STRATEGIC VOTING IN THREE OPTION CHOICE EXPERIMENTS:

A CASE STUDY OF THE FORSYTHE NATIONAL WILDLIFE REFUGE

by

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(Under the Direction of Craig Landry)

ABSTRACT

The process of environmental valuation is critical to modern natural resource management practices. A common format for natural resource valuation is the three-option choice experiment, which is appropriate for complex applications and efficiently estimates willingness to pay. Choice experiments, however, lack theoretical incentive compatibility according to the Gibbard-Satterthwaite Theorem. As a result, a major criticism of three-option choice experiments is their susceptibility to strategic voting. In this thesis, we investigate the impact of strategic voting by constructing a conceptual model that allows potential strategic voters to be identified and accounted for. The Forsythe Wildlife National Refuge restoration plan is valued using conditional logit, mixed logit, and attribute non-attendance models. Potential strategic voters are identified, and the models are adjusted using categorical variable interactions. The adjusted models perform better on information criteria tests, and a Wald test shows that the adjusted models are significantly different from the base models.

INDEX WORDS: Choice experiment, strategic voting, coastal, resource, valuation, attribute non-attendance, random utility model

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CHAPTER 1

INTRODUCTION

The process of environmental valuation is critical to modern natural resource management practices. Nonetheless, the methods of environmental valuation, especially stated preference (SP) methods, have been subject to controversy since their inception. A lack of incentive compatibility, where the utility maximizing choice for a respondent does not align with the respondent's true preference, is a major source of concern regarding the validity of SP methods. Multinomial choice experiments have been shown to lack incentive compatibility, but they are still widely used in the environmental valuation literature. This thesis sets out to answer the questions "how prevalent might strategic voting be in choice experiments?" and "what is the potential impact of strategic voting on 3-option choice experiments in the context of coastal resource management?" by providing a novel method for identifying potential strategic voters and isolating their impact on valuation models and empirical results.

The controversy surrounding stated preference methodology is well documented, and is integrated into the damage assessments and litigation that arose in the wake of the Exxon Valdez oil spill in the Prince William Sound of Alaska, USA (Hausmann, 1993; Arrow et al., 1993) and the Deepwater Horizon oil leak in the Gulf of Mexico, USA (Kling, Phaneuf, and Zhao 2012; Hausman 2012; Carson 2012). Researchers have addressed some perceived flaws in stated preference methods by introducing new survey formats like the double-bounded dichotomous choice method (Kanninen, 1993), one-and-a-half bounded dichotomous choice approach (Cooper et al., 2002), or adding cheap talk and "consequentiality" scripts to combat hypothetical bias

(Cummings and Taylor, 1999; Landry & List, 2007; Tonsor and Shupp, 2011; Haghani et al., 2021b). There has been a shift in design of choice experiments that can have significant implications for strategic voting: older multinomial choice experiments typically asked respondents to choose between several discrete policy options, recreation sites, or scenarios (Adamowicz et al., 1994; Boxall et al., 1996; Hanly et al., 1998), while more recent multinomial choice valuation literature often asks respondents to choose between various levels of investment within a single policy framework (Birol et al., 2006; Can and Alp, 2012; Borger et al., 2014b, Tan et al., 2018). This thesis contributes to the choice experiment validity literature by demonstrating the implications of this shift on the prevalence of strategic voting and to the coastal valuation literature by providing updated, strategic voting-adjusted, valuation estimates of the Forsythe National Wildlife Refuge restoration plan (New Jersey, USA).

The remainder of this thesis is organized as follows: first, an in depth literature review covering the history, controversy, and developments of stated preference valuation methods in a coastal valuation context is provided, then the data are presented; next is a short description of the empirical models, followed by a presentation of the results, and finally a discussion of the implications of the results on policy and the literature.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This thesis is focused on the prevalence of strategic voting in choice experiments. To convey the significance of this topic, it is important to understand the place of choice experiments within the larger environmental valuation landscape, as well as the long history of controversy surrounding stated preference valuation techniques.

The first valuation techniques were revealed preference methods. Revealed preference (RP) methods rely on observing consumer behavior and drawing conclusions about the value of non-market resources based on those observations. The use of actual consumer behavior can provide estimates of willingness to pay that are less affected by factors irrelevant to the value of the policy/product, yet RP approaches still employ many assumptions (e.g., information, awareness, market equilibrium conditions, etc.). Many of these assumptions can be tested, but some cannot be tested for all respondents or for all time periods. In addition, revealed preference methods rely on historical data, limiting their usefulness for valuing new policies or products (Whitehead et al., 2008). Harold Hotelling (1949) first suggested revealed preference methods as a way to value national parks or wilderness areas. The travel cost method was further refined by Clawson (1959) and has been widely applied to many resources around the world (Ward and Loomis, 1986; Das, 2013). Additional revealed preference methods emerged, including hedonic valuation (Brown and Pollakowski, 2007) and damage cost models (Dickie, 2003).

Stated preference techniques are valuation methods that focus on planned or contingent behavior with regards to prospective changes in environmental and natural resources. Stated preference methods can value new products and non-market goods, but their hypothetical nature can introduce bias (Whitehead et al., 2008). They were first suggested by Ciriacy-Wantrup (1947) and subsequently applied as the contingent valuation method (Davis, 1963; Baveye et al., 2013).

The concept of ecosystem services is central to the development of the environmental valuation literature. The term was popularized in Costanza et al. (1997), then the Millennium Ecosystem Assessment (2003) provided a framework for integrating ecosystem service valuation into policy. The concept of ecosystem services helps align the objectives of researchers, managers, and policymakers by making explicit the ways that the natural world benefits human civilization. It is much easier to value something if we have a common understanding about how it might benefit us. There is still uncertainty about how ecosystem processes generate ecosystem services, as processes can be unique, contextually dependent, and possibly only indirectly related to ecosystem service generation. More research linking ecosystem functions to ecosystem services is needed (Barbier et al., 2019).

As the literature has developed, new valuation methods have been introduced, and old valuation methods have become more reliable. For example, the travel cost method has been expanded to be able to value multiple sites, multiple locations within a trip, and multiple characteristics of a single site (Mendelsohn, 2019). Generally accepted best practices have evolved to make estimates more reliable, consistent, and comparable, and more relevant to policymakers and managers. For example, valuing quantifiable site attributes over qualitative attributes gives managers more actionable information (Borger et al., 2014a). The introduction of simulation methods to the field led to the development of more complex and flexible models. Simulation enables numerical approximation of integrals without closed-form solutions, allowing researchers to use models that more realistically represent complex economic relationships (Train, 2009).

Because environmental valuation methods are focused on estimating non-market values associated with ecological systems, conventional signals of economic value – like market prices, expenditures, market share, or contract terms – are not directly observable. Thus, accuracy and validity of estimates has been an important aspect of environmental valuation research protocol. The Exxon Valdez oil spill sparked an intense debate over the validity of stated preference techniques in damage assessment and government policy. Exxon sponsored a conference that labeled contingent valuation unreliable (Hausmann, 1993), which prompted the NOAA Blue Ribbon Panel (Arrow et al., 1993) to determine the usefulness of and identify best practices for contingent valuation. The Blue-Ribbon Panel set out preliminary guidelines for incorporating stated preference valuation work into policy and established quality standards that influenced subsequent revisions to best practice protocol. After the Blue-Ribbon Panel, stated preference techniques were increasingly integrated into policymaking, with more than 7,500 contingent valuation papers being published by 2011 (Carson, 2011).

The Deepwater Horizon oil leak was another catalyzing event in the history of marine resource valuation. Similar to the Exxon Valdez spill, an influx of government funds and public attention resulted in a rehash of the debates following the Exxon Valdez spill (Petrolia, 2015). Petrolia (2015) claims that the effect of Deepwater Horizon was limited to an initial rush of papers (Kling, Phaneuf, and Zhao 2012; Hausman 2012; Carson 2012) and did not have the same long-term impact as the Exxon Valdez spill. Further complicating matters, policies such as the

National Ocean Policy in the US and the Marine and Coastal Access Act in the UK were enacted that engendered a wave of valuation research papers around the same time. These policies mandated the use of valuation data in marine resource management, creating new demand for valuation work (Borger et al., 2014a).

2.2 Choice Experiment Validity

Stated preference methodology started with open-ended contingent valuation, but the prevalence of protest bids and concerns about the high cognitive burden of this format led to a preference for the dichotomous choice method (Hanley et al., 2001). Dichotomous choice is simple in that respondents only need to indicate a Yes or No response at a given offered price. It has the benefit of being incentive compatible under particular conditions, meaning that the utility optimizing choice for the respondent is to answer truthfully (Carson and Groves, 2007). For incentive compatibility to hold, the respondent must believe in the efficacy of their vote and believe that any costs associated with their choice could be realistically enforced, among other conditions. There are many ways that incentive compatibility can fail for a dichotomous choice survey, but the Gibbard-Satterthwaite theorem states that no response format with more than two options can be incentive compatible (Carson and Groves, 2007). Dichotomous choice methods, however, provide very little information on the magnitude of Willingness to Pay and are not well-suited to complex applications (Hanley et al., 2001). Researchers extended dichotomous choice methods to investigate more complex questions, creating sequential binary choice, equivalent value, and choice experiment methods. Gibbard (1973) and Satterthwaite (1975), however, showed that no response format that allows for more than two choice options can be incentive compatible without significant restrictions on the preferences of respondents. Multinomial choice formats (choice experiments) provide more detail and flexibility at the cost of limiting incentive compatibility (Carson and Groves, 2007).

