VALUATION OF THE ECOSYSTEM SERVICES OF COASTAL WETLAND RESTORATION IN FORSYTHE NATIONAL WILDLIFE REFUGE

by

AADESH SUBEDI

(Under the Direction of Craig Landry)

ABSTRACT

Coastal wetlands are valuable resources that provide essential ecosystem services. However, they are deteriorating due to various anthropogenic and natural causes. This deterioration has made coastal communities vulnerable to multiple natural calamities, particularly in the face of climate change. The restoration of these wetlands has become mandatory at present times. This study was carried out in the FNWR. Choice-based conjoint analysis was used to study the preference for different restoration options. Conditional and mixed logit was used to model the consumer preference for different levels of improvement in the wetland's various ecosystem services. Preference for the increase in the area of the restored land, improvement in recreation services, habitat protection, and flood protection were found significant. Willingness to pay was calculated using the parameters from the model. The marginal WTP for the improvement in habitat protection was highest, followed by improvement in the recreation service.

INDEX WORDS: Coastal restoration, Conjoint Analysis, Ecosystem Service, WTP

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

Hurricane Sandy (2012) inflicted significant damage and loss of life along the eastern seaboard of the United States, revealing the vulnerability of this densely populated area and highlighting the need for better environmental management of coastal resources, human development, and public infrastructure in light of projected sea level rise and climatic change. In response, Federal and State agencies have embarked on coastal restoration projects designed to ameliorate the status of coastal ecosystems, including salt marshes, estuaries, dunes, and beaches. To provide support and guidance for restoration decisions, it is useful to conceive of *ecosystem services* as anthropocentric benefits derived from functioning and healthy ecological systems. Barbier (2007) recognizes three classes of such benefits – i) "goods," such as fish and aquatic plant harvest; ii) "services", such as recreation and tourism, regulation and cycling of nutrients, and protection from shoreline erosion; and iii) cultural benefits relating to spiritual and religious beliefs, history, and heritage. Assessing and valuing these services provides a foundation for prioritizing restoration projects, making tradeoffs regarding the management of complex ecological systems, and analyzing policies designed to improve ecological function and service.

Major challenges in attempting to assess and value ecosystem services include adequately describing the array of services provided, understanding the linkages between ecological function and provision of services, recognizing the multitudinous and hierarchical structure of services provided, and incorporating the spatial and temporal variability of ecological services (Barbier, 2012; Boyd & Banzhaf, 2007; Granek et al., 2010). Biophysical process models can be used to quantify service provision and forge a link between ecological function and service flows (Jenkins et al., 2010). Ecological functions can exhibit jointness in the production of services, as an array of services can stem from a particular functionality, whereas other services may condition on multiple related functions (Granek et al., 2010). A realistic description of ecological services should recognize non-linear relationships between service and functional descriptors (e.g., ecosystem size, connectedness, seasonality, species interactions) and systematic variability in service provision, implying that the valuation of services needs to be spatially and temporally explicit (Barbier, 2012; Koch et al., 2009).

Ecological services can include the provision of commodities that ultimately make their way to the marketplace (e.g., fish, shellfish, seagrasses) and non-marketed economic commodities and services, such as recreation and tourism, absorption of pollutants, regulation and cycling of nutrients, floodwater conveyance and groundwater recharge, attenuation of storm waves, and protection from shoreline erosion. For marketed commodities, market prices provide a signal of the economic value of resource provision, though the quality of that signal depends upon the suitability of the market institution for maximizing human welfare and promoting sustainable exploitation (Barbier et al., 2011). For example, market values derived from open-access fisheries are likely to undervalue fishery catch due to over-exploitation of stocks, which lowers the price and imposes excessive marginal user costs on future stock levels (reflecting unsustainable harvest levels). A sustainably managed fishery, on the other hand, would provide for much more informative estimates of economic value, as the allocated quota and market prices would reflect optimal harvest levels and marginal user costs (that reflect fishery stock dynamics).

Economic values related to non-market commodities depend upon conventional utilitarian individual preference relations, but also human cognizance of service flows and some appreciation of the linkage between functions and services. Functioning ecological systems can be viewed as public goods, and their valuation can suffer from freeriding. Individual economic values for ecological services can be latent, as people are not accustomed to assessing their value for these commodities and usually have no experience making payments for their provision (Landry, 2017). Non-market values may include non-use components, such as values related to bequest for future generations, vicarious use of others, and the mere existence of ecosystems and biota (Barbier, 2012; Landry, 2017).

The study of economic values associated with cultural heritage and spiritual belief is still in its infancy (Navrud & Ready, 2002)**.** Cultural and spiritual resources exhibit inherently anthropocentric values that are often dissonant and contested due to the interests of diverse groups of beneficiaries with different objectives, perspectives, and worldviews (Granek et al., 2010; Snowball, 2008). Cultural goods are viewed from a social construct that can exhibit positive or negative framing depending upon individual perspectives (Noonan, 2003; Snowball, 2008). Nonetheless, the theory of cultural capital – which posits cultural assets as conveyors of cultural value - provides a conventional economic framework for understanding the value of cultural resources (Snowball, 2008; Throsby, 1994).

Koch et al. (2009) values wave attenuation services of coastal mangrove ecosystems, with explicit recognition of how coastal protection services vary over space, at various spatial scales, and across time. Their valuation scenario is a comparison of forested versus deforested mangroves so that the valuation metrics correspond with a *change* in the services (Toman, 1998). Using field data from Vietnam, they measure the wave attenuation of two mangrove species under diverse tidal conditions. They calculate the non-linear impacts of storm waves as a function of the extent of mangrove plantings and tidal level. Jenkins et al. (2010) values greenhouse gas (GHG) mitigation, nitrogen uptake, and waterfowl recreation associated with bottomland hardwood forests in the Mississippi Alluvial Valley. Their valuation scenarios compare forested land with conventional use in agriculture. Mitigation of GHG emissions is simulated by modeling growth rates in bottomland hardwood forests and comparing the resulting carbon flux to that stemming from conventional agricultural uses; the analysis allows for both increases (methane and nitrous oxides) and decreases (carbon dioxide) in GHGs under the forested scenario. Simulation of nitrogen mitigation captures denitrification due to plant uptake and reduced runoff from agricultural operations. Waterfowl recreation days were assumed in proportion to bottomland hardwood acreage. All service flows are modeled dynamically, valued using benefit transfer (wherein unit values from previous analyses are applied), and discounted to create present values per hectare.

Barbier et al. (2011) provides guidance for the valuation of estuarine and coastal ecosystem services, indicating how spatial and temporal variability impacts benefits and how synergies and connectivity across sea and landscapes can be incorporated. The first step in valuing ecosystem services is to determine how best to characterize the change in ecosystem structure, function, and/or process that engenders a change in the provision of services. The second step involves tracing how these changes ultimately affect the quality and quantity of various levels of service provision, after which values related to changing service levels can be assessed.

Assessments of ecosystem service values require explicit descriptions of relevant ecological functions and the resulting services that they support (NRC, 2005). Inadequatescientific understanding can make this linkage difficult, and disciplinary boundary can render thepractical linkage between service provision and valuation tenuous (NRC, 2005). If the valuation protocol involves surveying the general public, ecological functions and their link to relevant services must be described in terms that can be understood by normal people. Diversity of stakeholder beliefs and perspectives can create challenges in designing valuation protocols perceived as "salient, legitimate, and credible" (Cash et al., 2003). The use of stated preference methods to assess the contingent provision of ecological services via restoration can suffer from (perceived or actual) existence of ineffective governance institutions.

For five critical coastal and estuarine habitats, Barbier et al. (2011) identify the main ecosystem services supported, provide an overview of the ecological production function that produces service flows, and offers a brief overview of existing valuation estimates. We focus here on salt marsh habitat, which is most relevant for the Forsythe National Wildlife Refuge (New Jersey) and the Spring Creek Park/Jamaica Bay (New York) restoration projects.

