two ways: (1) the marsh provides food with leads to more and larger fish and (2) the marsh provides a nursery habitat for fish. The PES study estimated the value of these two aspects for PES salt marshes using simulation models. The value reflects the increase in value for commercial fishing. ERG updated the value from 1995 dollars to 2015 dollars using the CPI for the New York MSA (BLS, 2105c), resulting in a value of $545 per acre per year in 2015 dollars. The full size the Sunset Cove restoration area is approximately 13 acres, but only 4 of those acres are described as a marsh in the NY Rising Plan. Thus, the total annual value of the marsh restoration is $2,180 and the 25-year present value is $27,181.

[37] This included all of West 19th and West 20th Streets, the south side of West 18th Street, and the three properties closest to the Cover on East 20th Street.
[38] The NYC Tax Assessment page (NYC, 2015) refers to the values on the properties as "fair market values."

Wetland and shellfish area existence values

The PES study estimated resident and non-resident tourism willingness to pay for the continued existence of wetlands and shellfish areas using a contingent choice survey. ERG updated the estimates from 1995 dollars to 2015 dollars using the CPI for the New York MSA (BLS, 2015c). This resulted in a value of 10.6 cents per household per acre per year for wetlands existence and 6 cents per household per acre per year for shellfish area existence. For the wetlands, we used 13 acres in the calculation since the total size of Sunset Cove is approximately 13 acres. For shellfish, the size of the area is specified as 0.2 acres in the NY Rising Plan. According to the Census Bureau, Broad Channel has 796 households (Census Bureau, 2015).[39] We only used the number of households in Broad Channel since Sunset Cove is only a small portion of the Bay. The total existence value for wetlands is $1,101 per year for a 25-year present value of $13,730. The existence value for shellfish area is $9.50 per year for 25-year present value of $118.

Storm protection values

The Costanza et al. (2008) study estimated a regression model relating storm damages (as a proportion to GDP in the path of the storm) to wind speed and wetland area for 34 storms that have made landfall the U.S. since 1980. This regression equation is then combined with storm frequencies at the state level to derive estimates of the annual value per hectare of wetland for storm protection. ERG updated the value in Table 15 to 2015 dollars using the change in the U.S. CPI from June 2012 to June 2015 (BLS, 2015d), resulting in a benefit of $64,234 per hectare per year for wetlands in New York State. This value reflects the decreased potential impact of storms on economic activity (GDP) from each hectare of wetland. The 13 acres in Sunset Cove equal 5.252 hectares, thus the annual value for storm protection from the Sunset Cove restoration is $337,358. This translates to a 25-year present value of $4.21 million.

Summary of Sunset Cove Restoration Benefit Values

Table 18 summarizes the estimated values from this section. As noted, we do not add the totals together due to the potential for double-counting. According to the NY Rising Plan for Broad Channel, the total cost for the Sunset Cove restoration is $8 million. Thus, over half of the cost is covered by the storm protection benefits. However, even if we added up the total benefits (25-year present values plus the value of open space), the total would not exceed $8 million. However, we have not been able to estimate all benefits (e.g., improvements in eelgrass and associated benefits) and we have had to make some assumption to calculate others (e.g., increased number of recreation trips).

[39] Broad Channel is Census Tract 1072.01 in Queens County, New York.

Table 18 – Summary of Estimated Benefit Transfer-Based Values for Sunset Cove Case Study

Category	Description	Annual Value	25-Year Present Value
Recreation	The increase in willingness to pay for swimming, boating, recreational fishing, and birdwatching using an assumed increase of 10 trips per week during the summer for each activity.	$ 0	$ 0
Open space	The willingness to pay as capitalized into property values for living near an open space wetland.	$1,426,953 [a]	
Salt marsh productivity for commercial fisheries	The increase in commercial fisheries value from salt marshes stemming from improved food web support and improved nursery habitat.	$2,180	$27,181
Wetland and shellfish existence values	The willingness to pay for existence of the wetlands and shellfish areas being created under the restoration.	$1,111	$13,849
Storm protection	The value of reduced economic impact on area GDP associated with the Sunset Cove restoration.	$337,358	$4,206,626

[a] Value reflects neither an annual value nor a 25-year present value.

4.5 Spring Creek Park Case Study

Spring Creek Park is part of the Howard Beach Community in Jamaica Bay and sits at the northern tip of the Bay (see Figure 14). The park is divided into two sections: Upper Spring Creek Park is owned by the NYC Park Department and Lower Spring Creek Park is owned by National Parks Service (NPS) as part of the Gateway National Recreation Area. Howard Beach has approximately 20,000 residents with the population expected to get older on average in the future.

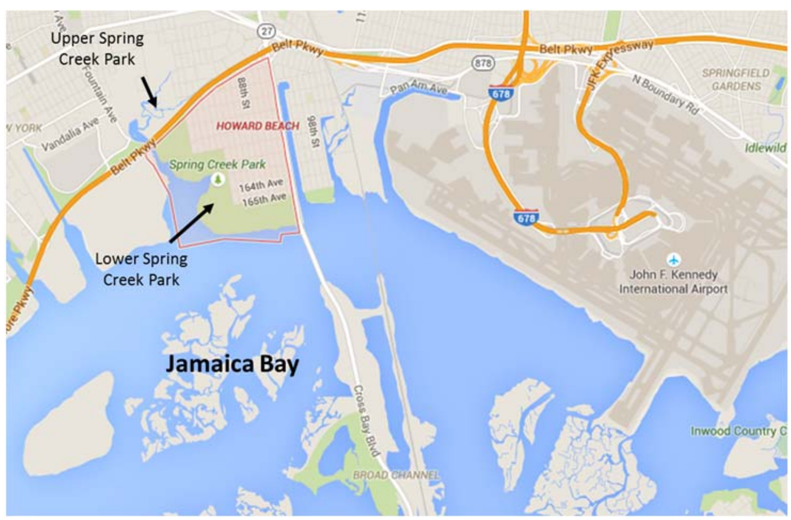

Figure 14 – Map of Howard Beach/Spring Creek Park (Source: Google Maps)

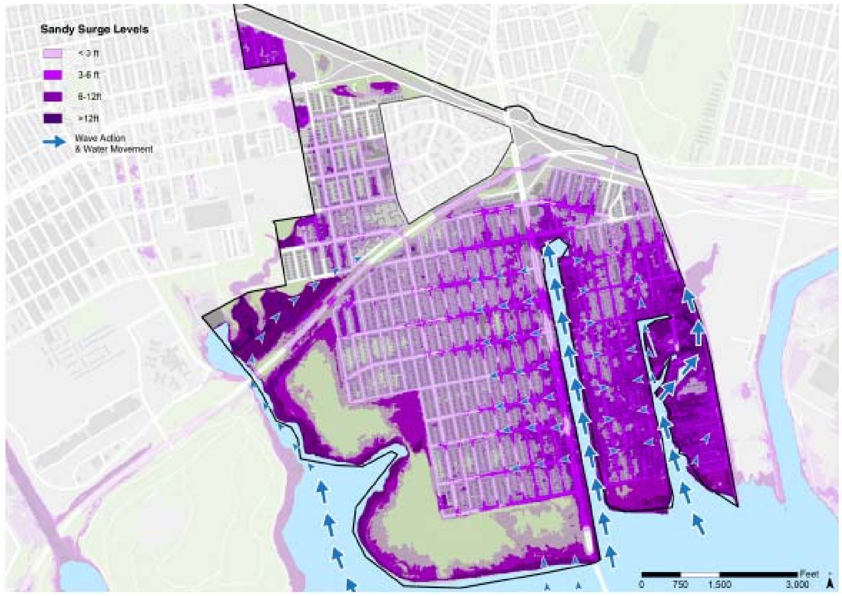

Figure 15 – Impact of Hurricane Sandy on Howard Beach (Source: NY Rising Community Reconstruction Plan for Howard Beach, Project Boards (part 1); http://stormrecovery.ny.gov/nyrcr/community/howard-beach)

Hurricane Sandy had a significant impact on Howard Beach with the primary impact being flooding. Figure 15 provides a map depicting the impact of Sandy on the Howard Beach area in terms of storm surge levels. As Sandy made landfall in New Jersey, the surge pushed water into New York Harbor and into Jamaica Bay; Howard Beach, which sits at the northern end of the Bay was one of the final stops for the surge. As noted in the NY Rising Howard Beach Community Reconstruction Plan (NY Rising, 2014c), every neighborhood in the community was affected by flooding with significant impacts on the business districts.

4.5.1 Restoration Project Description

The Spring Creek Park work is comprised of two distinct, but related, projects. For Upper Spring Creek Park (owned by NYC Parks), the work entails excavating and re-contouring uplands to form them into intertidal elevations and removing invasive species and replanting with native plants. The work will also involve adding in berms to protect from surge and adding walking trails. Overall, the project will entail creating 10.66 acres of low marsh, 2.33 acres of high marsh, 3.04 acres of high marsh transition, and 7.34 acres of maritime upland habitat (USACE, 2013). The Lower Spring Creek Park restoration work will entail restoring 151.6 acres of habitat, which would include 49 acres of low marsh, 10 acres of high marsh, and 6 acres of tidal creeks (USACE, 2013). Figure 16 provide NY Rising program maps depicting the restoration projects and Table 19 summarizes the ecosystem services that would be generated from the restoration work.

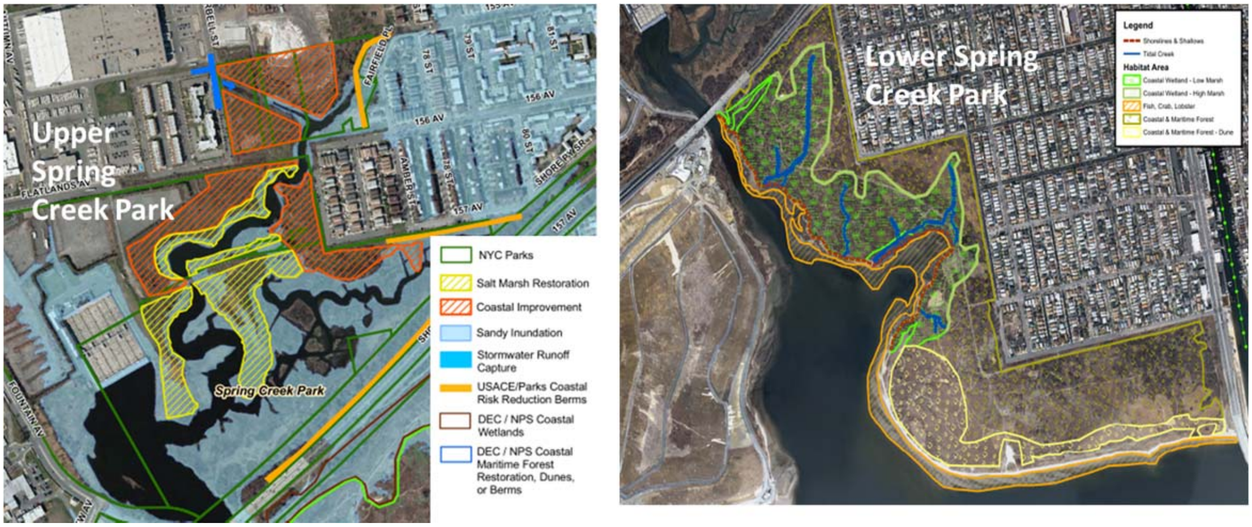

Figure 16 – Map of Upper and Lower Spring Creek Park Restoration Work (Source: NY Rising Community Reconstruction Plans, Project Boards Part 1 and 2; http://stormrecovery.ny.gov/nyrcr/community/howard-beach).

Table 19 – Summary of Ecosystem Service Improvements Stemming from Spring Creek Park Restoration

Ecosystem Service	Description of improvement
Flood Prevention	As evidenced by Sandy, the current area offers little flood protection. The restoration work will add in flood protection measures.
Recreational Fishing	The project will improve opportunities for recreational fishing by restoring the marsh area of the Park.
Commercial Fishing	Improvements to the marsh area of the Park will improve/restore the area as a nursery area for commercial fishing.
Birdwatching	Jamaica Bay itself is known for its bird habitat and as a place for migratory birds to stop. The restoration of the park will allow better opportunities for birdwatching.
Habitat	The restored marsh will offer habitat for a number of species that live in the Jamaica Bay area. This includes improving nursery habitat for fish.
Storm protection	The project will involve significant improvements to the marsh and coastal wetland in front of Howard Beach which will improve storm protection.

4.5.2 Identifying Relevant Ecosystem Service Values

ERG determined that the two studies we used for Sunset Cove were also relevant for valuing the restoration work at Spring Creek Park. Our process of searching for and selecting these studies is described in the Section 4.4.2 above. Table 20 re-summarizes information from Table 15 and provides context for using the information for the Spring Creek Park restoration project.

We focus on a smaller subset of ecosystem services relative to the Sunset Cove project. We expect our focus is on the primary ecosystem benefits that will be derived from this project, with the exception of non-storm related flood control. As noted above, the Howard Beach area suffered significant impacts from flooding related to storm surge. Our inclusion of the storm protection benefits should cover this type of impact. The project, however, will also add flood protection from non-storm sources; an area we have not covered.

Table 20 – Ecosystem Services and Values from Selected Studies and Relevancy to Spring Creek Park Restoration Work

Ecosystem Service	Source	Value in 2015 Dollars	Relevancy
Recreational fishing – The willingness to pay for recreational fishing trips	PES Study	$64.89 per trip	The improvements to Spring Creek Park will allow for better recreational fishing opportunities and improved birdwatching opportunities.
Birdwatching – The willingness to pay for birdwatching	PES Study	$80.34 per trip	
Open space – The willingness to pay (as capitalized into property values) associated with living next to an open space wetland.	PES Study	12.83 percent increase in property value for being adjacent to marsh	The restoration work will restore the marsh and Park area. Properties will continue to benefit from being near an open space. The value being created, however, is not creating an open space, but improving an existing open space.
Salt marsh productivity for commercial fisheries – The food web and nursery value to commercial fisheries associated with an improved salt marsh.	PES Study	$545 per acre per year	The improvements to the marsh area will improve food web and nursery values for fisheries.
Existence value for salt marshes – The willingness to pay to preserve salt marshes.	PES Study	10.6 cents per acre per household per year	The project will restore the marsh keeping it in existence.
Storm protection – The reduced impact on economic activity associated with marsh size.	Costanza et al. (2008)	$64,234 per hectare per year	The project centers on storm protection. Thus, the storm protection values are vitally important to this analysis.