A potential middle ground between binomial and multinomial formats is the sequential binomial method. This format asks a series of dichotomous choice questions in an effort to obtain more specificity about the WTP of respondents (Kanninen, 1993). An example of this is the double bounded dichotomous choice format, in which respondents are asked an initial dichotomous choice question, which is then followed up by a second choice depending on their answer. This has been shown to increase the statistical efficiency of the dichotomous choice format (Hanemann et al., 1991). Dichotomous choice is also associated with some drawbacks. There is evidence of inconsistency in responses, suggesting that follow-up questions can trigger strategic responses. The one-and-a-half bound method was introduced to maintain the efficiency gains of adding follow-up questions while reducing potential response bias (Cooper et al., 2002). Some point to the potential presence of strategic voting, hypothetical bias, and generally high WTP estimates as evidence of stated preference methods being inherently flawed (Hausman, 2012). This view arguably paints an overly simplistic picture, though the concerns presented are valid. For instance, Hausman's claim that hypothetical questions invariably lead to higher WTP values is misleading. Different response formats can cause upward or downward bias; open-ended CV methods tend to have lower estimates than dichotomous choice and CE methods (Boyle et al., 1996).

Hypothetical bias is another common source of concern with choice experiment methodology. Hypothetical bias refers to respondents indicating a willingness to pay for a good or service in a survey that differs from observed payment in real markets, as a result of the respondent not believing they will need to pay the indicated amount (Ajzen et al., 2004). Hypothetical bias is complex, with many factors that can contribute to or mitigate it. An illustrative example of this is the difference in observed hypothetical bias in CE studies of transportation and health economics. Haghani et al. (2021a) find that there is significantly less hypothetical bias in studies of healthcare than in studies of transportation, suggesting the difference could arise from the seriousness of healthcare decisions. The authors indicate this as an area for further exploration, but the difference remains a potent example of the context-dependent nature of hypothetical bias. The environmental economics field shows mixed results in tests for hypothetical bias, further complicated by the interrelated public/private nature of the goods valued in this field (Haghani et al., 2021a; Carlsson and Martinsson 2001). Hypothetical bias is a challenge, but it does not render choice experiments useless (Haghani et al., 2021a).

There are many ways that hypothetical bias can be introduced. One example is bidding-style choice experiments, where starting values can cause an "anchoring" effect that may influence subsequent valuation responses (Boyle et al., 1985). Similarly, there are also many ways that hypothetical bias can be addressed. Haghani et al. (2021b) identifies and examines ten methods of mitigating hypothetical bias. A "cheap talk" script is the most commonly used *ex-ante* mitigation strategy and has been shown to be effective (Cummings and Taylor, 1999; Martinsson and Carlsson, 2006; Landry and List 2007; Ami et al., 2011). "Certainty scale calibration" is the most prominent *ex-post* hypothetical bias mitigation technique. In this method, respondents rate how certain they are of their answer. Champ et al. (1997) found that respondents with high certainty were more accurate about their WTP when compared to their actual behavior. Other notable examples in an environmental context include Lundhede et al. (2009), which found that certainty scale calibration improved the reliability of responses but had a small effect on the WTP estimates, and Ready et al. (2010) which claimed to successfully address hypothetical bias in the context of wildlife rehabilitation using certainty calibration methods. The correct method or combination of methods for a given study is context-dependent. Hypothetical bias mitigation methods are generally (but not universally) effective and should be considered in most stated preference studies (Haghani et al., 2021b).

The cognitive burden of SP techniques can have a significant impact on the results of a study. Respondents can react to a complex SP study through increased protest votes or decreased strategic behavior (Hanley, 2001; Bassi, 2015). In choice experiment formats, respondents can react to complexity by ignoring one or more of the attributes or options presented. This violates a basic assumption of the random utility model, the fundamental framework for choice experiments. The random utility model assumes that the degradation of one attribute can be compensated by the increase of another attribute, but if the respondent does not pay attention to one or more attributes, this assumption fails. The attribute non-attendance model addresses this by assigning respondents to latent classes, where the non-attenders have zero utility for certain attributes, while the rest of the sample has non-zero utility. There is some controversy about whether the attribute non-attendance model is suitable (Alemu et al., 2013), but the attribute non-attendance model has been shown to be useful in a number of applications (Hensher et al., 2005; Scarpa et al., 2009; Gonçalves 2022).

A greater diversity of valuation methods can provide more robust results. By measuring the same underlying value using multiple methods, researchers can verify the accuracy of results. An example is how stated preference (SP) and revealed preference (RP) methods can be combined to produce more robust results. SP methods can reduce collinearity in RP data, allowing for the identification of previously weakly identified attribute effects. Furthermore, SP data can describe attribute changes that are outside the observed range in RP data (Adamowicz et al., 1994). By using RP and SP methods as complements, researchers can build on the strengths of each method while minimizing the weaknesses (Whitehead et al., 2008).

A fundamental assumption of choice experiments is that they correctly translate all individual responses into a preference ranking that represent collective preference of the group, a process called preference aggregation. A necessary condition of preference aggregation is that each respondent indicates their most-preferred option in each survey question (Tyszler and Schram, 2016). This condition can fail if strategic voting is present. Strategic voting occurs when a respondent selects an option, that is not the most-preferred alternative, in order to maximize individual welfare. This commonly happens in elections when an individual believes their most-preferred candidate is unlikely to win, so the individual chooses between the two candidates they believe to be the most likely to succeed. Carson and Groves (2007) examine the vulnerability of various stated preference techniques to strategic voting and find that dichotomous choice methods are the least susceptible to strategic voting, but strategic voting can still be a problem for improperly designed dichotomous choice instruments. The authors also discuss other methods, including open-ended CV and choice experiment methods and find that strategic voting is a concern for these alternatives, but that these methods can still provide useful information. Vossler and Holladay (2018) address concerns about strategic voting in non-dichotomous choice methods by identifying incentive compatibility conditions for open-ended and payment card formats.

Another type of strategic bias occurs when a respondent does not believe the organization conducting the survey will actually be able to collect the indicated payment, incentivizing the respondent to choose the highest-cost option if they are in favor of the policy in question. This type of strategic bias eliminates incentive compatibility regardless of survey design (Carson and Groves, 2007). There are numerous examples of respondents over-stating their WTP when the payment mechanism is voluntary (Seip and Strand 1992; Champ et al. 1997; Foster et al. 1997). The independence of irrelevant alternatives (IIA) assumption states that the preference ranking of any two alternatives must not change with the addition or removal of any other alternative (McFadden, 1980). If the IIA assumption fails, preference aggregation also fails (Arrow, 2012). The IIA assumption is frequently violated when there are more than two choice options in a CV survey (Carson and Groves, 2007).

Laboratory experiments have investigated the prevalence of strategic voting in a choice experiment context. Xu et al. (2013) confirmed that respondents will vote strategically if they perceive their most-preferred option to be the least popular. Tyszler and Schram (2016) used a laboratory choice experiment that compared the typical plurality decision rule with decision rules that were opaque to respondents, mirroring the way that CE results are used by managers and policymakers. They found that respondents still voted strategically, but at reduced levels for opaque decision rules. Additionally, more complex voting systems such as approval voting or a Borda count system have been found to result in less strategic voting (Bassi, 2015). More complex formats, however, can increase protest votes, also biasing results (Hanley, 2001). Collins and Vossler (2009) used induced demand experiments to ensure that respondents have uniform priors, allowing three-option CE to be incentive compatible, then tested voting behavior under an obscure decision rule. The authors found that respondents voted generally optimally (either sincerely or strategically, according to the utility maximizing strategy for their induced preference) and also found a small but significant status-quo bias. There was no statistical difference in the frequency of deviations from the theoretically predicted outcome between 2–

and 3–option choice methods with a plurality vote, although there were slightly more theoretical deviations under a random selection provision rule.

2.3 Coastal Resource Valuation

Coastal ecosystems are threatened by several factors, including the effects of climate change, such as sea level rise, and more direct anthropogenic sources, such as pollution and land use change. These threats require a holistic adaptation approach that includes restoration and maintenance of current resources, as well as systematic adjustment to new conditions (Powell et al., 2019). Six categories of coastal conservation are described by Powell et al. (2019): 1) restoration, 2) landscape conservation design, 3) living shorelines, 4) facilitated relocation, 5) open space preservation, and 6) land use planning. Each strategy has costs and benefits, and the valuation process can help policymakers and managers identify the best mix for their limited resources. Adaptation planning is increasing, but climate change impacts are currently outpacing planning efforts. New, innovative planning solutions must be developed (Weaver and Miller, 2019).