Saltmarshes are grassy, intertidal habitats that are formed in low wave-energy environments, typically found along the shore of bays and estuaries and behind barrier islands. Despite the low species diversity, saltmarshes exhibit high primary productivity. Ecological characteristics include low elevation, periodic flooding, variable salinity, stark plant zonation, and high nutrient availability. Community structure is controlled by competition and facilitation among plants and trophic cascades caused by herbivorous predation. Key ecological services include the provision of food and raw materials, support for estuarine and marine fisheries, protection of coastal lands from storms, floodwater storage, water purification, carbon sequestration, and recreation/tourism.

Food and raw material provision includes shellfish harvest, marsh grass harvest, and grazing lands for livestock. Due to the density of salt marsh vegetation and the complexity of community structure, these habitats provide shelter and nursery services for juvenile fishes and shellfish, increasing survival and growth. The location of saltmarshes along the coastal fringe provides protection from waves, storm surges, and coastal erosion; this service can be substantial if the hinterlands of the salt marsh are developed. Saltmarshes are natural water filters, removing suspended sediments and taking up nutrients, and can store and convey coastal floodwaters, providing a buffer to flooding. Due to their high primary productivity, global saltmarshes sequester millions of tons of carbon every year. The wildlife habitat and scenic beauty of salt marshes support recreational fishing, boating, birding, and affiliated tourist activities.

Major threats to salt marsh preservation include climate change and sea level rise, introducing exotic species, eutrophication, changing hydrological regimes, encroachment of development, and hardening of shorelines with erosion protection structures. During storms like Sandy, salt marshes can lose sediment that is washed out of the system, can suffer damage to shrubs and trees, and may be inundated by highly saline waters (which can impact freshwater invertebrates and migratory birds). These impacts are natural, but salt marshes may take significant time to recover ecological functions. Recovery may not happen with rising sea levels, altered hydrological regimes, etc. Storms along developed shorelines typically wash debris into saltmarshes as well; efforts can be taken to remove marine debris, such as oil tanks, chemical drums, and other contaminants.

CHAPTER 2

LITERATURE REVIEW

This chapter reviews relevant literature on nonmarket valuation techniques and coastal resource management.

2.1. Non-market valuation

The concept of non-market valuation was introduced to include environmental aspects in the decision-making process. One of the ways to measure environmental benefits is through travel cost analysis. Hotelling (1947) showed that people travel to different environmental sites and incur costs during their visits. This cost could be used for the valuation of the environmental sites. This type of valuation is revealed preference method of valuation. There are other types of revealed preference methods, such as market prices, replacement costs, and changes in production. The major advantage of the revealed preference method is that they are based on the actual data as internal cost and benefit are considered. Such data helps give better and more valid estimates of the willingness to pay. The primary issue, however, with revealed data is that it depends on historical data, and it is impossible to evaluate potential government policies using such data. In revealed preference, it may not be possible to examine all the variables of interest due to lesser variation, and there may be a strong correlation in the explanatory variable of interest (Kroes & Sheldon, 1988).

The other method of non-market valuation is the stated preference method. Maler (1974) was the first to evaluate willingness to pay through the stated preference method. The advantage of the SP is that it can easily be used to evaluate new policies as it is flexible, and various hypothetical choices could be presented to evaluate policies. However, the hypothetical nature of the data and the unfamiliarity of the hypothetical choices are its major limitations (Whitehead et al., 2008). It has been found that people tend to overstate their preference under this experimental condition (Lin & Stander, 1986). Due to this reason, relative utility weights are estimated rather than an absolute value of the utility if stated preferences are used. However, to evaluate the absolute demand, the stated preference method is used in conjunction with the revealed preference method (Kroes & Sheldon, 1988).

Contingent valuation is one of the widely used stated preference methods. The idea of contingent valuation was initiated by Robert Davis, who used the method known as the "interview method." Then this method was used by Randall et al. (1974) to value the aesthetic benefit of the cleaner air in which photographs were used to communicate the aesthetic level and elicit the willingness to pay. While the revealed preference methods, such as the travel cost method, required the actual behavior to be performed to evaluate the non-use values, contingent valuation does not need such observable action to be performed. Various limitations have been forwarded, though. Firstly, there have been questions if the household would truly reflect their willingness to pay even without market incentives. To address this problem bidding method was introduced in contingent valuation. However, starting point of the bidding option could bias the result as people would anchor to that value. The cognitive burden of the CV method is its next major limitation. (Banzhaf, 2016).

Choice Experiments could help in overcoming the problems of CV method. The major advantage of the choice experiment is that it can help evaluate multidimensional choices. While contingent valuation can help evaluate the multidimensional choices by including multiple CV questionnaires, it becomes costly and cumbersome. Also, CE is more informative than CV as the respondents get many opportunities than in CV to express their preferences. Choice modeling does not explicitly take the respondent's willingness to pay, but it indirectly infers the WTP. This reduces several limitations related to response difficulties in CV (Hanley et al., 2001).

The major problem, however, associated with the CE is high cognitive complexity in choosing between the complex choice that increases the number of random errors (Hausman & Ruud, 1987). Random and fatigue due to a large number of choices may lead to the choice of irrational options (Hanley et al., 2001)**.** Also, the major setback of the CE method is that the welfare estimates obtained from this method depend on the type of study design implemented (Hanley et al., 2001).

2.2. Coastal Resource and Valuation Management

Coastal resource management majorly includes six strategies such as restoration, landscape conservation, living shoreline, facilitated relocation, open space preservation, and land use planning (Powell et al., 2019). Restoration of the coastal wetland can take several approaches ranging from the adoption of nature-based options, such as restoration of the natural habitats, to the improvement of natural infrastructures to mitigate the waves (USGCRP, 2018). One of the nature-based options could be the exploitation of positive species interaction through trophic facilitation, stress reduction, and associational defense. For example, oxygen stress could be reduced by the interaction of the clumped marsh plant and mangrove plants, and sponge's ascidians in the roots of mangrove plants can protect the plant from root damage by isopods (Renzi et al., 2019).

Coral reefs and seagrass are the most expensive ecosystem to be restored, and the mangrove is the least expensive (Bayraktarov et al., 2016). Landry et al. (2003) analyzed different beach management practices such as shoreline retreat, beach nourishment with shoreline armoring, and beach nourishment without shoreline armoring. The study found beach nourishment with shoreline armoring as the least favorite alternative among all others.

The use of hardened structures such as seawalls, rocks, and bulkheads is also one of the effective techniques used to protect the shoreline as they would help dampen wave energy. However, this approach to protection can cause a significant amount of ecological damage (Council et al., 2007; Douglass & Pickel, 1999). The construction of the sea walls causes issues such as visual impacts, access restrictions, placement losses, and passive erosion (Griggs, 2005). Awareness of these detrimental impacts has recently increased, but there are few alternatives to such structures. One alternative is a living shoreline, such as a breakwater reef that protects coastal upland and helps preserve economically important fisheries. Living shoreline involves restoration of the natural biogenic habitat that provides ecological benefits and also acts as the buffer for wave action. But such technology alone is not sustainable. Engineering and ecology should be used in conjunction to effectively protect coastal habitats (Scyphers et al., 2011). The living shoreline mainly has twofold benefits. Firstly, it helps in stabilizing the coastal sediments, and it helps in the recovery of the habitat-forming species. However, the effectiveness of the living shoreline in rejuvenating the coastal habitats, depositing the fine sediments with higher amounts of organic matter, and reducing erosion is low, especially in the energetic shorelines. In such energetic shorelines combination of the semi-permeable break walls along with the oyster restoration structure was found to be effective (Safak et al., 2020).

Nature-based solutions such as creating living shorelines can significantly help in reducing the vulnerability of the coastal wetland to the rise in sea level. However, these solutions are most effective in areas with abundant sediment availability (Liu et al., 2021).