4.5.1 Value Estimation

ERG used the values from Table 20 and information on the restoration work derived from project documents. The USACE scoping plans for the Spring Creek work (USACE, 2013) and the NY Rising Howard Beach Reconstruction Plans (NY Rising, 2014c) were particularly helpful in this regard. We estimated annual values and 25-year present values. The 25-year present values were calculated using a 7 percent discount rate.

Recreation Values: Recreational Fishing and Birdwatching

ERG does not have a source of information to estimate the increased number of trips the Spring Creek Park project will generate. Instead, as we did for Sunset Cove, we assume an increased number of weekly trips between Memorial Day and Labor Day (summer). For Spring Creek Park, we assume that there will be 21 additional trips per week (an average of 3 per day) in the summer for a total of 315 additional trips each year. We expect this to be a conservative estimate of the increase in recreation trips associated with the restoration project.

Our estimates of the value of improved recreational opportunities appear in Table 21. Overall, we estimate that improved recreation at Spring Creek Park will lead to $45,749 in annual benefits with a present value of $570,458 over 25 years. As noted above, this based on an assumed increase of 21 trips per week in the summer for each recreational activity for a total of 315 trips per year. As with the Sunset Cove estimates, the values in Table 21 can be scaled up or down easily using an alternative assumption relative to the one we used. For example, if 42 trips per week were considered a more reasonable estimate for recreational fishing, then both the annual and 25-year present value could be multiplied by 2 (= 42 ÷ 21).

Table 21 – Estimate Values for Improved Recreation from Sunset Cove Restoration Project

Activity	Value per Trip ($2015)	Assumed Number of Annual Trips [a]	Annual Value of Increased Activity	Present Value Over 25 Years [b]
Recreational Fishing	$64.89	315	$20,442	$254,895
Birdwatching	$80.34	315	$25,307	$315,563
Totals	-	-	**$45,749**	**$570,458**

[a] ERG assumed an increase of 21 trips per week over the 15 weeks between Memorial Day and Labor Day.
[b] ERG used a 7 percent discount rate.

Value of open space

ERG reviewed a Howard Beach property map and identified properties that were "adjacent" to the Park (NYC, 2015a). This included properties that bordered the Park directly or that sat across a street from the Park. This included a total of 160 properties for a total of $96.3 million in total valuation ($601.9 thousand on average) (NYC, 2015a).[40] Thus, using the percentage associated with being adjacent to an open space marsh area, the value of the marsh (as capitalized into home values), is approximately $12.4 million. On average for the 160 properties were assessed, this means a value of $77.2 thousand per property adjacent to the Park.

Productivity value from salt marshes for commercial fisheries

Salt marshes provide input into commercial fishing in two ways: (1) the marsh provides food with leads to more and larger fish and (2) the marsh provides a nursery habitat for fish. The PES study estimated the value of these two aspects for PES salt marshes using simulation models. The value reflects the increase in value for commercial fishing. The Howard Beach restoration work will entail creating 10.66 acres of low marsh in Upper Spring Creek Park and 49 acres of low marsh in Lower Spring Creek Park for a total of 59.66 acres of marsh that will contribute to fisheries productivity. Using the $545 per year per acre benefit value, the total annual value of the marsh restoration is $32,512 and the 25-year present value is $405,400.

[40] The NYC Tax Assessment page (NYC, 2015) refers to the values on the properties as "fair market values."

Wetland area existence value

The PES study estimated resident and non-resident tourism willingness to pay for the continued existence of wetlands areas to be 10.6 cents per household per acre per year. The Spring Creek Park project will result in restoration of 23.37 acres in Upper Spring Creek Park and 151.6 acres in Lower Spring Creek Park[41] for a total of 174.97 acres which we rounded to 175 acres. Next, we need to determine the relevant number of households. The PES study used all households in the PES study area. For the Spring Creek Park restoration, we determined the relevant area must be larger than just Howard Beach. We selected three areas in NYC: Queens District #10, Queens District #9, and Brooklyn District #9 (NYC, 2015b). These planning districts are depicted in Figure 17. Based on data from the NYC Community Planning Portal website, there are a total of 141,136 households in these three areas (NYC, 2015b). Thus, the total existence value for wetlands at Spring Creek Park is $2.6 million per year for a 25-year present value of $32.8 million. If we limit the analysis to just the households close to the Park (Queens District #10, 40,794 total households), the existence value for wetland at Spring Creek Park is $759,660 per year for 25-year present value of $9.5 million.

Figure 17 – Map of NYC Planning Districts Used to Calculate Households for Wetlands Existence Value (Source: NYC Department of Planning, Community Planning Portal)

Storm protection values

ERG used the Costanza et al. (2008) study to estimate the value of storm protection from the project. Costanza et al. (2008) estimate that the storm protection value of wetlands in New York is $64,234 per hectare per year. This value reflects the decreased potential impact of storms on economic activity (GDP) from each hectare of wetland. The 175 acres in Sunset Cove equal 70.7 hectares, thus the annual value for storm protection from the Spring Creek Park restoration is $4.5 million which translates to a 25-year present value of $56.6 million.

Summary of Sunset Cove Restoration Benefit Values

Table 22 summarizes the estimated values from this section. As noted, we do not add the totals together due to the potential for double-counting. According to the USACE, the total cost for the Spring Creek Park work is approximately $120 million. As can be seen, this value is covered solely by the estimated storm protection benefits.

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[41] For the productivity valuation, we used only the acreage of marshes being restored. For the existence value, we are using the total area being restored.

Table 22 – Summary of Estimated Benefit Values

<table>
<tr><th>Category</th><th colspan="2">Description</th><th>Annual Value</th><th>25-Year Present Value</th></tr>
<tr><td>Recreation</td><td colspan="2">The increase in willingness to pay for recreational fishing, and birdwatching using an assumed increase of 21 trips per week during the summer for each activity.</td><td>$ 0</td><td>$ 0</td></tr>
<tr><td>Open space</td><td colspan="2">The willingness to pay as capitalized into property values for living near an open space wetland.</td><td colspan="2">$12,355.55 [a]</td></tr>
<tr><td>Salt marsh productivity for commercial fisheries</td><td colspan="2">The increase in commercial fisheries value from salt marshes stemming from improved food web support and improved nursery habitat.</td><td>$32,512</td><td>$405,400</td></tr>
<tr><td rowspan="2">Wetland existence value</td><td rowspan="2">The willingness to pay for existence of wetlands in the Park</td><td>All households in Queens District #s 9 and 10 and Brooklyn District #5.</td><td>$2,628,213</td><td>$32,772,066</td></tr>
<tr><td>Households in Queens District #9 only</td><td>$759,660</td><td>$9,472,450</td></tr>
<tr><td>Storm protection</td><td colspan="2">The value of reduced economic impact on area GDP associated with the Park restoration.</td><td>$12,355,547</td><td>$154,065,437</td></tr>
</table>

[a] Value reflects neither an annual value nor a 25-year present value.

4.6 Lessons Learned from the Case Studies

The process of developing the estimates in the two case studies and the resulting estimates themselves resulted in a number of lessons learned.

- **There is often a need to make assumptions to allow the study site estimates to work in the context of the policy site and the resulting estimates are usually sensitive to those assumptions.** The two case studies make a number of assumptions. The most explicit are the assumptions regarding the increased number of trips associated with recreation activities. However, an even larger assumption has to do with the number of households to apply to the existence value for wetlands. In the Sunset Cove case study we used just the number in Sunset Cove, a relatively small number. For the Spring Creek Park estimates, we selected all the households in three areas of NYC, a relatively large number. Even though the value is small (10.6 cents per household per acre), when applied to a large number of households (141 thousand) and the large number of acres (175), the final value is relatively large for Spring Creek ($2.6 million annually).
- **Sometimes the resulting estimates will be small.** The estimates for Sunset Cove for existence of shellfish areas is a $118 25-year present value. Values such as this contribute little to any discussion about restoration.

- **All large values need to be assessed thoroughly.** For example, the storm protection benefits from the Spring Creek Park restoration total $154 million when viewed as a 25-year present value. A value that, on its own, exceeds the cost of the project should be assessed for realism by decision-makers.

Finally, we can also assess the results from the case studies against the principles described in Section 4.3:

1. **Use/rely on economic expertise in developing benefit transfers.** ERG’s work to develop estimates for the case studies under this project was conducted by staff who are trained in economics.
2. **Benefit transfers are a good choice for situations where information is needed in a short amount of time.** The process of assembling the studies and developing estimates for the two case studies took less than two months.
3. **Benefit transfer values should be only *one* input into any decision-making process.** ERG’s work was done for example purposes only and not meant to influence any specific decision. However, given that our estimates are partially overlapping and that we were not able to include all benefits (e.g., flood and storm protection), these estimates should only be on input into any decision-making process.
4. **If possible, work on the benefit estimates as the projects are being scoped/defined.** This was not possible for ERG since we were performing this analysis as an instructive exercise.
5. **Post-disaster restoration differs from the context in which most value estimates are made.** The PES study was our primary input. That study focused on the value of ecosystem services from PES and was not related to any particular natural disaster. Thus, it may be the case that the values used from PES underestimate the values that households in Jamaica Bay may have after experiencing Sandy. This should be kept in mind when assessing these values.
6. **All benefit transfers involve error.** Although we used a study area that was near Jamaica Bay, there are some key differences. First, PES is much larger than Jamaica Bay, let alone our two small study areas. Second, the PES study reflects values estimated nearly 20 years ago. Finally, as noted in #5 above, the PES study values are not reflective of a post-disaster situation.
7. **Benefit transfer may be better used to compare across projects rather than to assess the worth of any one project.** ERG’s work only considered two already-scoped projects. However, these estimates could have been used to assess the relative value of these two projects or could have been used to compare to alternative at each site. Additionally, these estimates can be used to compare these two projects to other ones scoped by the NY Rising Program in Jamaica Bay.
8. **Look for specific studies first (or multiple studies to calculate an average) and then fill in any “gaps” using meta-function transfers.** ERG found two specific studies to use for this work.

9. **Calculate benefits over a reasonable time frame. ERG used a 25-year time frame.** This mirrored the time frame from the PES study.
10. **Do not necessarily aggregate over different benefit estimates**. ERG avoided aggregating benefits.
11. **Always assess the possibility of double counting, especially if more than one study is being used.** ERG provided comments on the possibility of double-counting when we identified the relevant studies.
12. **The area being improved by the restoration work may be larger than then area where work is being performed.** ERG took this into account for each area. For the Sunset Cove case study this was particularly relevant since the area was specified as a 0.2 acres in the NY Rising plan, but the area affected was closer to 13 total acres.

SECTION 5: VALUING CARBON SEQUESTRATION AT FORSYTHE NATIONAL WILDLIFE REFUFGE

5.1 Overview

The Social Cost of Carbon (SCC) is an estimate of the economic damage associated with an increase in carbon dioxide (CO_2) emissions over a given period of time. The measure is used by federal agencies to help estimate the climate benefits of rulemakings and can also be used to assess the benefits of reducing CO_2 emissions (EPA, 2013). As part of this project, ERG applied the SCC approach to estimate the carbon sequestration benefits associated with salt marsh restoration at Forsythe National Wildlife Refuge.

Salt marshes are one of three major marine ecosystems that serve as carbon sinks, termed "blue carbon" (the others being mangroves and sea grasses). Salt marshes sequester carbon by filtering and capturing carbon from materials moving through the ecosystem which contributes to the below-ground carbon stocks in the sediment. Salt marshes also capture atmospheric carbon through their array of vegetation, which tends to decay slowly in the anaerobic soil types found in healthy marshes.

Habitat disturbances, such as prolonged flooding or transfer of sediment into the marsh during a storm, have the potential to alter the salt marsh's ability to sequester carbon in a manner similar to pre-disturbance levels. Loss of salt marsh vegetation can reduce the amount of carbon that the marsh traps as material filters through the marsh and also alters the amount of atmospheric carbon that the marsh captures through the plant themselves. Disturbance of the marsh can also lead to the loss of carbon stored in marsh sediment through erosion, leaching, and microbial mineralization.

Hurricane Sandy brought attention to the severely degraded status of the Forsythe salt marshes. Pollution, human modification, and sea level rise have reduced the elevation of the salt marshes and altered water flow in the marsh area; potentially reducing the marsh's ability to sequester carbon. In response, the U.S. Fish and Wildlife Service and the U.S. Army Corp of Engineers, in cooperation with local governments and the State of New Jersey, have initiated restoration projects in the Refuge such as conducting thin layer placement on the marshes. Thin layer placement will serve two purposes in additional to raising the marsh elevation: 1) filling in linear mosquito ditches and 2) tidal flow restoration.

This section of the report applies the SCC approach to the restoration work being conducted at Forsythe in order to estimate the benefits of carbon sequestration and avoided CO_2 emissions benefits attributable to the salt marsh restoration. The primary steps taken to implement this approach include:

- Developing a restoration scenario to use as the basis of the SCC calculation.
- Estimating the volume of CO_2 sequestered by the acres of restored marsh.
- Estimating the rate of CO_2 emissions per acre of marsh in order to develop an estimate of avoided CO_2 emissions as marsh acres are restored.

- Applying a monetary value to the estimated volume of avoided CO_2 by multiplying the Whitehouse and EPA SCC value by the volume of avoided CO_2 emissions.[42]

We describe each of these steps in calculating the SCC benefits associated with restoring acres of salt marsh at Forsythe in the Methods and Data Section below. The SCC estimates for Forsythe are presented in Section 5.3.