Restoring marine and coastal habitat can be difficult and expensive. The cost of restoring one hectare of coastal habitat is reported to be at least $80,000, without including capital and operating costs (Bayraktarov et al., 2016). Exacerbating the challenge of high costs, coastal wetlands are difficult to value, and therefore it is difficult to assess efficiency of preservation and restoration. The link between ecological processes and ecosystem services is not clear; economists can estimate how much people value ecosystem services, but it is difficult to pinpoint the environmental processes that change the quantity or quality of those services (Barbier et al., 2019). Wedding et al. (2022) address the link between ecological processes and the provision of ecosystem services by using the InVEST model to identify the restoration and conservation policies that will have the biggest impact for a given study area, but more work to develop these linkages is needed. Despite the high cost, coastal wetlands provide a disproportionate amount of ecosystem services, estimated to be 43.1% of all ecosystem services globally (Davidson et al., 2019). The cost of conserving and restoring wetlands is high, but the benefits have been shown to outweigh the costs in many cases (Weaver and Miller, 2019).

The environmental valuation literature contains choice experiments that ask respondents to choose between both discrete and continuous options for environmental management policies. Older publications more commonly used discrete options. Adamowicz et al. (1994), the first choice experiment in an environmental context, asked respondents to choose between different types of fishing location. Boxall et al. (1996) elicited hunters' choice among various moose hunting locations. Hanley et al. (1998) asks respondents to choose between photographs of a landscape that had been altered in various ways. In the recent literature, it is more common to use choice experiments to value different attribute levels associated with a single policy. Borger et al. (2014b) asks respondents to choose between options for updating the Dogger Bank Management Plan: respondents choose between three options, each with four associated attributes: diversity of species; protection of porpoises, seals, and seabirds; prevalence of invasive species; and additional tax. More protection requires higher taxes, although the invasive species attribute could increase with increased protection due to overall habitat expanding, thus providing more resources for all species, including invasive ones. Tan et al. (2018) similarly asks respondents to choose between three coastal wetland restoration plans that only differ in attribute levels for Ximen Island Special Marine Protected Area, China; the attributes were mangrove area, biodiversity, water quality, and one-time payment. All attributes increase with cost. There are numerous other examples of this standard choice experiment setup (Birol et al., 2006; Can and Alp, 2012).

My thesis will contribute to the Choice Experiment Validity literature by investigating the effect of strategic voting in CE responses, presenting a novel method of identifying potential strategic voters, and providing an updated view of the impact of strategic voting on choice experiments in light of recent changes in the field.

CHAPTER 3

DATA

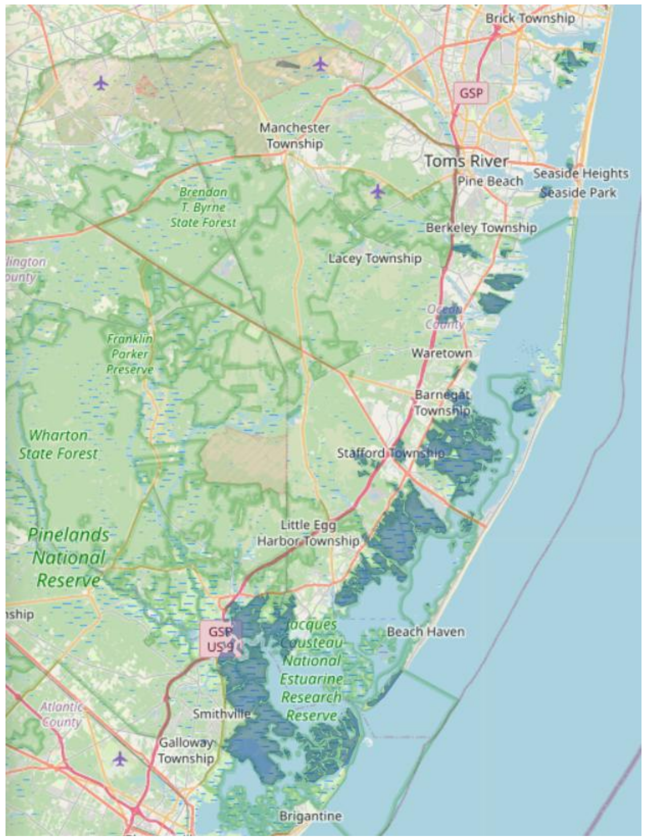

Figure 1. Map of FWNR (U.S. Fish and Wildlife)

The Forsythe National Wildlife Refuge (FNWR) provides wildlife habitat, flood protection, and recreation opportunities. The FNWR protects an area of more than 48,000 acres in New Jersey. Its northern extent is just south of Brick Township, covering more than 50 non-contiguous miles of coastline to an area just north of the town of Brigantine. The FNWR sits along the busiest migratory bird flight path on the Atlantic coast, providing an important stopover for birds along their journey. By buffering against storms, FNWR protects over 34,000 homes in 5 coastal communities. The marshes of FNWR help to prevent flooding by providing space for rising waters to go without damaging homes, businesses, and infrastructure. The FNWR is also a popular attraction, drawing more than 100,000 visitors per year for recreation opportunities such as hiking, bird watching, and canoeing.

The data for this project were collected in 2015 through GfK, an internet-based survey platform that claims the gold-standard in statistical sampling for reliability and representativeness. The geographical extent of the survey was chosen based on proximity to Forsythe National Wildlife Refuge, including 21 counties from New Jersy, Pennsylvania, Delaware, and Maryland. The survey provides brief background information about FNWR, the ecosystem services it provides, and the deleterious effects of Hurricane Sandy. Respondents were asked about their knowledge of FNWR, past visits to FNWR, and personal impacts of Hurricane Sandy. Respondents were informed that their responses would be relayed to policy makers and, thus, the information provided could provide guidance for future policy decisions regarding FNWR

The potential scope of the restoration efforts was determined in consultation with scientists at NOAA. Approximately 3,000 acres of marsh were targeted for restoration. Five New Jersey communities border the restoration region: Eagleswood, Little Egg, Stafford, Tuckerton, and Barnegat. There are 34,051 homes in those communities that will benefit from storm surge protection. 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) during Hurricane Sandy. NOAA used the value of 3,072 with significant/severe damage as an approximate mid-point.

The survey included a discrete choice experiment designed to measure household preferences for FNWR restoration options. The respondents were presented with a series of choice sets, in which they were instructed to choose one of three options: status quo (no investments nor additional cost) versus two possible investment options for FNWR (with additional costs). There are six restoration attributes: storm protection, flood protection, acreage of saltmarsh, habitat quality, recreation quality, and tax level.

- The status quo description of storm protection is: "Homes in the coastal area are under increased risk from storm damage." The conceptual description of the two invest options are identical, varying only by number of homes and businesses protected: "Protects X 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)", where X = 3,000 or 6,000 (see Table 2).
- The status quo description of flood protection is: "Homes in the coastal areas are under increased risk of suffering flood damage," and the investment option descriptions are: "Protects X homes and businesses from a 20-year flood (a flood that would occur only once every 20 years)", where X = 7,000 or 10,000 (see Table 2).
- The status quo description of Amount of Marsh that is Restored is "none," while the invest options were "X acres" where X was high or low.
- The description of the status quo option for habitat is: "Provides no improvement - Habitats for migratory birds continue to deteriorate with the marsh; over time fewer birds would visit the marsh." The description of the invest options for habitat options are: "Provides *minimal* improvements in habitat for migratory birds – marsh restoration leads to a small increase in the number of birds that visit the march each year" and "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 march each year."
- The description of the status quo option for recreation is: "Provides no improvement - recreational opportunities decline as the marsh deteriorates; over time there would be fewer places to fish, hunt, and hike trails." While the descriptions of the invest options are: "Provides *minimal* improvement in recreation – restoration would make some small improvements to fishing, hunting, and hiking opportunities at the marsh" and "Provides *significant* improvement in recreation – restoration would make some large and noticeable improvements to fishing, hunting, and hiking opportunities at the marsh."

- The cost attribute is presented as a value: $0 for status quo, then two other values for the invest options. The invest options were presented as option A and option B, only differing in attribute levels, but for convenience the invest options will be referred to as "low-invest" and "high-invest" based on the cost levels.

Respondents indicated their preferences, how confident they were in their choices, and what they expected the most common preference among other respondents to be. There were 4611 responses in total. The low-invest option is the most commonly chosen (2460), followed by-high invest (1149), and status quo (1002). No expectation of others' vote/preference is the most common expectation (2229), followed by status quo (1098), low-invest (906), and high-invest (378).

After the choice experiment, respondents were asked if they believed in the efficacy of the survey in order to investigate the presence of hypothetical bias. Respondent expectations of the outcome of the survey can play an important role in how they respond to questions. It has been theoretically (Carson and Groves, 2007) and empirically (Xu et al., 2013; Tyszler and Schram, 2016) shown that respondent expectations can impact the outcome and validity of choice experiments. By obtaining the respondent's expectations, we can observe and measure the impact of potential strategic voting. The survey also measures knowledge, attitudes, and belief about climate change and restoration options.