The coastal wetland provides several ecosystem services. It provides protection against storm protection by attenuating or dissipating the wave and buffering the wind. Sediment stabilization and soil retention help in erosion control, and water flow regulation help in flood control. Similarly, by providing suitable habitat for different flora and fauna, coastal wetland also helps provide recreation services. In addition, coastal wetland also provides other ecosystem services such as carbon sequestration and climate regulation. The studies done in the valuation of ecosystem services are very narrow and focus on a few services, such as habitat protection, recreation, and storm protection. Very few studies have been carried out that focus on other important services, such as flood control and temperature and precipitation maintenance (Barbier, 2019). Tourism, recreation, and storm protection are the most commonly valued ecosystem services. Storm protection and recreation are most often valued higher than any other services. In terms of the valuation method, avoided damage, replacement, and substitute cost method are the most used methods, followed by stated preference and production-based methods to value ecosystem services such as storm protection and flood protection (Mehvar et al., 2018). Wedding et al. (2022) found that coastal habitats such as seagrass, mangrove, and coral reefs play an important role in reducing exposure to erosion and inundation through Marin County in the pacific west. By linking the quantification of ecosystem services directly to the climate adaptation decision making, the study recommended beach nourishment and dunes restoration for the locations with the dune habitat and horizontal levee option for the coastal wetlands.

There are three major steps in the valuation of ecosystem services. The first step is determining the best way to characterize change in the ecosystem structure, function, and process that causes a change in the ecosystem services. The second step involves tracing how the change in these aspects affects the quality and quantity of the ecosystem services available to the people. The final step then includes the use of the existing economic tools to evaluate the change in human well-being due to the changes in the ecosystem services (Barbier et al., 2011).

These ecosystem services are not uniformly distributed in the coastal ecosystem. These variations may be due to the structure, function, and production process of the ecosystem. The spital variation may also be due to other causes such as geomorphology, tidal flows, or other physical features. This spatial variation should be addressed while valuing the ecosystem services (Barbier, 2019).

The ecosystem services provided by the coastal wetland have a huge economic value. The coastal wetland in US, for instance, would provide 23.2 billion per year in coastal storm protection services (Costanza et al., 2008). Camacho-Valdez et al. (2013) found that coastal wetlands in Sinaloa, Mexico provided a service worth 1.07 billion dollars to the surrounding area annually. Fant et al. (2022)

estimated that the total value of ecosystem services from coastal wetlands would be around $ 2.1 billion to $ 6.5 billion annually in the US. The monetary value of ecosystem services provided by all the natural wetlands around the world is 4.7 trillion per year. Although coastal wetlands only form 15% of the total wetlands around the world, they provide ecosystem services worth more than 43.1% of total global ecosystem services provided by the natural wetlands (Davidson et al., 2019). The storm protection value of the coastal wetland in the US was around $23 billion per year, and the flood protection value of the coastal wetland during the super storm Sandy was around $625 million in the mid-Atlantic states (Boutwell & Westra, 2015; Narayan et al., 2017). While estimating the nonmarket value of the restoration of coastal dunes in the US using the stated preference method, Nguyen et al. (2023) found that people had a positive willingness to pay for the restoration options in terms of area and flood protection, but they had a negative willingness to pay for the increase in the recreational activity.

CHAPTER 3

SURVEY DESIGN AND METHODOLOGY

3.1. Survey Design

The data for the study were collected via internet survey by GfK (formerly known as Knowledge Networks); GfK provided an online panel of households in specific counties in close proximity to FNWR in New Jersey, Pennsylvania, Delaware, and Maryland. The questionnaire of the research consisted of information on the purpose of the research, the benefits of the wetland services provided by it, and the importance of the research. The major portion of the questionnaire contained questions on the familiarity with the marshes and damage inflicted by Sandy and finally with three sets of choices for restoration. Two choices consisted of the combination of different levels of the alternative, and third choice consisted of the status quo.

Before survey, NOAA had discussions with the representative at Forsythe, who providedinformation on the scope of the restoration. Forsythe provided the number of acres (approximately3,000) and the areas of the marsh in which restoration would occur. Second, NOAA based the number of homes protected based on research into the communities surrounding the areas where restoration would take place. For storm surge, there are 34,051 houses in the five communities thatborder the area where the restoration will occur (Eagleswood, Little Egg, Stafford, Tuckerton, andBarnegat). 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). NOAA used the value of 3,072 with significant/severe damage as an approximate mid-point. Sincethis is a choice experiment, we added what we expect are reasonable values above and below thesevalues. For flooding, FEMA has

7,552 policies in place in the five communities. As above, we rounded down to 7,000 and used that as the mid-point and varied it above and below. Habitat and recreation descriptions were developed as simple qualitative descriptions following "no," "small,"and "large" categories. The cost values we used represent values typically seen in the literature. For example, in a study on the value of restoring Louisiana wetlands, Petrolia and co-authors 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.

Table 3.1. Choice Experiment Values for Forsythe Survey

Category	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 • Protects 3,000 homes from a 5-foot storm surge • Protects 6,000 homes from a 5-foot storm Surge	• Homes in the coastal area are under increased risk from storm damage.

Flood protection	• 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.
Habitat	• Provides no improvements for migratory birds • Provides small/minor improvements in habitat for migratory birds • Provides significant improvements in habitat for migratory birds.	• Habitats for wildlife continue to deteriorate with the marsh
Recreation	• Provides no improvement in recreation. • Provides small/minimal improvement in recreation. • Provides significantly better recreation	• Recreational opportunities decline as the marsh deteriorates.
Cost: one-time increase in federal income taxes	• $25 • $70 • $130	• $0

3.2. Data

The data was collected from four states in 2015. The data was collected from non-institutionalized adults over 18 years of age and also the resident of the following states and associated counties: New Jersey: Burlington County, Camden County, Gloucester County, Salem County, Mercer County, Cumberland County, Cape May County, Atlantic County, Hunterdon County, Somerset County, Middlesex County, Monmouth County, Ocean County, Essex County, Union County, Morris County; Pennsylvania: Bucks County, Chester County, Delaware County, Montgomery County, Philadelphia County; Maryland: Cecil County; Delaware: New Castle County. This survey was conducted using the sample from the Knowledge panel. A total of 1000 respondents were sent the survey based on random digit dialing and address-based sampling. 531 responses were collected and dimmed to be valid for the analysis. The response rate of the respondents was 53%.