5.2 Methods and Data

This section describes the methods and data used to estimate the benefits associated with the restoring portions of the Forsythe salt marsh, including:

- Estimating the amount of CO_2 sequestered by restoring acres of salt marsh over time.
- Estimating the amount of CO_2 emissions avoided by restoring acres of salt marsh.
- Applying a monetary value the volumes of CO_2 sequestered and the CO_2 emissions avoided due to restoration efforts.

5.2.1 Establishing CO_2 Sequestration Rates

Site-specific carbon sequestration data were not available for the Forsythe salt marshes; therefore, carbon sequestration rates were obtained from public literature. Since carbon sequestration rates can vary by type of salt marsh, health and functioning of the marsh, and ecosystems characteristics specific to a geographical area (e.g., soil and vegetation types), ERG searched for carbon sequestration rates representative of:

- Salt marshes with similar ecosystem characteristics and/or in close geographic proximity to Forsythe.
- Restored or healthy, well-functioning salt marshes— to represent the restored marsh sequestration rates.
- Degraded or poorly functioning salt marshes — to represent the sequestration rate of degraded marsh that has yet to be restored.

Literature findings primarily revealed estimates of healthy marshes, with little to no emphasis on sequestration rates of degraded marshes. Table 23 shows the carbon sequestration values and literature sources identified for use in the calculation of SCC. These values were used to establish sequestration rates for healthy and/or restored salt marshes (rates for degraded marshes are addressed below).[43]

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[42] EPA, 2015. http://www.epa.gov/climatechange/EPAactivities/economics/scc.html.

[43] While literature suggests that carbon sequestration rates vary with the degree and type of restoration (Artigas et al, 2015), little information or data was available to estimate sequestration rates for phases of restoration at Forsythe. The sequestration rates for healthy marshes were, therefore, used as a proxy for rates associated with restored marshes.

Table 23 – Carbon Sequestration Estimates from Available Literature

Ecosystem Type	Carbon Sequestration Rate (MT CO_2 per acre per year)	Geographic Area Addressed by Estimate	Reference
Low salt marsh [a]	1.3	Schoodic Peninsula, ME	Sorell (2010)
High salt marsh [a]	1.1-5.9	Several New England high marshes	FWS (1982)
Salt marsh (general) [b]	2.2	Global Average	Duarte et al. (2005)
	0.7-3.7	National Average	Crooks et al. (2009)
	2.2-2.8	NW Atlantic region	Ouyang and Lee (2013)
	2.5	Northeast USA Atlantic coast (average)	Craft (2007)
	2.3	Nauset Bay, MA	Chmura et al. (2003)
	2.4-3.4	Nauset Marsh, MA	Roman et al. (1997)
	2.1	Great Marshes, MA	Middelburg et al. (1997);

[a] High marsh is defined as salt marsh area that is above the mean high-water mark and is only infrequently inundated by tides. Low marsh are salt marsh areas that are frequently inundated by tides.
[b] Estimates from heavily cited studies that span beyond the Forsythe region (e.g., global studies) were also included.

The values obtained in literature appearing in Table 23 were used to develop low, average, and high sequestration estimates. This was done by developing a spreadsheet that listed each literature source that provided carbon or CO_2 sequestration rates. ERG converted any carbon sequestration rates provided into CO_2 sequestration rates and then entered all sequestration rates into the spreadsheet. We recorded the low, high, and average values into corresponding columns in our spreadsheet; if the study provided only one value, we used that one value for the low, high, and average value in the spreadsheet. We then averaged the low, average, and high rate columns to develop summary values for each. This resulted in the low rate of 1.9 metric tons (MT) CO_2 per acre per year, an average rate of 2.4 MT CO_2 per acre per year, and a high rate of 2.9 MT CO_2 per acre per year for healthy/restored marshes. This range of estimates were developed for several reasons:

- Forsythe NWR is currently in the process of categorizing the type of salt marsh covering portions of the reserve (e.g., low salt versus high salt marsh), so it is unclear whether preference should be given to certain marsh types.
- In the absence of site-specific carbon sequestration data at Forsythe, it is unclear which studies are most representative of rates applicable to the study site.
- Since some studies provide a range of sequestration rates, developing a range of estimates for Forsythe reflects various sequestration scenarios.

Applying CO2 Sequestration Rates to Marsh Acreage

There are currently 36,660 acres of salt marsh in Forsythe, and approximately 2,326 acres are anticipated to be restored through current restoration efforts.[44] To estimate the total carbon sequestered by Forysthe salt marshes, ERG: (1) determined the number of acres restored per year and then (2) multiplied the number of restored acres with the three possible carbon sequestration rates (low, average, and high) developed in the previous section. To determine the number of restored acres of salt marsh over time, the following assumptions were made:

- The proportion of salt marsh acres currently being restored was used to estimate that approximately one percent of salt marsh at Forsythe might be restored per year if restoration efforts continued over time a 25-year timeframe.
- Under restoration scenarios, it was assumed that marsh was either “degraded” or “restored,” with the total acreage of marsh staying the same. In this case, each year, one percent of marsh was converted from being categorized as degraded to that of being restored.

Limitations

There are two primary limitations with respect to the development of estimates of CO_2 sequestered by acres of restored marsh at Forsythe, including:

- Sequestration rates are not specific to Forsythe. While an effort was made to obtain sequestration rates from salt marshes that might have similar characteristics to Forsythe, it is unclear how accurately the rates used reflect the sequestration processes at the site since Forsythe is in a partly degraded state and the rates in the literature reflect healthy marshes.
- The restoration scenario might not be accurate. The restoration scenario upon which the sequestration volumes are based (i.e., restoring one percent of salt per year) may not reflect the rate that restoration actually occurs at the marsh. As the number of acres restored in a given year increases, so does the volume of CO_2 sequestered. Nevertheless, providing benefit estimate for a one percent per year restoration of the marsh provides stakeholder with an estimate of the value of long-term restoration.

5.2.2 Estimating Avoided CO_2 Emissions

The volume of avoided CO_2 emissions attributable to restoring acres of salt marsh at Forsythe were calculated by estimating CO_2 emission volumes and then applying those emission volumes to the portion of marsh being restored. With no site data available on the CO_2 emission rates of the salt marshes at Forsythe and the absence of applicable emission rates in literature, a method of calculating CO_2 emissions developed by Pendleton (2012) was explored. Although the Pendleton (2012) method

[44] Forsythe officials estimated that 1,040 acres would undergo thin layer sediment enrichment and 1,286 acres would be restored through tidal flow restoration. The acres covered by each of the restoration efforts were believed to be mutually exclusive for the most part, so the total restored acres used in the SCC calculation is the sum of acres for these two activities.

was instructive, a lack of data to use in the method still remained and we needed to rely on an assumption. This section begins by describing how CO_2 emissions can be based on the approach developed by Pendleton (2012) and then describes the approach we took to estimate avoided CO_2 emissions for acres of restored marsh.

In contrast to CO_2 sequestration rates, CO_2 emission rates are not readily available in published literature (Pendleton, 2012). Pendleton (2012) calculates CO_2 emission rates by estimating the volume of CO_2 that can *potentially* be emitted from a site by multiplying the amount of stored carbon at the site by the molecular weight ratio CO_2 to carbon (3.67) and then taking a percentage of the *potentially* emitted CO_2 to represent the amount of carbon that might *actually* be released. Since data on the carbon storage of the Forsythe salt marshes was not available, ERG used the volumes of sequestered CO_2 identified in Section 5.2.1 to calculate the volume of potential CO_2 emissions per acre of restored marsh.[45] To estimate the volume of CO_2 that might actually be emitted, ERG applied the following two CO_2 emission scenarios:[46]

- Scenario 1: Avoided CO_2 emissions equal the amount of CO_2 sequestered
- Scenario 2: Avoided CO_2 emissions are 50 percent greater than the volume of CO_2 sequestered

For both scenarios, emission rates were estimated for each of the three CO_2 sequestration rate scenarios (low, average, and high sequestration rates). The scenarios and associated sequestration and emission rates are summarized in Table 24. We calculated total carbon benefits assuming one percent of the marsh would be restored annually. We also calculated the benefit associated with the proposed restoration at Forsythe.

Table 24 – Scenarios for Estimating Carbon Sequestration

Scenario	Sequestration Rate(s) Used To Calculate CO_2 Emissions	Emission Rate(s)
Scenario 1	Low , average, and high sequestration rates	Emission rate equals sequestration rate
Scenario 2	Low , average, and high sequestration rates	Emission rate equals 50% (or 1.5 times) the sequestration rate

There are several limitations with respect to how the avoided CO_2 emissions were estimated including:

- The lack of site-specific data on stored carbon. Using the volumes of sequestered CO_2 to develop avoided CO_2 emissions rate is somewhat problematic in that it: (1) excludes the volumes of deeply stored carbon, and therefore might underrepresent the amount of CO_2

[45] The sequestration rates in the previous section were already converted to CO2 emissions, therefore, they did not need to be multiplied by the by the molecular weight ratio to convert carbon to CO2.
[46] These scenarios were based on ERG's best professional judgement and are meant to highlight potential benefits if carbon sequestration.

that could be released under certain marsh degradation scenarios, and (2) it builds upon data that were not site specific and was based on certain assumptions (as discussed in the previous section).

- The emission rate scenarios may not be representative of actual emission rates. The estimate incorporates the assumptions that emissions rate might be equal to or 50 percent greater than the sequestration rate. Without site specific data or additional data from literature, the actual emission rate and/or how they might relate, proportionately, to sequestration rates are unknown.

The combined effect of these two limitations in light of our approach implies that our estimates of carbon benefits, and thus the economic value of those benefits, should be conservative.

5.2.3 Valuing the Benefits of Restored Marsh

The benefits associated with restoring acres of salt marsh at Forsythe (volumes of CO_2 sequestered plus CO_2 emissions avoided) were valued by utilizing the social cost of carbon (SCC). This method was developed through a White House interagency working group under Executive Order 12866. Intended to monetize the incremental annual increases in carbon, SCC considers the changes in "net agricultural productivity, human health, property damages from increased flood risk, and the value of ecosystem services due to climate change" (Interagency Working Group, 2010). Table 25 provides the values at five-year intervals for a three percent discount rate. These were used as a basis for calculating SCC values used in our analysis. One complication was that Table 25 only reflects values for every five years. ERG performed a linear extrapolation to fill in values in the intervening years. This was necessary since we calculated annual values for the sequestered carbon and avoided emissions. Additionally, the increasing cost over time in Table 25 reflects the increasing harm of continued CO_2 emissions over time.

Table 25 – Social Cost of Carbon for 2015 to 2050 (in 2014 Dollars per metric ton CO_2), 3 Percent Discount Rate

Year	Social Cost of Carbon
2015	$40
2020	$47
2025	$51
2030	$56
2035	$61
2040	$67
2045	$71
2050	$77

Source: EPA, 2015

5.3 Results

The benefits associated with restoring acres of salt marsh at Forsythe were estimated for currently planned restoration efforts as well as a scenario whereby one percent of marsh acreage is restored each year over a 25-year timeframe. The benefits estimated include:

- The volume of CO_2 sequestered by restoring marsh acreage
- The avoided CO_2 emissions associated with restoring marsh acreage
- The SCC values for the sequestered CO_2, avoided CO_2 emissions, and combined benefits of sequestered CO_2 plus avoided CO_2 emissions

This section begins by presenting the estimated benefits of conducting the planned restoration work, followed by the estimated benefits of marsh restoration over a 25-year timeframe.

5.3.1 Planned Restoration

The planned salt marsh restoration at Forsythe involves thin layer placement and tidal flow restoration of 2,326 acres the marsh. Table 26 shows the estimated benefits associated with planned restoration. The results in Table 26 show that the benefits of planned restoration are estimated to range from $416,198 to $808,317 when combining the volumes of CO_2 sequestered as well as the CO_2 emissions avoided by restoring those acres. Results indicate that the planned restoration will sequester between 4,015 and 6,239 MT CO_2 and avoid the emission of 4,015 to 9,358 MT CO_2 (depending on sequestration rates used) for total carbon benefits of 8,030 to 15,597 MT CO_2. As noted above, we expect that these estimate are conservative given our approach to estimating avoided emissions.

Table 26 – The Benefits of Planned Salt Marsh Restoration at Forsythe for Three Sequestration Rate Scenarios [a]

Sequestration Rate Scenario	CO_2 Sequestered (MT CO_2)	SCC of Sequestered CO_2 ($2014/MT CO_2)	Emission Rates based on Sequestration Rates			Emission Rates based on 1.5X Sequestration Rates		
			Avoided Emissions (MT CO_2)	SCC of Avoided Emissions ($2014/MT CO_2)	Combined SCC [b] ($2014/MT CO_2)	Avoided CO2 Emissions (MT CO_2)	SCC of Avoided Emissions ($2014/MT CO_2)	Combined SCC [b] ($2014/MT CO_2)
Low	4,354	$208,099	4,354	$208,099	$416,198	6530	$312,149	$520,248
Average	5,559	$265,713	5,559	$265,713	$531,426	8338	$398,569	$664,282
High	6,764	$323,327	6,764	$323,327	$646,654	10146	$484,990	$808,317

Note: ERG used a SCC value of $47.80 per MT of CO_2 for these calculations. This was calculated by extrapolating to 2021 from the rate of change in the SCC value between 2020 and 2025 in Table 25.
[a] To estimate planned restoration benefits, values for restoring 2,326 acres of salt marsh by 2021 were used.
[b] Total SCC combines the SCC for Sequestered CO_2 with the SCC of Avoided CO_2 emissions.