For a full factorial survey design, 729 combinations are required for the attributes and levels included in this survey. This is unfeasible. To address this issue, SAS macros were used to generate a fractional factorial design. This process resulted in 27 choice sets (eliminating dominated options), which were divided into 9 blocks, each with three choice sets. Each respondent was shown one of the 9 blocks, and the sequence was randomized to control for order effects.

Table 1 presents demographic statistics. There were initially 527 respondents, but after dropping respondents that completed the survey in under four minutes (quality control), there were 487 total observations remaining. Of these, 41% were male and 59% were female. The average age of a respondent was just under 57 years old, with the youngest being 18 and the oldest being 90. The average household income was $87,062 per year, with a (mid-point) range of $5000 to $200,000. Household size ranged from 1 to 9 people, with an average of 2.38 people per household. The majority of respondents (55%) were from New Jersey, with 38% from Pennsylvania and about 6% from Delaware. Only 2 (0.4%) were gathered from Maryland. Eighty percent of respondents self-identified as white, while just over 10% self-identified as black. The majority of respondents had at least some college experience – 28%: some college; 30%: college grads; 23%: graduate or professional degree – with just over 16% having high school as their highest educational attainment.

Table 2 shows the frequency of responses for question 19, "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?". Options for Question 19 range from "1: very likely" to "4: very unlikely", with "5: I don't know", and "-1: missing". The most common response to Question 19 was "2: somewhat likely" (33%), but "1: very likely" was the least common response (2%). A large proportion of respondents chose "5: I don't know" (21%). Respondent uncertainty about the impact of their vote may be a concern, but Collins and Vossler (2009) use an induced demand experiment to show that a large majority of respondents continue to act in a theoretically consistent manner under uncertain provision rules. Another concern is that 43% of respondents chose either "3: somewhat unlikely" or "4: very unlikely", compared to only 35% selecting "1:

very likely" or "2: somewhat likely". This could indicate that a high proportion of respondents do not believe in the efficacy of the survey, which could make hypothetical bias more prevalent.

Question 20 asks respondents how important they believe the various benefits of salt marshes to be. Response options range from 1: not important at all to 5: extremely important. Water purification and wildlife habitat are perceived as the most important, while recreation is perceived as the least important. Storm protection, flood protection, wildlife habitat, fish/seafood spawning ground, and water purification are clustered tightly; the average scores range from 3.78 to 3.92. Carbon storage trails in perceived importance with an average score of 3.4, and recreation is perceived as the least important with an average score of 2.78.

Question 21 investigates respondents' opinions on topics associated with climate and damaging storms. Response options range from 1: strongly disagree to 5: strongly agree. The statement that garnered the most agreement was "The climate is changing in ways that could be harmful to the coast," while the statement "Hurricane Sandy was a rare event and a similar storm is unlikely to occur in my lifetime" was least agreed with.

Question 22 gathers information about respondents' outdoor recreation practices. The most common outdoor activity was hiking/nature walking (44%), followed by no outdoor activities (35%). Hunting was the least common activity (1.9%).

Questions 8, 12, and 16 follow each choice set, and ask respondents how confident they were in their responses. Options range from 1: very confident to 4: not confident at all. The average confidence was 1.94, just above 2: somewhat confident. This is a relatively high confidence value, which can indicate a low amount of hypothetical bias (Champ et al., 1997; Lundhede et al., 2009; Ready et al., 2010)

Table 1. Demographics

	count	mean	sd	min	max
hs	487	0.164271	0.370902	0	1
some_coll	487	0.283368	0.451097	0	1
college	487	0.301848	0.459532	0	1
grad	487	0.234086	0.423862	0	1
age	487	56.85626	14.98517	18	90
white	487	0.802875	0.398237	0	1
black	487	0.106776	0.309146	0	1
male	487	0.414784	0.493191	0	1
head_household	487	0.864476	0.342634	0	1
hhsize	487	2.38809	1.250227	1	9
income	487	87062.11	50898.91	5000	200000
nj	487	0.546201	0.498373	0	1
pa	487	0.383984	0.486854	0	1
de	487	0.065708	0.248027	0	1
md	487	0.004107	0.064018	0	1

Table 2. Question 19 frequency table

Q19	No.	%
-1	33	1
1	108	2
2	1,446	33
3	1,293	30
4	558	13
5	927	21
Total	4,365	100

Table 3. Efficacy, Attitudes, Activities, and Confidence

Question No.	Question Text (Abbreviated)	n	mean	SD	min	max
Q20_1	How important is storm protection	4656	3.794459	1.082851	1	5
Q20_2	How important is flood protection	4665	3.787138	1.125834	1	5
Q20_3	How important is wildlife habitat	4674	3.926829	1.051323	1	5
Q20_4	How important is fish/seafood spawning ground	4665	3.802572	1.045202	1	5
Q20_5	How important is water purification	4674	3.928113	1.052022	1	5
Q20_6	How important is recreation	4638	2.78978	1.101887	1	5
Q20_7	How important is carbon storage	4620	3.405195	1.149138	1	5
Q21_1	Do you agree: The climate is changing in ways that could be harmful to the coast.	4698	3.966794	0.961115	1	5
Q21_2	Do you agree: Hurricane Sandy was a rare event and a similar storm is unlikely to occur in my lifetime	4692	2.613171	1.039295	1	5
Q21_3	Do you agree: I expect coastal storms will be more destructive in the future than in the past.	4692	3.754476	0.953531	1	5
Q21_4	Do you agree: It is the responsibility of the federal government to fund restoration efforts related to Hurricane Sandy.	4692	3.603581	0.93405	1	5
Q21_5	Do you agree: Federal and state governments can effectively implement environmental restoration projects	4683	3.68738	0.915284	1	5
Q22_1	Do you engage in Freshwater fishing	4719	0.104895	0.306451	0	1
Q22_2	Do you engage in saltwater fishing	4719	0.097266	0.296352	0	1
Q22_3	Do you engage in boating/canoeing	4719	0.169739	0.375443	0	1
Q22_4	Do you engage in hunting	4719	0.019072	0.136792	0	1
Q22_5	Do you engage in bird watching	4719	0.14876	0.35589	0	1
Q22_6	Do you engage in hiking/nature walking	4719	0.440559	0.496507	0	1

Q22_7	Do you engage in other (text box)	4719	0.129688	0.335996	0	1
Q22_8	I don't engage in any outdoor activities	4719	0.3541	0.47829	0	1
Q8, 12, 16	confidence	4719	1.948506	0.846468	1	4

CHAPTER 4

METHODS

We use three models in our analysis. Conditional logit is straightforward, easy to compute, and commonly used in the field, but our application almost certainly violates the independence of irrelevant alternatives (IIA) assumption. The mixed logit model alleviates the IIA concerns but increases complexity. We chose to additionally use an Attribute Non-Attendance model because the flood and storm surge protection attributes are very similar and could cause confusion for respondents, which could lead to respondents ignoring one or both of those attributes. Additionally, respondents that reside outside of areas at risk of storms or floods may not want to pay for protection for others.

Purchasing power varies dramatically within the study area, especially with regards to housing and real estate. To address this, costs were normalized by Housing Price Index (HPI). HPI was used over CPI because the flood and storm protection attributes are related to the value of the respondent's house, and HPI is available at the county level while CPI is only available at the regional level, which does not provide sufficient variation within the study area.

4.1 Random Utility Model

The Random Utility Maximization (RUM) model is the basis for discrete choice models. A brief derivation following Train (2009) is presented here. A decisionmaker *n* chooses between *J* alternatives. The decisionmaker receives utility U_{nj} for each j = 1, … , J. The utility is known to the decisionmaker but not the researcher. The decisionmaker chooses alternative *i* if $U_{ni} > U_{nj}$ for all $j \neq i$. The utility can be decomposed into two parts, a deterministic portion that the researcher can observe, $\beta' x_{ni}$, and a stochastic element that contains all other determinants of utility, ε_{nj}:

$$U_{ni} = \beta' x_{ni} + \varepsilon_{nj} \tag{1}$$

ε_n is assumed to be random, with the probability density function f(ε_n). The researcher can assume different PDFs for f(ε_n), resulting in different discrete choice models. The probability that the decisionmaker chooses alternative *i* is:

$$P_{ni} = Pr(U_{ni} > U_{nj} \; \forall \, j \neq i)$$

$$P_{ni} = \Pr\,(\beta' x_{ni} + \varepsilon_{ni} > \beta' x_{nj} + \varepsilon_{nj} \; \forall \, j \neq i)$$

$$P_{ni} = \Pr\,(\varepsilon_{nj} - \varepsilon_{ni} < \beta' x_{ni} - \beta' x_{nj} \; \forall \, j \neq i)$$

This probability is a cumulative distribution and can be re-written as an integral, where *I(.)* is an indicator function that equals 1 when the expression in the parenthesis is true and 0 otherwise:

$$P_{ni} = \int_{\varepsilon} I\big(\varepsilon_{nj} - \varepsilon_{ni} < \beta' x_{ni} - \beta' x_{nj} \; \forall \, j \neq i\big) f(\varepsilon_n) d\varepsilon_n \tag{2}$$

4.2 Conditional Logit

The conditional logit model is based on the assumption that ε_n has an independently and identically distributed extreme value distribution. This assumption leads to a closed-form solution for the probability of decisionmaker *n* choosing option *i*:

$$P_{ni} = \frac{e^{\beta' x_{ni}}}{\sum_j e^{\beta' x_{nj}}} \tag{3}$$

The closed form solution allows for easy computation but also requires the restrictive independence of irrelevant alternatives (IIA) assumption: the preference ranking of any two alternatives must not change with the addition or removal of any other alternative. The IIA assumption also implies that substitution among alternatives must be proportional: an increase in the probability of choosing one alternative results in an equal decrease in the probability of selecting all other alternatives. This assumption is appropriate in certain scenarios but is often violated. When the IIA assumption is violated, conditional logit is not appropriate, and researchers must turn to more complex models (Train, 2009).