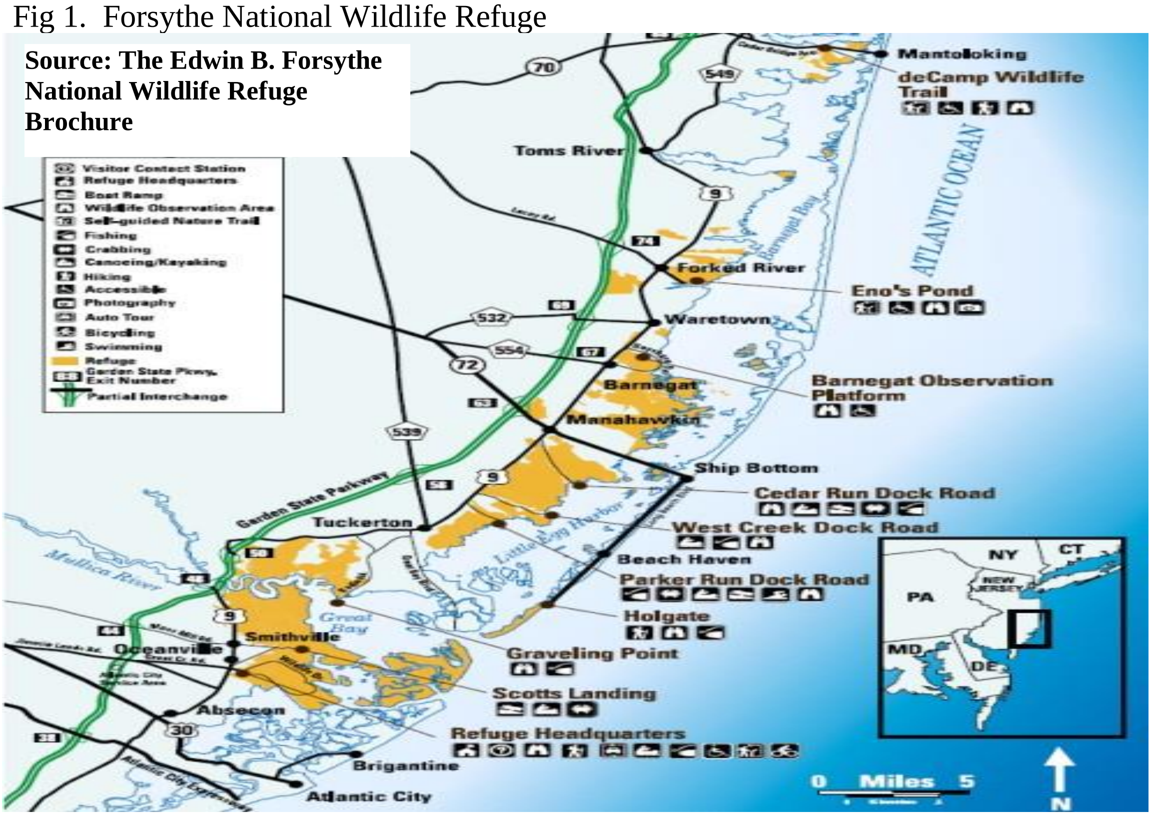
3.3. Experimental Design

In the full factorial design for the above attributes and level, the design should have 729 combinations of the treatment that should be examined. However, it is not feasible for the consumers to evaluate all the 729 combinations. Therefore, SAS algorithms such as mktruns and mktdes were used to generate fractional factorial design to create an optimal number of choice sets. SAS algorithm first creates a full factorial design and then chooses a definite number combination of the attributes from the full factorial through an iterative process. This procedure suggested 27 choice sets as the optimal fractional design. However, it is still cumbersome for everyrespondent to evaluate all 27 choice sets. Thus, those 27 sets were divided into 9 blocks, each containing three choice sets. Each block was then presented to each respondent to evaluate in thequestionnaire.

3.4. Study Area

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 (See the orange shaded area on map). The wildlife refuge serves as a regional attraction, with an estimated 100,000 visitors each year. The refuge is protected and managed forits coastal wetland habitat, which includes salt marsh and coastal forest 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. 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.

Fig 1. Forsythe National Wildlife Refuge



Source: The Edwin B. Forsythe National Wildlife Refuge Brochure

3.5. Empirical Model

Random Utility Model does the analysis of the data under the discrete choice framework.

Under the Random Utility framework, the consumer tends to maximize the utility. The utility takes a probabilistic behavior and has systemic and random components. Utility can be defined by the function:

$$U_i = V_i(\beta, X_i) + \varepsilon_i \qquad (1)$$

Where V_i is the systematic component of the choice and ε_i is the random component in the choice.

The decision maker knows the value of β and the value of ε_i and chooses the alternative with higher utility. The researcher, however, doesn't have the information β and only knows the value of. If the researchers have known the value of β, then the probability of choosing the restoration option i over j is given by:

$$Prob\ (U_i = V_i(\beta, X_i) + \varepsilon_i) > Prob\ (U_j = V_j\left(\beta, X_j\right) + \varepsilon_j) \qquad (2)$$

Probability of choosing i over other j options = $\frac{e^{V_i(\beta,X_i)}}{\sum e^{V_j\left(\beta,X_j\right)}}$ (McFadden, 1980) (3)

As this equation is based on the condition that the researchers know, the value of β this is known as the conditional logit.

The functional form in V could be specified, and then the maximum likelihood method could be used to evaluate the parameters in V. There are other different forms of logit regression that could be used in modeling the choice behavior of the people. The multinomial logit is used when the choice of the alternatives depends on the attributes of the individual making the choice (Wooldridge, 2010). Nested logit can be used when the choices are made sequentially, and conditional logit is used when the choice decision is affected by alternative specific attributes (Train, 2009) **.**

However, the conditional logit model is restrictive and fails to address the fact that people may have different preferences. The major assumption of the conditional logit mode is the independence of Irrelevant Alternative (IIA) which means that the choice of one alternative over the other is not affected by the presence or absence of the third alternative (Boever & R.W. Harrison, 2011).

Mixed logit, on the other hand, is flexible and addresses the limitation of the conditional logit by relaxing the assumption of the independent and identical distribution of the error term and allowing correlation among the unobserved factor, unrestricting the substitution pattern and considering the preference heterogeneity among people. The parameters in the mixed logit model are usually assumed to be distributed normally or log-normally. In such a case scenario, the unconditional probability of choosing option i is given by the equation:

$$\int \frac{e^{V_i(\beta, X_i)}}{\sum e^{V_j(\beta, X_j)}} f(\beta, \Phi)\, \partial\beta \quad \text{(Train, 2009)} \qquad (4)$$

Where $f(\beta, \Phi)$ is the density function with Φ as a parameter. The integral in the mixed logit does not have a closed form; thus, it must be evaluated through a numerical procedure such as Halton or random draw. However, the Halton draw sequence is efficient and superior (Train, 2001).

The value of the marginal willingness to pay for the improvement in certain attributes could be calculated by evaluating the ratio of estimates of the coefficient of the attribute of interest and the coefficient estimate of the price by using the formula(Louviere et al., 2000):

$$MWTP_i = \frac{-\beta_i}{\beta_p} \qquad (5)$$

Where $MWTP_i$ is the marginal willingness to pay for the variable *I*, β_i is the coefficient associated with the variable *I*, and β_p is the coefficient associated with the price variable.

The total willingness to pay was calculated by using the log sum approach. When the utility is linear in income, then the expected value of the consumer surplus is given by the equation:

$$E(CS_n) = \frac{1}{\alpha_n} \ln\left(\Sigma e^{v^1 n_j}\right) + C \qquad (6)$$

Where C is the constant that addresses the fact that the absolute value of the utility can never be known. Then the value of willingness to pay can be calculated by the difference in the expected value of the consumer surplus from two different scenarios, given by the equation:

$$\Delta E(CS_n) = \frac{1}{\alpha_n}[\ln(\Sigma e^{v^1 n_j}) - \ln(\Sigma e^{v^0 n_j})] \text{ (de Jong et al., 2007)} \qquad (7)$$

Where subscript 0 represents the condition when a certain policy is absent, and 1 represents the condition when the policy is present. α_n represents the marginal utility of the income. This can be used to calculate the total willingness to pay for different options available to the respondents.

3.6. Description of variables

Table 3.2. Description of the variable used in the model.

Variables	Description
Mod_acreage	3000 acres
Sig_acreage	5000 acres
Sig_storm	Protection of 6,000 homes from a 5-foot storm surge.
Mod_storm	Protection of 3000 homes from 5-foot storm surge
Sig_habitat	Provides significant improvements in habitat.
Min_habitat	Provides significant improvement in habitat
Mod_flood	Protects 7,000 homes from a 20-year flood.
Sig_flood	Protects 10,000 homes from a 20-year flood.
Sig_rec	Provides significant improvement in recreation
Min_rec	Provides minimum improvement in recreation.
Tax_	Represents tax value of $25, $70 & $120
Sq	Status quo
Sq_cFNWR	Interaction of status quo with degree of concern for the wildlife refuge

CHAPTER 4

RESULTS

4.1.Demographics

Table 4.1. Demographics of the respondents

Variable	Obs	Mean	Std. Dev.	Min	Max
Highschool	531	.164	.37	0	1
Some college degree	531	.282	.451	0	1
College	531	.294	.456	0	1
Grad	531	.243	.429	0	1
Age	531	55.817	15.256	18	90
White	531	.797	.403	0	1
Black	531	.107	.31	0	1
Male	531	.412	.493	0	1
Head household	531	.861	.347	0	1
Household size	531	2.42	1.27	1	9
Income	531	87245.763	51070.545	5000	200000
New Jersey	531	.548	.498	0	1
Pennsylvania	531	.382	.486	0	1
Delaware	531	.064	.245	0	1
Maryland	531	.006	.075	0	1

In the case of demographics, out of 531 respondents, 312 were female, and 219 were male. In the same way, the age of the respondents varied between 18 years and 90 years, with a mean age of 55.81 years. The income of the respondents ranged between 5000 dollars per annum and to 200,000 dollars per annum, with a mean income of 87,245.6 dollars. The maximum household size among the respondents was nine, whereas the minimum household size was 1. The mean household number was around 2.41. Of 531 respondents, 291 were from New Jersey, three were from Maryland, 34 were from Delaware, and 203 were from Pennsylvania twenty-three of the respondents in the survey were white, and 108 respondents were black. In the case of educational background, 150 respondents had some college degree,87 of the respondents had high school education, 156 had a college degree, and 129 had a graduate degree. In the survey, 457 of the respondents were the head of the household, whereas 74 were not the household head.