5.3.2 One Percent Per Year Restoration of the Marsh Over 25 Years

Restoration benefits were also estimated assuming that one percent of the marsh would be restored per year over a 25-year time horizon. By the year 2039, this equates to a shift from 36,660 acres of unrestored (deteriorated) salt marsh at present to nearly 8,000 acres of restored marsh, with just under 29,000 acres still in a degraded state. Table 27 shows the benefits of restoring these 7,857 acres of salt marsh at Forsythe over a 25 year time period. The benefits are estimated using the low, average, and high sequestration rate scenarios. Full tables of the benefits estimates can be found in Appendix F.

Table 27 – The Benefits of Restoring Salt Marsh at Forsythe at a Rate of 1% per Year Over 25 Years for Three Sequestration Rate Scenarios

Sequestration Rate Scenario	CO_2 Sequestered (MT CO_2)	SCC of Sequestered CO_2 ($2014/MT CO_2)	Emission Rates based on Sequestration Rates			Emission Rates based on 1.5X Sequestration Rates		
			Avoided Emissions (MT CO_2)	SCC of Avoided Emissions ($2014/MT CO_2)	Combined SCC [a] ($2014/MT CO_2)	Avoided CO_2 Emissions (MT CO_2)	SCC of Avoided Emissions ($2014/MT CO_2)	Combined SCC [a] ($2014/MT CO_2)
Low	14,706	$782,728	14,706	$782,728	$1,565,457	22,059	$1,174,093	$1,956,821
Average	18,777	$999,433	18,777	$999,433	$1,998,865	28,166	$1,499,149	$2,498,581
High	22,849	$1,216,137	22,849	$1,216,137	$2,432,273	34,273	$1,824,205	$3,040,342

[a] Total SCC combines the SCC for Sequestered CO_2 with the SCC of Avoided CO_2 emissions.

The results in Table 27 suggest that by restoring one percent of salt marsh acreage each year for the next 25 years, the total benefits could range from approximately $1.6M to $3M dollars when factoring in the CO_2 sequestered by the restored marsh as well as the CO_2 emissions avoided by restoring that acreage (and depending on the sequestration rate scenario applied). Results indicate that over the 25 year timeframe, total CO_2 sequestered from the restored marsh ranges from 14,706 to 22,849 MT CO_2, while the total avoided CO_2 emissions range from 14,706 to 34,273 (depending on the sequestration rates used in the calculation).

5.3.3 Considerations for Future Work

While the estimated benefits of restoring acres of salt marsh at Forsythe appear to be positive over time based on the methods used in this project, the ability to inform the tradeoffs of future restoration work at this or other sites is limited by the lack of data and the associated assumptions upon which the benefits were estimated. Primary data collection that is site-specific would allow for: (1) more accurate estimates of sequestered CO_2 and avoided CO_2 emissions and (2) benefits to be estimated through other methods, such as considering how the net carbon (carbon sequestered minus carbon emitted) fluctuates with different types and amounts of restoration. The following types of data could greatly improve the accuracy SCC benefits estimations and their ability to inform future restoration choices:

- **GIS mapping and field measurements of current marsh ecosystem.** Understanding the marsh's composition as it relates to land area (e.g., on an acre by acre basis) can inform how certain types of changes (e.g., rising water table, erosion from a severe storm) will likely change the marsh ecosystem over time, thereby shifting its ability to sequester and/or emit carbon.

- **Volume of CO_2 sequestered.** Field measurements of how much CO_2 the marsh is sequestering (and for what area of the marsh) can be used to establish a baseline of CO_2 sequestered by the marsh; a point from which to gauge changes in sequestration resulting from degradation or restoration of the marsh.
- **Volume of CO_2 emissions.** CO_2 emission rates for degraded salt marshes are lacking in literature. Developing a baseline of how different areas of the marsh emit CO_2 (and under what conditions) could inform future restoration work and help provide the data needed to more accurately calculate the volume of emissions offset by completing restoration work.
- **Volume of stored carbon.** The volume of stored carbon (near-surface and deeply buried) greatly impacts the potential amount of emissions that could be released under different degradation scenarios or incidents as calculated using the Pendleton (2012). Estimating this volume can help inform a more accurate assessment of how much carbon is at risk if degradation continues or, conversely, how much avoided emissions can be anticipated if restoration occyrs.

In the absence of primary data collection, obtaining CO_2 emission rates for similar salt marsh types could improve benefits estimates. These emission rate estimates are not readily available in literature at the present time, however, if they were to become available, gathering these estimates from literature in a manner similar to that conducted for sequestration rates under this project might improve upon the current benefits estimated.

SECTION 6: SUMMARY

This report has provided methods and estimates for valuing changes related to restoration work following Hurricane Sandy and estimates of the value that households place on coastal protection options. We have also provided a set of principles to consider in applying benefit transfers to post-disaster restoration decisions. Overall, we performed four analytical components under this project:

1) **Valuing salt marsh restoration at Forsythe National Wildlife Refuge (NWR)** – We presented estimates of the value that people place on trade-offs between ecosystem services provided by salt marshes. This was done by implementing a choice experiment survey in the New Jersey area.
2) **Valuing preferences for shoreline armoring versus living shorelines** – This was done by implementing a discrete choice contingent valuation survey in the New York City (NYC) area using Jamaica Bay as the context for coastal protection. The results provide decision-makers with information on people's preferences for and valuation of shoreline armoring and living shorelines.
3) **Guidelines for implementing benefit transfer in post-disaster restoration decisions** – We presented a set of guidelines that decision-makers can use to implement benefit transfers in restoration decisions and provide two case studies to demonstrate their use. The purpose of the guidelines is to provide decision-makers with a means of obtaining economic value information in the near term (i.e., not having to wait for a complete primary valuation study to be performed or when funding is not available for a primary valuation study) to influence restoration decisions.
4) **Valuing the carbon-related benefits from salt marsh restoration at Forsythe NWR** – We presented an estimate of the social cost of carbon associated with salt marsh restoration at Forsyth NWR. This component provides a method and information that can be used for estimating carbon sequestration benefits from marshes.

This section summarizes the estimates we developed in the four main sections of this report.

6.1 Valuing Trade-Offs Between Ecosystem Services in Salt Marsh Restoration

ERG implemented a choice experiment valuation survey in August of 2015 which involved collection of data from 531 respondents. The choice experiment involved four ecosystem services: bird habitat, recreation, protection of homes from storm surge, and protection of homes from non-surge flooding. We also included the number of acres being restored, allowing us to value restoration acreages as well. The statistical estimates indicated that households valued protection of homes from surge and protection of homes from non-surge flooding equally; this led us to develop a combined estimate for homes protected from flooding (surge and non-surge combined). Thus, our best estimates resulted in values for:

- Minimal improvements in habitat

- Significant improvement in habitat
- Minimal improvements in recreation
- Significant improvement in recreation
- Protection of homes flooding (surge and non-surge related)
- The number of acres being restored

Table 28 summarizes the estimated willingness to pay (WTP) values.

Table 28 – Summary of Forsythe NWR WTP Estimates

Ecosystem Service/Level	Estimated WTP Values (per Household per Year)
Minimum habitat improvements	$50.33
Significant habitat improvements	$90.95
Minimum recreation improvements	$30.71
Significant recreation improvements	$45.35
Protecting 5,000 homes from storm surge	-
Protecting 5,000 homes from non-surge flooding	-
Protecting 5,000 homes from surge or non-surge flooding	$9.95
Restoring 1,000 acres of salt marsh	$8.96

We also explored how WTP varied with distance from Forsythe to assess how WTP values decline over distance from a restoration site. We found that households living 100 miles from Forsythe are willing to pay:

- 60 percent of the amount that households within a mile of Forsythe are willing to pay for protecting 5,000 homes from flooding
- 95 percent of the amount that households within a mile of Forsythe are willing to pay for minimal or significant habitat improvements
- 35 percent of the amount that households within a mile of Forsythe are willing to pay for minimal recreational improvements and 49 percent of the amount for significant recreation improvements

Finally, we explored how WTP varied with the reported impact of Sandy on the survey respondents. We found that households that reported no impact of Sandy were not willing to pay anything for protecting homes from flooding, very little for minimal recreation improvements (approximately $2 per household per year), and slightly more for significant recreation improvements (approximately $17 per household per year). On the other hand, those who reported no impact were willing to pay close to $70 (per household per year) for significant habitat improvements.

6.2 Valuing Preference for Coastal Protection Options in Jamaica Bay

ERG implemented a discrete choice contingent valuation survey in July and August of 2015 which resulted in the collection of data from 541 respondents. ERG estimated WTP values for living shorelines and shoreline armoring using two approaches. First, we estimated WTP values using the Turnbull method which provides a lower bound estimate of WTP. Second, we estimated mean WTP for each coastal protection option using a conditional logistic regression model.

The results of both approaches appear in Table 29. The lower bound estimates for WTP were $110 for living shorelines and $33 for shoreline armoring. The mean WTP estimates were $278 for living shorelines and $59 for shoreline armoring. Thus, ERG found that households are willing to pay 3.3 times more for living shorelines compared to shoreline armoring in the lower bound WTP case and 4.7 times more in the mean WTP case. These ratios can be used by coastal decision-makers who are considering either living shorelines or shoreline armoring as a coastal protection measure.

Table 29 – Estimated WTP Value for Living Shorelines and Shoreline Armoring Using Turnbull Method and Statistical Modeling

Coastal Protection Option	Turnbull Method: Lower Bound WTP Estimates (per household, per year)	Statistical Modeling: Mean WTP Estimates (per household, per year)
Living shorelines (LS)	$110	$278
Shoreline armoring (SA)	$33	$59
Ratio of LS to SA	3.3	4.7

6.3 Applying Benefit Transfers to Restoration Situations: Principles and Case Studies

ERG developed a set of principles and a process to use in applying benefit transfers to restoration decisions. The principles and process are described in detailed in Appendix E; the principles can be summarized as follows:

1. Use/rely on economic expertise in developing benefit transfers.
2. Benefit transfers are a good choice for situations where information is needed in a short amount of time.
3. Benefit transfer values should be only *one* input into any decision-making process.
4. If possible, work on the benefit estimates as the projects are being scoped/defined.
5. Post-disaster restoration differs from the context in which most value estimates are made.
6. All benefit transfers involve error.
7. Benefit transfer may be better used to compare across projects rather than to assess the worth of any one project.

8. Look for specific studies first (or multiple studies to calculate an average) and then fill in any "gaps" using meta-function transfers.
9. Calculate benefits over a reasonable time frame.
10. Do not necessarily aggregate over different benefit estimates.
11. Always assess the possibility of double counting, especially if more than one study is being used.
12. The area being improved by the restoration work may be larger than then area where work is being performed.

We developed these principles and the steps to take by applying benefit transfer to two case studies in Jamaica Bay: a salt marsh restoration project at Sunset Cove in Broad Channel and the restoration of Upper and Lower Spring Creek Park in the Howard Beach section of Jamaica Bay. Table 30 provides the 25-year present values for both case studies.

Table 30 – Summary of Benefit Transfer-Based Estimates for Sunset Cover and Spring Creek Park Case Studies, 25-Year Present Values

Category	Description	Sunset Cove	Spring Creek Park
Recreation	The increase in willingness to pay for swimming, boating, recreational fishing, and birdwatching using an assumed increase of 10 trips per week during the summer for each activity.	$ 0	$570,000
Open space	The willingness to pay as capitalized into property values for living near an open space wetland.	$1.4 million [a]	$12.4 million [a]
Salt marsh productivity for commercial fisheries	The increase in commercial fisheries value from salt marshes stemming from improved food web support and improved nursery habitat.	$27,000	$405,000
Wetland and shellfish existence values	The willingness to pay for existence of the wetlands and shellfish areas being created under the restoration.	$14,000	$9.8 million
Storm protection	The value of reduced economic impact for storms on local-area GDP associated with the Sunset Cove restoration.	$4.2 million	$154 million

Note: all numbers are rounded from the value that appear in the main text of the report.
[a] Values are not 25-year present values; see description.

6.4 Valuing Carbon Benefits Associated with Salt Marsh Restoration at Forsythe

ERG used a social cost of carbon approach to estimate the benefit of improved carbon sequestration at Forsythe. We developed estimates for the currently planned restoration work at Forsythe and a situation where one percent of the marsh is restored each year over years. Our method involved a low, average, and high rate of sequestration and we estimated avoided CO_2 emissions under two different scenarios. Our estimates are provided in Table 31. We estimated that the currently planned restoration effort at Forsythe will result in benefits valued at $416,000 to $808,000 for 2015-

2050. Additionally, if one percent of the marsh were restored each year over 25 years, we estimate the total benefits to be between $1.6 and $3.0 million between 2015 and 2050.

Table 31 – Estimated Benefits for Increased Carbon Sequestration at Forsythe: Planned Restoration and an Assumed One Percent per Year Restoration Effort (2015-2050, $1,000s, $2014)

CO_2 Sequestration Rate	Planned Restoration Effort at Forsythe		One Percent (of acres) per Year Restoration Effort Over 25 Years	
	Scenario 1	Scenario 2	Scenario 1	Scenario 2
Low (1.9 MT CO_2/year)	$416.2	$520.2	$1,565.5	$1,956.8
Average (2.4 MT CO_2/year)	$531.4	$664.3	$1,998.9	$2,498.6
High (2.9 MT CO_2/year)	$646.7	$808.3	$2,432.3	$3,040.3

Scenario 1: Avoided emissions of CO_2 from degraded marsh that are restored assumed to be equal to the amount of CO_2 sequestered in the restored marsh.
Scenario 2: Avoided emissions of CO_2 from degraded marsh that are restored assumed to be 1.5 times the amount of CO_2 sequestered in the restored marsh.