4.3 Mixed Logit

The mixed logit model addresses some of the drawbacks of conditional logit by allowing the coefficients of the decisionmakers' utility to vary across the population with density $f(\beta)$. The probability of decisionmaker *n* choosing option *i* is:

$$P_{ni} = \int \frac{e^{\beta' x_{ni}}}{\sum_j e^{\beta' x_{nj}}} f(\beta) d(\beta) \tag{4}$$

The integral is taken over all possible values of β, and does not have a closed-form solution; simulation is required to estimate the parameters. The values of β that maximize the likelihood of the decisionmaker choosing alternative *i* are selected. Allowing preferences to vary for individuals relaxes the IIA assumption and allows for unrestricted substitution patterns (Train, 2009).

4.4 Attribute Non-Attendance

A basic assumption of the RUM is that the degradation of one attribute can be compensated by the improvement of another. If respondents do not pay attention to certain attributes, this assumption fails because no amount of improvement of the ignored attribute will compensate the respondent. One way to address this issue is with the attribute non-attendance

(ANA) approach. The ANA model is built on the latent class framework, which is similar to mixed logit models, but introduces heterogeneity in discrete groups rather than according to a continuous distribution. The latent class model arises if $f(\beta)$ in equation 4 is discrete rather than continuous. The parameter vector β takes on a finite set of values, $b_1 \ldots b_M$ with probability s_m that $\beta = b_m$. The probability that decisionmaker *n* chooses option *i* is then:

$$P_{ni} = \sum_{m=1}^{M} s_m \left(\frac{e^{b_m{}' x_{ni}}}{\sum_j e^{b_m{}' x_{nj}}} \right) \tag{5}$$

Where there are *M* segments of the population. The ANA model allows respondents to belong to latent classes where the utility of certain attributes is zero, and the non-zero attributes share the same value across classes, and IIA applies within each latent segment. The ANA model can mitigate bias caused by non-attendance by allowing respondents to gain zero utility from certain attributes (Scarpa 2009).

In all three models, marginal willingness to pay (mWTP) for an attribute is calculated by dividing the coefficient for that attribute by the coefficient of the cost attribute, then multiplying by negative one:

$$mWTP = -1 \left(\frac{\beta_{attribute}}{\beta_{cost}} \right) \tag{6}$$

4.5 Conceptual Model

In our survey, we ask respondents which option they expect the majority of other respondents to select. For convenience, this response is referred to as “expected winner.” There are 9 pairs of expected winner/vote selection (3 expected winners × 3 vote selections). Our goal is to identify potential strategic voting patterns (respondents that may have selected an option other than their most-preferred option) based on this information. To use this information to identify potential strategic voters, we must assume convex preferences (a standard assumption in utility theory); the reasons for this assumption will be detailed below.

An unexamined distinction between various choice experiment formats stems from asking respondents to choose between discrete policy options (often "branded" in design parlance) versus those that ask respondents to choose between differing levels within a single policy, where the levels are selected from a range by the researchers. The distinction may have significant strategic voting implications. In the literature discussing the incentive compatibility properties of choice experiments, it is typically assumed that respondents choose between discrete policy alternatives. Carson and Groves (2007) use political races, choices between discrete goods, and choices between different recreational sites as examples. Collins and Vossler (2009) use laboratory experiments with induced demand to study the incentive compatibility properties of three-option choice experiments and assume the respondents choose between three distinct options. Xu et al. (2013) perform a laboratory test with the intention of simulating a choice experiment and provide the respondents with a choice between three discrete goods. Tyszler and Schram (2016) also run a laboratory experiment that assumes three discrete candidates, although in a more abstracted manner, assigning respondents preference orderings of three (fully discrete) options without defining what the options represented.

The focus on fully discrete choice options follows the early choice experiment literature, which featured choices between fishing sites (Adamowicz et al., 1994), hunting sites (Boxall et al., 1996), and images of a landscape (Hanly et al. 1998). Researchers use the results of choice experiments to evaluate the willingness to pay for various attributes, which is often continuous. The presentation of discrete choice options, however, can introduce strategic voting because discrete options can have unobserved effects associated with each option in addition to the attributes being valued. Respondents can have preferences about recreation sites that are independent of the attributes identified in a survey, and in the case of Hanley et al. (1998), aesthetic preference can be independent of any underlying implications about ecosystem services provided by a landscape. Further contributing to strategic voting, the presentation of discrete options is often presented in a setting where only one of the options can "win", despite the underlying goal of identifying where on the willingness to pay spectrum people place certain attributes. A respondent must evaluate the likelihood of their most-preferred option to win, and if they believe that option is least likely to win, they may misrepresent their preferences by voting against their least-preferred option.

In recent years, the choice experiment literature has evolved to include many studies that ask respondents to choose between levels of a single policy (Birol et al., 2006; Can and Alp, 2012; Borger et al., 2014b; Tan et al., 2018). These choice experiments ask respondents to choose between options that are only differentiated by the amount or quality of the attributes provided by the policy. This attenuates the influence of unobserved effects that are introduced by discrete choice options. Additionally, the presentation of options pulled from a continuum implies that a synthesis or aggregation of the results will occur, which more accurately represents the valuation process to respondents and provides greater incentive for respondents to indicate their true preference. Even if the respondent believes their most-preferred option is least likely to win, it is clear that their vote still impacts the final output of the analysis.

To identify potential strategic voters, we looked at all combinations of vote selection, expected winner, and 3-option preference relation. We assume that respondents believe that the services proposed in the survey can be provided and that payment can be collected, and we assume that any strategic voting behavior observed does not come from these sources; that is, we assume consequentiality – a necessary condition for incentive compatibility. We can observe vote selection and expected winner, but we cannot observe the respondent's true preference relation, so the goal is to identify vote selection/expected winner pairs that are potentially strategic. We use the generic A, B, and C to represent the options. In the discrete case, these are fully distinct. In the case where the options are pulled from a continuum, A represents the lowest option (in our case, *status quo*), C represents the highest option, and B is an intermediate option.

We begin with the discrete case. There are 6 unique three-option preference relations, 3 possible expected winners, and 3 possible vote selections, which result in 54 possible combinations. These combinations are listed in Appendix A1. Not all 54 possibilities are rational, so we must introduce two conditions. The first is that respondents should always vote for their most-preferred option if they expect that option to win. This condition eliminates 12 possibilities (rows 9, 10, 17, 18, 19, 20, 35, 36, 37, 38, 45, 46 in Appendix A1). The second condition is that respondents should never vote for their least-preferred option. Even if the respondent believes their most-preferred option is least expected to win, they can vote for their second-most preferred option. Either their most or second-most preferred option will be one of the two most expected to win. In other words, it is always possible to vote against their least-preferred option. This condition removes an additional 12 possibilities (4, 6, 12, 16, 23, 26, 29, 32, 39, 43, 49, and 51 in Appendix A1), leaving 30 possibilities. Of the original total 54 possibilities, there are 36 where the vote selection does not align with the most-preferred option (are potentially strategic). Of the 36 strategic possibilities, there are 12 that are also rational, according to the conditions above. Our goal is to identify which expected winner/vote selection combinations are potentially strategic. The 12 rational and strategic possibilities include all 9 expected winner/vote selection combinations (3 expected winners × 3 vote selections), showing that any combination of expected winner and vote selection can be potentially strategic in the fully discrete case.