4.2.Conditional logit

Table 4.2. Conditional logit model with flood and storm protection as continuous variable

Choice	Coef.	Std error	[95% Conf	Interval]
min_habitat	.53***	0.091	.352	.709
sig_habitat	1.076***	0.097	.887	1.266
min_rec	.358***	0.099	.165	.552
sig_rec	.629***	0.132	.371	.887
acres	.066*	.0.028	.01	.121
storm_prot	.001	.021	-.04	.042
flood_prot	.028*	.013	.003	.053
tax_	-.011***	0.001	-.014	-.008
altA	.178	.116	-.049	.405
Status quo	.858***	0.217	.434	1.283
sq_cFNWR	-1.493***	0.210	-1.905	-1.081

Mean dependent var	0.333	SD dependent var	0.471
Pseudo r-squared	0.174	Number of obs	4641

Chi-square	319.166	Prob > chi2	0.000
Akaike crit. (AIC)	2833.068	Bayesian crit. (BIC)	2910.380

**** p<.01, ** p<.05, * p<.1*

Table 4.2 and 4.3 presents regression results for the conditional logit model, including storm risk, nuisance flooding, and restoration acres as continuous and dummy variables, respectively. Among all the models ran for the conditional logit, the results in 4.3 fit the best, as indicated by the lower value of the AIC and BIC score. The coefficient for minimum habitat and significant habitat protection are both significant and positive, indicating that people have higher utility from these changes. In the same way, minimum improvement, significant improvement in recreation, and the number of acres restored have a positive and significant coefficient indicating that the people derive higher utility from these changes. As expected, tax has a negative but significant coefficient indicating that people prefer the lower amount of tax to those alternatives with a higher amount. In the same way, the status quo variable has a positive and significant coefficient, while the coefficient of interaction between concern for the wetland and the status quo is negative and significant, indicating that the people who are concerned about the wetland derive greater utility from the shift in the current status quo scenario.

Table 4.3. Conditional logit model with flood and storm protection as dummy variable

choice	Coef.	St.Err.	[95% Conf	Interval]
min_habitat	.604***	.086	.435	.773
sig_habitat	1.07***	.094	.885	1.255
min_rec	.369***	.089	.195	.543
sig_rec	.518***	.09	.341	.695
mod_acreage	.131	.087	-.04	.302
sig_acreage	.369***	.082	.208	.53

mod_storm	.015	.081	-.145	.174
sig_storm	.105	.092	-.076	.285
mod_flood	.294***	.089	.119	.468
sig_flood	.169**	.084	.004	.333
tax_	-.011***	.001	-.013	-.009
Mean dependent var	0.333	SD dependent var	0.471	
Pseudo r-squared	0.135	Number of obs	4641	
Chi-square	273.387	Prob > chi2	0.000	
Akaike crit. (AIC)	2963.266	Bayesian crit. (BIC)	3034.135	

*** *p<.01, ** p<.05, * p<.1*

The table presents the conditional logit results where the variable such as acres, storm protection and flood protection are treated as dummy variable. As in the results above, coefficient of habitat and recreation are significant and positive. In the case of area of protection, sig_acreage that represents higher area of protection is significant. The variables on any level of storm protection are insignificant. In case of flood protection both higher level and moderate level of protection is significant. As in the result mentioned in the table above the coefficient on the tax is significant and negative.

Table 4.3. Marginal willingness to pay calculated from result of conditional logit in table 4.3.

Choice	Coefficient	Std. err.	[95% conf.	Interval]
mWTP_minhab	51.52117***.	8.599767	34.66594	68.37641
mWTP_sighab	94.12947***	9.253405	75.99314	112.2658
mWTP_minrec	29.50229***	7.664976	14.47921	44.52536
mWTP_sigrec	44.04205***	8.270302	27.83256	60.25154
mWTP_acres	8.101805***	1.811895	4.550557	11.65305

mWTP_storm	1.294104	1.530077	-1.704791	4.293
mWTP_flood	2.130597**	.9803799	.2090882	4.052107

**** p<.01, ** p<.05, * p<.1*

The marginal willingness to pay coefficient is calculated using the coefficients from the above regression. All the coefficients of the marginal willingness to pay are significant except the coefficient for storm protection. The marginal willingness to pay for the minimum improvement in the habitat is $51.52, and that for significant improvement in the habitat is $94.12. In the sameway, the marginal willingness to pay for the minimum improvement in recreation is $29.50, and significant improvement in recreation is $44.04. The willingness to pay for additional 1000 acresof restoration of the marsh is $8.10, and that of protection of additional 1000 homes from the floodin the next 20 years is $2.13.

Table 4.6. Marginal willingness to pay is calculated from the result of conditional logit in table 4.5.

Choice	Coefficient.	Std. err.	[95% conf.	Interval]
mWTP_hab1	56.24433***	8.69468	39.20306	73.28559
mWTP_hab2	99.58352***	11.06017	77.90599	121.261
mWTP_rec1	34.33599***	8.358315	17.954	50.71799
mWTP_rec2	48.22539***	9.121589	30.3474	66.10337
mWTP_acres1	12.16492	8.125939	-3.761627	28.09147
mWTP_acres2	34.36441***	7.868444	18.94254	49.78628
mWTP_storm1	1.390022	7.560773	-13.42882	16.20887
mWTP_storm2.	9.728854	8.56142	-7.05123	26.50894
mWTP_flood1	27.35196***	8.27766	11.12804	43.57588
mWTP_flood2	15.7199**	7.67886	.6696012	30.7702

**** p<.01, ** p<.05, * p<.1*

The table above represents the marginal willingness to pay when in addition to habitat and recreation, acres of marshland restored, storm protection and flood protection are also represented, and recreation is a little higher in this model than the previous model. 1 in each variable represent a lower level of an attribute, and 2 represents a higher level. The willingness to pay for the restoration of additional 5000 acres of the marshland is $34.36. Similarly, the willingness to pay for the protection of additional 7000 homes from flood for the next 20 years is $27.35, and additional 10,000 homes is $15.71. The value of the marginal willingness to pay for storm protection variable is insignificant.

4.7. Total willingness to pay calculated by using the log sum approach from the result in table 4.3

Variable	Obs	Mean	Std. Dev.	Min	Max
maxu	4779	5.199	.013	5.174	5.234
WTP BEST	4779	272.891	23.593	224.79	324.808
WTP SQ	4779	.629	.448	.259	1.207

The total willingness to pay was calculated using the log sum approach. From the above table, we can see that the average total willingness to pay for the best option is $272.891. The best option includes the best alternative of each attribute. Similarly, the willingness to pay for no improvement or status quo is very low as indicated by the result above.