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APPENDIX A:

FORSYTHE NATIONAL WILDLIFE REFUGE SALT MARSH RESTORATION SURVEY INSTRUMENT

NOTES:

- **Attribute levels used in valuation questions can be found in Table 2 in Section 2.2.1 of the main body of the report.**
- **Question numbers reflect the values used to track questions during instrument development and pre-testing. We have not re-numbered in this Appendix to reflect order presented to the respondent. Respondents did not see question numbers in the implementation.**

OMB Control #: 0648-0714
Expires May 31, 2018

- This research study is being conducted by Eastern Research Group, Inc. on behalf of the National Oceanic and Atmospheric Administration (NOAA).
- Your participation is absolutely voluntary and you may stop at any time.
- The survey will take approximately 20 minutes of your time to complete.
- You will not be individually identified and your responses will be used for statistical purposes only.
- If you have questions about your rights as a participant in this survey, or are dissatisfied at any time with any aspect of the survey, you may contact {*ERG CONTACT*}.

Public reporting burden for this collection of information is estimated to average 20 minutes per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other suggestions for reducing this burden to Peter Wiley, NOAA Office for Coastal Management 1315 East-West Highway, Silver Spring, MD 20910 (Peter.Wiley@noaa.gov, 301- 563-1141).

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In October of 2012, Hurricane Sandy inflicted significant damage and loss of life along the eastern seaboard of the U.S. One of the natural areas affected was **Forsythe National Wildlife Refuge** (NWR) near Atlantic City in southern New Jersey.

- The Refuge contains more than 37,000 acres of land, 78% of which is a coastal salt marsh.
- The Refuge offers a stop-over for tens of thousands migratory birds along the Atlantic Flyway.
- The Refuge is primarily located within Ocean County New Jersey and the local towns that surround the marsh are home to approximately 75,000 people and 28,000 homes.

Aside from the large amount of debris that was washed into the Refuge, Hurricane Sandy brought attention to the severely degraded status of the Forsythe salt marshes. Pollution, human modification, and sea level rise have reduced the elevation of the salt marshes and altered water flow in the marsh area. These changes impact the services provided by the Refuge, including:

- **Coastal storm protection** – sand and thick grass in salt marshes protect coastal buildings and roads from surging storm waters and erosion.
- **Flood protection** – marshes reduce flooding by slowing and absorbing rainwater.
- **Contaminant removal** – marshes improve water quality for fish and bird habitats by filtering out contaminants (such as excess nitrogen from fertilizers).
- **Habitat** – marshes provides an important resting place for migratory birds, home for nesting birds, and space for fish and shellfish to spawn.
- **Recreation** – marshes provide numerous recreational opportunities such as bird watching, nature/walking trails, canoeing, and kayaking.
- **Food web support for fish** – biological processes in marshes provide the basis of the food web for recreational and commercial fisheries.
- **Carbon storage** - salt marshes absorb and store large quantities of carbon dioxide from the atmosphere, reducing the amount of carbon in the atmosphere (which can help to manage climatic change).

These benefits are made possible by salt marshes being a combination of tall, strong grasses (*Spartina alterniflora*) and the channels of water that connect the marsh to the ocean. Salt marshes require ocean tides to come in and flood the marsh and then to go out and allow the marsh to briefly dry out. As living matter (grasses) settle and decay, the marsh land compacts and sinks (subsides). In “healthy” marshes, tides will bring new sediment (soil) to raise the elevation of the marsh again, maintaining the area as a salt marsh. If tides do not bring enough sediment or if water (sea) levels increase, however, lower areas of a marsh will be continually flooded with water leading to the marsh grass dying off and those areas to be transformed to open water or mud flats. If not counterbalanced somehow, large areas of marshes can be eventually transformed to open water or mud flats.

In response to the damage from Hurricane Sandy at the Forsythe marsh, the U.S. Fish and Wildlife Service and the U.S. Army Corp of Engineers, in cooperation with local governments and the State of New Jersey, have initiated restoration projects in the Refuge. These projects include work to raise the elevation of the marshes, improve water flow, remove debris left by Sandy and previous storms, and remove old telephone poles and wires. These efforts should help to maintain and improve the services provided by the Refuge. Some Federal funds have been authorized to begin restoration efforts, but additional future funds may be needed to further restore and maintain the marshes in the future.

The goal of this survey is to collect information from people like you to assist in better decision-making about restoration activities following natural events such as Hurricane Sandy. We are interested in what you think of marsh restoration and the environmental services it can generate. The survey is also designed to assess how much people like you value the services provided by the marsh.

Q4. Prior to reading the last page that described the benefits of salt marshes, how familiar were you with the environmental services of salt marshes?

Very familiar 1
Somewhat familiar...........................2
Somewhat unfamiliar........................3
Not at all familiar 4

ZIP. What is your ZIP code? (This will help us understand where you live in relation to Forsythe National Wildlife Refuge)

_______ ZIP CODE

Q1. How familiar are you with Forsythe National Wildlife Refuge?

Very familiar 1
Somewhat familiar...........................2
Not very familiar 3
Have never heard of it.....................4

Q2. Have you ever visited the Forsythe National Wildlife Refuge?

Yes 1
No..2

Q3. How many times did you visit the Forsythe National Wildlife Refuge in the previous 12 months?

_____ trips

Q3a. Have you visited the Forsythe National Wildlife Refuge since Hurricane Sandy?

Yes 1
No..2

Q5. Overall, how concerned are you about the status of the Forsythe National Wildlife Refuge and the environmental services it provides?

Very concerned 1
Somewhat concerned 2
Not very concerned 3
Not at all concerned 4
Unsure / Don't know.........................5

Q5a. Were you living in the New York/New Jersey area when Hurricane Sandy struck?

Yes 1
No..2

Q6. How would you describe the impact that Hurricane Sandy had on you?

Very significant.................................1
Moderate impact 2
Small impact.....................................3
No impact at all 4

The results of this survey are *advisory.* In other words, they can be used to inform policymakers on the opinions and preferences of people such as yourself about funding for restoration of coastal marshes. We would like to better understand your level of support for salt marsh restoration at **Forsythe National Wildlife Refuge**. To do so, we will ask you to vote on different restoration options. Each option can offer improvements in environmental services, but will require public money to implement the project. One alternative is to not invest in marsh restoration, in which case no public money will be needed.

The restoration options we will ask you about involve restoring a number of acres of salt marsh at Forsythe and some potential benefits from restoring those acres. The acres currently being considered for restoration represent approximately 2% - 13% of the Forsythe marsh. These acres represent areas of the marsh that are in most need of restoration and can be reasonably restored in the short term. Further restoration in the future is also possible.

The benefits we describe are in terms of number of homes protected, habitat restored, and recreation offered. Since any restoration project will produce specific benefits based on its location and details, the benefits described in this survey are meant to be general.

As a voting taxpayer, you have an opportunity provide feedback to policymakers regarding your support for – and willingness to pay for – marsh restoration projects. One way that policymakers might evaluate whether or not to do this work at the salt marsh is through an advisory referendum or special ballot question used to gauge voter opinion. In what follows, we will ask you to choose between different marsh restoration options. Each option will have a cost associated with it in terms of the amount your household would have to pay in annual income tax.

Please think carefully about how you would actually vote. We want you to respond as if your taxes would actually increase if restoration projects are implemented.

Please remember, paying for restoration means your household would have less money to spend on other goods like food, clothing, trips, and less toward other environmental problems that you care about.

There are no right or wrong answers. We have found some people would support these kinds of projects and others would not support them. Both kinds of voters have good reasons for why they would vote one way or the other.

Q7. The table below provides two potential restoration options, the potential benefits from those options, and the associated cost to taxpayers. You can choose to vote for one of the two options or choose neither one (i.e., the “status quo” option).

Category	Status quo	Option A	Option B
Amount of the marsh that is restored	None	____ acres	____ acres
Storm protection	Homes in the coastal area are under increased risk from storm damage.	Protects ___ homes and businesses from a 5-foot storm surge (a rise of water generated by a storm that is 5 ft over and above the predicted tide level)	Protects ____ homes and businesses from a 5-foot storm surge (a rise of water generated by a storm that is 5 ft over and above the predicted tide level)
Flood protection	Homes in the coastal areas are under increased risk of suffering flood damage.	Protects ____ homes and businesses from a 20-year flood (a flood that would occur only once every 20 years)	Protects _____ homes and businesses from a 20-year flood (a flood that would occur only once every 20 years)
Habitat	Habitats for migratory birds continue to deteriorate with the marsh; over time fewer birds would visit the marsh.	_____	_____
Recreation	Recreational opportunities decline as the marsh deteriorates; over time there would be fewer places to fish, hunt, and hike trails.	_____	______
Cost - Increase in your annual income tax	$0	$____	$____
Vote	☐	☐	☐

Q8. How confident were you in the choice you made?

Very confident 1
Somewhat confident........................2
Somewhat unsure 3
Not at all confident (I guessed) 4

Q9. When voting, what expectations, if any, did you have about how others might vote?

I thought most people would vote for the status quo option. 1
I thought most people would vote for Option A. 2
I thought most people would vote for Option B. 3
I didn't really think about it...4

[IF Q7=1 "STATUS QUO"]

Q10. You chose to vote for neither Option A nor Option B on the referendum. What was your reasoning?

I don't really have a specific reason why. 1
I'm interested, but I can't afford it. 2
I don't think the expected benefits are worth it. 3
Society has more important problems than restoring salt marshes. 4
I do not support any kind of tax increases. 5
I do not live in the area – only people who live in the area should pay for the project. 6
Other **[TEXTBOX]** 7

Q11. The table below provides <u>two more</u> potential restoration options, the potential benefits from those options, and the associated cost to taxpayers. You can choose to vote for one of the two options or choose neither one (i.e., the "status quo" option). When reviewing this second set, assume that the first sets we asked about above are no longer relevant and that these are your only choices.

Category	**Status quo**	**Option A**	**Option B**
Amount of the marsh that is restored	None	_____ acres	_____ acres
Storm protection	Homes in the coastal area are under increased risk from storm damage.	Protects ___ homes and businesses from a 5-foot storm surge (a rise of water generated by a storm that is 5 ft over and above the predicted tide level)	Protects ____ homes and businesses from a 5-foot storm surge (a rise of water generated by a storm that is 5 ft over and above the predicted tide level)
Flood protection	Homes in the coastal areas are under increased risk of suffering flood damage.	Protects ____ homes and businesses from a 20-year flood (a flood that would occur only once every 20 years)	Protects _____ homes and businesses from a 20-year flood (a flood that would occur only once every 20 years)
Habitat	Habitats for migratory birds continue to deteriorate with the marsh; over time fewer birds would visit the marsh.	______	______
Recreation	Recreational opportunities decline as the marsh deteriorates; over time there would be fewer places to fish, hunt, and hike trails.	______	_______
Cost - Increase in your annual income tax	$0	$____	$____
Vote	☐	☐	☐

Q12. How confident were you in the choice you made on the second referendum?

Very confident 1
Somewhat confident........................2
Somewhat unsure 3
Not at all confident (I guessed) 4

Q13. When voting, what expectations, if any, did you have about how others might vote on the second referendum?
I thought most people would vote for the status quo option. 1
I thought most people would vote for Option A. 2
I thought most people would vote for Option B. 3
I didn't really think about it..4

[IF Q11=1 "STATUS QUO"]
Q14. You chose to vote for neither Option A nor Option B on the second referendum. What was your reasoning?

I don't really have a specific reason why. 1
I'm interested, but I can't afford it. 2
I don't think the expected benefits are worth it. 3
Society has more important problems than restoring salt marshes. 4
I do not support any kind of tax increases. 5
I do not live in the area – only people who live in the area should pay for the project. 6
Other **[TEXTBOX]** 7

Q15. The table below provides two final potential restoration options, the potential benefits from those options, and the associated cost to taxpayers. You can choose to vote for one of the two options or choose neither one (i.e., the "status quo" option). When reviewing this final set, assume that the previous sets we asked about above are no longer relevant and that these are your only choices.

Category	Status quo	Option A	Option B
Amount of the marsh that is restored	None	_____ acres	_____ acres
Storm protection	Homes in the coastal area are under increased risk from storm damage.	Protects ___ homes and businesses from a 5-foot storm surge (a rise of water generated by a storm that is 5 ft over and above the predicted tide level)	Protects ____ homes and businesses from a 5-foot storm surge (a rise of water generated by a storm that is 5 ft over and above the predicted tide level)
Flood protection	Homes in the coastal areas are under increased risk of suffering flood damage.	Protects ____ homes and businesses from a 20-year flood (a flood that would occur only once every 20 years)	Protects _____ homes and businesses from a 20-year flood (a flood that would occur only once every 20 years)
Habitat	Habitats for migratory birds continue to deteriorate with the marsh; over time fewer birds would visit the marsh.	_____	_____
Recreation	Recreational opportunities decline as the marsh deteriorates; over time there would be fewer places to fish, hunt, and hike trails.	_____	_______
Cost - Increase in your annual income tax	$0	$____	$____
Vote	☐	☐	☐

Q16. How confident were you in the choice you made on the third referendum?

Very confident 1
Somewhat confident........................2
Somewhat unsure 3
Not at all confident (I guessed) 4

Q17. When voting, what expectations, if any, did you have about how others might vote on the third referendum?

I thought most people would vote for the status quo option. 1
I thought most people would vote for Option A. 2
I thought most people would vote for Option B. 3
I didn't really think about it..4

[IF Q15=1 "STATUS QUO"]

Q18. You chose to vote for neither Option A nor Option B on the third referendum. What was your reasoning?

I don't really have a specific reason why. 1
I'm interested, but I can't afford it. 2
I don't think the expected benefits are worth it. 3
Society has more important problems than restoring salt marshes. 4
I do not support any kind of tax increases. 5
I do not live in the area – only people who live in the area should pay for the project. 6
Other **[TEXTBOX]** 7

Q19. How likely do you think it is that the results of this survey will shape the direction of future policy at the Forsythe National Wildlife Refuge?

Very likely.......................................1
Somewhat likely 2
Somewhat unlikely 3
Very Unlikely 4
I don't know 5

Q20. How important to you are each of the following benefits of salt marshes?