Now we move to the case where the options are pulled from a continuum. The same 54 possible combinations of preference relation, expected winner, and vote selection are present. These are shown in Appendix A2. The shift to options pulled from a continuum requires one of the conditions to be relaxed and two more to be introduced. The first condition is the same: respondents should always vote for their most-preferred option if they expect it to win. This eliminates the same 12 possibilities as in Appendix A1 (rows 9, 10, 17, 18, 19, 20, 35, 36, 37, 38, 45, 46). The second condition – if the least-preferred option is expected to win, it should not be selected – is relaxed. There are now possibilities that introduce strategic voting for the least-preferred option (to be explained). The relaxed second condition only eliminates voting for the least-preferred option when it is expected to win (rows 4, 6, 26, 29, 49, and 51 in Appendix A2). The third condition is that if an extreme is most preferred (A or C), it should be selected. This is because even if the respondent believes their most-preferred option is the least likely to win, they benefit by truthfully representing their preference and shifting the outcome of the analysis closer to their preference. This condition removes 12 possibilities (rows 5, 11, 12, 23, 24, 25, 30, 31, 32, 43, 44, 50 in Appendix A2). This condition relies on the assumption of convex preferences. This assumption can fail if respondents have an aversion to the intermediate option, or a “no half measures” attitude. If the assumption fails, four more rational and strategic possibilities are introduced (rows 5, 11, 44, 50 in Appendix A2), all of which represent unique expected winner/vote selection pairs, and the categorization of potential strategic voters fails. The final condition is: if the intermediate option is most preferred but not expected to win, the extreme that is not expected to win should be selected. This is because the respondent should strategically shift the outcome of the analysis as close to their preference as possible by voting for the opposite extreme. This eliminates 6 possibilities (rows 3, 21, 22, 33, 34, 52 in Appendix A2). Rows 21, 22, 33, and 34 are sincere B voters. Arguably, these voters are rational, even if they are not maximally moving the outcome to their preference. These voters may believe their vote to be highly pivotal, and they do not want to over-shoot their preference. Regardless, they are not strategic voters, so their categorization as rational or irrational does not impact the analysis. There are again 36 strategic voting possibilities. Of those, there are only 4 that are rational according to the above conditions. Of the 9 expected winner/ vote selection pairs, only 2 are present here, those that expect A to win and vote for C and those that expect C to win and vote for A.

After isolating the expected winner/ vote selection pairs that contain potential strategic voters, we assign a categorical variable that equals 1 for potential strategic voters. We then interact that categorical variable with each variable in our models to isolate the effect of potential strategic voters. By running each of our models with the new interaction terms and generating mWTP values from the non-interacted parameters, we can adjust mWTP to control for the influence of potential strategic voters.

There are two ratios that reflect the impact potential strategic voting has when choice options are pulled from a continuum: the ratio of “low” votes (A) to “high” votes (C), and the ratio of potentially strategic votes to total votes. The first ratio determines the potential direction of bias caused by strategic voting, and the second determines the magnitude of potential bias. Our sample contains more high-invest voters than status quo voters but a low overall number of potential strategic voters, which should result in a small downward shift in mWTP estimations after the potential strategic voters are accounted for.

4.6 Model Specification

$$choice = \beta_1 minHab + \beta_2 sigHab + \beta_3 minRec + \beta_4 sigRec + \beta_5 acres + \beta_6 stormProtection + \beta_7 floodProtection + \beta_8 tax + \beta_9 sq + \beta_{10} sqcFNWR \quad (7)$$

Our base model (equation 7) includes marsh acres, storm protection, flood protection, and tax variables. It also includes the qualitative variables min_hab and sig_hab, as well as min_rec and sig_rec. There are four levels of habitat and recreation restoration (0-3, 3 is the highest), with each choice set containing three values randomly selected from the four possibilities. Min_hab and Min_rec are categorical variables that equal 1 when level 2 is selected, while sig_hab and sig_rec equal 1 when level 3 is selected. This setup enables the calculation of mWTP for habitat and recreation relative to current (level 1) and expected future (level 0) conditions. The variable sq is a categorical variable that equals 1 when status quo is selected, and sqcFNWR is an interaction term between cFNWR¸ concern for status of FNWR, and the status quo categorical variable. cFNWR cannot enter the specification on its own because it does not vary within each individual. By interacting sq and cFNWR, we introduce variation within each individual, enabling the investigation of the impact of concern for FWNR on level of status quo utility. We run this specification in conditional logit, mixed logit, and attribute non-attendance models. The attribute non-attendance models allow the storm and flood protection attributes to be ignored.

$$
\begin{aligned}
choice = {} & \beta_1 minHab + \beta_2 sigHab + \beta_3 minRec + \beta_4 sigRec \\
& + \beta_5 acres + \beta_6 stormProtection \\
& + \beta_7 floodProtection + \beta_8 tax + \beta_9 sq + \beta_{10} sqcFNWR \\
& + potStrat * [\beta_{11} minHab + \beta_{12} sigHab + \beta_{13} minRec \\
& + \beta_{14} sigRec + \beta_{15} acres + \beta_{16} stormProtection \\
& + \beta_{17} floodProtection + \beta_{18} tax + \beta_{19} sq \\
& + \beta_{20} sqcFNWR]
\end{aligned}
\tag{8}
$$

The potential strategic voter interaction model (equation 8) keeps all the variables from the base model but adds an interaction terms. The potential strategic voter categorical variable equals 1 if a respondent selects either the high invest option and the status quo expectation or if a respondent selects the status quo option and the high invest expectation. By interacting the potential strategic voter term with all variables, we can isolate the potential impact of strategic voting and produce mWTP estimates that are unbiased by strategic voting.

CHAPTER 5

RESULTS

We find limited evidence of strategic voting in our survey. Slightly less than half of votes exhibited no expectation of others' votes (2319 vs 2409). Under a convex preference assumption and the conditions for rational strategic voting presented above, the only possible strategic voters in this survey are those that expect an extreme and vote for the opposite. We cannot know the respondent's true preference, so we do not know the true proportion of strategic voters. There are 228 responses (just under 5% of total responses) for which the respondent selected high invest while expecting the status quo, and 54 responses (about 1.2% of total responses) for which the respondent selected the status quo while expecting high invest. Among those that selected the status quo, respondents expecting the high invest option are the smallest group. Among those that selected high invest, those expecting the status quo are the 2nd smallest group, with only expect high invest being more common.

The base models contain all observations, including those that are potentially strategic. The base model output can be seen in Table 4. The ANA model produced the most number of statistically significant model parameters; all but min_rec are significant at the 90% level. When an information criteria test is applied to the models, the mixed logit model performs best, with the lowest Akaike Information Criteria (AIC) and Bayesian Information Criteria (BIC) scores of the three models. The ANA model has the second-lowest AIC and BIC, while the conditional logit has the highest AIC and BIC. This indicates that the mixed logit model explains more of the variation in the sample (controlling for the number of model parameters), but the ANA model produces more precise estimates of the effects of individual parameters. This could be due to the ANA model setting the marginal effect of storm and flood protection to zero for some respondents, lowering the overall explained variance but producing better parameter estimates for respondents that care about storm and flood protection. The tax parameter estimate is negative and significant for all three models, as expected. All site attributes have positive parameter estimates.

Base model mWTP values can be seen in Table 5. The mWTP values for the base models are generally positive. Acres is positive and significant across all three models; the ANA model produces the highest mWTP for Acres at $11.55. Storm protection is positive across all three models, but only significant in the ANA model. The ANA model mWTP estimate for storm protection is $36.94, nearly an order of magnitude larger than the next highest storm protection mWTP value, the mixed logit model at $3.88. This disparity can likely be traced to the ANA model excluding non-attending respondents. We used the eaalogit STATA package to calculate the probability of an observation being assigned to the flood protection or storm protection non-attendance latent classes. For the base model, the probability for storm protection non-attendance was 0.76. This indicates that willingness to pay for storm protection among respondents who pay attention to it is quite high, but many respondents do not have a strong opinion on storm protection, potentially due to the respondent not living in an area threatened by floods or storms. Flood protection mWTP follows a similar pattern, positive across all three models, but only significant and much higher for ANA. The probability for flood protection non-attendance was 0.67. The reasons for the disparity between the ANA model and the other models are likely the same as for storm protection, as storm and flood protection are the two variables allowed to be non-attended in the ANA specification. The expected mWTP for a non-attended parameter can be calculated by multiplying the probability of attendance by the mWTP. This operation results in an expected mWTP of $8.86 for storm protection and $7.24 for flood protection.

Min_hab, Sig_hab, Min_rec, and Sig_rec have significant and very high mWTP values across all three models. Since these are discrete variables, marginal WTP calculations are not well suited to evaluating preferences. Total WTP calculations can be employed, but they are beyond the econometric scope of this thesis.

The interaction term models separate the impact of potential strategic voters from the effects associated with the rest of the sample. The results of the interaction term models are similar to the base models, with the same parameters having significant results. The sign for all parameters is also the same. Among the interaction terms, min_hab, tax, status quo, and sq_cFNWR are significant in all models. Sig_hab is significant in the mixed logit model; acres is significant in the mixed logit and ANA models, and min_rec is significant in the conditional logit model. The tax and acres interaction terms are positive, suggesting that potential strategic voters may have shifted the overall results upward. The information criteria test shows the same ordering of models as the base models: mixed logit > ANA > conditional logit. All information criteria values are lower in the interaction term models than the base models, giving support to the significance of identifying potential strategic voters. Parameter estimates in the non-interacted terms are generally lower than in the base model, because of influence from potential strategic voters (and smaller sample sizes).