4.5. Mixed logit

Table 4.7. Mixed logit model with flood and storm protection as a continuous variable

Choice	Coefficient	Std error	[95% conf	Interval]
Mean				
Tax_	-0.027***	0.004	-0.034	-0.020
Sq_cFNWR	-3.201***	0.555	-4.288	-2.114
Sq	1.361*	0.804	-0.215	2.936
Acres	0.139	0.057	0.027	0.250

Storm_prot	-0.037	0.063	-0.161	0.087
Flood_prot	0.480*	0.235	0.019	0.941
fp2	-0.038	0.018	-0.073	-0.003
min_habitat	1.566	0.336	0.907	2.225
sig_habitat	2.500	0.373	1.770	3.231
min_rec	0.425	0.282	-0.128	0.978
sig_rec	1.080	0.273	0.546	1.614
SD				
acres	0.660	0.119	0.428	0.893
storm_prot	0.827	0.140	0.553	1.101
flood_prot	0.473	0.065	0.346	0.600
fp2	-0.002	0.013	-0.027	0.023
min_habitat	-0.295	0.359	-0.998	0.408
sig_habitat	-1.104	0.563	-2.207	-0.001
min_rec	-2.441	0.500	-3.420	-1.461
sig_rec	1.220	1.017	-0.773	3.214

Pseudo r-squared	0.135	Number of obs	4641
Chi-square	111.40	Prob > chi2	0.000
Log likelihood	-1184.449		

*** *p<.01*, ** *p<.05*, * *p<.1*

In the above mixed logit model, storm protection and flood protection are represented as the quantitative variable. Random parameters in this logit are acres, storm protection, flood protection, the square of flood protection, habitat protection, and recreation. Similarly, the fixed variable includes tax, status quo, and the interaction between status quo and level of concern for the status of the Forsythe National Wildlife Refuge. The variable level of concern represents 1 for very concerned and somewhat concerned individuals and 0 otherwise.

The parameter coefficient of tax is negative and significant as people prefer options with lower tax values with other things remaining constant. Though the status quo has a positive and significant coefficient indicating that people prefer to be in the current status, the parameter flips its sign when interacted with the level of concern for the FNWR. This means that people who are highly concerned about the status of the refuge want to move away from its current status of it. In the same way, the parameters on the acres, flood protection, square of the flood protection(fp2), minimum and significant habitat protection, and significant recreation are positive and significant. This indicates that the respondents' utility increases with an increase in the level of each attribute. Among the parameters that had statistically significant mean value, acres, flood protection, and significant habitat protection has statistically significant value of the standard deviation, which indicates that there is heterogeneity in the preference of these attributes across the sample population.

Mean value of 0.139 for acres and a standard deviation of 0.660 implies that 58% of the distribution in the variable is above zero and 42% is below zero. This means that 58% of the population want more marsh area to be restored, while 42% derive negative utility if more marsh area is restored. Similarly, the mean value of the flood protection variable is 0.480, and the standard deviation is 0.473. From these values, it can be computed that 84% of the population wants higher number of houses to be protected from flood damage, and 16% of the population gets lesser utility if the numbers of houses protected from flood damage are increased. Also, 99% of the population want significant improvement in the habitat of the migratory bird and only 1% of the population don't want significant improvement.

Table 4.8. Mixed logit model with flood and storm protection as dummy variable

Choice	Coefficient	std. error	[95% conf.	Interval]
Mean				
tax_	-0.050***	0.012	-0.074	-0.026
acres	0.383**	0.185	0.020	0.745
mod_storm	-0.696	0.447	-1.571	0.180
sig_storm	0.323	0.458	-0.575	1.220
mod_flood	0.845	0.602	-0.334	2.024
sig_flood	0.831*	0.494	-0.136	1.799
min_habitat	2.698**	0.547	1.626	3.771
sig_habitat	4.927**	1.324	2.332	7.522
min_rec	1.066**	0.462	0.160	1.972
sig_rec	2.642**	0.608	1.451	3.833
SD				
acres	1.475***	0.306	0.874	2.075
mod_storm	-3.875***	1.219	-6.264	-1.486
sig_storm	4.665***	1.356	2.007	7.324
mod_flood	-4.920***	1.498	-7.857	-1.983
sig_flood	4.199***	1.255	1.739	6.659
min_habitat	-2.271*	1.163	-4.551	0.009
sig_habitat	4.85***	1.368	2.171	7.532
min_rec	5.617***	1.725	2.235	8.998
sig_rec	-1.116	0.852	-2.787	0.555

Prob > chi2	0.000	Number of obs	4641
Chi-square	44.10	Log likelihood	-1263.6501

**** p<.01, ** p<.05, * p<.1*

The mixed logit model in the table has storm protection and flood protection as the dummy variable. Variable mod_storm has one if people choose to protect 3000 homes from a 5-foot storm surge and 0 otherwise. Similarly, sig_storm has one if people choose option to protect 6000 homes from the 5-foot storm and 0 otherwise. In flood protection sig_flood has one if people decide to protect 10,000 homes from 20-year flood, and min_flood has 1 for choosing to protect 7000 homes from 20-year flood damage. As shown in the above table variable such as tax, acres, and dummy variable significant recreation are significant and have expected signs. Among the new variables in the model, only significant flood protection is significant. In the case of the significant flood, the mean value is 0.831, and standard deviation is 4.199. From these values, we can compute that 58% of the distribution lies above zero value and 42% lies below zero value. This implies that 58% of the sample in the population have a propensity towards significant protection from flood, and rest 42%, do not prefer significant flood protection.

The above tables show that most of the parameter estimates (mean value) in the mixed logit models are higher than the conditional logit model. This is because mixed logit decomposes the unobserved part of the utility and normalizes the parameter with a particular scale factor (Sillano & de Dios Ortúzar, 2005).

Table 4.9. Marginal willingness to pay calculated from result of mixed logit in table 4.7.

Choice	Coefficient	Std. err.	[95% conf.	Interval]
mWTP_minhab	49.20601***	8.871584	31.81803.	66.594
mWTP_sighab	84.66186***	10.75889	63.57481	105.7489
mWTP_minrec	12.73261	8.6182	-4.158748	29.62398
mWTP_sigrec	33.37379***	9.12772	15.48379	51.2638
mWTP_acres	5.236831**	2.599854	.1412101	10.33245
mWTP_storm	-2.799143	2.346062	-7.39734	1.799054
mWTP_flood	6.664569**	2.731077	1.311756	12.01738

**** p<.01, ** p<.05, * p<.1*

Table 4.9 shows the willingness to pay from the mixed logit regression in table 4.7. The result in the above table is not the mean value of the willingness to pay, but they are the value derived from the parameter of the average person in the distribution and thus should not be used in benefit-cost analysis (Sillano & de Dios Ortúzar, 2005). However, the distribution of these estimates could also be estimated using Willingness to pay space method rather than the preference space method. Such a method is not widely used as it is not implemented in the standard statistical software packages (Hole & Kolstad, 2012). The marginal willingness to pay for the minimum improvement in habitat is $49.2, and for a significant improvement in habitat is $84.66. People have the highest willingness to pay for habitat improvement than any other attribute. In the same way, the marginal willingness to pay for the minimum improvement in recreation is not significant. However, mWTP for significant improvement in recreation is significant and has the value of $33.37. The marginal willingness to pay for the improvement in the extra 1000 acres of marsh land is $5.23. Similarly, the marginal willingness to pay for an additional 1000 homes to be protected from flood damage in the next 20 years is $6.66.

Table 4.10. Marginal willingness to pay calculated from the result of mixed logit in table 4.5.2.

Choice	Coefficient	Std. err.	[95% conf.	Interval]
mWTP_hab1	54.15466***	12.51573	29.62428	78.6850
mWTP_hab2	98.87586***	14.10469	71.23117	126.5206
mWTP_rec1	21.39031*	11.00552	-.1801145	42.96073
mWTP_rec2	53.01819***	10.18612	33.05376	72.98262
mWTP_acres	7.681053**	2.512148	2.757333	12.60477
mWTP_storm1.	-13.96214*	7.825967	-29.30076	1.376469
mWTP_storm2	6.475683	9.150084	-11.45815	24.40952
mWTP_flood1	16.95935***	9.523393	-1.706153.	35.62486

mWTP_flood2	16.68126**	8.040365	.9224384.	32.44009

*** *p<.01*, ** *p<.05*, * *p<.1*

The marginal willingness to pay for habitat protection, acres of wetland restored, flood protection and recreation are a little higher in this model than previous one in table. Though the value of willingness to pay for storm protection was insignificant in the model presented in the table. The willingness to pay for minimum storm protection is significant in this model.