Not at all important	Slightly important	Moderately important	Very important	Extremely important
1	2	3	4	5

Q20_1. Storm protection
Q20_2. Flood protection
Q20_3. Wildlife habitat
Q20_4. Fish/seafood spawning ground
Q20_5. Water purification
Q20_6. Recreation
Q20_7. Carbon storage

Q21. To what extent do you agree with the following statements?

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
1	2	3	4	5

Q21_1. The climate is changing in ways that could be harmful to the coast.
Q21_2. Hurricane Sandy was a rare event and a similar storm is unlikely to occur in my lifetime.
Q21_3. I expect coastal storms will be more destructive in the future than in the past
Q21_4. It is the responsibility of the federal government to fund restoration efforts related to Hurricane Sandy.
Q21_5. Federal and state governments can effectively implement environmental restoration projects.

Q22. Which, if any, of the following outdoor activities do you engage in?

Freshwater fishing...................................... 1
Saltwater fishing... 2
Boating/Canoeing....................................... 3
Hunting.. 4
Bird watching.. 5
Hiking/nature walking 6
Other **[TEXTBOX]**... 7
[SPACE]
I don't engage in any outdoor activities....... 8

APPENDIX B:

STATISTICAL MODELING RESULTS FOR FORSYTHE NWR ANALYSIS

Table B-1 – Estimated Base Statistical Models for Estimating Willingness to Pay for Ecosystem Service Improvements at Forsythe NWR

Factor	Model 1A (Surge and Non-Surge Protection Separate)	Model 1B (Surge and Non-Surge Protection Combined)
Minimum habitat improvements	0.533 (5.84)***	0.546 (6.00)***
Significant habitat improvements	0.971 (11.35)***	0.987 (11.64)***
Minimum recreation improvements	0.330 (3.93)***	0.333 (3.95)***
Significant recreation improvements	0.474 (5.43)***	0.492 (5.71)***
Number of homes protected from storm surge	1.95e-05 (1.16)	-
Number of homes protected from non-surge flooding	1.79e-05 (1.66)*	-
Number of homes protected from surge and non-surge flooding	-	2.16e-05 (1.94)**
Number of salt marsh acres restored	9.55e-05 (4.67)***	9.73e-05 (4.74)***
Tax	-0.011 (-1295)***	-0.011 (-12.86)***
Likelihood ratio	431.96***	430.22***
Pseudo R^2	0.129	0.128
N	4,576	4,576

* Statistically significant at the 10 percent level

** Statistically significant at the five percent level

* Statistically significant at the one percent level.

Table B-2 – Estimated Statistical Models for Estimating Willingness to Pay for Ecosystem Service Improvements Adjusted for Distance from Forsythe NWR

Factor	Model 2A (Homes protected interacted with distance from FNWR)	Model 2B (Habitat improvements interacted with distance from FNWR)	Model 2C (Recreation improvements interacted with distance from FNWR)
Minimum habitat improvements	0.638 (7.20)***	0.672 (3.18)***	0.635 (7.17)***
Significant habitat improvements	1.031 (12.13)***	1.066 (5.02)***	1.029 (12.10)***
Minimum or significant habitat improvements interacted with distance from FNWR	-	5.5e-04 (-0.18)	-
Minimum recreation improvements	0.372 (4.46)***	0.372 (4.46)***	0.624 (2.96)***
Significant recreation improvements	0.542 (6.27)***	0.543 (6.27)***	0.798 (3.71)***
Minimum or significant recreation improvements interacted with distance from FNWR	-	-	-0.004 (-1.29)
Number of homes protected from surge and non-surge flooding	4.88e-05 (1.83)**	385e-05 (3.61)***	3.84e-05 (3.59)***
Number of homes protected from surge and non-surge flooding interacted with distance from FNWR	-1.66e-07 (-0.42)	-	-
Tax	-0.010 (-12.34)***	-0.010 (-12.34)***	0.010 (-12.34)***
Likelihood ratio	403.86***	403.72***	405.37***
Pseudo R^2	0.121	0.121	0.122
N	4,549	4,549	4,549

* Statistically significant at the 10 percent level
** Statistically significant at the five percent level
* Statistically significant at the one percent level.

Table B-3 – Estimated Statistical Models for Estimating Willingness to Pay for Ecosystem Service Improvements Adjusted for Reported Impact of Sandy on Respondent

Factor	Model 3A (Homes protected interacted with impact on Sandy)	Model 3B (Habitat improvements interacted with impact on Sandy)	Model 3C (Habitat improvements interacted with impact on Sandy)	Model 3D (Acres restored interacted with impact on Sandy)
Minimum habitat improvements	0.557 (6.10)***	0.086 (0.50)	0.556 (6.08)***	0.554 (6.06)***
Significant habitat improvements	0.992 (11.68)***	0.522 (3.09)***	0.987 (11.60)***	0.994 (11.70)***
Minimum or significant habitat improvements interacted with reported impact of Sandy	-	0.211 (3.16)***	-	-
Minimum recreation improvements	0.338 (4.00)***	0.335 (3.97)***	-0.233 (-1.34)	0.336 (3.97)***
Significant recreation improvements	0.502 (5.81)***	0.500 (5.77)***	-0.066 (-0.38)	0.506 (5.84)***
Minimum or significant recreation improvements interacted with reported impact of Sandy	-	-	0.255 (3.73)***	-
Number of homes protected from surge and non-surge flooding	-3.6e-05 (-1.63)	2.25e-05 (2.01)**	2.26e-05 (2.03)**	2.17e-05 (1.94)*
Number of homes protected from surge and non-surge flooding interacted with reported impact of Sandy on respondent	2.62e-05 (3.04)***	-	-	-
Number of salt marsh acres restored	9.65e-05 (4.69)***	9.78e-05 (4.75)***	9.77e-05 (4.74)***	-3.70e-05 (-0.85)
Number of salt marsh acres restored interacted with reported impact of Sandy on respondent	-	-	-	6.06e-05 (3.52)***
Tax	-0.011 (-12.83)***	-0.011 (-12.87)***	-0.011 (-12.83)***	-0.011 (-12.80)***
Likelihood ratio	418.26***	441.22	445.19	443.69
Pseudo R^2	0.125	0.132	0.133	0.133
N	4,567	4,567	4,567	4,567

* Statistically significant at the 10 percent level
** Statistically significant at the five percent level
* Statistically significant at the one percent level.

APPENDIX C:

JAMAICA BAY COASTAL PROTECTION SURVEY INSTRUMENT

NOTES:

- **Attribute levels used in valuation questions can be found in Table 9 in Section 3.2.2 of the main body of the report.**

OMB Control #: 0648-0714
Expires May 31, 2018

- o This research study is being conducted by Eastern Research Group, Inc. on behalf of the National Oceanic and Atmospheric Administration (NOAA).
- o Your participation is absolutely voluntary and you may quit at any time.
- o The survey will take approximately 25 minutes of your time to complete.
- o You will not be individually identified and your responses will be used for statistical purposes only.
- o If you have questions about your rights as a participant in this survey, or are dissatisfied at any time with any aspect of the survey, you may contact Melanie.Sands@erg.com.

Public reporting burden for this collection of information is estimated to average 25 minutes per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other suggestions for reducing this burden to Peter Wiley, NOAA Office for Coastal Management 1315 East-West Highway, Silver Spring, MD 20910 (Peter.Wiley@noaa.gov, 310- 563-1141).

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In October of 2012, Hurricane Sandy inflicted significant damage and loss of life along the eastern seaboard of the U.S. One of the areas significantly affected was the **Jamaica Bay** area of New York City.

Since Hurricane Sandy, there has been an active debate on the best ways to protect areas such as Jamaica Bay from storms like Sandy. One possible approach involves building sea walls (or flood walls) and other "hard" structures that shield buildings, roads, and utilities from storm surge and strong waves caused by coastal storms. This is often referred to as "**shoreline armoring**." A second approach is to use natural features, such as dunes, native plants, and stones that will protect coastal areas, while also providing wildlife habitat and recreational opportunities for people. This approach is sometimes referred to as "**living shorelines**." The two options are not "all-or-nothing". They can be combined as part of a region-wide strategy. Furthermore, some specific locations are better suited for one approach over the other (for various reasons). In many cases and at some locations, however, decision-makers will need to choose between the two options.

The purpose of this survey is to help NOAA better understand how and why people value the different shoreline protection options. In what follows, we'll provide some information on the pros and cons of each approach and then ask you a series of questions, including a question about your willingness to pay for both types of storm protection.

As you are probably aware, significant work is underway to restore Jamaica Bay from the impacts of Sandy. There is still, however, much to be done to protect Jamaica Bay and other parts of NYC from future storms, and a good deal of thought has been given to what types of protective measures should be used. There are many options being considered, some of which involve **shoreline armoring** and some of which involve **living shorelines**.

The goal of this survey is to collect information from people like you to assist in better decision-making. We are interested in what you think of different storm protection options and the value you place on that protection.

The choice between **shoreline armoring** and **living shorelines** is not a simple one; each offers pros and cons relative to the other. The following table describes some of these pros and cons for sea walls (a form of armoring) and living shorelines.

	Sea walls (shoreline armoring)	**Living shorelines**
Amount of protection from storms	A sea wall offers significant protection from a storm. A sea wall repels most coastal storm waves which protects structures from damage. They can be designed to withstand certain storm "levels" (e.g., a 5-foot storm surge or a 50-year storm).	Dunes slow waves down and, if large enough, repel the waves. Living shorelines can also involve stone breakwaters that are placed offshore which slow down waves. Large waves, however, can wash over dunes and breakwaters.
Time it takes to get to full protection	Once it is installed, a sea wall offers immediate protection from coastal storms. Planning and design of the sea walls, however, could take one to three years.	A living shoreline can be built within a few months. If the design involves native plants (most do), then it may take a few years for those plants to fully mature and offer any benefits.
Longevity of protection	Over time, a sea wall will deteriorate and require maintenance and, eventually, replacement.	Living shorelines should last a long time. If built correctly, a living shoreline should improve in strength over time. Nevertheless, strong storms such as Sandy can damage living shorelines.
Beach erosion	Sea walls located in front of beaches will cause the beach to erode as waves bounce off of the wall and take sand with them back into the ocean.	Living shorelines will protect beaches from erosion by absorbing wave energy and providing sand to replace sand that is washed out to sea.
Aesthetics (how nice the feature looks)	Sea walls are just that, a wall, and are not necessarily considered pleasing to look at by some people.	Some may consider living shorelines more pleasant to look at compared to sea walls, but large dunes (which offer more storm protection) can block views of the ocean.
Benefits besides storm protection	None	Living shorelines provide habitat for birds and other wildlife. They also provide recreational opportunities such as wildlife watching and beach-going for people.

For reference, here are some examples of what sea walls (shoreline armoring) look like after installation.

For reference, these are some images of living shorelines …

ZIP. What is your ZIP code? (This will help us understand where you live in relation to Jamaica Bay)

________ ZIP CODE

Q1. How familiar are you with Jamaica Bay?

Very familiar 1
Somewhat familiar............................2
Not very familiar 3
Have never heard of it......................4

Q2. Do you live in one of the communities in and around Jamaica Bay?

Yes 1
No...2

[IF Q2=2 'NO']

Q3. How frequently do you visit Jamaica Bay?

Very often.......................................1
Often 2
Sometimes 3
Rarely..4
Never...5

[IF Q2=2 'NO']

Q4. In the previous 12 months, how many trips did you take to the Jamaica Bay area for the purpose of performing some form of outdoor recreation such as going to the beach, hiking, or bird-watching?

______ trips

Q5. Were you living in the New York/New Jersey area during Hurricane Sandy?

Yes 1
No...2

Q6. How would you describe the impact that Sandy on you?

Very significant................................1
Moderate impact 2
Small impact....................................3
No impact at all 4

The results of this survey are *advisory.* In other words, they can be used to inform policymakers on the opinions and preferences of people, such as yourself, about different types of coastal protection measures. To provide information to policymakers, we will ask you to vote on different options that involve **shoreline armoring** (sea walls) and **living shoreline** coastal protection measures. These projects are *not* currently proposed projects or ones that are being considered at this time. In fact, we have kept the details general in order to focus on the trade-offs between **shoreline armoring** and **living shoreline** options. In other words, the options we present are examples rather than specific projects.

Importantly, we'll also be asking whether you'd be willing to incur additional annual income tax to fund these coastal protection measures. As a voting taxpayer, you have an opportunity to provide feedback to policymakers regarding your support for – and willingness to pay for – coastal protection projects. Naturally, one alternative is to not invest in additional coastal protection, in which case no public money will be needed. If, however, the public values coastal protection, the results of this survey may be used to assess public preferences and how much people are willing to pay. This information may influence financing decisions, which can affect taxation policies.

Please think about your budget and keep in mind other things you might spend your money on instead of coastal protection projects. Honestly assess the tradeoffs involved with supporting a proposed project or not supporting it.

There are no right or wrong answers. We have found some people would support these kinds of projects and others would not support them. Both kinds of voters have good reasons for why they would vote one way or the other.

Below we provide two potential coastal protection options, one focused on shoreline armoring and one on living shorelines. We describe each option and the associated cost to taxpayers. You can choose to vote for one of the two options or choose to support neither one.

Shoreline armoring option. Under this option, sea walls would be built to protect coastal areas within Jamaica Bay. The walls would provide protection against a {LEVEL OF STORM}. The walls would take two to three years to plan and build and, once completed, would provide immediate protection from storms. The walls would last approximately {LONGEVITY OF PROTECTION}**,** but would require some maintenance every year with more maintenance being required toward the end of the wall's lifetime. Any beaches in front of the sea walls would erode completely within 1-2 years after completion. Building these walls to protect coastal areas in Jamaica Bay would result in an increase of {COST} each year to your household income taxes over the next 10 years.