In the interaction term model, marginal WTP is slightly lower than in the base models. The ANA model estimated the mWTP for acres to be $8.38, storm protection to be $35.27, and flood protection to be $20.31. Multiplying the attendance probability of flood and storm protection by their mWTP results in a mWTP of $8.46 for storm protection and $4.87 for flood protection. The mWTP was reduced from the base ANA model by 27.4% for acres, 4.52% for storm protection, and 7.39% for flood protection. Only the acres interaction coefficient was significant in the conditional logit and mixed logit models, with mWTP estimates of $9.27 and $9.05, respectively. All mWTP estimates have the expected sign, with the exception of storm and flood protection in the mixed logit model, but those estimates are small in magnitude and not statistically significant. The high disparity between the ANA model and the other models' mWTP estimates for storm and flood protection is likely due to the high number of non-attenders for those variables. These results demonstrate that storm and flood protection are not viewed as relevant to the majority of respondents, but the respondents who do pay attention to storm and flood protection value it highly. The overall lower mWTP values for the interaction term models are caused by the isolation of the potential strategic voters, the majority of whom selected the high invest option. Removing these respondents lowers the mWTP estimates.

We conducted a Wald test on each model specification, testing the null hypothesis that the coefficients of the interacted terms were jointly zero. The Wald test rejects that null hypothesis at the <1% level for all three models. This means that the potential strategic voters had significantly different valuations of the site attributes than the sample as a whole, and including the potential strategic voter categorical variables improves model fit. This result is evidence of strategic voting, as isolating the impact of potential strategic voters improves model performance.

Lastly, we regressed the potential strategic voter dummy on household characteristics using a logit model to investigate patterns of strategic voting. The only significant parameter estimates were "some college" and "graduate" education, with positive effects relative to high school education. This could indicate that increased education increases likelihood to strategically vote, but the effects are relatively small and the college category is insignificant. These results suggest that there are not demographic indicators that predict strategic voting.

Table 4. Base Model Results

	cLogit	**mLogit**	**ANA**
min_habitat	0.4076***	1.2509**	0.4912**
	(0.1476)	(0.4991)	(0.1907)
sig_habitat	0.8272***	2.3042***	0.9583***
	(0.1395)	(0.5242)	(0.1761)
min_rec	0.3507**	0.4497	0.3244
	(0.1561)	(0.5338)	(0.2108)
sig_rec	0.5240***	1.1343**	0.6017***
	(0.1493)	(0.4994)	(0.2046)
acres	0.1297***	0.2844**	0.1672***
	(0.0354)	(0.1381)	(0.0437)
storm_prot	0.0283	0.0565	0.5350***
	(0.0286)	(0.1217)	(0.0731)
flood_prot	0.0189	0.0005	0.3177***
	(0.0194)	(0.0588)	(0.0369)
tax_adj	-0.0113***	-0.0298***	-0.0145***
	(0.0015)	(0.0077)	(0.0019)
sq	0.5778*	0.2272	1.3282***
	(0.3126)	(0.8321)	(0.4000)
sq_cFNWR	-0.9873***	-2.5115*	-1.2439***
	(0.3591)	(1.2857)	(0.4718)

Table 5. Base Model mWTP

	cLogit	**cLogit SE**	**mLogit**	**mLogit SE**	**ANA**	**ANA SE**
Acres	11.49***	3.18	9.54***	3.64	11.54***	3.16
Storm	2.50	2.57	1.89	3.88	36.94***	5.40
Flood	1.67	1.74	0.02	1.97	21.93***	3.29
min_hab	36.12***	13.52	41.96**	17.03	33.92**	13.73
sig_hab	73.30***	14.11	77.30***	15.25	66.18***	13.80
min_rec	31.08**	14.48	15.09	18.10	22.40	15.33
sig_rec	46.44***	14.70	38.05**	15.70	41.55***	16.09

Table 6. Interaction Term Model Results

	cLogit	mLogit	ANA
min_habitat	0.3706**	1.6476***	0.4247**
	(0.1488)	(0.5499)	(0.1967)
sig_habitat	0.8119***	2.7938***	0.9404***
	(0.1379)	(0.8794)	(0.1811)
min_rec	0.3615**	0.3876	0.3550
	(0.1590)	(0.5950)	(0.2256)
sig_rec	0.5462***	1.2457**	0.6591***
	(0.1561)	(0.4911)	(0.2286)
acres	0.1210***	0.4114**	0.1500***
	(0.0360)	(0.1944)	(0.0464)
storm_prot	0.0461	-0.0084	0.6314***
	(0.0291)	(0.0940)	(0.0829)
flood_prot	0.0160	-0.1068	0.3636***
	(0.0191)	(0.0765)	(0.0399)
tax_adj	-0.0130***	-0.0454***	-0.0179***
	(0.0016)	(0.0155)	(0.0022)
sq	0.7236**	-0.6227	1.5056***
	(0.3110)	(0.8867)	(0.3881)
sq_cFNWR	-1.1541***	-3.7966***	-1.5234***
	(0.3476)	(1.4683)	(0.4852)
pot_min_hab	-1.6081***	-15.2257***	-2.0368***
	(0.4657)	(4.5479)	(0.5671)
pot_sig_hab	-0.3904	3.2086*	-0.5828
	(0.5440)	(1.7992)	(0.6151)
pot_min_rec	-0.8172	-0.9931	-0.5326
	(0.5098)	(2.3444)	(0.6362)
pot_sig_rec	-0.0240	6.8480**	-0.0705
	(0.6038)	(2.7630)	(0.7309)
pot_acres	0.2328*	4.2526***	0.3031**
	(0.1259)	(1.1600)	(0.1472)
pot_storm_prot	-0.0335	-0.7236**	-0.2236*
	(0.1056)	(0.3627)	(0.1196)
pot_flood_prot	-0.0107	0.9418***	-0.1747*
	(0.0950)	(0.3310)	(0.1020)
pot_tax_adj	0.0533***	0.5207***	0.0657***
	(0.0065)	(0.1495)	(0.0075)
pot_sq	3.9837***	39.4114***	3.9304**
	(1.2959)	(12.6540)	(1.5664)
pot_sq_cFNWR	-1.4447	-7.5881*	-2.1963*
	(1.1312)	(4.4176)	(1.3176)

Table 7. Interaction Term Model mWTP

	cLogit	cLogit SE	mixLogit	mixLogit SE	ANA	ANA SE
Acres	9.27***	2.75	9.05***	2.7	8.38***	2.67
Storm	3.53*	2.29	-0.18	2.07	35.27***	4.75
Flood	1.22	1.48	-2.35	1.62	20.31***	2.9
min_hab	28.4***	11.63	36.26***	10.81	23.72**	11.32
sig_hab	62.24***	11.93	61.49***	11.39	52.53***	11.36
min_rec	27.71**	12.53	8.53	14.13	19.83*	13.23
sig_rec	41.87***	13.04	27.41**	13.28	36.82***	14.37

Table 8. Potential Strategic Voters HH Characteristics

	cLogit
potStrat	
age	0.0052
	(0.0110)
hhsize	-0.0181
	(0.1421)
some_coll	1.0317*
	(0.6168)
college	0.7178
	(0.6229)
grad	1.5225**
	(0.6121)
black	-1.0256*
	(0.5963)
male	0.3402
	(0.2960)
income_adj	0.0000
	(0.0000)
Constant	-4.3193***
	(0.9827)

CHAPTER 6

DISCUSSION

Strategic voting is one of the primary concerns with discrete choice valuation techniques. There are many reasons that a respondent may misrepresent their preferences, making it difficult for the researcher to tell sincere votes from strategic votes. This thesis provides a framework that helps to address concerns about strategic voting. It demonstrates that, under common survey design conditions, strategic voting may be significantly less prevalent than previously thought. Second, it provides a method for identifying potential strategic voters and adjusting mWTP values to account for their influence.

After accounting for potential strategic voters, mWTP values were slightly lower than the non-adjusted models. Information criteria tests and Wald tests show that the model specifications that include potential strategic voter interaction variables have better fit. These results indicate that strategic voting could be present, but our results indicate a moderate potential effect on mWTP estimates. The mixed logit models had the best information criteria test results, but the individual attribute estimates exhibited higher precision (statistical significance) for the ANA models. This suggests that the mixed logit model explains more variance in the data overall, but the ANA model produces better parameter estimates for respondents, particularly those that cared about flood and storm protection. The low attendance probability for flood and storm protection explains this discrepancy: the ANA model more accurately models the preferences of respondents who value flood and storm protection, perhaps those that live in flood or storm threatened areas, but less accurately explains the preferences of the majority of respondents.