CHAPTER 5

CONCLUSION AND POLICY RECOMMENDATION

The research was conducted with the objective of estimating the consumers' willingness to pay for the restoration of the coastal wetland in FNWR. Coastal wetlands are degrading due to various factors depriving the people of valuable ecosystem services. Fant et al. (2022) have predicted that about 1.8 million to 2.4 million acres of wetland will be lost by 2050, and 3.5 million to 4.2 million acres will be lost by 2100. This has made the coastal areas vulnerable to the effects of climate change, as evidenced by the extent of damage inflicted by natural disasters such as hurricane sandy. Thus, it has become important to know the public perception and support for restoring these ecosystems, which is the primary objective of this research.

To conduct the research, conjoint analysis was used to create choice sets using six different attributes, each containing a different level of restoration option. Using SAS, an optimal number of choice sets for the study was found to be 27. These 27 choice sets were then grouped into nine blocks, each containing three choice sets. Each respondent was then provided with these three choice sets, along with other questionnaires containing demographic and their knowledge and concern about the coastal wetland.

Conditional and Mixed logit were used to model the response of the people who participated in the survey. As expected, the mixed logit performed better than the conditional logit. Most of the parameters in both of these models were found to be significant in both models except storm protection. The study conducted by Petrolia et al. (2014) found the parameter associated with habitat protection significant, but unlike the result in this study, the storm parameters associated with storm protection were also found significant in that study. The plausible explanation for the storm protection coefficient not being significant can be that most of the people surveyed were not in the high-risk zone of the storm that would be protected by FNWR restoration. We attempted to control for adjacency to FNWR using ZIP codes, but we did not have sufficient data to precisely estimate an effect for this group (though the coefficients were positive). The standard deviation parameters of most of the effects in the mixed logit model were significant, indicating heterogeneity in the preference behavior of the respondents. Marginal willingness to pay for each attribute was calculated using the mixed and conditional logit parameters. In both models, the willingness to pay for habitat improvement was highest, followed by the improvement in recreation. The study conducted in Tokyo for the valuation of coastal restoration also found that people value habitat protection most, followed by recreational value (Tokunaga et al., 2020). The total willingness to pay for the restoration of the wetland using the best option in each attribute was found to be $272.89.

Regarding policy implication, the overall proposed strategy for the wetland restoration is effective, as suggested by the significance of the models during the analysis. Similarly, the foremost priority during the restoration should be habitat protection, as the willingness to pay for habitat protection is highest. The results of this study would be very beneficial in guiding and implementing the restoration effort when a large amount of the budget is being granted for the restoration of FNWR(*$4.99M NJ Grant Awarded To Brick For Salt Marsh Restoration Project*, 2023). The result showed that the parameter for the status quo variable was significant and positive, suggesting that people generally had higher utility from the status quo scenario than they would have with the restoration. However, when the status quo scenario interacted with the concern for the wetland, the interaction variable was found to be significant and negative. This implies that for the change, the people should be made aware of the ecosystem services provided by the wetland and how these wetlands are degrading. This could raise their level of concern and, subsequently, their support.

References

$4.99M NJ Grant Awarded To Brick For Salt Marsh Restoration Project. (2023, January 19). Brick, NJ Patch. https://patch.com/new-jersey/brick/4-99m-nj-grant-awarded-brick-salt-marsh-restoration-project

Adamowicz, W., Boxall, P., Williams, M., & Louviere, J. (1998). Stated Preference Approaches for Measuring Passive Use Values: Choice Experiments and Contingent Valuation. *American Journal of Agricultural Economics*, *80*(1), 64–75. https://doi.org/10.2307/3180269

Banzhaf, H. S. (2016). Constructing markets: Environmental economics and the contingent valuation controversy. *MPRA Paper*, Article 78814. https://ideas.repec.org//p/pra/mprapa/78814.html

Barbier, E. B. (2019). Chapter 27—The Value of Coastal Wetland Ecosystem Services. In G. M. E. Perillo, E. Wolanski, D. R. Cahoon, & C. S. Hopkinson (Eds.), *Coastal Wetlands (Second Edition)* (pp. 947–964). Elsevier. https://doi.org/10.1016/B978-0-444-63893-9.00027-7

Barbier, E. B., Hacker, S. D., Kennedy, C., Koch, E. W., Stier, A. C., & Silliman, B. R. (2011). The value of estuarine and coastal ecosystem services. *Ecological Monographs*, *81*(2), 169–193. https://doi.org/10.1890/10-1510.1

Bayraktarov, E., Saunders, M., Abdullah, S., Mills, M., Beher, J., Possingham, H., Mumby, P., & Lovelock, C. (2016). *The cost and feasibility of marine coastal restoration*. *26*, 1055–1074. https://doi.org/10.5061/dryad.rc0jn

Boutwell, L., & Westra, J. (2015). The Economic Value of Wetlands as Storm Buffers. *2015 Annual Meeting, January 31-February 3, 2015, Atlanta, Georgia*, Article 196854. https://ideas.repec.org//p/ags/saea15/196854.html

Camacho-Valdez, V., Ruiz-Luna, A., Ghermandi, A., & Nunes, P. A. L. D. (2013). Valuation of ecosystem services provided by coastal wetlands in northwest Mexico. *Ocean & Coastal Management*, *78*, 1–11. https://doi.org/10.1016/j.ocecoaman.2013.02.017

Costanza, R., Pérez-Maqueo, O., Martinez, M. L., Sutton, P., Anderson, S. J., & Mulder, K. (2008). The Value of Coastal Wetlands for Hurricane Protection. *Ambio*, *37*(4), 241–248.

Council, N. R., Studies, D. on E. and L., Board, O. S., & Coasts, C. on M. S. E. A. S. (2007). *Mitigating Shore Erosion Along Sheltered Coasts*. National Academies Press.

Davidson, N. C., Dam, A. A. van, Finlayson, C. M., McInnes, R. J., Davidson, N. C., Dam, A. A. van, Finlayson, C. M., & McInnes, R. J. (2019). Worth of wetlands: Revised global monetary values of coastal and inland wetland ecosystem services. *Marine and Freshwater Research*, *70*(8), 1189–1194. https://doi.org/10.1071/MF18391

de Jong, G., Daly, A., Pieters, M., & van der Hoorn, T. (2007). The logsum as an evaluation measure: Review of the literature and new results. *Transportation Research Part A: Policy and Practice*, *41*(9), 874–889. https://doi.org/10.1016/j.tra.2006.10.002

Douglass, S. L., & Pickel, B. H. (1999). The Tide Doesn't Go Out Anymore- The Effect of Bulkheads on Urban Bay Shorelines. *Shore & Beach*, *67*(2), 19–25.

Fant, C., Gentile, L. E., Herold, N., Kunkle, H., Kerrich, Z., Neumann, J., & Martinich, J. (2022). Valuation of long-term coastal wetland changes in the U.S. *Ocean & Coastal Management*, *226*, 106248. https://doi.org/10.1016/j.ocecoaman.2022.106248

Griggs, G. (2005). The impacts of coastal armoring. *Shore and Beach*, *73*, 13–22.

Hanley, N., Mourato, S., & Wright, R. E. (2001). *CHOICE MODELLING APPROACHES: A SUPERIOR ALTERNATIVE FOR ENVIRONMENTAL VALUATION?*

Hausman, J., & Ruud, P. (1987). Specifying and testing econometric models for rank-ordered data. *Journal of Econometrics*, *34*(1–2), 83–104.