Living shorelines option. Under this option, living shorelines would be built in Jamaica Bay to provide coastal protection. The living shorelines would be built to provide protection against a {LEVEL OF STORM}. The living shorelines would take a year to plan and build and, once built, would provide immediate protection. The living shorelines would require little maintenance over time and, if built properly, would become stronger over time as they become "established". Large storms, however, can and will damage these areas. Under this option, we would expect the living shorelines to last {LONGEVITY OF PROTECTION} before being damaged by storms and needing repair. The living shorelines would also provide habitat for birds and other animals. Building living shorelines to protect coastal areas in Jamaica Bay would result in an increase of {COST} each year to your household income taxes over the next 10 years.

Q7. What option would you choose?

Please note, you can also choose to vote for neither option. Voting for neither option results in no additional cost to you, but no additional protection to the coastline is added.

Option	Increased annual household income tax you would have to pay	Vote
Shoreline armoring (sea walls)	{COST}	
Living shorelines	{COST}	
Neither	$0	

Q8. How confident were you in the choice you made?

Very confident 1
Somewhat confident........................2
Somewhat unsure 3
Not at all confident 4

Q9. When voting, what expectations, if any, did you have about how <u>others</u> might vote?

I thought most people would vote for the “neither approach” option 1
I thought most people would vote for shoreline armoring.......................... 2
I thought most people would vote for living shorelines.............................. 3
I didn’t really think about it... 4

Q10. How likely do you think it is that the results of <u>this survey</u> will shape the direction of future policy in Jamaica Bay?

Very likely.......................................1
Somewhat likely 2
Somewhat unlikely 3
Very unlikely....................................4
I don’t know 5

[IF Q7=3 'NEITHER']

Q11. You chose to vote neither shoreline armoring nor living shorelines on the referendum. What was the <u>primary reason</u> for your decision?

I don't really have a specific reason why. 1
I'm interested, but I can't afford it. 2
I don't think the expected benefits are worth it. 3
Society has more important problems than coastal protection. 4
I do not support any kind of tax increases. 5
I do not live in the area – only people who live in the area should pay for the project 6
Other: **[TEXTBOX]** 7

Q12. To what extent do you agree with the following statements?

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
1	2	3	4	5

Q12_1. The climate is changing in ways that could be harmful to the coast.
Q12_2. It is the responsibility of the federal government to fund restoration efforts related to Sandy.
Q12_3. Sandy was a rare event and a similar storm is unlikely to occur again in my lifetime.
Q12_4. I expect coastal storms will be more destructive in the future than in the past.
Q12_5. Where possible, natural options for shoreline protection should be used before any man-made options.

Q13. Which, if any, of the following outdoor activities do you engage in?

Freshwater fishing 1
Saltwater fishing 2
Boating/Canoeing 3
Hunting 4
Bird watching 5
Hiking/nature walking 6
Other **[ ]** 7
I don't engage in any outdoor activities 8

APPENDIX D:

STATISTICAL MODELING RESULTS FOR JAMAICA BAY ANALYSIS

Table D-1 – Turnbull Estimate WTP Calculation for Living Shorelines

Tax	Number of "No" Responses	Total Number of Responses	Proportion that Responded "No"	Cumulative Density [a]	WTP Calculation [b]
$0					$0.00
$30	60	137	0.438	0.438	$1.20
$70	65	136	0.478	0.040	$3.88
$140	72	135	0.533	0.055	$10.04
$240	72	119	0.605	0.072	$94.79
$240+			1	0.395	
				Estimated WTP:	**$109.91 [c]**
				95 Percent Confidence Interval for WTP: [d]	**$98.53 - $121.28**

[a] For each row, calculated as the difference between the proportion that responded "no" for the specified tax amount and the proportion that responded "no" for the tax amount in the prior row. For example, for tax = $70, 0.040 = 0.0478 – 0.438.
[b] Calculated by multiplying the tax amount in the row by the cumulative density for the next row.
[c] Calculated as the sum of the column.
[d] This is calculated based on the expression for variance of the estimate reported in Haab and McConnell (2002), page 78.

Table D-2 - Turnbull Estimate WTP Calculation for Shoreline Armoring

Tax	Number of "No" Responses	Total Number of Responses	Proportion that Responded "No"	Re-Pooled Proportion that Responded "No"	Cumulative Density [b]	WTP Calculation [c]
$0						$0.00
$30	108	130	0.831	0.828 [a]	0.828	$1.11
$70	116	140	0.829	Pooled above	-	-
$140	114	138	0.826	Pooled above	-	-
$240	103	119	0.866	0.866	0.037	$32.27
$240+			1	1	0.134	
					Estimated WTP	**$33.38 [d]**
					95 Percent Confidence Interval for WTP: [e]	**$26.96 - $39.81**

[a] Pooled proportion for tax amounts of $30, $70, and $140. These values were pooled since the proportion that responded "no" in the prior column reflected a decreasing proportion when moving from $30 to $70 and from $70 to $140.
[b] For each row, calculated as the difference between the re-pooled proportion that responded "no" for the specified tax amount and the re-pooled proportion that responded "no" for the tax amount in the prior row.
[c] Calculated by multiplying the tax amount in the row by the cumulative density for the next row.
[d] Calculated as the sum of the column.
[e] This is calculated based on the expression for variance of the estimate reported in Haab and McConnell (2002), page 78.

Table D-3 – Conditional Logistic Regression Model for Calculating WTP for Jamaica Bay Analysis

Factor	Estimated Regression Coefficient (z-Statistic)	z-Statistic
Factors affecting all choices		
Level of protection offered by option	-0.010	-0.50
Longevity of the protection	-0.002	-0.23
Tax amount	-0.003	-3.50***
Factor effects on living shorelines		
Income	$-4.44e^{-07}$	-0.18
Impact of Sandy on respondent	-0.446	-1.66*
High risk	-0.682	-2.55**
Participation in outdoor activities	-0.438	-1.63
Constant term	0.498	1.29
Factor effects on living shorelines		
Income	$4.16e^{-06}$	2.00**
Impact of Sandy on respondent	-0.206	-0.88
Expectation of more destructive storms in the future	0.453	1.87**
Participation in outdoor activities	0.558	2.37**
Constant term	0.147	0.51
Number observations (individuals)	1,581 (527)	
Wald chi-square statistic	64.33***	
Log likelihood ratio	-493.08	

APPENDIX E:

GUIDELINES FOR USING BENEFIT TRANSFER IN COASTAL RESTORATION DECISIONS

This Appendix provides the guidelines ERG developed for applying benefit transfers to restoration decisions following events such as natural disasters. The guidelines consist of two separate and related components: (1) a set of "guiding principles" and (2) a process to use in applying benefit transfers to restoration projects. The intended audience for these guidelines are individuals who need to make restoration decisions; economists who assist those making restoration decisions should be familiar with the methods and approaches we are proposing. Although we expect, and highly encourage, the use of individuals with economic expertise to develop the benefit estimates for restoration projects, we also believe that decision-makers need to understand the process used, the advantages, and the limitations of benefit transfers.

The main body of this report also contains two cases studies that apply these principles and the process to estimating benefits for two restoration projects in Jamaica Bay in New York City following Hurricane Sandy. The guidelines we provide here are meant to stand alone, but reading the two case studies can provide additional context and understanding of applying benefit transfers to restoration projects.

E.1 Guiding Principles

1. **Use/rely on economic expertise in developing benefit transfers.** Benefit transfers take values estimated using economic valuation techniques at one location (a "study site") and apply those values (with some adjustment) to another location (a "policy site"). This process involves multiple crucial decisions that are best made by someone with economic expertise. For example, decisions need to be made on the appropriateness of the methods used at the study site, how to make adjustments, and valid data to use for the adjustments. These decisions are best done by someone who understand the underpinnings of the economic valuation studies.
2. **Benefit transfers are a good choice for situations where information is needed in a short amount of time.** Developing a study that is specific to the restoration work will take time (and resources). However, the timeline for deciding on restoration work may be short. Benefit transfers can be done in a relatively short amount of time, usually within a few months. Thus, in situation such as coastal restoration where some information is needed quickly, benefit transfers offer the ability to develop benefit estimates that can be used in decision-making.
3. **Benefit transfer values should be only *one* input into any decision-making process.** More specifically, we do not recommend that a value (or values) derived from a benefit transfer process be used as a sole (or driving) factor in making decision. A number of the guiding principles deal with reasons why this is the case. First, all benefit transfer involve error in some form or another; this is discussed in more detail below. Second, in using benefit transfer, only values for some ecosystem services may be available.
4. **If possible, work on the benefit estimates as the projects are being scoped/defined.** It's preferable to have economists working on the benefits estimates during the project scoping, or to at least have them sitting in on the meetings where the work is being defined. This will allow the economist to begin collecting studies and review options early on.

5. **Post-disaster restoration differs from the context in which most value estimates are made.** Most studies that estimate the benefits of ecosystem services are not focused on post-disaster restoration. That matters for understanding benefit values. In the immediate wake of a disaster, the relative values that people place on different restoration options will mostly likely differ from what they were before a disaster. For example, people may be more willing to pay for protective measures immediately following a disaster. As the disaster fades from memory, people's relative valuation of restoration options will continue to evolve, but may never revert to pre-disaster levels. For example, many people living along the New Jersey shoreline may have an increased value of dunes (as protective measures) relative to the amenity value (ocean views) that dunes degrade compared to before Sandy. Thus, in using benefit transfer values, one should keep in mind that relative values can and will change in post-disaster situations and that the values being used in the transfer may not fully reflect the relative values of stakeholders who experienced the disaster.
6. **All benefit transfers involve error.** There are a number of reasons why benefit transfers involve error. First, study sites and policy sites will differ. Even if an economist can make adjustments based on data, some differences between the physical environment and the social characteristics will remain between study and policy sites. These differences generate some level of error. Second, a study that estimates benefits at a study site has some error itself. Specifically, if statistical procedures are used, the resulting estimates will end up with some confidence level around the final value. In summary, taking estimates from one site or sites (the study site(s)) and applying the estimates to another site (policy site) is an imperfect process.
7. **Benefit transfer may be better used to compare across projects rather than to assess the worth of any one project.** If only one restoration project is being considered, using benefit transfers to assess the value of the project is worthwhile. The resulting benefit estimate can provide a sense of whether the project will generate net benefits, subject to the errors involved. ERG expects a better approach would be to use benefit transfers to compare across projects. If benefit transfers are used to generate benefit estimates for multiple projects and those estimates are compared across the projects, the errors will, presumably, be roughly the same for each benefit estimate. This means it may be better to compare relative values derived from benefit transfers rather than a single value itself. A caveat to this, however, would be if studies of differing quality are used in generating the benefit estimates; in this case, the relative values also reflect errors related to the quality of the studies.
8. **Look for specific studies first (or multiple studies to calculate an average) and then fill in any "gaps" using meta-function transfers.** There are a number of ways to perform benefit transfers: (1) find a specific study and use the value from that study, (2) use an average value from multiple studies, (3) apply the statistical function from a previously-estimated study, or (4) use a meta-function estimated from multiple studies. The process we recommend involves first applying (1) and (2) from above and, if no *directly relevant studies* are available, to turn to using a meta-function. One particularly useful set of tools we recommend are the ones developed by John Loomis and

colleagues at Colorado State University which provides meta functions to use in benefit transfer exercises.[47]

9. **Calculate benefits over a reasonable time frame.** The benefits will accrue to people over time. Furthermore, costs are incurred up-front on restoration work. The benefits should be calculated for a reasonable time frame and the net present value of the benefits should be compared to costs. In other words, restoration project costs should be viewed as an investment with the return being the ecosystem service values that are generated. To determine the time frame to use, one needs to determine how long the restoration will benefit people. Additionally, all benefit estimates need to be adjusted for inflation.
10. **Do not necessarily aggregate over different benefit estimates.** In cases where benefit estimates for different ecosystem services are drawn from different studies, care should be taken in adding up the values. Additionally, care should also be taken in adding up estimates from a single study if the study used different methods to estimate different values.[48] This is where economic expertise is valuable. An economist can determine when estimated values are comparable and can be added together. Also, there may be some usefulness in providing separate values for different services, allowing stakeholders to better understand where value is being derived in a particular project.
11. **Always assess the possibility of double counting, especially if more than one study is being used.** When using more than one study to estimate benefits, it's necessary to understand if double-counting is occurring. Double-counting may not be clearly seen either. For example, a study may not be explicitly estimating the value of a specific service, but the study's estimates may implicitly include the value of the service. Once again, having an economist selecting and reviewing studies is crucially important.
12. **The area being improved by the restoration work may be larger than then area where work is being performed.** The costs and project specifications for restoration work may involve a relatively small area compared to the area that benefits from the work. For example, in our Sunset Cove case study below, we found that the project was specified as a 0.2 acre restoration. This was true, approximately 0.2 acres were going to have work performed. However, the Sunset Cove salt marsh was closer to 13 acres.

E.2 Process

1. **Obtain economic expertise.** The first step a decision-maker should take is to find economic expertise in developing the benefit transfer estimates. The expertise can come internally from a decision-maker's organization, or it can be external. In terms of external expertise, we recommend starting with NOAA's Office for Coastal Management and also contacting local universities that have natural resource economics departments. Ultimately, the decision-maker will need someone who

[47] http://dare.agsci.colostate.edu/outreach/tools/
[48] This will be highlighted in the case studies we present below.

can apply benefit transfer methods in a valid manner and then assist in interpreting the resulting estimates.

2. **Develop a narrative that links the restoration to benefits.** A key piece of information will be how the proposed restoration work will generate benefits. We propose a simple tabular format for this narrative. The table should describe intended work, identify the ecosystem services that will be impacts, describe how the work will improve ecosystem services, and then describe how the ecosystem service benefits people. This narrative will assist the economist in identifying relevant values to use.