The conceptual model provides the basis for analysis by identifying which vote selection/ expected winner pairs are potentially strategic. Categorizing responses as potentially strategic bridges the divide between the theoretical, experimental, and empirical strategic voting literature. By identifying potential strategic voters, this thesis examines the potential effects of strategic voting, extending the theoretical literature that has only shown that discrete choice methods are susceptible to strategic voting. This thesis highlights a hidden assumption in the experimental literature: all options in a discrete choice study are conceptually distinct, carrying unobserved brand effects. By showing that choice options pulled from a continuum might avoid unobserved brand effects, this thesis opens new possibilities for experimental exploration of strategic voting. This thesis provides support for the voracity of the results of the empirical choice experiment literature by showing that methodological changes in choice experiments may have made them less susceptible to strategic voting. These methodological changes have come about as a response to shifting natural resource management strategies and new legislation mandating the use of valuation data in resource management. The shift to valuing levels of a single policy rather than different sites or policies was not intended to curtail strategic voting, but may have encouraged new designs that can perform better in this regard.

This thesis is an exploratory step that opens up new possibilities for strategic voting research. Formalization of the conceptual model into microeconomic theory would identify inconsistencies or overlooked details that may compromise the results, as well as provide a more solid foundation to move forward with experimental work. Experimental validation of the results of this thesis would show the extent to which the findings of this thesis are generalizable and provide more evidence for the voracity of these findings. An induced demand experimental framework would allow researchers to see in detail when strategic voting occurs.

Based on the findings of this thesis, future discrete choice surveys could add a question asking respondents which option they believe would win. The inclusion of this question allows researchers to identify and adjust for potential strategic voters, and it is a fairly simple addition to a survey. There should be some concern that asking respondents about their expectations may cause them to develop expectations where they did not have them before, but our results show a high proportion of people willing to indicate a lack of expectations, somewhat alleviating these concerns Including an expected winner question on a properly formatted survey is a low-cost method to address strategic voting concerns.

CHAPTER 7

CONCLUSION

The goal of this research was to assess preferences for coastal restoration and investigate the impact of potential strategic voting in the context of multinomial choice experiments. We reason that under a three-option choice experiment setup that asks respondents to select an option from a continuous range of investment, strategic voting is less likely than under traditional discrete choice frameworks. After isolating the effect of potential strategic voters, the WTP for all site attributes was slightly lower. A series of Wald tests were used to investigate the significance of isolating potential strategic voters. Results of the Wald tests were statistically significant for each model specification that accounted for potential strategic response, indicating that the interaction terms lead to significantly different parameter estimates and an improvement in model fit. Information criteria tests returned lower values for all interaction term models than their base model counterparts, implying that the interaction term models explain more variation than the base models.

The most significant limitation of this study is that the outcome of the empirical tests is a result of the assumptions made about which respondents are potentially strategic, and those assessments are based on non-incentivized responses to post-valuation survey questions regarding expectations of other respondents' votes. Empirical analysis of choice data cannot determine the sincerity of respondents. This thesis should be seen as an exploration of the effect of a novel method of identifying potential strategic voters, rather than evidence of the accuracy of that method. There are (at least) two directions for further research to address this weakness. The first is a rigorous theoretical assessment of the difference in the strategic voting patterns of utility-maximizing respondents with discrete and continuum-derived alternatives. The second is an experimental approach to the same problem. The hypothesis that survey respondents have different strategic voting patterns for discrete and continuum-derived alternatives could be tested with an induced demand experiment similar to the work of Collins and Vossler (2009) or Tszler and Schram (2016).

This thesis contributes to the choice experiment validity literature by demonstrating the difference in potential strategic voting behavior between discrete choice alternatives and choice alternatives pulled from a continuum. This thesis also contributes to the coastal valuation literature by providing updated, strategic voting-adjusted, valuation estimates of the Forsythe National Wildlife Sanctuary restoration plan.

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Appendix A1: Strategic Voting Patterns for Discrete Options

Conditions:

1. If most-preferred is expected, it should be selected

2. should never select least-preferred

Rational and Strategic

Index	True Pref	Expected Winner	Vote	Rational?	Strategic?	Rational+Strategic
1	A>B>C	A	A	1	0	0
2	A>C>B	A	A	1	0	0
3	B>A>C	A	A	1	1	1
4	B>C>A	A	A	0	1	0
5	C>A>B	A	A	1	1	1
6	C>B>A	A	A	0	1	0
7	A>B>C	B	A	1	0	0
8	A>C>B	B	A	1	0	0
9	B>A>C	B	A	0	1	0
10	B>C>A	B	A	0	1	0
11	C>A>B	B	A	1	1	1
12	C>B>A	B	A	0	1	0
13	A>B>C	C	A	1	0	0
14	A>C>B	C	A	1	0	0
15	B>A>C	C	A	1	1	1
16	B>C>A	C	A	0	1	0
17	C>A>B	C	A	0	1	0
18	C>B>A	C	A	0	1	0
19	A>B>C	A	B	0	1	0
20	A>C>B	A	B	0	1	0
21	B>A>C	A	B	1	0	0
22	B>C>A	A	B	1	0	0
23	C>A>B	A	B	0	1	0
24	C>B>A	A	B	1	1	1
25	A>B>C	B	B	1	1	1
26	A>C>B	B	B	0	1	0
27	B>A>C	B	B	1	0	0
28	B>C>A	B	B	1	0	0
29	C>A>B	B	B	0	1	0
30	C>B>A	B	B	1	1	1
31	A>B>C	C	B	1	1	1

32	A>C>B	C	B	0	1	0
33	B>A>C	C	B	1	0	0
34	B>C>A	C	B	1	0	0
35	C>A>B	C	B	0	1	0
36	C>B>A	C	B	0	1	0
37	A>B>C	A	C	0	1	0
38	A>C>B	A	C	0	1	0
39	B>A>C	A	C	0	1	0
40	B>C>A	A	C	1	1	1
41	C>A>B	A	C	1	0	0
42	C>B>A	A	C	1	0	0
43	A>B>C	B	C	0	1	0
44	A>C>B	B	C	1	1	1
45	B>A>C	B	C	0	1	0
46	B>C>A	B	C	0	1	0
47	C>A>B	B	C	1	0	0
48	C>B>A	B	C	1	0	0
49	A>B>C	C	C	0	1	0
50	A>C>B	C	C	1	1	1
51	B>A>C	C	C	0	1	0
52	B>C>A	C	C	1	1	1
53	C>A>B	C	C	1	0	0
54	C>B>A	C	C	1	0	0

Appendix A2: Strategic Voting Patterns for Continuum-Derived Options

Conditions:

1. If most-preferred is expected, it should be selected
2. If least-preferred is expected, it should not be selected
3. If an extreme is preferred, it should be selected
4. If the intermediate is preferred and not expected, the extreme that is not expected should be selected

Non-Convex Preference

Rational and Strategic

Index	True Pref	Expected Winner	Vote	Rational?	Strategic?	Rational+Strategic
1	A>B>C	A	A	1	0	
2	A>C>B	A	A	1	0	
3	B>A>C	A	A	0	1	
4	B>C>A	A	A	0	1	
5	C>A>B	A	A	0	1	
6	C>B>A	A	A	0	1	
7	A>B>C	B	A	1	0	
8	A>C>B	B	A	1	0	
9	B>A>C	B	A	0	1	
10	B>C>A	B	A	0	1	
11	C>A>B	B	A	0	1	
12	C>B>A	B	A	0	1	
13	A>B>C	C	A	1	0	
14	A>C>B	C	A	1	0	
15	B>A>C	C	A	1	1	1
16	B>C>A	C	A	1	1	1
17	C>A>B	C	A	0	1	
18	C>B>A	C	A	0	1	
19	A>B>C	A	B	0	1	
20	A>C>B	A	B	0	1	
21	B>A>C	A	B	0*	0	
22	B>C>A	A	B	0*	0	
23	C>A>B	A	B	0	1	
24	C>B>A	A	B	0	1	
25	A>B>C	B	B	0	1	
26	A>C>B	B	B	0	1	
27	B>A>C	B	B	1	0	

28	B>C>A	B	B		1	0	
29	C>A>B	B	B		0	1	
30	C>B>A	B	B		0	1	
31	A>B>C	C	B		0	1	
32	A>C>B	C	B		0	1	
33	B>A>C	C	B	0*		0	
34	B>C>A	C	B	0*		0	
35	C>A>B	C	B		0	1	
36	C>B>A	C	B		0	1	
37	A>B>C	A	C		0	1	
38	A>C>B	A	C		0	1	
39	B>A>C	A	C		1	1	1
40	B>C>A	A	C		1	1	1
41	C>A>B	A	C		1	0	
42	C>B>A	A	C		1	0	
43	A>B>C	B	C		0	1	
44	A>C>B	B	C		0	1	
45	B>A>C	B	C		0	1	
46	B>C>A	B	C		0	1	
47	C>A>B	B	C		1	0	
48	C>B>A	B	C		1	0	
49	A>B>C	C	C		0	1	
50	A>C>B	C	C		0	1	
51	B>A>C	C	C		0	1	
52	B>C>A	C	C		0	1	
53	C>A>B	C	C		1	0	
54	C>B>A	C	C		1	0	