Hotelling, H. (1947, June 18). [Personal communication].

Interis, M. G., & Petrolia, D. R. (2016). Location, Location, Habitat: How the Value of Ecosystem Services Varies across Location and by Habitat. *Land Economics*, *92*(2), 292–307. https://doi.org/10.3368/le.92.2.292

Kroes, E. P., & Sheldon, R. J. (1988). Stated Preference Methods: An Introduction. *Journal of Transport Economics and Policy*, *22*(1), 11–25.

Landry, C. E., Keeler, A. G., & Kriesel, W. (2003). An Economic Evaluation of Beach Erosion Management Alternatives. *Marine Resource Economics*, *18*(2), 105–127.

Liu, Z., Fagherazzi, S., & Cui, B. (2021). Success of coastal wetlands restoration is driven by sediment availability. *Communications Earth & Environment*, *2*(1), Article 1. https://doi.org/10.1038/s43247-021-00117-7

Louviere, J. J., Hensher, D. A., & Swait, J. D. (2000). *Stated Choice Methods: Analysis and Applications*. Cambridge University Press. https://doi.org/10.1017/CBO9780511753831

McFadden, D. (1980). Econometric Models for Probabilistic Choice Among Products. *The Journal of Business*, *53*(3), S13–S29.

Mehvar, S., Filatova, T., Dastgheib, A., De Ruyter van Steveninck, E., & Ranasinghe, R. (2018). Quantifying Economic Value of Coastal Ecosystem Services: A Review. *Journal of Marine Science and Engineering*, *6*(1), Article 1. https://doi.org/10.3390/jmse6010005

Narayan, S., Beck, M., Wilson, P., Thomas, C., Guerrero, A., Shepard, C., Reguero, B. G., Franco, G., Ingram, J., & Trespalacios, D. (2017). The Value of Coastal Wetlands for Flood Damage Reduction in the Northeastern USA. *Scientific Reports*, *7*, 9643. https://doi.org/10.1038/s41598-017-09269-z

Nguyen, T., Kling, D. M., Dundas, S. J., Hacker, S. D., Lew, D. K., Ruggiero, P., & Roy, K. (2023). Quality over Quantity: Nonmarket Values of Restoring Coastal Dunes in the U.S. Pacific

Northwest. *Land Economics*, *99*(1), 63–79. https://doi.org/10.3368/le.040721-0036R

Petrolia, D. R., Interis, M. G., & Hwang, J. (2014). America's Wetland? A National Survey of Willingness to Pay for Restoration of Louisiana's Coastal Wetlands. *Marine Resource Economics*, *29*(1), 17–37. https://doi.org/10.1086/676289

Powell, E. J., Tyrrell, M. C., Milliken, A., Tirpak, J. M., & Staudinger, M. D. (2019). A review of coastal management approaches to support the integration of ecological and human community planning for climate change. *Journal of Coastal Conservation*, *23*(1), 1–18. https://doi.org/10.1007/s11852-018-0632-y

Randall, A., Ives, B., & Eastman, C. (1974). Bidding games for valuation of aesthetic environmental improvements. *Journal of Environmental Economics and Management*, *1*(2), 132–149.

Renzi, J. J., He, Q., & Silliman, B. R. (2019). Harnessing Positive Species Interactions to Enhance Coastal Wetland Restoration. *Frontiers in Ecology and Evolution*, *7*. https://www.frontiersin.org/articles/10.3389/fevo.2019.00131

Safak, I., Norby, P. L., Dix, N., Grizzle, R. E., Southwell, M., Veenstra, J. J., Acevedo, A., Cooper-Kolb, T., Massey, L., Sheremet, A., & Angelini, C. (2020). Coupling breakwalls with oyster restoration structures enhances living shoreline performance along energetic shorelines. *Ecological Engineering*, *158*, 106071. https://doi.org/10.1016/j.ecoleng.2020.106071

Scyphers, S. B., Powers, S. P., Jr, K. L. H., & Byron, D. (2011). Oyster Reefs as Natural Breakwaters Mitigate Shoreline Loss and Facilitate Fisheries. *PLOS ONE*, *6*(8), e22396. https://doi.org/10.1371/journal.pone.0022396

Tokunaga, K., Sugino, H., Nomura, H., & Michida, Y. (2020). Norms and the willingness to pay for coastal ecosystem restoration: A case of the Tokyo Bay intertidal flats. *Ecological Economics*, *169*, 106423. https://doi.org/10.1016/j.ecolecon.2019.106423

Train, K. (2001). Halton Sequences for Mixed Logit. *Econometrics*, Article 0012002.

https://ideas.repec.org//p/wpa/wuwpem/0012002.html

Train, K. (2009). *Discrete Choice Methods with Simulation* [Cambridge Books]. Cambridge University Press. https://econpapers.repec.org/bookchap/cupcbooks/9780521766555.htm

USGCRP. (2018). *Fourth National Climate Assessment* (pp. 1–470). U.S. Global Change Research Program, Washington, DC. https://nca2018.globalchange.govhttps://nca2018.globalchange.gov/chapter/8

Wedding, L. M., Reiter, S., Moritsch, M., Hartge, E., Reiblich, J., Gourlie, D., & Guerry, A. (2022). Embedding the value of coastal ecosystem services into climate change adaptation planning. *PeerJ*, *10*. https://doi.org/10.7717/peerj.13463

Whitehead, J. C., Pattanayak, S. K., Van Houtven, G. L., & Gelso, B. R. (2008). Combining Revealed and Stated Preference Data to Estimate the Nonmarket Value of Ecological Services: An Assessment of the State of the Science. *Journal of Economic Surveys*, *22*(5), 872–908. https://doi.org/10.1111/j.1467-6419.2008.00552.x

Wooldridge, J. M. (2010). Econometric Analysis of Cross Section and Panel Data. *MIT Press Books*, *1*. https://ideas.repec.org//b/mtp/titles/0262232588.html

Appendix A

Conditional logit with variables v_t, alt A and sq

choice	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
min_habitat	.536	.09	5.94	0	.359	.713	***
sig_habitat	1.061	.095	11.16	0	.875	1.247	***
min_rec	.369	.099	3.73	0	.175	.563	***
sig_rec	.629	.129	4.87	0	.376	.882	***
acres	.061	.028	2.21	.027	.007	.116	**
storm_prot	-.002	.021	-0.08	.932	-.042	.039	
flood_prot	.028	.013	2.26	.024	.004	.053	**
tax_	-.011	.001	-7.50	0	-.014	-.008	***
v_t	0	.002	0.26	.799	-.003	.004	
altA	.186	.113	1.65	.1	-.035	.407	*
sq	.07	.185	0.38	.704	-.292	.432	

Mean dependent var	0.333	SD dependent var	0.471
Pseudo r-squared	0.134	Number of obs	4641
Chi-square	287.958	Prob > chi2	0.000
Akaike crit. (AIC)	2966.165	Bayesian crit. (BIC)	3037.034

*** *p<.01, ** p<.05, * p<.1*

APPENDIX B

Conditional logit with variable v_t

choice	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
min_habitat	.561	.086	6.49	0	.391	.73	***
sig_habitat	1.024	.093	11.00	0	.842	1.207	***
min_rec	.321	.088	3.63	0	.148	.494	***
sig_rec	.479	.09	5.32	0	.303	.656	***
acres	.088	.02	4.43	0	.049	.127	***
storm_prot	.014	.018	0.78	.435	-.021	.049	
flood_prot	.023	.011	2.11	.035	.002	.045	**
tax_	-.011	.001	-7.79	0	-.014	-.008	***
v_t	0	.002	0.26	.798	-.003	.004	

Mean dependent var	0.333	SD dependent var	0.471
Pseudo r-squared	0.133	Number of obs	4641
Chi-square	265.005	Prob > chi2	0.000
Akaike crit. (AIC)	2964.383	Bayesian crit. (BIC)	3022.367

**** p<.01, ** p<.05, * p<.1*