3. **Identify relevant values to use for valuation.** A key part of any benefit transfer is to identify the relevant values. In the guiding principles above, we recommend looking for specific studies first and then turning to meta-analyses. Three potential sources of studies, and ultimately values, are:

   - The GECOSERV database (http://www.gecoserv.org/) maintained by Harte Institute. Although this database is focused on the ecosystem services in the Gulf of Mexico, it still contains studies from around the U.S. and the world. The advantage of GECOSERV is its focus on coastal and ocean ecosystem services.
   - The Ecosystem Services Partnership Database (http://www.fsd.nl/esp/80763/5/0/50) – This database is maintained by the United Nations Environmental Program (UNEP) The Economics of Ecosystems and Biodiversity (TEEB) project. This database of valuation studies absorbed a number of other databases in the last few years and is recognized as a fairly comprehensive database of valuation studies.
   - The Benefit Transfer and Use Estimating Model Toolkit (http://dare.agsci.colostate.edu/outreach/tools/) developed by John Loomis and colleagues – This set of reports and spreadsheets provides an integrated set of studies that have been rigorously vetted for methods and relevancy. The kit includes spreadsheet models based on meta-analyses that can be used to estimate values in a variety of contexts, as well as average values across studies valuing similar services. The kit also contains references to each study used in the kit so that researchers can explore the studies and find relevant values from the specific studies themselves.

4. **Identify the units needed for estimates.** This step and the prior one are usually done iteratively. We recommend using units such as acres or households. The reason is that those units are usually more easily adapted to available estimates. In many cases, different ecosystem services will require different units. Thus, it may not be possible to select one unit for a valuation project. Rather, unit are selected for each service in conjunction with selecting estimated values to use in the transfer.

5. **Estimate the values for the ecosystem services.** Once values have been selected, the value for the improvements can be estimated. This is step where the economist will need to be heavily involved.

6. **Identify the benefits that cannot be assigned a value and developed a qualitative description of the benefit.** It may not be possible to assign a value to all benefits. In these cases, we recommend

developing a narrative that can be used to describe the benefit. A good starting point is the narrative from Step 2 above.

7. **Interpret the estimates.** Values from benefit transfers retain the attributes of the source studies. For example, in our case studies in the main section of the report, we estimated the value of "open space" in terms of property values. It is important to provide the contextual interpretation of the estimated values. In our case studies, the open space estimates are all phrased as the property value associated with open space.

8. **Step back and assess validity.** Once the estimates are available and have been interpreted, it is important to take a step and assess the estimates for their validity. Are the estimates believable? Do they make sense? Once again, an economist can assist in putting the estimates into perspective.

9. **Add up where possible.** In many cases, benefit transfer estimates cannot be added together due to the potential for double-counting. In some cases, adding up will be possible and adding them together is a good idea in those cases. However, when the estimates cannot be added together, we recommend presenting them as separate lines in a table with a full description of their interpretation.

10. **Compare to costs.** The final step is to compare the estimated benefits to the costs of the restoration work. We recommend caution here for a number of reasons. First, as we noted in the guidelines, benefit transfers will contain some level of error. Thus, a basic cost-benefit comparison (e.g., does the estimated benefit exceed the cost?) does not work well for benefit transfers. As we noted above, benefit transfers may be more useful in comparing across restoration projects in which case comparing the ratio of benefits to costs may be a useful metric. Second, as noted in Step 6, not all benefits may be included in the quantitative estimates. There may also be missing cost components as well. Thus, any set of estimated benefits should be used with caution and should be considered as one piece of information to use in making a decision.

APPENDIX F:

SOCIAL COST OF CARBON DETAILED TABLES

Table F-1 – Marsh Acre Calculations for SCC Analysis

Marsh Acre Calculations			
Year	Acres of Deteriorated Marsh	Acres of Restored Marsh	Acres of Marsh Restored in Year
2015	36,660	0	0
2016	36,293	367	367
2017	35,930	730	363
2018	35,571	1,089	359
2019	35,215	1,445	356
2020	34,863	1,797	352
2021	34,515	2,145	349
2022	34,170	2,490	345
2023	33,828	2,832	342
2024	33,490	3,170	338
2025	33,155	3,505	335
2026	32,823	3,837	332
2027	32,495	4,165	328
2028	32,170	4,490	325
2029	31,848	4,812	322
2030	31,530	5,130	318
2031	31,214	5,446	315
2032	30,902	5,758	312
2033	30,593	6,067	309
2034	30,287	6,373	306
2035	29,984	6,676	303
2036	29,685	6,975	300
2037	29,388	7,272	297
2038	29,094	7,566	294
2039	28,803	7,857	291
TOTALS			

Table F-2 – Calculation Using Low CO2 Sequestration Rates

	Calculation Using Low CO2 Sequestration Estimate							
			Emission Rates based on Sequestration Rates			Emission Rates based on 1.5X Sequestration Rates		
Year	CO2 Sequestered (Low Estimate) (MT CO2)	SCC of Sequestered CO2 ($2014/MT CO2)	Potential Avoided CO2 Emissions Equal to CO2 Sequestered (MT CO2)	SCC of Avoided CO2 Emissions Equalling Sequestered CO2 ($2014/MT CO2)	Total SCC (value of CO2 sequestered + avoided CO2 emissions) ($2014/MT CO2)	Actual Avoided CO2 Emissions: 1.5x CO2 Potential (MT CO2)	SCC of Avoided CO2 Emissions ($2014/MT CO2)	Total SCC (value of CO2 sequestered + avoided CO2 emissions) ($2014/MT CO2)
2015	0	$0	0	$0	$0	0	$0	$0
2016	686	$28,407	686	$28,407	$56,814	1,029	$42,611	$71,018
2017	679	$29,074	679	$29,074	$58,148	1,019	$43,611	$72,685
2018	673	$29,725	673	$29,725	$59,449	1,009	$44,587	$74,312
2019	666	$30,360	666	$30,360	$60,719	999	$45,539	$75,899
2020	659	$30,979	659	$30,979	$61,957	989	$46,468	$77,447
2021	653	$31,191	653	$31,191	$62,382	979	$46,786	$77,977
2022	646	$31,396	646	$31,396	$62,792	969	$47,094	$78,490
2023	640	$31,594	640	$31,594	$63,187	959	$47,390	$78,984
2024	633	$31,784	633	$31,784	$63,568	950	$47,676	$79,460
2025	627	$31,968	627	$31,968	$63,936	940	$47,952	$79,919
2026	621	$32,269	621	$32,269	$64,537	931	$48,403	$80,672
2027	614	$32,560	614	$32,560	$65,121	922	$48,840	$81,401
2028	608	$32,843	608	$32,843	$65,686	912	$49,264	$82,107
2029	602	$33,117	602	$33,117	$66,233	903	$49,675	$82,791
2030	596	$33,382	596	$33,382	$66,763	894	$50,072	$83,454
2031	590	$33,638	590	$33,638	$67,276	885	$50,457	$84,095
2032	584	$33,886	584	$33,886	$67,771	876	$50,829	$84,714
2033	578	$34,125	578	$34,125	$68,250	868	$51,188	$85,313
2034	573	$34,357	573	$34,357	$68,713	859	$51,535	$85,891
2035	567	$34,580	567	$34,580	$69,160	850	$51,870	$86,450
2036	561	$34,908	561	$34,908	$69,815	842	$52,361	$87,269
2037	556	$35,225	556	$35,225	$70,450	833	$52,838	$88,063
2038	550	$35,533	550	$35,533	$71,066	825	$53,300	$88,833
2039	545	$35,831	545	$35,831	$71,662	817	$53,747	$89,578
TOTALS	**14,706**	**$782,728**	**14,706**	**$782,728**	**$1,565,457**	**22,059**	**$1,174,093**	**$1,956,821**

Table F-3 – Calculation Using Average CO2 Sequestration Rates

	Calculation Using Average CO2 Sequestration Estimate							
			Emission Rates based on Sequestration Rates			Emission Rates based on 1.5X Sequestration Rates		
Year	CO2 Sequestered (Average Estimate) (MT CO2)	SCC of Sequestered CO2 ($2014/MT CO2)	Potential Avoided CO2 Emissions Equal to CO2 Sequestered (MT CO2)	SCC of Avoided CO2 Emissions Equalling Sequestered CO2 ($2014/MT CO2)	Total SCC (value of CO2 sequestered + avoided CO2 emissions) ($2014/MT CO2)	Actual Avoided CO2 Emissions: 1.5x CO2 Potential (MT CO2)	SCC of Avoided CO2 Emissions ($2014/MT CO2)	Total SCC (value of CO2 sequestered + avoided CO2 emissions) ($2014/MT CO2)
2015	0	$0	0	$0	$0	0	$0	$0
2016	876	$36,272	3,215	$133,117	$169,389	4,823	$199,676	$235,947
2017	867	$37,123	3,183	$136,243	$173,366	4,775	$204,364	$241,487
2018	859	$37,954	3,151	$139,292	$177,246	4,727	$208,938	$246,892
2019	850	$38,765	3,120	$142,267	$181,032	4,680	$213,400	$252,165
2020	842	$39,555	3,089	$145,168	$184,724	4,633	$217,753	$257,308
2021	833	$39,826	3,058	$146,163	$185,989	4,587	$219,245	$259,071
2022	825	$40,088	3,027	$147,123	$187,211	4,541	$220,685	$260,773
2023	817	$40,340	2,997	$148,050	$188,390	4,495	$222,074	$262,415
2024	808	$40,584	2,967	$148,943	$189,526	4,450	$223,414	$263,998
2025	800	$40,818	2,937	$149,803	$190,621	4,406	$224,705	$265,523
2026	792	$41,202	2,908	$151,213	$192,415	4,362	$226,819	$268,022
2027	784	$41,575	2,879	$152,580	$194,155	4,318	$228,870	$270,444
2028	777	$41,936	2,850	$153,904	$195,840	4,275	$230,856	$272,792
2029	769	$42,285	2,822	$155,186	$197,472	4,232	$232,780	$275,065
2030	761	$42,623	2,793	$156,428	$199,051	4,190	$234,642	$277,265
2031	754	$42,951	2,765	$157,629	$200,580	4,148	$236,444	$279,394
2032	746	$43,267	2,738	$158,791	$202,058	4,107	$238,186	$281,453
2033	739	$43,573	2,710	$159,913	$203,486	4,066	$239,870	$283,443
2034	731	$43,868	2,683	$160,997	$204,866	4,025	$241,496	$285,364
2035	724	$44,154	2,656	$162,044	$206,197	3,985	$243,066	$287,219
2036	717	$44,572	2,630	$163,579	$208,151	3,945	$245,369	$289,941
2037	709	$44,978	2,604	$165,068	$210,045	3,905	$247,602	$292,579
2038	702	$45,371	2,578	$166,510	$211,881	3,866	$249,765	$295,136
2039	695	$45,751	2,552	$167,907	$213,658	3,828	$251,861	$297,612
TOTALS	**18,777**	**$999,433**	**68,913**	**$3,667,917**	**$4,667,350**	**103,369**	**$5,501,876**	**$6,501,309**

Table F-4 – Calculation Using High CO2 Sequestration Rates

	Calculation Using High CO2 Sequestration Estimate							
			Emission Rates based on Sequestration Rates			Emission Rates based on 1.5X Sequestration Rates		
Year	CO2 Sequestered (Average Estimate) (MT CO2)	SCC of Sequestered CO2 ($2014/MT CO2)	Potential Avoided CO2 Emissions Equal to CO2 Sequestered (MT CO2)	SCC of Avoided CO2 Emissions Equalling Sequestered CO2 ($2014/MT CO2)	Total SCC (value of CO2 sequestered + avoided CO2 emissions) ($2014/MT CO2)	Actual Avoided CO2 Emissions: 1.5x CO2 Potential (MT CO2)	SCC of Avoided CO2 Emissions ($2014/MT CO2)	Total SCC (value of CO2 sequestered + avoided CO2 emissions) ($2014/MT CO2)
2015	0	$0	0	$0	$0	0	$0	$0
2016	1,066	$44,136	1,066	$44,136	$88,273	1,599	$66,205	$110,341
2017	1,055	$45,173	1,055	$45,173	$90,345	1,583	$67,759	$112,932
2018	1,045	$46,184	1,045	$46,184	$92,367	1,567	$69,276	$115,459
2019	1,034	$47,170	1,034	$47,170	$94,340	1,552	$70,755	$117,925
2020	1,024	$48,132	1,024	$48,132	$96,264	1,536	$72,198	$120,330
2021	1,014	$48,462	1,014	$48,462	$96,924	1,521	$72,693	$121,155
2022	1,004	$48,780	1,004	$48,780	$97,560	1,506	$73,170	$121,951
2023	994	$49,087	994	$49,087	$98,175	1,491	$73,631	$122,718
2024	984	$49,383	984	$49,383	$98,767	1,476	$74,075	$123,459
2025	974	$49,669	974	$49,669	$99,338	1,461	$74,503	$124,172
2026	964	$50,136	964	$50,136	$100,272	1,446	$75,204	$125,341
2027	955	$50,589	955	$50,589	$101,179	1,432	$75,884	$126,474
2028	945	$51,028	945	$51,028	$102,057	1,417	$76,543	$127,571
2029	936	$51,454	936	$51,454	$102,907	1,403	$77,181	$128,634
2030	926	$51,865	926	$51,865	$103,731	1,389	$77,798	$129,663
2031	917	$52,264	917	$52,264	$104,527	1,375	$78,395	$130,659
2032	908	$52,649	908	$52,649	$105,297	1,362	$78,973	$131,622
2033	899	$53,021	899	$53,021	$106,042	1,348	$79,531	$132,552
2034	890	$53,380	890	$53,380	$106,761	1,335	$80,071	$133,451
2035	881	$53,727	881	$53,727	$107,455	1,321	$80,591	$134,318
2036	872	$54,236	872	$54,236	$108,473	1,308	$81,355	$135,591
2037	863	$54,730	863	$54,730	$109,460	1,295	$82,095	$136,825
2038	855	$55,208	855	$55,208	$110,416	1,282	$82,812	$138,020
2039	846	$55,671	846	$55,671	$111,343	1,269	$83,507	$139,178
TOTALS	**22,849**	**$1,216,137**	**22,849**	**$1,216,137**	**$2,432,273**	**34,273**	**$1,824,205**	**$3,040,342**